Appendix C

Background Chemical Concentrations in Soil

Metals occur naturally in environmental media, including soil. Additionally, several anthropogenic chemicals, such as PCBs and dioxins/furans, have become widespread due to transport and deposition from global and regional sources. Therefore, anthropogenic chemicals may be detected in soil samples far removed from point sources. It is important to be able to differentiate the natural or regional concentrations of hazardous substances from those that are associated with a source and pathway at a specific site.

The U.S. EPA collected soil samples from two reference locations in the vicinity of the Site in 2001 (EPA 2002). The locations of reference samples (Station ID Nos. SS-RF1-01 and SS-RF2-01) are shown in Figure 3-6. Soil samples were collected from the 0- to 1-foot interval and analyzed for metals, VOCs, SVOCs, and dioxins. The limited number of site-specific reference soil samples precludes the application of rigorous statistical comparisons of site and reference data. The maximum detected concentration of chemicals at the Site will be compared to the maximum detected concentration in the two reference area samples. In this comparison, the maximum site value is treated as a conservative surrogate for the upper confidence limit of the mean and the maximum site-specific reference value is treated as a conservative estimate of the mean for the reference area. If the maximum detected site concentration is less than the maximum detected reference concentration, it can be safely concluded that the chemical level at the site is not elevated above background. However, because of the small number of reference area samples, it cannot be safely concluded that the chemical concentration at the Site is elevated if the maximum detected site concentration is greater than the maximum detected reference concentration. Additional sources of information on background soil concentrations were obtained to strengthen the background evaluation.

No single additional source of background data was found that contained information on all of the metals of interest, and sources varied with respect to their relevance to the area of the Site. The published sources of soil background information used in this evaluation, in descending order of precedence given, are:

- ***Pierce et al. (1982)***—The authors measured the concentrations of six trace metals (cadmium, chromium, copper, lead, nickel, and zinc) in soil samples collected from 16 soil series in Minnesota. Sample locations were in undisturbed, uncultivated areas at a sufficient distance from major roadways to minimize contamination. Results for the nitric acid extraction were used.
- ***Shacklette and Boerngen (1984***)—The authors evaluated the analytical results of sampling the upper 20 cm of soil collected from 1,318 locations about 80 km apart throughout the conterminous United States. Samples were collected from locations that were unaltered or minimally altered from their natural condition. Summary results for the eastern United States were used.

- ***Kabata-Pendias and Pendias (1984)***—The authors reviewed results of studies from around the world. No attempt was made to review the original cited papers, and we report only the summary findings.

For the Pierce et al. (1982) and Shacklette and Boerngen (1984) data sets, the authors provided mean, maximum, and minimum values that were useful for evaluating background conditions. In addition, the 90th percentile value was estimated using the mean and standard deviation supplied by the authors using the following equation:

$$90^{th} \text{ percentile} = x + (Z_{90} * sd)$$

where;

x = mean of the sample population chemical concentrations,

Z_{90} = the standard normal deviate (Z value) for the area of the normal distribution curve at the 90th percentile, and

sd = standard deviation of the sample population chemical concentrations.

In the above calculation, the background data sets are assumed to be normally distributed. This assumption is conservative in comparison to the assumption of a lognormal distribution, which would yield a higher estimate for the 90th percentile background value.

Dioxins/furans are ubiquitous in environmental media throughout the world (EPA 2000). EPA (2000) provides typical background concentrations for dioxins/furans in soils in rural and urban areas of North America. PAHs are also ubiquitous in the environment originating from both anthropogenic (e.g., fuel combustion) and natural (forest fires) sources (Eisler 1987, ATSDR 1995). ATSDR provides soil background concentrations of PAHs for the United States and other countries. The minimum and maximum values for soil samples collected from rural and agricultural areas were used.

Table C-1 provides the background soil chemical data. These data will be used to compare concentrations of chemicals detected in soil samples from the St. Regis Paper Company Site with background concentrations. As stated in EPA's RAGS "care must be taken in using literature sources [of background analytical data], because the data contained therein might represent [regional, national, or international] variation in a particular parameter rather than variation typical of the geographic region or geological setting in which the site is located" (EPA 1989). Of the three literature sources discussed above, only Pierce et al. 2002, is based on soil samples collected in Minnesota. The other two literature sources present results collected over very large geographical areas that may or may not reflect soil types that are representative of the site area. Therefore, analytical results from the St. Regis Paper Company Site will be compared to analytical results for background/reference locations using the following order of preference for identifying relevant background/reference locations (from most to least

preferred): (1) site-specific (e.g. background/reference locations), (2) regional (e.g. state-specific locations), and (3) national or international locations.

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Table C-1. Background Concentrations of Chemicals in Soil

	Units	Site-Specific Background		Literature Background				Source of Literature Background
		Minimum	Maximum	Minimum	Maximum	Mean[1]	90th percentile[2]	
Analyte Metals								
Aluminum	mg/kg	2370	3450	7000	>100000	33000	69793	Shacklette and Boerngen (1984)
Antimony	mg/kg	1.3 U	1.4 U	<1	8.8	0.52	3.57	Shacklette and Boerngen (1984)
Arsenic	mg/kg	1 J	1.1	<0.1	73	4.8	8.08	Shacklette and Boerngen (1984)
Barium	mg/kg	91	101	10	1500	290	293	Shacklette and Boerngen (1984)
Beryllium	mg/kg	0.055 J	0.093 J	<1	7	0.55	3.79	Shacklette and Boerngen (1984)
Cadmium	mg/kg	0.1 U	0.22	0.02	0.56	0.17	0.39	Pierce et al. (1982)
Calcium	mg/kg	2680	3660	100	280000	3400	42886	Shacklette and Boerngen (1984)
Chromium	mg/kg	4.6	5.4	3.1	9	4.7	6.5	Pierce et al. (1982)
Cobalt	mg/kg	3	3.1	<0.3	70	5.9	9.2	Shacklette and Boerngen (1984)
Copper	mg/kg	2.5	2.7	2.4	19.3	7.4	13.2	Pierce et al. (1982)
Iron	mg/kg	3430	4720	100	>100000	1400	50793	Shacklette and Boerngen (1984)
Lead	mg/kg	9.7	11.4	0.7	9.4	4.8	8.13	Pierce et al. (1982)
Magnesium	mg/kg	868	894	50	50000	2100	47611	Shacklette and Boerngen (1984)
Manganese	mg/kg	718	1080	<2	7000	260	265	Shacklette and Boerngen (1984)
Mercury	mg/kg	0.032	0.039	0.01	3.4	0.081	3.3	Shacklette and Boerngen (1984)
Nickel	mg/kg	3.7	4.6	2.8	19	8.1	15.2	Pierce et al. (1982)
Potassium	mg/kg	276	423	50	37000	12000	21615	Shacklette and Boerngen (1984)
Selenium	mg/kg	0.41 U	0.47 U	<0.1	3.9	0.03	3.4	Shacklette and Boerngen (1984)
Silver	mg/kg	0.17 U	0.20 U	0.03	0.09	NA	NA	Kabata-Pendias and Pendias (1984)
Sodium	mg/kg	91.7	116	<500	50000	2500	60831	Shacklette and Boerngen (1984)
Thallium	mg/kg	0.19 U	0.22 U	0.02	2.8	NA	NA	Kabata-Pendias and Pendias (1984)
Vanadium	mg/kg	5.9	8.2	<7	300	43	46.2	Shacklette and Boerngen (1984)
Zinc	mg/kg	13.2	35.1	5.6	38.8	14.9	24.3	Pierce et al. (1982)
Dioxins								
2,3,7,8-TCDD TEQ (ND=1/2DL)	ng/kg	1.25	1.28	NA	NA	NA	NA	
2,3,7,8-TCDD TEQ (ND=0)	ng/kg			0.12 (2.21)	4.41 (21.0)	2.9 (9.4)	NA	EPA (2000)
SVOCs								
Acenaphthylene	µg/kg	4 U	5	5	5	NA	NA	ATSDR 1995
Anthracene	µg/kg	4 U	8	11	13	NA	NA	ATSDR 1995
Benzo(a)anthracene	µg/kg	28	45	5	110	NA	NA	ATSDR 1995

Table C-1. Background Concentrations of Chemicals in Soil (continued)

	Units	Site-Specific Background		Literature Background				Source of Literature Background
		Minimum	Maximum	Minimum	Maximum	Mean	90th percentile[2]	
Benzo(a)pyrene	µg/kg	26	42	2	1,300	NA	NA	ATSDR 1995
Benzo(g,h,i)perylene	µg/kg	24	37	10	70	NA	NA	ATSDR 1995
Benzo(k)fluoranthene	µg/kg	28	52	10	250	NA	NA	ATSDR 1995
Bis(2-ethylhexyl)phthalate	µg/kg	41 J	370 U	NA	NA	NA	NA	
Chrysene	µg/kg	38	63	38.3	120	NA	NA	ATSDR 1995
Dibenz(a,h)anthracene	µg/kg	6	8	NA	NA	NA	NA	
Dibenzofuran	µg/kg	3 J	4 U	NA	NA	NA	NA	
Fluoranthene	µg/kg	60	92	0.3	210	NA	NA	ATSDR 1995
Indeno(1,2,3-cd)pyrene	µg/kg	24	40	10	100	NA	NA	ATSDR 1995
Pentachlorophenol	µg/kg	10	61	NA	NA	NA	NA	
Phenanthrene	µg/kg	18	30	30	140	NA	NA	ATSDR 1995
Pyrene	µg/kg	53	72	1	150	NA	NA	ATSDR 1995
VOCs								
Acetone	µg/kg	1200 J	1300 J	NA	NA	NA	NA	
Carbon Disulfide	µg/kg	2 J	22 UJ	NA	NA	NA	NA	
Methyl Acetate	µg/kg	490 J	1000 J	NA	NA	NA	NA	
Toluene	µg/kg	14 J	15 J	NA	NA	NA	NA	

Notes:

NA – not available

Dioxin background values are from rural and urban (in parentheses) areas

PAH background levels are the minimum and maximum from rural and agricultural soils.

[1] Pierce et al. (1982) reported the arithmetic mean, while Shacklette and Boerngen (1984) reported the geometric mean.

[2] The 90th percentile was calculated for Pierce et al. (1982) using the arithmetic mean and standard deviation, and for Shacklette and Boerngen (1984) using the geometric mean and standard deviation.