Exponent®

Technical Memorandum

Supplemental Risk Calculations for the Former Alaska Pulp Company Mill Facility

Prepared for

City of Sitka
Sitka, Alaska

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Prepared for

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February 2005

Doc. no. 8602384.002 0201 0205 LY01

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Acronyms and Abbreviations

APC	Alaska Pulp Company
CoPC	chemical of potential concern
CSF	cancer slope factor
DEC	Alaska Department of Environmental Conservation
DRO	diesel-range organics
EPA	U.S. Environmental Protection Agency
HHRA	human health risk assessment
NCP	National Contingency Plan
PAH	polycyclic aromatic hydrocarbon
PCDD/F	polychlorinated dibenzo-*p*-dioxin and polychlorinated dibenzofuran
RAGS	Risk Assessment Guidance for Superfund
RBA	relative bioavailability adjustment
RBC	risk-based concentration
RfD	reference dose
RME	reasonable maximum exposure
RRO	residual-range organics
TCDD	2,3,7,8-tetrachlorodibenzo-*p*-dioxin
TEQ	toxicity equivalent
the City	the City and Borough of Sitka
UCL	upper confidence limit

Supplemental Risk Calculations for the Former Alaska Pulp Company Mill Facility

This technical memorandum describes a focused human health risk assessment (HHRA) conducted by Exponent to evaluate a proposed change in land use at the former Alaska Pulp Company (APC) Mill property in Sitka, Alaska. Exponent conducted this work at the request of the City and Borough of Sitka (the City) with regulatory oversight from the Alaska Department of Environmental Conservation (DEC). The City received a request for a change in land use at the former facility that would involve residence at the facility for part or all of the year. Because this site use is counter to the current deed restriction that precludes residence onsite, additional risk calculations were conducted to evaluate whether the use under consideration would constitute a human health risk.

Background

This analysis draws from data and site information provided in the following two documents, which summarize an extensive site characterization and risk assessment:

- *Alaska Pulp Corporation Sitka Mill Site Final Mill Operable Unit Remedial Investigation Report* (Foster Wheeler 1998b), which provided a summary of the site environmental characterization
- *Alaska Pulp Corporation Sitka Mill Site Human Health Risk Assessment Report* (Foster Wheeler 1998a), which provided the methodology and results of the final HHRA for the site.

In this assessment, Exponent evaluated risks associated with the proposed use through application of default risk assessment assumptions for an adult living at the facility year-round and for a part-year residence scenario. In addition, to provide further information to risk managers, Exponent also evaluated risks for year-round residence and part-year residence for a young child. Only soil exposures were considered, consistent with the finding that risks related

to water consumption from Blue Lake were 1×10^{-8} under a residential scenario (Foster Wheeler 1998a, Tables 3-13 and 5-1). Thus, water exposures are not considered likely to be substantial contributors to site risks.

Focused HHRA for Former Mill

The purpose of this focused HHRA is to determine whether adverse impacts to human health or the environment could occur now or under reasonably likely future use, as a result of direct or indirect exposure to site-related chemicals in soil under the proposed part-time residence scenario. The risk assessment was focused on evaluating the incremental risk related to operations of the former facility. The results of the risk assessment are intended to help risk managers evaluate whether a modification of the deed restrictions may be appropriate. The HHRA was conducted in accordance with risk assessment guidance provided by DEC (2000a,b, 2002a,b) and the U.S. Environmental Protection Agency (EPA) (U.S. EPA 1989, 1991, 1992, 1997, 2004, 2005b). These risk assessment elements are described in the following sections.

This technical memorandum describes the methodology used to evaluate risk to human health posed by potential future exposure to residual chemicals in soil at the former mill area and includes the four steps recommended in EPA guidance for risk assessment:

- Identification of chemical of potential concerns (CoPCs)
- Exposure assessment
- Toxicity assessment
- Risk characterization.

An uncertainty assessment is included in the risk characterization to place potential site risks in context. The uncertainty assessment discusses HHRA assumptions that may over- or underestimate potential site risks.

1 Chemicals of Potential Concern for Human Health

The risk calculations conducted for the former APC Mill were based on the CoPCs and exposure point concentrations identified in the 1998 HHRA prepared by Foster Wheeler for the onsite worker in the mill facility. This approach provided a conservative means to evaluate the specific site area under consideration because the CoPC screening used residential exposure assumptions. Because of the lack of any indication of contaminant sources in the proposed bunkhouse location, this area was not directly sampled during the remedial investigation and feasibility study. Application of data for the entire area, however, provided a means to consider any potential exposure at the site.

In identifying CoPCs for the site, Foster Wheeler (1998a) compared site data with risk-based concentrations (RBCs) derived by EPA Region III. These RBCs provided a protective means to identify potential CoPCs because they were derived to be protective of residential site use and are based on the lower of either a 10^{-6} cancer risk or a hazard index of 0.1. Foster Wheeler reviewed former APC Mill site soils and identified the following CoPCs (Table 1-1):

- Polychlorinated dibenzo-*p*-dioxins (PCDDs), which were evaluated as toxicity equivalents (TEQs)
- Arsenic
- Chromium
- Nickel
- Petroleum hydrocarbons
- Carcinogenic polycyclic aromatic hydrocarbons (PAHs), which were evaluated as TEQs.

2 Exposure Assessment

Exposure assessment is the process of identifying human populations that could potentially contact site-related CoPCs and estimating the magnitude, frequency, duration, and route(s) of potential exposures. This section begins with a discussion of potential human exposure pathways and then provides assumptions used in quantifying each of the complete pathways.

2.1 Potential Human Receptors and Exposure Pathways

An exposure pathway is the course a chemical takes from a source to an exposed receptor. Exposure pathways consist of the following four elements: 1) a source; 2) a mechanism of release, retention, or transport of a chemical to a given medium (e.g., air, water, soil); 3) a point of human contact with the medium (i.e., exposure point); and 4) a route of exposure at the point of contact (e.g., incidental ingestion, dermal contact). If any of these elements is missing, the pathway is considered incomplete (i.e., it does not present a means of exposure). Only those exposure pathways judged to be potentially complete are of concern for human exposure.

Exposure assumptions for the residential scenario were those identified in current DEC and EPA guidance for the residential scenario. The part-year scenario was evaluated using the same exposure assumptions, with the exception of exposure duration and exposure frequency; it was assumed that an adult worker would live at the site for 150 days per year over a 25-year exposure duration.

2.1.1 Potential Human Receptors

The site is not currently in use. The future use under consideration is seasonal workers living at the site for part of the year. This site use is evaluated here under a part-year residential scenario. Although future residential use of the area is unlikely, it was evaluated here for adults and children to provide information for risk managers and interested parties. Similarly, although the seasonal work residence is expected to include only adults, hypothetical risks for children are

also considered in this part-year scenario to provide additional information regarding potential future site use.

2.1.2 Potential Exposure Routes and Exposure Pathways

Potential exposure routes evaluated were ingestion and dermal contact with chemicals in soil. In addition, inhalation exposures were evaluated through estimates of concentrations of chemicals in air that could be generated from soil concentrations. Potential exposures for the following receptors and exposure pathways are quantified in the risk assessment:

- **Hypothetical Future Residents—**A hypothetical residential scenario was evaluated here, in which adults or children come into contact with soils within the site area through ingestion, dermal contact, or inhalation.
- **Workers Who Reside at the Site for Part of the Year—**Adults who work at the site and live onsite for part of the year could be exposed to chemicals in soils through ingestion, dermal contact, or inhalation. Children's exposures were also evaluated in this scenario. These risk estimates provide a health protective means to consider children who might visit parents or relatives at the site.

2.2 Quantification of Exposure

This section describes the methodology to evaluate exposure for the complete exposure pathways identified above. Consistent with the DEC *Risk Assessment Procedures Manual* (DEC 2000b), an reasonable maximum exposure (RME) scenario was evaluated. The RME scenario is intended to provide an estimate based on the highest exposure that is reasonably expected to occur at a site. Estimates were derived using deterministic methodology and are intended to be both health-protective and reasonable. The rationale for all assumptions applied here is described in this section.

Exposure estimates provided in DEC's *Cleanup Level Guidance* (DEC 2002a) were a primary basis used in calculations, as well as exposure assessment guidance provided by U.S. EPA (1989, 1991, 1997, 2004) and DEC (2000a,b, 2002a,b). Best professional judgment regarding future site use was also applied.

Exposure assessment for all CoPCs was conducted by combining estimates of soil or air intake with estimates of the CoPC concentration in those media. The chronic daily exposure to each CoPC was estimated using the following general algorithm:

$$CDI \quad (mg/kg-day) = \frac{C \times CF \times CR_m \times ED \times EF \times RBA}{BW \times AT}$$

where:

CDI	=	chronic daily exposure
C	=	chemical concentration in soil or air
CF	=	conversion factor as needed to correct units in soil
CR_m	=	contact rate for soil or air
ED	=	exposure duration (years)
EF	=	exposure frequency (days/year)
RBA	=	relative bioavailability adjustment—absorption from site soil (unitless)
BW	=	body weight (kg)
AT	=	averaging time (days)
		noncarcinogens—exposure duration × 365 days
		carcinogens—70-year lifetime × 365 days.

This exposure assessment first describes the derivation of exposure point concentrations for CoPCs in site soil and air. Subsequent sections provide the methodology for calculating each of the exposure pathways and the rationale for exposure assumptions applied in those estimates. Table 2-1 provides exposure algorithms unique to each pathway and the exposure assumptions applied.

2.2.1 Estimation of Exposure Frequency and Duration

Exposure frequency is used in the HHRA as the assumed number of days an individual is in contact with site media per year, and exposure duration is the assumed number of years of exposure to site media. Exposure durations of 30 years for adults and 6 years for young children were applied to the hypothetical future residential scenario consistent with residential exposure assumptions provided by DEC (2002a) and U.S. EPA (1989, 2004). This 30-year adult exposure duration is based on the 90th percentile of time that individuals live in one residence. The exposure frequency for hypothetical future residents was 330 days, consistent with DEC (2002a) guidance for areas with more than 40 in. of rainfall per year. In the future part-time residence scenario, the exposure frequency was reduced to 150 days per year, and the exposure duration was 25 years for adults and 6 years for the hypothetical childhood residence scenario.

2.2.2 Derivation of Exposure Point Concentrations

Exposure point concentrations applied in this risk assessment were taken from Table 3-13 of Foster Wheeler (1998a), which were derived for that HHRA using methods described in Section 3.3.1.1 of Foster Wheeler (1998a). As indicated there, EPA's *Risk Assessment Guidance for Superfund* (RAGS) (U.S. EPA 1989) recommends that the 95 percent upper confidence limit (UCL) on the mean be used in estimating exposure concentrations for the RME scenarios because of the uncertainty associated with estimating the mean exposure concentration. Specifically, UCLs were calculated consistent with supplemental guidance to RAGS (U.S. EPA 1992). Consistent with guidance from U.S. EPA (1989), exposure point concentrations applied in the RME calculations were the lower of either the UCL on the mean concentration or the maximum concentration.

Inhalation risks were also evaluated in Foster Wheeler (1998a) through derivation of exposure point concentrations for air from soil concentrations. Specifically, a particulate emissions factor was applied to the soil exposure point concentration to estimate an air concentration.

The exposure point concentrations for soil and the estimated air concentrations from Foster Wheeler (1998a) are shown in risk calculation tables in Appendix A.

2.2.3 Incidental Ingestion of Surface Soil

Exposure estimates for incidental ingestion of surface soil or sediments were quantified for each of the exposure scenarios evaluated using the soil or sediment data groups described above (Table 2-1). Adults and children may contact soils or sediments during outdoor activities and some proportion of that soil may be ingested. In addition, a portion of particles inhaled are ultimately swallowed and, thus, ingested. Soil ingestion rates have been estimated from studies evaluating the excretion of certain minerals present in soils and include both the soil that is directly ingested and the portion that is swallowed following inhalation. For the childhood exposure scenarios (i.e., hypothetical, future full- or part-time residents), an ingestion rate of 200 mg/day was applied, consistent with the parameters used in DEC's *Cleanup Levels Guidance* (DEC 2002a) and with EPA guidance (U.S. EPA 1991).

U.S. EPA (1997) does not provide an upper-bound value for soil ingestion for adults. However, U.S. EPA (1991) has identified 100 mg/day as an upper-bound intake rate, and this intake rate is also applied for adults by DEC (2002a). Therefore, this value was used as the intake rate for adults in all of the risk estimates for adults.

Chemical-specific relative bioavailability adjustments (RBAs) account for reduced absorption of chemicals from soil in comparison with absorption in the studies used to derive the toxicity values. In this HHRA, an RBA was applied to risk estimates for ingestion of PCDD and polychlorinated dibenzofuran (PCDD/F) in soil based on evidence of reduced absorption from ingested soil. Oral absorption of chemicals (i.e., oral bioavailability) in soil is generally less than that of chemicals in water or food. An RBA can be applied to exposure estimates to account for observed differences in bioavailability. For chemicals other than lead, EPA does not provide default assumptions for gastrointestinal absorption from soil. Instead, bioavailability from soil of chemicals such as arsenic and PCDD/Fs is often assumed to equal absorption of these chemicals in the studies used by EPA to derive their respective toxicity

values. However, the studies used to derive the toxicity factors are not based on exposure to chemicals in soil. EPA's cancer slope factor (CSF) used to evaluate PCDD/Fs is based on absorption of PCDD/Fs dissolved in acetone that was mixed with food. The following paragraphs provide the basis for RBAs used in exposure estimates for arsenic, PAHs, and PCDD/Fs in soil. Evidence suggests that PAHs are also incompletely absorbed from soil.

Foster Wheeler (1998a) identified an RBA of 0.6 for arsenic, citing U.S. EPA (1996) and noting that this value was identified by EPA as an RBA for arsenic originating from sources other than smelters. In addition, Foster Wheeler (1998a) identified an RBA of 0.84 for PAHs, which was identified as the upper end of a range of absorption estimates of 0.078 to 0.84 identified in ATSDR (1993). These RBA values were used in the risk calculations in this assessment (Table 2-1).

Oral absorption of PCDD/Fs varies with the medium in which the compounds are administered. In studies where PCDD/Fs were administered to rats by gavage (i.e., through a tube inserted into the animal's throat to its stomach) in an acetone-corn oil mixture, absorption from the gastrointestinal tract ranged from 70 to 83 percent (Rose et al. 1976; Piper et al. 1973). Oral absorption of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) administered to rats in the diet was reported to be 50–60 percent (Fries and Marrow 1975). In the study that was used as the basis for EPA's CSF, 2,3,7,8-TCDD was administered to rats mixed in their food (Kociba et al. 1978).

Absorption of ingested PCDD/Fs from soil is dependent on conditions and physical characteristics of the soil. The Agency for Toxic Substances and Disease Registry (DeRosa et al. 1997) identifies bioavailability of PCDD/Fs in soil as critical to calculating the exposure to PCDD/Fs through soil ingestion, noting that "[i]f assumed that 100% of TCDD is bioavailable, risk may be overestimated." Absorption from soil has been measured at levels varying from 0.5 to 50 percent (DeRosa et al. 1997; Paustenbach et al. 1992). Some authors have reported that the bioavailability of PCDD/Fs adhering to material with low organic content appeared to be on the low end of the range (i.e., 1 to 10 percent [van den Berg et al. 1985]). A study conducted by Shu et al. (1988) examined the bioavailability of 2,3,7,8-TCDD from Times

Beach soil relative to its bioavailability when administered in corn oil. The relative bioavailability estimates ranged from 37 to 49 percent with a mean value of 43 percent.

Using the results from the Shu et al. (1988) study and the range of bioavailability estimates for 2,3,7,8-TCDD in corn oil discussed above (70–83 percent), the absolute bioavailability of 2,3,7,8-TCDD from the test soil can be estimated as 30–36 percent (e.g., 43 percent multiplied by 70 percent equals 30 percent). Then, using the range of bioavailability estimates for 2,3,7,8-TCDD in the diet discussed above (50–60 percent), the bioavailability of 2,3,7,8-TCDD in soil relative to that from the diet can be estimated as 50–70 percent (e.g., 30 percent divided by 50 percent equals 60 percent). For the risk calculations presented in this report, the midpoint of this range (i.e., 60 percent) was selected as a conservative estimate of the RBA for PCDD/Fs ingested in soil. This value is somewhat higher than the assumption applied in the Foster Wheeler HHRA, which was an estimate of 0.43 identified as a midpoint from soil ingestion studies reviewed there.

2.2.4 Dermal Contact with Surface Soil

Dermal exposure was expressed as an absorbed dose by incorporating a contaminant-specific dermal absorption factor into the exposure equation using guidance provided in the EPA *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)* (U.S. EPA 2004). Dermal absorption reflects desorption of the contaminant from soil and the absorption of the contaminant across the skin and into the bloodstream (U.S. EPA 2004).

A dermal absorption factor accounts for the difference between the amount of the contaminant that is absorbed into the body through the skin relative to the amount that contacts the skin. Dermal exposures result in an estimate of absorbed dose, not the amount of contaminant that comes in contact with the skin (i.e., intake). Because oral toxicity values (i.e., CSFs and reference doses [RfDs]) are usually expressed as intakes, they must be adjusted with oral absorption factors to obtain reference toxicity values expressed as an absorbed dose. To calculate an adjusted toxicity value, a CSF is divided by the oral absorption factor, and an RfD

is multiplied by the oral absorption factor (U.S. EPA 1989). Table 2-2 provides the oral absorption factors used for relevant CoPCs in this HHRA as well as the adjusted toxicity values applied in dermal exposure estimates. The dermal absorption factors used in the HHRA are based on U.S. EPA (2004). In the case of diesel-range organics (DRO) and residual-range organics (RRO), no guidance is provided on dermal absorption. For risk calculations conducted here, an absorption factor of 0.13 was applied for dermal absorption of these petroleum mixtures based on dermal absorption recommended for benzo[a]pyrene.

A skin surface area term is used in dermal exposure estimates to reflect the amount of skin, in cm^2, that may come into contact with a contaminant in the exposure scenario. For adult dermal contact with outdoor soil in a residential scenario, U.S. EPA (2004) recommends using 5,700 cm^2 as an RME estimate. This value represents the average of the 50th percentile of surface area for males and females older than 18 years of age and was used in dermal exposure estimates in the adult hypothetical full-time and part-time residential scenarios (Table 2-1). Similarly, for evaluating a child's dermal contact with outdoor soil, U.S. EPA (2004) recommends using 2,800 cm^2 for RME estimates, based on the 50th percentile of surface area for males and females ages 1–6 years. This surface area estimate was applied in the hypothetical full- and part-time residential scenarios for a child.

A soil-to-skin adherence factor is also applied in dermal exposure estimates to estimate the amount of soil that remains deposited on the skin after contact (Table 2-1). Adherence factors vary by soil type (e.g., moisture content, particle size), by the body part contacting the soil, and by the activity being conducted while in contact with the soil. U.S. EPA (2004) has recommended application of assumed dermal absorption factors of 0.07 mg/cm^2 for adults and 0.2 mg/cm^2 for children in residential scenarios. EPA derived these adherence factors based on adherence measurements for various activities, time-weighted to reflect residential activity patterns for adults and children. An adherence factor of 0.2 mg/cm^2 is recommended by U.S. EPA (2004) for evaluation of workers' exposure to soil and was developed by EPA using data for utility workers. For this evaluation, because the primary use of the area is as a workplace, the adherence factor of 0.2 mg/cm^2 was applied in both scenarios for adults based on workplace

exposures. The 0.2 mg/cm^2 adherence factor was also applied in scenarios for children based on residential scenarios.

3 Toxicity Assessment

In the toxicity assessment, the hazards associated with CoPCs at the site are evaluated. For noncarcinogenic chemicals, EPA has developed a specific toxicity value called an RfD. An RfD is an estimate of the level of daily exposure that is likely to avoid appreciable risk of health effects over a lifetime, even in sensitive populations. Potential carcinogenic effects are evaluated through application of a CSF. The first resource for these toxicity values is EPA's Integrated Risk Information System, which is available online (U.S. EPA 2005b), and was the basis for most of the toxicity values applied here. In addition, EPA provides toxicity values within the Health Effects Assessment Summary Tables and in documentation provided by the EPA National Center for Environmental Assessment, which are available as hard copy and are also compiled and kept up-to-date within the EPA Region 9 RBC tables (U.S. EPA 2005a). All toxicity values used in this assessment are described in Tables 3-1 through 3-4.

Toxicity values for petroleum hydrocarbon ranges were those identified by DEC and are based on the closest approximate toxicity surrogate from DEC (2000a) guidance.

4 Risk Characterization

In risk characterization, quantitative exposure estimates and toxicity factors are combined to calculate numerical estimates of potential health risk. In this section, potential cancer and noncancer health risks are estimated assuming long-term exposure to contaminants detected in site media. The risk characterization methods described in DEC and EPA guidance were applied to calculate potential RME and typical excess lifetime cancer risks for carcinogens and hazard indices for contaminants with noncancer health effects. These methods and the results of the risk characterization are described below.

4.1 Evaluation of Carcinogenic Effects and Risk Estimates

Quantifying total excess cancer risk requires calculating risks associated with exposure to individual carcinogens and aggregating risks associated with simultaneous exposure to multiple carcinogenic contaminants. A cancer risk estimate for a single carcinogen is calculated by multiplying the carcinogenic chronic daily intake of the contaminant by its slope factor. A 1×10^{-6} cancer risk represents a one-in-one-million additional probability that an individual may develop cancer over a 70-year lifetime as a result of the exposure conditions evaluated. Because cancer risks are assumed to be additive, risks associated with simultaneous exposure to more than one carcinogen in a given medium will be aggregated to determine a total cancer risk for each exposure pathway. Total cancer risks for each pathway are then summed for reasonable combinations of exposure pathways to determine the total cancer risk for the population of concern.

The likelihood that actual risks are greater than estimated risks is very low because of the conservative assumptions used to develop cancer risk estimates; in fact, actual risks may be significantly less than predicted values. EPA's *Guidelines for Cancer Risk Assessment* state ". . . the linearized multistage procedure (typically used to calculate CSFs) leads to a plausible upper limit to the risk that is consistent with proposed mechanisms of carcinogenesis . . . . The true value of the risk is unknown, and may be as low as zero" (51 Fed. Reg. 185:33992, 33998).

Carcinogenic risk estimates were calculated for children and adults in the RME scenarios as the probability of additional cancers associated with the exposure pathways evaluated. Table 4-1 provides an overview of RME cancer risk estimates for all complete ingestion and dermal exposure pathways. The risk estimates for adults and children in the hypothetical future resident scenarios were the highest estimates (i.e., 2×10^{-5} and 3×10^{-5}, respectively). Risk estimates for part-time workers residing there were 9×10^{-6} and 2×10^{-5} for adults and children, respectively.

4.2 Evaluation of Noncancer Effects and Risk Estimates

Unlike carcinogenic effects, other potential adverse health effects are not expressed as a probability. Instead, these effects are expressed as the ratio of the estimated exposure over a

specified period to the RfD derived for a similar exposure period. This ratio is termed a hazard quotient and is calculated through application of this general algorithm:

$$\text{Hazard Quotient} = \frac{\text{Intake}}{\text{RfD}}$$

A hazard quotient less than 1 implies that exposure is below the level that is expected to result in a significant health risk. A hazard quotient greater than 1 does not necessarily mean that an effect would occur, but rather that exposure may exceed a general level of concern for potential health effects in sensitive populations. Exposures resulting in a hazard quotient less than or equal to 1 are very unlikely to result in noncancer adverse health effects. EPA states that the range of possible values around RfDs is "perhaps an order of magnitude" (U.S. EPA 2005b). Therefore, the significance of intakes exceeding the RfD by one-half an order of magnitude or less (i.e., hazard indices less than 5) must be carefully considered. Uncertainties in data supporting RfDs may cause their use to underestimate risk. However, because RfDs include uncertainty factors used to ensure protectiveness for sensitive human populations, they may also overestimate risks for most individuals.

In initial risk calculations, hazard quotients for individual CoPCs are summed for each exposure pathway to derive a hazard index. As indicated in DEC (2002b) guidance, a hazard index representing cumulative risk is then derived by summing "…all of the HQs [hazard quotients] for all pathways and exposure routes that affect the same target organ or system endpoint." Only the RfDs for DRO and RRO are based on effects in the same target organ (i.e., the liver). Nevertheless, for this risk assessment, hazard quotients for all CoPCs (except DRO and RRO fractions) and all pathways were summed.

Noncarcinogenic risks were calculated as RME estimates of the probability of adverse health effects other than cancer. No pathway or cumulative hazard indices exceeded 1 in any scenarios for adults or children (Table 4-2). These risk estimates indicate that no adverse effects related to noncancer endpoints would be expected to result from exposure to CoPCs under the assumed exposure conditions.

4.3 Risk Levels for Carcinogens and Noncarcinogens

The determination of an acceptable risk level is ultimately a decision to be made by risk managers. DEC has adopted risk management standards for evaluation of the incremental risk associated with a site. These standards were set to ensure the same level of protection of human health for all land uses. Consistent with these standards, the findings of the HHRA can be compared with the cumulative carcinogenic risk level of 1×10^{-5} and a hazard index of 1. In addition, the broader range of acceptable risk levels (i.e., risks up to 1×10^{-4}) cited in EPA's National Contingency Plan (NCP) (40 CFR 300) may be applied at DEC's discretion. Considerations in applying this range include the following:

- Site-specific conditions
- Land use
- Contaminant characteristics
- Statutory compliance
- Protection of health and the environment
- Implementability of cleanup
- Long- and short-term effectiveness
- Public comment
- Cost.

This range is identified in the NCP, which states that risk levels in the range of 10^{-4} to 10^{-6} and lower are considered to be within the range of acceptable risks. Once target risk levels are agreed upon with DEC, these levels will also be applied in deriving risk-based cleanup levels.

4.4 Uncertainty Assessment

Because risk characterization serves as a bridge between risk assessment and risk management, it is important that major assumptions, scientific judgments, and estimates of uncertainties be described in the assessment. Risk assessment methods are designed to be conservative to address the uncertainties associated with each step in the risk assessment process. Thus, "true" site risks are likely to be less than risks estimated using standard risk assessment methods.

Risk assessment is subject to a number of uncertainties. General sources of uncertainty include the site characterization (adequacy of the sampling plan and quality of the analytical data), the exposure assumptions, and estimation of chemical toxicity, background concentrations, and the present state of the science involved. In this section, several key sources of uncertainty related to this site are evaluated, including the following: risk estimates for petroleum hydrocarbons; uncertainties related to oral absorption from soil; and the concentration of arsenic in background soil.

4.4.1 Risk Estimates for Petroleum Hydrocarbons

Petroleum hydrocarbon fractions were detected at the site at concentrations greater than screening levels. These fractions are representative of a range of carbon-based compounds and as such, are imprecise values. Because data were available for toxic constituents of petroleum hydrocarbons in site media (i.e., PAHs), risk estimates for DRO and RRO fraction calculations are included here in the uncertainty assessment as well as in Appendix B. The petroleum fraction data available in Foster Wheeler (1998a) was matched with the closest possible toxicity value available in DEC guidance as follows:

Foster Wheeler (1998a) Fraction	DEC Toxicity Value Applied	RfD (mg/kg-day)
C_9–C_{18} aliphatic	DRO (C_{10}–C_{25}) aliphatic	0.10
C_{10}–C_{22} aromatic	DRO (C_{10}–C_{25}) aromatic	0.04
C_{19}–C_{36} aliphatic	RRO (C_{25}–C_{36}) aliphatic	2.0

Source: Toxicity values from Tables 6 and 8 of DEC (2000a).

No hazard indices exceeded 1 in any of the residential scenarios (Appendix B and Table 4-2). There is considerable uncertainty associated with the risk calculations, but because there are data for the PAHs, the uncertainty is reduced.

4.4.2 Uncertainties Related to Oral Absorption from Soil

For relative bioavailability, the following adjustment factors were applied as described in the toxicity assessment: arsenic—0.6; PCDD/F—0.6; and PAHs—0.84. Because there are uncertainties related to the degree of absorption that may occur from soil in a given setting, calculations were also performed assuming 100 percent absorption from soil and are presented in Table 4-3. As indicated there, risk estimates increase somewhat, but the highest risk estimate for the adult worker residing at the site in the future part-time scenario is still 1×10^{-5}, which is not above the DEC target risk level.

4.4.3 Concentrations of Arsenic in Background Soil

Arsenic occurs naturally in soil and food due to its presence in the earth's crust. Arsenic concentrations ranging from undetected to 7.6 mg/kg were detected in residential soil samples in Ketchikan, Alaska (Exponent 1998), at locations with no known arsenic sources. In addition, Washington State has identified a concentration of 20 mg/kg for arsenic in soil as a default cleanup level based on typical background levels in soil.[1] Thus, the site concentration of 11 mg/kg may be similar or within natural background concentrations for arsenic in soil.

Conclusions of HHRA

Health protective means were applied to estimate potential human health risks related to hypothetical residential use of the former APC Mill property. Three potential exposure scenarios resulted in risk estimates greater than the cumulative carcinogenic risk level of 1×10^{-5} identified in the DEC regulations but within the acceptable risk range of 10^{-4} to 10^{-6}. These

[1] http://www.ecy.wa.gov/pubs/wac173340.pdf

hypothetical scenarios were the full-time worker and the child who reside at the site year round, which had cumulative cancer risk estimates of 2×10^{-5} and 3×10^{-5}, respectively, and the child who resides at the site for 150 days per year, which had a risk estimate of 2×10^{-5}. The majority of site risks were associated with PAHs, arsenic, and PCDD/Fs. The part-time residential worker scenario, which assumed a worker resides at the site for 150 days per year, had a risk estimate of 9×10^{-6}, which is lower than the DEC target. No hazard indices exceeded the target index of 1 identified by DEC, suggesting that no adverse effects would be expected under the exposure conditions evaluated. These risk calculations indicate that future use for workers who reside at the former APC Mill site for part of the year would not exceed acceptable risk levels identified by DEC.

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Tables

Table 1-1. Summary of chemicals detected at concentrations greater than human health screening levels at the former APC Mill site—Sitka, Alaska[a]

Analyte	Mill Site Soil
Inorganics	
Arsenc	X
Chromium	X
Nickel	X
Organics	
DRO	
C_9–C_{18} aliphatic (as DRO aliphatic)	X
C_{10}–C_{22} aromatic (as DRO aromatic)	X
RRO	
C_{19}–C_{36} aliphatic (as RRO aliphatic)	X
PAHs	
Carcinogenic PAHs	X
PCDD/Fs	X

Note: DRO - diesel-range organics
PAH - polycyclic aromatic hydrocarbon
PCDD/F - polychlorinated dibenzo-*p*-dioxin and polychlorinated dibenzofuran
RRO - residual-range organics

[a] Based on chemical of potential concern screening conducted by Foster Wheeler (1998a) for entire mill site area.

Table 2-1. Values used for daily intake calculations for soil ingestion and dermal exposure[a]

Soil Ingestion			Full-Time Resident Worker		Part-Time Resident Worker	
Chronic daily intake (CDI) CDI= (CS*RBA*CF*FI*IR*EF*ED)/(BW*AT)			Adult Resident/ Worker	Child Resident	Adult Resident/ Worker	Child Part-year Resident
Exposure Assumptions[a]:						
Chemical concentration in soil/sediment	CS	mg/kg	--	--	--	--
Relative bioavailability adjustment[b]	RBA	unitless				
Conversion factor	CF	kg/mg	1E-6	1E-6	1E-6	1E-6
Ingestion rate[c]	IR	mg soil/day	100	200	100	200
Fraction ingested	FI	unitless	1	1	1	1
Exposure frequency	EF	days/year	330	330	150	150
Exposure duration[d]	ED	years	30	6	25	6
Body weight	BW	kg	70	15	70	15
Averaging time - carcinogen	AT.c	days	25,550	25,550	25,550	25,550
Averaging time - noncarcinogen	AT.n	days	10,950	2,190	9,125	2,190

Soil Dermal			Full-Time Resident Worker		Part-Time Resident Worker	
CDI (as absorbed dose) = CDI = (CS*CF*SA*AF*EF*ED)/(BW*AT)			Adult Resident/ Worker	Child Resident	Adult Resident/ Worker	Child Part-year Resident
Exposure Assumptions[a]:						
Chemical concentration in soil/sediment	CS	mg/kg	--	--	--	--
Conversion factor	CF	kg/mg	1E-6	1E-6	1E-6	1E-6
Skin surface area available for contact[e]	SA	cm^2/event	5,700	2,800	5,700	2,800
Dermal absorption factor	ABS	unitless	--	--	--	--
Soil or sediment-to-skin adherence factor[e]	AF	mg/cm^2	0.2	0.2	0.2	0.2
Exposure frequency	EF	days/year	330	330	150	150
Exposure duration[d]	ED	years	30	6	25	6
Body weight	BW	kg	70	15	70	15
Averaging time - carcinogen	AT.c	days	25,550	25,550	25,550	25,550
Averaging time - noncarcinogen	AT.n	days	10,950	2,190	9,125	2,190

Note: -- - chemical-specific
EPA - U.S. Environmental Protection Agency

[a] General methodology based on guidance in U.S. EPA (1989) and DEC (2002b). Exposure assumptions for residential and occupational soil ingestion based on DEC (2002b), which is consistent with EPA references. Reasonable maxium exposure estimate.

[b] Relative bioavailability adjustments presented in Table 2-2.

[c] Soil ingestion rates for RME residents and visitors consistent with DEC (2002b) resident.

[d] Exposure frequency and duration for residents consistent with DEC (2002b) and other EPA references.

[e] Dermal surface area and adherence factors based on U.S. EPA (2004).

Table 2-2. Summary of dermal and oral absorption factors used to assess dermal and oral exposure to chemicals in soil

Chemical of Potential Concern	Dermal Absorption Factors[a] (unitless)	Oral Absorption from Soil[b] (unitless)
Inorganics		
Arsenic	0.04	0.6
Organics		
DRO	0.13	1
RRO	0.13	1
PAHs		
Benzo[a]pyrene (TEQ)	0.13	0.84
PCDD/F TEQs	0.03	0.6

Note: DRO - diesel-range organics
PAH - polycyclic aromatic hydrocarbon
PCDD/F - polychlorinated dibenzo-*p*-dioxin and polychlorinated dibenzofuran
RRO - residual-range organics
TEQ - toxicity equivalent

[a] Dermal absorption factors from U.S. EPA (2004). Consistent with guidance from U.S. EPA (2004), where data for absorption from soil are not available, dermal exposure is evaluated qualitatively.

[b] Oral absorption of arsenic and PAHs from soil based on references described in Foster Wheeler (1998a) (see text). Oral absorption of PCDD/F based on Shu et al. (1988) (see text).

Table 3-1. Noncancer toxicity data—oral/dermal reference doses

Chemical of Potential Concern	Oral Chronic RfD (mg/kg-day)	Oral-to-Dermal Adjustment Factor	Adjusted Dermal RfD[a] (mg/kg-day)	Primary Target Organ or System	Combined Uncertainty/ Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ[b]
Inorganics							
Arsenic (inorganic)	0.0003	1	0.0003	Hyperpigmentation, keratosis and possible vascular complications	3/1	IRIS	1/27/2005
Chromium (as Chromium (VI))[c]	0.003	0.025	0.000075	None reported	300/3	IRIS	1/27/2005
Nickel (soluble salts)	0.02	0.04	0.0008	Body/organ weight	300/1	IRIS	1/27/2005
Organics							
DRO							
C_9–C_{18} aliphatic (as DRO aliphatic)	0.10	1	0.10	Liver/hematologic	--	DEC[d]	NA
C_{10}–C_{22} aromatic (as DRO aromatic)	0.04	1	0.04	Body weight	--	DEC[d]	NA
RRO							
C_{19}–C_{36} aliphatic (as RRO aliphatic)	2.0	1	2.0	Liver	--	DEC[d]	NA

Note:
-- - not available
DEC - Alaska Department of Environmental Conservation
DRO - diesel-range organics
EPA - U.S. Environmental Protection Agency
IRIS - Integrated Risk Information System
RfD - reference dose
RRO - residual-range organics

[a] Consistent with U.S. EPA (2004), where oral absorption is less than 50 percent, oral RfDs are adjusted by multiplying by the oral-to-dermal adjustment factor.

[b] Date when IRIS was searched.

[c] Because the chemical forms of chromium present are not known, the human health risk assessment conservatively assumes that all chromium is present as chromium(VI).

[d] Toxicity values obtained from DEC and are based on closest approximate toxicity surrogate from http://www.state.ak.us/dec/spar/csp/guidance/petr2000.pdf.

Table 3-2. Oral toxicity values for estimating excess cancer risks associated with chemicals of potential concern

Chemicals of Potential Concern	Oral Cancer Slope Factor $(mg/kg\text{-}day)^{-1}$	EPA Weight-of-Evidence Classification	Oral-to-Dermal Adjustment Factor[a]	Adjusted Dermal CSF[a] (mg/kg-day)	Type of Cancer	Basis of Cancer Slope Factor	Source of CSF	Date of CSF Source[b]
Arsenic	1.5	A	1	1.5	Skin, liver, lung, kidney, bladder	Human drinking water	IRIS	1/27/2005
PAH Compounds[c]								
Benzo[a]pyrene (applied to TEQ)	7.3	B2	1	7.3	Forestomach, squamous cell papillomas and carcinomas	Mouse diet	IRIS	1/27/2005
PCDD/F TEQs[d]	150,000	--	1	150,000			EPA Region 9	

Note: -- - information not available
A - known human carcinogen
B2 - probable human carcinogen; sufficient evidence in animals and inadequate or no evidence in humans
CSF - cancer slope factor
EPA - U.S. Environmental Protection Agency
IRIS - Integrated Risk Information System
NA - not applicable
PAH - polycyclic aromatic hydrocarbon

[a] Consistent with U.S. EPA (2004), where oral absorption is less than 50 percent, oral reference doses are adjusted by multiplying by the oral-to-dermal adjustment factor. See Table 2-2 for dermal adjustment factor.

[b] Date when IRIS was searched.

[c] CSFs for PAH compounds are based on potency relative to benzo[a]pyrene per EPA guidance (U.S. EPA 2005a).

[d] CSFs as cited by U.S. EPA Region 9 (U.S. EPA 2005a).

Table 3-3. Inhalation toxicity values for estimating excess cancer risks associated with chemicals of potential concern

Chemicals of Potential Concern	Unit Risk	Units	Adjustment[a]	Inhalation Cancer Slope Factor	Units	EPA Weight-of-Evidence Classification	Source	Date of CSF Source[b]
Inorganic Analytes								
Arsenic	4.3E-03	$(\mu g/m^3)^{-1}$	3,500	15	$(mg/kg\text{-}day)^{-1}$	A	IRIS	1/27/2005
Chromium (as Chromium(VI))	1.2E-02	$(\mu g/m^3)^{-1}$	3,500	42	$(mg/kg\text{-}day)^{-1}$	A	IRIS	1/27/2005
Nickel (refinery dust)	2.4E-04	$(\mu g/m^3)^{-1}$	3,500	0.84	$(mg/kg\text{-}day)^{-1}$	A	IRIS	1/27/2005
PAHs[c]								
Benzo[a]pyrene (applied to TEQ)	--	--	--	7.3	$(mg/kg\text{-}day)^{-1}$	--	EPA Region 9[d]	NA
PCDD/F[e]	--	--	--	150,000	$(mg/kg\text{-}day)^{-1}$	--	EPA Region 9[d]	NA

Note: -- - information not available
A - known human carcinogen
CSF - cancer slope factor
EPA - U.S. Environmental Protection Agency
IRIS - Integrated Risk Information System
NA - not applicable
PAH - polycyclic aromatic hydrocarbon
TEQ - toxicity equivalent quotient

[a] Adjustment factor applied to Unit Risk to calculate Inhalation Cancer Slope Factor = 70 kg $\times$ 1/20m^3/day $\times$ 1,000 μg/mg. Adjustment factor applied to Inhalation Cancer Slope Factor to calculate Unit Risk = 20 m^3/day $\times$ 1/ 70kg $\times$ 1/1,000 μg/mg.

[b] Date when IRIS was searched.

[c] CSFs for PAH compounds are based on potency relative to benzo[a]pyrene per EPA guidance (U.S. EPA 2005a).

[d] Based on route-to-route extrapolation.

[e] CSF as cited by U.S. EPA Region IX (U.S. EPA 2005a).

Table 3-4. Inhalation toxicity values for estimating excess noncancer hazards associated with chemicals of potential concern

Chemical of Potential Concern	Chronic/ Subchronic	Inhalation RfC	Units	Adjusted Inhalation RfD	Units	Primary Target Organ or System	Combined Uncertainty/ Modifying Factors	Sources of RfC:RfD	Date of RfC:RfD Source[b]
Inorganic Analytes									
Chromium particulates	Chronic	0.0001	mg/m^3	0.000029	mg/kg-day	Lung effects	300/1	IRIS	1/27/2005
Organics									
DRO									
C_9–C_{18} aliphatic (as DRO aliphatic)	Chronic	1.0	mg/m^3	0.29	mg/kg-day	Liver/hematologic	--	DEC[b]	NA
C_{10}–C_{22} aromatic (as DRO aromatic)	Chronic	0.20	mg/m^3	0.057	mg/kg-day	Body weight	--	DEC[b]	NA

Note: Adjustment factor applied to RfC to calculate RfD = 1/70 kg $\times$ 20 m^3/day. Adjustment factor applied to RfD to calculate RfC = 70 kg $\times$ 1/20 m^3/day.

-- - not available
DEC - Alaska Department of Environmental Conservation
DRO - diesel-range organics
EPA - U.S. Environmental Protection Agency
IRIS - Integrated Risk Information System
NA - not applicable
NCEA - National Center for Environmental Assessment
PAH - polycyclic aromatic hydrocarbon
RfC - reference concentration
RfD - reference dose

[a] Date when IRIS was searched.

[b] Toxicity values obtained from DEC and are based on closest approximate toxicity surrogate from http://www.state.ak.us/dec/spar/csp/guidance/petr2000.pdf.

Table 4-1. Summary of total excess lifetime cancer risks for reasonable maximum exposure scenarios

Receptor/Exposure Pathway	Cancer Risk	Percent Contribution by Pathway	Cancer Risk	Percent Contribution by Pathway	Chemicals Accounting for 90 Percent of Cancer Risk for Each Pathway
	Adult		Child		
Former APC Mill Site					
Hypothetical Future Resident					
Ingestion of Surface Soil	1E-5	53%	2E-5	82%	Arsenic, PCDDs/PCDFs, PAHs
Dermal Contact with Surface Soil	1E-5	47%	5E-6	18%	PAHs, Arsenic, PCDDs/PCDFs
Inhalation of Particulates	9E-10	0.004%	4E-10	0.001%	Chromium
Total Cancer Risk:	**2E-5**	100%	**3E-5**	100%	
Former APC Mill Site					
Hypothetical Future Part-Time Resident					
Ingestion of Surface Soil	5E-6	53%	1E-5	85%	Arsenic, PCDDs/PCDFs, PAHs
Dermal Contact with Surface Soil	4E-6	47%	2E-6	15%	PAHs, Arsenic
Inhalation of Particulates	9E-10	0.01%	4E-10	0.00%	Chromium
	9E-6	100%	**2E-5**	100%	

Note:

APC - Alaska Pulp Company
PCDD - polychlorinated dibenzo-*p*-dioxins
PCDF - polychlorinated dibenzofurans
PAH - polycyclic aromatic hydrocarbons

Table 4-2. Summary of total noncancer hazard indices for reasonable maximum exposure scenarios

Receptor/Exposure Pathway	Hazard Index	Percent Contribution by Pathway	Hazard Index	Percent Contribution by Pathway	Chemicals Accounting for 90 Percent of the Total Hazard Quotient for Each Pathway
	Adult		Child		
Former APC Mill Site					
Hypothetical Future Resident					
Ingestion of Surface Soil	0.058	77%	0.54	93%	Arsenic, Chromium, Nickel
Dermal Contact with Surface Soil	0.017	23%	0.039	7%	Arsenic
Inhalation of Particulates	0.000002	0.002%	0.0000008	0.0001%	Chromium
Total Noncancer Risk	**0.075**	100%	**0.58**	100%	
Former APC Mill Site					
Hypothetical Future Part-Time Resident					
Ingestion of Surface Soil	0.026	77%	0.25	93%	Arsenic, chromium, nickel
Dermal Contact with Surface Soil	0.0077	23%	0.018	7%	Arsenic
Inhalation of Particulates	0.000002	0.005%	0.0000008	0.0003%	Chromium
	0.034	100%	**0.26**	100%	
Uncertainty Assessment - Petroleum Hydrocarbons					
Ingestion of Surface Soil	0.0087	38%	0.081	73%	C_9–C_{18} aliphatics, C_{10}–C_{22} aromatics, C_{19}–C_{36} aliphatics
Dermal Contact with Surface Soil	0.013	57%	0.029	27%	C_9–C_{18} aliphatics, C_{10}–C_{22} aromatics, C_{19}–C_{36} aliphatics
Inhalation of Particulates	0.0012	5%	0.00056	0.5%	C_9–C_{18} aliphatics, C_{10}–C_{22} aromatics
Total Noncancer Risk TPH	**0.023**	100%	**0.11**	100%	
Total Noncancer Risk All Chemicals Full-Time Resident:	**0.13**		**0.96**		
Total Noncancer Risk All Chemicals Part-Time Resident:	**0.06**		**0.37**		

Note:

APC - Alaska Pulp Company

TPH - total petroleum hydrocarbons

Table 4-3. Summary of total excess lifetime cancer risks for reasonable maximum exposure scenarios (assuming complete [100%] oral absorption from soil)

Receptor/Exposure Pathway	Cancer Risk	Percent Contribution by Pathway	Cancer Risk	Percent Contribution by Pathway	Chemicals Accounting for 90 Percent of Cancer Risk for Each Pathway
	Adult		Child		
Former APC Mill Site					
Hypothetical Future Resident					
Ingestion of Surface Soil	2E-5	64%	4E-5	88%	Arsenic, PCDDs/PCDFs, PAHs
Dermal Contact with Surface Soil	1E-5	36%	5E-6	12%	Arsenic, PCDDs/PCDFs, PAHs
Inhalation of Particulates	9E-10	0.003%	4E-10	0.001%	Chromium
Total Cancer Risk:	**3E-5**	100%	**4E-5**	100%	
Former APC Mill Site					
Hypothetical Future Part-Time Resident					
Ingestion of Surface Soil	8E-6	64%	2E-5	88%	Arsenic, PCDDs/PCDFs, PAHs
Dermal Contact with Surface Soil	4E-6	36%	2E-6	12%	Arsenic, PCDDs/PCDFs, PAHs
Inhalation of Particulates	9E-10	0.008%	4E-10	0.002%	Chromium
	1E-5	100%	**2E-5**	100%	

Note:

APC - Alaska Pulp Company
PCDD - polychlorinated dibenzo-*p*-dioxins
PCDF - polychlorinated dibenzofurans
PAH - polycyclic aromatic hydrocarbons

Appendix A

Risk Calculations for Chemicals of Potential Concern

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Soil
Exposure Point: Former Mill Site Area
Receptor Population: Hypothetical Future Resident
Receptor Age: Adult

Table A-1-RME
Calculation of Noncancer Hazards
Adult Soil Exposure: Reasonable Maximum Hypothetical Residential
Former APC Mill Site

Exposure Route	Chemical of Concern	Medium EPC Value[a]	Medium Units	Oral or Dermal Absorption Factor[b]	Route EPC	Route EPC Units	EPC Applied	Intake (Non-cancer)	Intake (Non-cancer) Units	Reference Dose[c]	Reference Dose Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Ingestion	**Metals**													
	Arsenic	11.5	mg/kg	0.60	11.5	mg/kg	M	8.9E-6	mg/kg-day	3.0E-4	mg/kg-day	--	--	0.030
	Chromium	60.0	mg/kg	--	60.0	mg/kg	M	7.7E-5	mg/kg-day	3.0E-3	mg/kg-day	--	--	0.026
	Nickel	39.0	mg/kg	--	39.0	mg/kg	M	5.0E-5	mg/kg-day	2.0E-2	mg/kg-day	--	--	0.0025
	PAHs													
	Carcinogenic PAH B[a]P TEQ	1.0	mg/kg	0.84	1.0	mg/kg	M	--	--	ND	--	--	--	--
	PCDD/F TEQ	0.00008	mg/kg	0.60	0.00008	mg/kg	M	--	--	ND	--	--	--	--
													Hazard Index:	0.058
Dermal	**Metals**													
	Arsenic	11.5	mg/kg	0.03	11.5	mg/kg	M	5.1E-6	mg/kg-day	3.0E-4	mg/kg-day	--	--	0.017
	PAHs												--	
	Carcinogenic PAH B[a]P TEQ	1.0	mg/kg	0.13	1.0	mg/kg	M	--	--	ND	--	--	--	--
	PCDD/F TEQ	0.00008	mg/kg	0.03	0.00008	mg/kg	M	--	--	ND	--	--	--	--
													Hazard Index:	0.017
Inhalation	**Metals**													
	Arsenic	3.4E-11	mg/m^3	--	3.4E-11	mg/m^3	M	--	--	ND	--	--	--	--
	Chromium	1.8E-10	mg/m^3	--	1.8E-10	mg/m^3	M	4.6E-11	mg/kg-day	2.9E-05	mg/kg-day	--	--	0.000002
	Nickel	1.2E-10	mg/m^3	--	1.2E-10	mg/m^3	M	--	--	ND	--	--	--	--
	PAHs													
	Carcinogenic PAH B[a]P TEQ	3.1E-12	mg/m^3	--	3.1E-12	mg/m^3	M	--	--	ND	--	--	--	--
	PCDD/F TEQ	2.4E-16	mg/m^3	--	2.4E-16	mg/m^3	M	--	--	ND	--	--	--	--
													Hazard Index:	0.000002
													Total Hazard Index Across All Exposure Routes/Pathways:	0.075

Note:

-- - not applicable
APC - Alaska Pulp Company
B[a]P - Benzo[a]pyrene
EPA - U.S. Environmental Protection Agency
EPC - exposure point concentration
M - medium-specific
ND - not determined (EPA)/not considered a carcinogen
PAHs - polycyclic aromatic hydrocarbons
PCDD/Fs - polychlorinated dibenzo-*p*-dioxins and dibenzofurans
RME - reasonable maximum exposure
TEQ - toxicity equivalent

[a] Values taken from Table 3-13 of Foster Wheeler (1998a) and are taken from statistical analysis of measured data (for soil) or are derived from transport modeling (for air).
[b] Dermal absorption values are from U.S. EPA (2004). Oral absorption factors from soil are from Foster Wheeler (1998a) and from Shu et al. (1988).
[c] Toxicity values obtained from either EPA Integrated Risk Information System (IRIS) January (U.S. EPA 2005b) or from EPA Region 9 (2005a).

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Soil
Exposure Point: Former Mill Site Area
Receptor Population: Hypothetical Future Resident
Receptor Age: Child

Table A-2-RME
Calculation of Noncancer Hazards
Child Soil Exposure: Reasonable Maximum Hypothetical Residential
Former APC Mill Site

Exposure Route	Chemical of Concern	Medium EPC Value[a]	Medium Units	Oral or Dermal Absorption Factor[b]	Route EPC	Route EPC Units	EPC Applied	Intake (Non-cancer)	Intake (Non-cancer) Units	Reference Dose[c]	Reference Dose Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Ingestion	**Metals**													
	Arsenic	11.5	mg/kg	0.60	11.5	mg/kg	M	8.3E-5	mg/kg-day	3.0E-4	mg/kg-day	--	--	0.28
	Chromium	60.0	mg/kg	--	60.0	mg/kg	M	7.2E-4	mg/kg-day	3.0E-3	mg/kg-day	--	--	0.24
	Nickel	39.0	mg/kg	--	39.0	mg/kg	M	4.7E-4	mg/kg-day	2.0E-2	mg/kg-day	--	--	0.024
	PAHs													
	Carcinogenic PAH B[a]P TEQ	1.0	mg/kg	0.84	1.0	mg/kg	M	--	--	ND	--	--	--	--
	PCDD/F TEQ	0.00008	mg/kg	0.60	0.00008	mg/kg	M	--	--	ND	--	--	--	--
													Hazard Index:	0.54
Dermal	**Metals**													
	Arsenic	11.5	mg/kg	0.03	11.5	mg/kg	M	1.2E-5	mg/kg-day	3E-4	mg/kg-day	--	--	0.039
	PAHs												--	
	Carcinogenic PAH B[a]P TEQ	1.0	mg/kg	0.13	1.0	mg/kg	M	--	--	ND	--	--	--	--
	PCDD/F TEQ	0.00008	mg/kg	0.03	0.00008	mg/kg	M	--	--	ND	--	--	--	--
													Hazard Index:	0.039
Inhalation	**Metals**													
	Arsenic	3.4E-11	mg/m^3	--	3.4E-11	mg/m^3	M	--	--	ND	--	--	--	--
	Chromium	1.8E-10	mg/m^3	--	1.8E-10	mg/m^3	M	2.2E-11	mg/kg-day	2.9E-05	mg/kg-day	--	--	0.0000008
	Nickel	1.2E-10	mg/m^3	--	1.2E-10	mg/m^3	M	--	--	ND	--	--	--	--
	PAHs													
	Carcinogenic PAH B[a]P TEQ	3.1E-12	mg/m^3	--	3.1E-12	mg/m^3	M	--	--	ND	--	--	--	--
	PCDD/F TEQ	2.4E-16	mg/m^3	--	2.4E-16	mg/m^3	M	--	--	ND	--	--	--	--
													Hazard Index:	0.0000008
													Total Hazard Index Across All Exposure Routes/Pathways:	0.58

Note:

-- - not applicable
APC - Alaska Pulp Company
B[a]P - Benzo[a]pyrene
EPA - U.S. Environmental Protection Agency
EPC - exposure point concentration
M - medium-specific
ND - not determined (EPA)/not considered a carcinogen
PAHs - polycyclic aromatic hydrocarbons
PCDD/Fs - polychlorinated dibenzo-*p*-dioxins and dibenzofurans
RME - reasonable maximum exposure
TEQ - toxicity equivalent

[a] Values taken from Table 3-13 of Foster Wheeler (1998a) and are taken from statistical analysis of measured data (for soil) or are derived from transport modeling (for air).
[b] Dermal absorption values are from U.S. EPA (2004). Oral absorption factors from soil are from Foster Wheeler (1998a) and from Shu et al. (1988).
[c] Toxicity values obtained from either EPA Integrated Risk Information System (IRIS) January (U.S. EPA 2005b) or from EPA Region 9 (2005a).

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Soil
Exposure Point: Former Mill Site Area
Receptor Population: Hypothetical Future Part-Year Resident
Receptor Age: Adult

Table A-3-RME
Calculation of Noncancer Hazards
Adult Soil Exposure: Reasonable Maximum Hypothetical Residential
Former APC Mill Site

Exposure Route	Chemical of Concern	Medium EPC Value[a]	Medium Units	Oral or Dermal Absorption Factor[b]	Route EPC	Route EPC Units	EPC Applied	Intake (Non-cancer)	Intake (Non-cancer) Units	Reference Dose[c]	Reference Dose Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Ingestion	**Metals**													
	Arsenic	11.5	mg/kg	0.60	11.5	mg/kg	M	4E-6	mg/kg-day	3E-4	mg/kg-day	--	--	0.014
	Chromium	60.0	mg/kg	--	60.0	mg/kg	M	4E-5	mg/kg-day	3E-3	mg/kg-day	--	--	0.012
	Nickel	39.0	mg/kg	--	39.0	mg/kg	M	2E-5	mg/kg-day	2E-2	mg/kg-day	--	--	0.0011
	PAHs													
	Carcinogenic PAH B[a]P TEQ	1.0	mg/kg	0.84	1.0	mg/kg	M	--	--	ND	--	--	--	--
	PCDD/F TEQ	0.00008	mg/kg	0.60	0.00008	mg/kg	M	--	--	ND	--	--	--	--
													Hazard Index:	0.026
Dermal	**Metals**													
	Arsenic	11.5	mg/kg	0.03	11.5	mg/kg	M	2.3E-6	mg/kg-day	3E-4	mg/kg-day	--	--	0.0077
	PAHs												--	
	Carcinogenic PAH B[a]P TEQ	1.0	mg/kg	0.13	1.0	mg/kg	M	--	--	ND	--	--	--	--
	PCDD/F TEQ	0.00008	mg/kg	0.03	0.00008	mg/kg	M	--	--	ND	--	--	--	--
													Hazard Index:	0.0077
Inhalation	**Metals**													
	Arsenic	3.4E-11	mg/m^3	--	3.4E-11	mg/m^3	M	--	--	ND	--	--	--	--
	Chromium	1.8E-10	mg/m^3	--	1.8E-10	mg/m^3	M	4.6E-11	mg/kg-day	2.9E-05	mg/kg-day	--	--	0.000002
	Nickel	1.2E-10	mg/m^3	--	1.2E-10	mg/m^3	M	--	--	ND	--	--	--	--
	PAHs													
	Carcinogenic PAH B[a]P TEQ	3.1E-12	mg/m^3	--	3.1E-12	mg/m^3	M	--	--	ND	--	--	--	--
	PCDD/F TEQ	2.4E-16	mg/m^3	--	2.4E-16	mg/m^3	M	--	--	ND	--	--	--	--
													Hazard Index:	0.000002
													Total Hazard Index Across All Exposure Routes/Pathways:	0.034

Note:

-- - not applicable
APC - Alaska Pulp Company
B[a]P - Benzo[a]pyrene
EPA - U.S. Environmental Protection Agency
EPC - exposure point concentration
M - medium-specific
ND - not determined (EPA)/not considered a carcinogen
PAHs - polycyclic aromatic hydrocarbons
PCDD/Fs - polychlorinated dibenzo-*p*-dioxins and dibenzofurans
RME - reasonable maximum exposure
TEQ - toxicity equivalent

[a] Values taken from Table 3-13 of Foster Wheeler (1998a) and are taken from statistical analysis of measured data (for soil) or are derived from transport modeling (for air).
[b] Dermal absorption values are from U.S. EPA (2004). Oral absorption factors from soil are from Foster Wheeler (1998a) and from Shu et al. (1988).
[c] Toxicity values obtained from either EPA Integrated Risk Information System (IRIS) January (U.S. EPA 2005b) or from EPA Region 9 (2005a).

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Soil
Exposure Point: Former Mill Site Area
Receptor Population: Hypothetical Future Part-Year Resident
Receptor Age: Child

Table A-4-RME
Calculation of Noncancer Hazards
Child Soil Exposure: Reasonable Maximum Hypothetical Residential
Former APC Mill Site

Exposure Route	Chemical of Concern	Medium EPC Value[a]	Medium Units	Oral or Dermal Absorption Factor[b]	Route EPC	Route EPC Units	EPC Applied	Intake (Non-cancer)	Intake (Non-cancer) Units	Reference Dose[c]	Reference Dose Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Ingestion	**Metals**													
	Arsenic	11.5	mg/kg	0.60	11.5	mg/kg	M	3.8E-5	mg/kg-day	3E-4	mg/kg-day	--	--	0.13
	Chromium	60.0	mg/kg	--	60.0	mg/kg	M	3.3E-4	mg/kg-day	3E-3	mg/kg-day	--	--	0.11
	Nickel	39.0	mg/kg	--	39.0	mg/kg	M	2.1E-4	mg/kg-day	2E-2	mg/kg-day	--	--	0.011
	PAHs													
	Carcinogenic PAH B[a]P TEQ	1.0	mg/kg	0.84	1.0	mg/kg	M	--	--	ND	--	--	--	--
	PCDD/F TEQ	0.00008	mg/kg	0.60	0.00008	mg/kg	M	--	--	ND	--	--	--	--
													Hazard Index:	0.25
Dermal	**Metals**													
	Arsenic	11.5	mg/kg	0.03	11.5	mg/kg	M	5.3E-6	mg/kg-day	3E-4	mg/kg-day	--	--	0.018
	PAHs												--	
	Carcinogenic PAH B[a]P TEQ	1.0	mg/kg	0.13	1.0	mg/kg	M	--	--	ND	--	--	--	--
	PCDD/F TEQ	0.00008	mg/kg	0.03	0.00008	mg/kg	M	--	--	ND	--	--	--	--
													Hazard Index:	0.018
Inhalation	**Metals**													
	Arsenic	3.4E-11	mg/m^3	--	3.4E-11	mg/m^3	M	--	--	ND	--	--	--	--
	Chromium	1.8E-10	mg/m^3	--	1.8E-10	mg/m^3	M	2.2E-11	mg/kg-day	2.9E-05	mg/kg-day	--	--	0.0000008
	Nickel	1.2E-10	mg/m^3	--	1.2E-10	mg/m^3	M	--	--	ND	--	--	--	--
	PAHs													
	Carcinogenic PAH B[a]P TEQ	3.1E-12	mg/m^3	--	3.1E-12	mg/m^3	M	--	--	ND	--	--	--	--
	PCDD/F TEQ	2.4E-16	mg/m^3	--	2.4E-16	mg/m^3	M	--	--	ND	--	--	--	--
													Hazard Index:	0.0000008
													Total Hazard Index Across All Exposure Routes/Pathways:	0.26

Note:

-- - not applicable
APC - Alaska Pulp Company
B[a]P - Benzo[a]pyrene
EPA - U.S. Environmental Protection Agency
EPC - exposure point concentration
M - medium-specific
ND - not determined (EPA)/not considered a carcinogen
PAHs - polycyclic aromatic hydrocarbons
PCDD/Fs - polychlorinated dibenzo-*p*-dioxins and dibenzofurans
RME - reasonable maximum exposure
TEQ - toxicity equivalent

[a] Values taken from Table 3-13 of Foster Wheeler (1998a) and are taken from statistical analysis of measured data (for soil) or are derived from transport modeling (for air).
[b] Dermal absorption values are from U.S. EPA (2004). Oral absorption factors from soil are from Foster Wheeler (1998a) and from Shu et al. (1988).
[c] Toxicity values obtained from either EPA Integrated Risk Information System (IRIS) January (U.S. EPA 2005b) or from EPA Region 9 (2005a).

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Soil
Exposure Point: Former Mill Site Area
Receptor Population: Hypothetical Future Resident
Receptor Age: Adult

Table A-5-RME
Calculation of Cancer Risks
Adult Soil Exposure: Reasonable Maximum Hypothetical Residential
Former APC Mill Site

Exposure Route	Chemical of Concern	Medium EPC Value[a]	Medium Units	Oral or Dermal Absorption Factor[b]	Route EPC	Route EPC Units	EPC Applied	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor[c]	Cancer Slope Factor Units	Cancer Risk
Ingestion	**Metals**											
	Arsenic	11.5	mg/kg	0.60	11.5	mg/kg	M	3.8E-6	mg/kg-day	1.5	(mg/kg-day)-1	6E-6
	Chromium	60.0	mg/kg	--	60.0	mg/kg	M	--	--	ND	--	--
	Nickel	39.0	mg/kg	--	39.0	mg/kg	M	--	--	ND	--	--
	PAHs											
	Carcinogenic PAH B[a]P TEQ	1.0	mg/kg	0.84	1.0	mg/kg	M	4.6E-7	mg/kg-day	7.3	(mg/kg-day)-1	3E-6
	PCDD/F TEQ	0.00008	mg/kg	0.60	0.00008	mg/kg	M	3E-11	mg/kg-day	150,000	(mg/kg-day)-1	4E-6
											Total Risk:	1E-5
Dermal	**Metals**											
	Arsenic	11.5	mg/kg	0.03	11.5	mg/kg	M	2.2E-6	mg/kg-day	1.5	(mg/kg-day)-1	3E-6
	PAHs											
	Carcinogenic PAH B[a]P TEQ	1.0	mg/kg	0.13	1.0	mg/kg	M	8.2E-7	mg/kg-day	7.3	(mg/kg-day)-1	6E-6
	PCDD/F TEQ	0.00008	mg/kg	0.03	0.00008	mg/kg	M	2E-11	mg/kg-day	150,000	(mg/kg-day)-1	2E-6
											Total Risk:	1E-5
Inhalation	**Metals**											
	Arsenic	3.4E-11	mg/m^3	--	3.4E-11	mg/m^3	M	3.8E-12	mg/kg-day	1.5E+1	$(mg/kg\text{-}day)^{-1}$	6E-11
	Chromium particulates[c]	1.8E-10	mg/m^3	--	1.8E-10	mg/m^3	M	2.0E-11	mg/kg-day	4.2E+1	$(mg/kg\text{-}day)^{-1}$	8E-10
	Nickel	1.2E-10	mg/m^3	--	1.2E-10	mg/m^3	M	1.3E-11	mg/kg-day	8.4E-1	$(mg/kg\text{-}day)^{-1}$	1E-11
	PAHs											
	Carcinogenic PAH B[a]P TEQ	3.1E-12	mg/m^3	--	3.1E-12	mg/m^3	M	3.4E-13	mg/kg-day	7.3E+0	$(mg/kg\text{-}day)^{-1}$	3E-12
	PCDD/F TEQ	2.4E-16	mg/m^3	--	2.4E-16	mg/m^3	M	2.7E-17	mg/kg-day	1.5E+5	$(mg/kg\text{-}day)^{-1}$	4E-12
												9E-10
											Total Risk Across all Exposure Pathways:	2E-5

Note:

-- - not applicable
APC - Alaska Pulp Company
B[a]P - Benzo[a]pyrene
EPA - U.S. Environmental Protection Agency
EPC - exposure point concentration
M - medium-specific
ND - not determined (EPA)/not considered a carcinogen
PAHs - polycyclic aromatic hydrocarbons
PCDD/Fs - polychlorinated dibenzo-*p*-dioxins and dibenzofurans
RME - reasonable maximum exposure
TEQ - toxicity equivalent

[a] Values taken from Table 3-13 of Foster Wheeler (1998a) and are taken from statistical analysis of measured data (for soil) or are derived from transport modeling (for air).

[b] Dermal absorption values are from U.S. EPA (2004). Oral absorption factors from soil are from Foster Wheeler (1998a) and from Shu et al. (1988).

[c] Toxicity values obtained from either EPA Integrated Risk Information System (IRIS) January (U.S. EPA 2005b) or from EPA Region 9 (2005a).

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Soil
Exposure Point: Former Mill Site Area
Receptor Population: Hypothetical Future Resident
Receptor Age: Child

Table A-6-RME
Calculation of Cancer Risks
Child Soil Exposure: Reasonable Maximum Hypothetical Residential
Former APC Mill Site

Exposure Route	Chemical of Concern	Medium EPC Value[a]	Medium Units	Oral or Dermal Absorption Factor[b]	Route EPC	Route EPC Units	EPC Applied	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor[c]	Cancer Slope Factor Units	Cancer Risk
Ingestion	**Metals**											
	Arsenic	11.5	mg/kg	0.60	11.5	mg/kg	M	7.1E-6	mg/kg-day	1.5	(mg/kg-day)-1	1E-5
	Chromium	60.0	mg/kg	--	60.0	mg/kg	M	--	--	ND	--	--
	Nickel	39.0	mg/kg	--	39.0	mg/kg	M	--	--	ND	--	--
	PAHs											
	Carcinogenic PAH B[a]P TEQ	1.0	mg/kg	0.84	1.0	mg/kg	M	8.7E-7	mg/kg-day	7.3	(mg/kg-day)-1	6E-6
	PCDD/F TEQ	0.00008	mg/kg	0.60	0.00008	mg/kg	M	5E-11	mg/kg-day	150,000	(mg/kg-day)-1	7E-6
											Total Risk:	2E-5
Dermal	**Metals**											
	Arsenic	11.5	mg/kg	0.03	11.5	mg/kg	M	1.0E-6	mg/kg-day	1.5	(mg/kg-day)-1	1E-6
	PAHs											
	Carcinogenic PAH B[a]P TEQ	1.0	mg/kg	0.13	1.0	mg/kg	M	3.8E-7	mg/kg-day	7.3	(mg/kg-day)-1	3E-6
	PCDD/F TEQ	0.00008	mg/kg	0.03	0.00008	mg/kg	M	7E-12	mg/kg-day	150,000	(mg/kg-day)-1	1E-6
											Total Risk:	5E-6
Inhalation	**Metals**											
	Arsenic	3.4E-11	mg/m^3	--	3.4E-11	mg/m^3	M	1.8E-12	mg/kg-day	1.5E+1	$(mg/kg\text{-}day)^{-1}$	3E-11
	Chromium particulates[c]	1.8E-10	mg/m^3	--	1.8E-10	mg/m^3	M	9.3E-12	mg/kg-day	4.2E+1	$(mg/kg\text{-}day)^{-1}$	4E-10
	Nickel	1.2E-10	mg/m^3	--	1.2E-10	mg/m^3	M	6.2E-12	mg/kg-day	8.4E-1	$(mg/kg\text{-}day)^{-1}$	5E-12
	PAHs											
	Carcinogenic PAH B[a]P TEQ	3.1E-12	mg/m^3	--	3.1E-12	mg/m^3	M	1.6E-13	mg/kg-day	7.3E+0	$(mg/kg\text{-}day)^{-1}$	1E-12
	PCDD/F TEQ	2.4E-16	mg/m^3	--	2.4E-16	mg/m^3	M	1.2E-17	mg/kg-day	1.5E+5	$(mg/kg\text{-}day)^{-1}$	2E-12
												4E-10
											Total Risk Across all Exposure Pathways:	3E-5

Note:

-- - not applicable
APC - Alaska Pulp Company
B[a]P - Benzo[a]pyrene
EPA - U.S. Environmental Protection Agency
EPC - exposure point concentration
M - medium-specific
ND - not determined (EPA)/not considered a carcinogen
PAHs - polycyclic aromatic hydrocarbons
PCDD/Fs - polychlorinated dibenzo-*p*-dioxins and dibenzofurans
RME - reasonable maximum exposure
TEQ - toxicity equivalent

[a] Values taken from Table 3-13 of Foster Wheeler (1998a) and are taken from statistical analysis of measured data (for soil) or are derived from transport modeling (for air).
[b] Dermal absorption values are from U.S. EPA (2004). Oral absorption factors from soil are from Foster Wheeler (1998a) and from Shu et al. (1988).
[c] Toxicity values obtained from either EPA Integrated Risk Information System (IRIS) January (U.S. EPA 2005b) or from EPA Region 9 (2005a).

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Soil
Exposure Point: Former Mill Site Area
Receptor Population: Hypothetical Future Part-Year Resident
Receptor Age: Adult

Table A-7-RME
Calculation of Cancer Risks
Adult Soil Exposure: Reasonable Maximum Hypothetical Residential
Former APC Mill Site

Exposure Route	Chemical of Concern	Medium EPC Value[a]	Medium Units	Oral or Dermal Absorption Factor[b]	Route EPC	Route EPC Units	EPC Applied	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor[c]	Cancer Slope Factor Units	Cancer Risk
Ingestion	**Metals**											
	Arsenic	11.5	mg/kg	0.60	11.5	mg/kg	M	1.4E-6	mg/kg-day	1.5	(mg/kg-day)-1	2E-6
	Chromium	60.0	mg/kg	--	60.0	mg/kg	M	--	--	ND	--	--
	Nickel	39.0	mg/kg	--	39.0	mg/kg	M	--	--	ND	--	--
	PAHs											
	Carcinogenic PAH B[a]P TEQ	1.0	mg/kg	0.84	1.0	mg/kg	M	1.8E-7	mg/kg-day	7.3	(mg/kg-day)-1	1E-6
	PCDD/F TEQ	0.00008	mg/kg	0.60	0.00008	mg/kg	M	1.0E-11	mg/kg-day	150,000	(mg/kg-day)-1	2E-6
											Total Risk:	5E-6
Dermal	**Metals**											
	Arsenic	11.5	mg/kg	0.03	11.5	mg/kg	M	8.2E-7	mg/kg-day	1.5	(mg/kg-day)-1	1E-6
	PAHs											
	Carcinogenic PAH B[a]P TEQ	1.0	mg/kg	0.13	1.0	mg/kg	M	3.1E-7	mg/kg-day	7.3	(mg/kg-day)-1	2E-6
	PCDD/F TEQ	0.00008	mg/kg	0.03	0.00008	mg/kg	M	5.7E-12	mg/kg-day	150,000	(mg/kg-day)-1	9E-7
											Total Risk:	4E-6
Inhalation	**Metals**											
	Arsenic	3.4E-11	mg/m^3	--	3.4E-11	mg/m^3	M	3.8E-12	mg/kg-day	1.5E+1	$(mg/kg\text{-}day)^{-1}$	6E-11
	Chromium particulates[c]	1.8E-10	mg/m^3	--	1.8E-10	mg/m^3	M	2.0E-11	mg/kg-day	4.2E+1	$(mg/kg\text{-}day)^{-1}$	8E-10
	Nickel	1.2E-10	mg/m^3	--	1.2E-10	mg/m^3	M	1.3E-11	mg/kg-day	8.4E-1	$(mg/kg\text{-}day)^{-1}$	1E-11
	PAHs											
	Carcinogenic PAH B[a]P TEQ	3.1E-12	mg/m^3	--	3.1E-12	mg/m^3	M	3.4E-13	mg/kg-day	7.3E+0	$(mg/kg\text{-}day)^{-1}$	3E-12
	PCDD/F TEQ	2.4E-16	mg/m^3	--	2.4E-16	mg/m^3	M	2.7E-17	mg/kg-day	1.5E+5	$(mg/kg\text{-}day)^{-1}$	4E-12
												9E-10
											Total Risk Across all Exposure Pathways:	9E-6

Note:

--	--	-	not applicable
APC	APC	-	Alaska Pulp Company
B[a]P	B[a]P	-	Benzo[a]pyrene
EPA	EPA	-	U.S. Environmental Protection Agency
EPC	EPC	-	exposure point concentration
M	M	-	medium-specific
ND	ND	-	not determined (EPA)/not considered a carcinogen
PAHs	PAHs	-	polycyclic aromatic hydrocarbons
PCDD/Fs	PCDD/	-	polychlorinated dibenzo-*p*-dioxins and dibenzofurans
RME	RME	-	reasonable maximum exposure
TEQ	TEQ	-	toxicity equivalent

[a] Values taken from Table 3-13 of Foster Wheeler (1998a) and are taken from statistical analysis of measured data (for soil) or are derived from transport modeling (for air).

[b] Dermal absorption values are from U.S. EPA (2004). Oral absorption factors from soil are from Foster Wheeler (1998a) and from Shu et al. (1988).

[c] Toxicity values obtained from either EPA Integrated Risk Information System (IRIS) January (U.S. EPA 2005b) or from EPA Region 9 (2005a).

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Soil
Exposure Point: Former Mill Site Area
Receptor Population: Hypothetical Future Part-Year Resident
Receptor Age: Child

Table A-8-RME
Calculation of Cancer Risks
Child Soil Exposure: Reasonable Maximum Hypothetical Residential
Former APC Mill Site

Exposure Route	Chemical of Concern	Medium EPC Value[a]	Medium Units	Oral or Dermal Absorption Factor[b]	Route EPC	Route EPC Units	EPC Applied	Intake (Cancer)	Intake (Cancer) Units	Cancer Slope Factor[c]	Cancer Slope Factor Units	Cancer Risk
Ingestion	**Metals**											
	Arsenic	11.5	mg/kg	0.60	11.5	mg/kg	M	3.2E-6	mg/kg-day	1.5	(mg/kg-day)-1	5E-6
	Chromium	60.0	mg/kg	--	60.0	mg/kg	M	--	--	ND	--	--
	Nickel	39.0	mg/kg	--	39.0	mg/kg	M	--	--	ND	--	--
	PAHs											
	Carcinogenic PAH B[a]P TEQ	1.0	mg/kg	0.84	1.0	mg/kg	M	4.7E-7	mg/kg-day	7.3	(mg/kg-day)-1	3E-6
	PCDD/F TEQ	0.00008	mg/kg	0.60	0.00008	mg/kg	M	3.8E-11	mg/kg-day	150,000	(mg/kg-day)-1	6E-6
											Total Risk:	1E-5
Dermal	**Metals**											
	Arsenic	11.5	mg/kg	0.03	11.5	mg/kg	M	4.5E-7	mg/kg-day	1.5	(mg/kg-day)-1	7E-7
	PAHs											
	Carcinogenic PAH B[a]P TEQ	1.0	mg/kg	0.13	1.0	mg/kg	M	1.7E-7	mg/kg-day	7.3	(mg/kg-day)-1	1E-6
	PCDD/F TEQ	0.00008	mg/kg	0.03	0.00008	mg/kg	M	3.2E-12	mg/kg-day	150,000	(mg/kg-day)-1	5E-7
											Total Risk:	2E-6
Inhalation	**Metals**											
	Arsenic	3.4E-11	mg/m^3	--	3.4E-11	mg/m^3	M	1.8E-12	mg/kg-day	1.5E+1	$(mg/kg-day)^{-1}$	3E-11
	Chromium particulates[c]	1.8E-10	mg/m^3	--	1.8E-10	mg/m^3	M	9.3E-12	mg/kg-day	4.2E+1	$(mg/kg-day)^{-1}$	4E-10
	Nickel	1.2E-10	mg/m^3	--	1.2E-10	mg/m^3	M	6.2E-12	mg/kg-day	8.4E-1	$(mg/kg-day)^{-1}$	5E-12
	PAHs											
	Carcinogenic PAH B[a]P TEQ	3.1E-12	mg/m^3	--	3.1E-12	mg/m^3	M	1.6E-13	mg/kg-day	7.3E+0	$(mg/kg-day)^{-1}$	1E-12
	PCDD/F TEQ	2.4E-16	mg/m^3	--	2.4E-16	mg/m^3	M	1.2E-17	mg/kg-day	1.5E+5	$(mg/kg-day)^{-1}$	2E-12
												4E-10
											Total Risk Across all Exposure Pathways:	2E-5

Note:

-- - not applicable
APC - Alaska Pulp Company
B[a]P - Benzo[a]pyrene
EPA - U.S. Environmental Protection Agency
EPC - exposure point concentration
M - medium-specific
ND - not determined (EPA)/not considered a carcinogen
PAHs - polycyclic aromatic hydrocarbons
PCDD/Fs - polychlorinated dibenzo-*p*-dioxins and dibenzofurans
RME - reasonable maximum exposure
TEQ - toxicity equivalent

[a] Values taken from Table 3-13 of Foster Wheeler (1998a) and are taken from statistical analysis of measured data (for soil) or are derived from transport modeling (for air).
[b] Dermal absorption values are from U.S. EPA (2004). Oral absorption factors from soil are from Foster Wheeler (1998a) and from Shu et al. (1988).
[c] Toxicity values obtained from either EPA Integrated Risk Information System (IRIS) January (U.S. EPA 2005b) or from EPA Region 9 (2005a).

Appendix B

Risk Calculations for Petroleum Hydrocarbons

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Soil
Exposure Point: Former Mill Site Area
Receptor Population: Hypothetical Future Resident
Receptor Age: Adult

Table B-1. RME
Calculation of Noncancer Hazards for Petroleum Fractions
Adult Soil Exposure: Reasonable Maximum Recreational
Former APC Mill Site

Exposure Route	Chemical of Concern	Medium EPC Value[a]	Medium Units	Dermal Absorption Factor[b]	Route EPC	Route EPC Units	EPC Applied	Intake (Non-cancer)	Intake (Non-cancer) Units	Reference Dose[c]	Reference Dose Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Ingestion														
	DRO													
	C_9–C_{18} aliphatic (as DRO aliphatic)	106	mg/kg	--	106	mg/kg	M	1.4E-4	mg/kg-day	1.0E-1	mg/kg-day	--	--	0.0014
	C_{10}–C_{22} aromatic (as DRO aromatic)	163	mg/kg	--	163	mg/kg	M	2.1E-4	mg/kg-day	4.0E-2	mg/kg-day	--	--	0.0053
	RRO													
	C_{19}–C_{36} aliphatic (as RRO aliphatic)	3144	mg/kg	--	3144	mg/kg	M	4.1E-3	mg/kg-day	2.0E+0	mg/kg-day	--	--	0.0020
													Hazard Index:	0.0087
Dermal														
	DRO													
	C_9–C_{18} aliphatic (as DRO aliphatic)	106	mg/kg	0.13	106	mg/kg	M	2.0E-4	mg/kg-day	1.0E-1	mg/kg-day	--	--	0.0020
	C_{10}–C_{22} aromatic (as DRO aromatic)	163	mg/kg	0.13	163	mg/kg	M	3.1E-4	mg/kg-day	4.0E-2	mg/kg-day	--	--	0.0078
	RRO													
	C_{19}–C_{36} aliphatic (as RRO aliphatic)	3144	mg/kg	0.13	3144	mg/kg	M	6.0E-3	mg/kg-day	2.0E+0	mg/kg-day	--	--	0.0030
													Hazard Index:	0.013
Inhalation														
	DRO													
	C_9–C_{18} aliphatic (as DRO aliphatic)	1.8.E-03	mg/kg	0.13	1.8.E-03	mg/kg	M	6.0E-5	mg/kg-day	2.9E-1	mg/kg-day	--	--	0.00021
	C_{10}–C_{22} aromatic (as DRO aromatic)	1.7.E-03	mg/kg	0.13	1.7.E-03	mg/kg	M	5.7E-5	mg/kg-day	5.7E-2	mg/kg-day	--	--	0.0010
	RRO													
	C_{19}–C_{36} aliphatic (as RRO aliphatic)	9.4.E-09	mg/kg	0.13	9.4.E-09	mg/kg	M	--	--	ND	--	--	--	--
													Hazard Index:	0.0012
													Total Hazard Index Across All Exposure Routes/Pathways:	0.023

Note:

-- - not applicable
DRO - diesel-range organics
EPA - U.S. Environmental Protection Agency
EPC - exposure point concentration
M - medium-specific
ND - not determined (EPA)/not considered a carcinogen
RME - reasonable maximum exposure
RRO - residual-range organics

[a] Values taken from Table 3-13 of Foster Wheeler (1998a) and are taken from statistical analysis of measured data (for soil) or are derived from transport modeling (for air).

[b] Dermal absorption values are from U.S. EPA (2004).

[c] Toxicity values obtained from the Alaska Department of Environmental Conservation and are based on closest approximate toxicity surrogate from http://www.state.ak.us/dec/spar/csp/guidance/petr2000.pdf.

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Soil
Exposure Point: Former Mill Site Area
Receptor Population: Future Hypothetical Resident
Receptor Age: Child

Table B-2. RME
Calculation of Noncancer Hazards for Petroleum Fractions
Child Soil Exposure: Reasonable Maximum Hypothetical Residential
Former APC Mill Site

Exposure Route	Chemical of Concern	Medium EPC Value[a]	Medium Units	Dermal Absorption Factor[b]	Route EPC	Route EPC Units	EPC Applied	Intake (Non-cancer)	Intake (Non-cancer) Units	Reference Dose[c]	Reference Dose Units	Reference Concentration	Reference Concentration Units	Hazard Quotient
Ingestion														
	DRO													
	C_9–C_{18} aliphatic (as DRO aliphatic)	106	mg/kg	--	106	mg/kg	M	1.3E-3	mg/kg-day	1.0E-1	mg/kg-day	--	--	0.013
	C_{10}–C_{22} aromatic (as DRO aromatic)	163	mg/kg	--	163	mg/kg	M	2.0E-3	mg/kg-day	4.0E-2	mg/kg-day	--	--	0.049
	RRO													
	C_{19}–C_{36} aliphatic (as RRO aliphatic)	3144	mg/kg	--	3144	mg/kg	M	3.8E-2	mg/kg-day	2.0E+0	mg/kg-day	--	--	0.019
													Hazard Index:	0.081
Dermal	DRO													
	C_9–C_{18} aliphatic (as DRO aliphatic)	106	mg/kg	0.13	106	mg/kg	M	4.7E-4	mg/kg-day	1.0E-1	mg/kg-day	--	--	0.0047
	C_{10}–C_{22} aromatic (as DRO aromatic)	163	mg/kg	0.13	163	mg/kg	M	7.2E-4	mg/kg-day	4.0E-2	mg/kg-day	--	--	0.018
	RRO													
	C_{19}–C_{36} aliphatic (as RRO aliphatic)	3144	mg/kg	0.13	3144	mg/kg	M	1.4E-2	mg/kg-day	2.0E+0	mg/kg-day	--	--	0.0069
													Hazard Index:	0.029
Inhalation														
	DRO													
	C_9–C_{18} aliphatic (as DRO aliphatic)	1.8.E-03	mg/kg	0.13	1.8.E-03	mg/kg	M	2.8E-5	mg/kg-day	2.9E-1	mg/kg-day	--	--	0.00010
	C_{10}–C_{22} aromatic (as DRO aromatic)	1.7.E-03	mg/kg	0.13	1.7.E-03	mg/kg	M	2.7E-5	mg/kg-day	5.7E-2	mg/kg-day	--	--	0.00047
	RRO													
	C_{19}–C_{36} aliphatic (as RRO aliphatic)	9.4.E-09	mg/kg	0.13	9.4.E-09	mg/kg	M	--	mg/kg-day	ND	mg/kg-day	--	--	--
														0.00056
													Total Hazard Index Across All Exposure Routes/Pathways:	0.11

Note:

-- - not applicable
DRO - diesel-range organics
EPA - U.S. Environmental Protection Agency
EPC - exposure point concentration
M - medium-specific
ND - not determined (EPA)/not considered a carcinogen
RME - reasonable maximum exposure
RRO - residual-range organics

[a] Values taken from Table 3-13 of Foster Wheeler (1998a) and are taken from statistical analysis of measured data (for soil) or are derived from transport modeling (for air).

[b] Dermal absorption values are from U.S. EPA (2004).

[c] Toxicity values obtained from the Alaska Department of Environmental Conservation and are based on closest approximate toxicity surrogate from http://www.state.ak.us/dec/spar/csp/guidance/petr2000.pdf.