5.0 SUMMARY OF RISK ASSESSMENT

Baseline human health and ecological risk assessments were conducted to determine if residual petroleum at the SWMU 62, New Housing Fuel Leak site would pose unacceptable risk to human health or the environment if no cleanup actions were to take place. Contaminant concentrations reported in Section 4 were used to calculate risks and hazards. Hazards calculated for human exposures to chemicals in soil were found to be greater than target health goals. Target health goals established for free-product petroleum sites at the former Adak Naval Complex are the following:

- Human health cancer risk (CR) of 1 x 10^{-5}
- Human health hazard index (HI) of 1 based on compounds other than total petroleum hydrocarbon (TPH) compounds
- Human health HI of 1 based on TPH
- Ecological HI of 1

5.1 HUMAN HEALTH

Alaska DEC provides guidance for four methods of determining cleanup levels (beginning with Method One) that increase in level of effort and site-specificity. Method Four uses risk assessment to determine site specific cleanup levels (ADEC 2000a). Sufficient site information is available to determine Method Four cleanup levels and the results are summarized below. Details are provided in Appendix C of the FFS report (URS 2005a).

Previous investigations have identified petroleum compounds in soil and groundwater and surface water and sediment of the East Canal ditch at concentrations above regulatory levels. These elevated concentrations at the site are likely the result of leakage from subsurface heating fuel distribution lines. The risk assessment, conducted according to the risk assessment procedures specified by Alaska DEC (2000a), evaluated whether potential health risks were present if people encountered these petroleum-impacted materials in their environment. Exposure pathways were determined to be complete and significant based on the site-specific human health conceptual site model (CSM). The human health CSM for the SWMU 62, New Housing Fuel Leak site is depicted on Figure 5-1. This section provides a summary of the human health risk assessment conducted for this site. The complete, detailed human health risk assessment is included as Appendix C of the FFS report (URS 2005a).

5.1.1 Human Health Risk Assessment Procedures

A baseline risk assessment typically consists of four major steps: (1) data evaluation, (2) exposure assessment, including development of a CSM, (3) toxicity assessment, and (4) risk characterization and calculation of cleanup levels. A final step is a qualitative analysis of the major uncertainties involved in risk assessment calculations. Details of the procedures used to calculate the health risks are summarized below.

Data Evaluation

At step one, the data applicable to human health exposures are selected and compared to de minimis health-based screening levels. Chemicals with concentrations greater than the de minimis levels are selected as "COPCs" for evaluation in the risk assessment. Eight chemicals were selected as COPCs in groundwater:

- 2-Methylnaphthalene
- Benzene
- Ethylbenzene
- Naphthalene
- Toluene
- Xylenes
- DRO
- GRO

One chemical, DRO was selected as a COPC in soil. DRO and benzo(a)pyrene were selected as COPCs in sediment. DRO and benzene were selected as COPCs in surface water.

Exposure Assessment

Once COPCs are selected, the second step in risk assessment is an evaluation of the exposure pathways by which people could encounter chemicals. The exposure assessment identifies the populations potentially exposed to chemicals at the site, the means by which exposure occurs, and the amount of chemical received from each exposure medium (i.e., the dose). Only complete exposure pathways are quantitatively evaluated. Complete pathways consist of four elements: (1) a source and mechanism of chemical release, (2) a retention or transport medium (e.g., groundwater), (3) a point of potential human contact with the affected medium, and (4) a means of entry into the body at the contact point. Figure 5-1 presents the CSM, which depicts the complete pathways for this site.

Future land use at the SWMU 62, New Housing Fuel Leak site is classified as mostly residential reuse with adjacent areas a mixture of commercial and public land uses. Several areas adjacent

to the housing areas were impacted by fuel releases associated with the SWMU 62, New Housing Fuel Leak site. Therefore, for the purposes of the risk assessment, these areas were evaluated as part of the SWMU 62, New Housing Fuel Leak site. These areas include the area of SWMU 62, New Housing Fuel Leak site between Sandy Cove Housing and Eagle Bay Housing which is classified as public facilities and contains the elementary school and the high school buildings; and the areas immediately west of Sandy Cove Housing and Eagle Bay Housing which are designated as commercial reuse. Building T-2776 is currently used intermittently as a vehicle maintenance building and is expected to continue to be used as such. Therefore, building workers of Building T-2776 are considered a population of concern. Although no construction activities are planned at this time, intrusive subsurface activities could occur in the future. Construction workers could be exposed to both soil and groundwater during intrusive activities. Adults and children currently occupy some of the Sandy Cove Housing units. Eagle Bay is currently not occupied; however, it could be occupied in the future. Therefore, current residents of Sandy Cove Housing and future potential residents of Eagle Bay Housing are populations of concern for exposure to surface soil and groundwater. The East Canal of the airport ditch system is about 300 feet from the western boundary of the SWMU 62, New Housing Fuel Leak site, but approximately 1,800 feet from the nearest occupied homes. Although residents are not living near the East Canal, trespassers may occasionally enter the East Canal ditch. Currently, there is no fence surrounding the East Canal but the area is restricted to airport personnel. The populations of concern for exposure to surface water and sediment from East Canal are trespassing, elementary-aged school children (aged 6 to 12 years) who may travel from the housing areas.

The following exposure pathways were selected for quantitative evaluation under current and future conditions:

- Construction workers potentially disturbing soil in the course of construction activity could be exposed through incidental ingestion, dermal contact, and inhalation of fugitive dust and volatile chemicals in soil (to a depth of 15 feet).

- Construction workers conducting intrusive subsurface work could be exposed to chemicals in shallow groundwater (less than 15 feet bgs) through dermal contact and inhalation of volatile chemicals.

- On-site workers occupying Building T-2776 could be exposed to vapors in indoor air volatilizing from groundwater beneath the building. In addition, on-site workers could be exposed to chemicals in surface soil through incidental ingestion and dermal contact.

- Current and future child and adult residents of the SWMU 62, New Housing Fuel Leak site could be exposed to vapors in indoor air volatilizing from groundwater

beneath the housing units. In addition, residents could be exposed to chemicals in surface soil through incidental ingestion and dermal contact.

- Elementary School-Aged Child Trespassers could be exposed to chemicals in surface water and sediment of the East Canal of the airport ditch system through incidental ingestion and dermal contact. Surface water and sediment data collected from the East Canal of the airport ditch system in the vicinity of the SWMU 62, New Housing Fuel Leak site, as well as downgradient to the cross-over canal were included in the evaluation of recreational child exposures in the East Canal of the airport ditch system. While not all of the data were collected specifically for the evaluation of contamination from the New Housing Fuel Leak, the downgradient locations were included to fully characterize exposures of child residents of the SWMU 62, New Housing Fuel Leak site to contamination in the East Canal ditch.

Ingestion of groundwater is considered an incomplete pathway for all receptors. Institutional controls are currently in place for groundwater which restrict the use of groundwater as drinking water.

The exposure factors used in the risk calculations for each population are summarized on Tables 5-1 through 5-8.

5.1.2 Toxicity Assessment

The third step in risk assessment is an evaluation of the toxicity of the COPCs by an assessment of the relationship between the dose of a chemical and the occurrence of toxic effects. Chemical toxicity criteria, which are based on this relationship, consider both cancer effects and effects other than cancer (noncancer effects). Tables 5-9 and 5-10 present the cancer and noncancer criteria, respectively. The toxicity criteria are combined with the exposure factors when quantifying potential health risks for each COPC. The toxicity criteria are required in order to quantify the potential health risks due to the COPCs. Benzene and ethylbenzene in groundwater, and benzo(a)pyrene in surface water were evaluated for cancer effects; and the other chemicals (where toxicity information exists) were evaluated for noncancer effects.

Note, only noncancer toxicity criteria are available for the petroleum groups. Carcinogenic effects are not evaluated for the petroleum ranges. Rather, the individual carcinogenic compounds present in petroleum (i.e., benzene) are evaluated separately.

5.1.3 Risk Characterization

The last step in human health risk assessment is a characterization of the health risks. The exposure factors, media concentrations, and toxicity criteria are combined to calculate health risks. Health risks are calculated differently for chemicals that cause cancer and for chemicals that cause noncancer effects. The calculation of CR assumes that no level of the chemical is without some risk, whereas for chemicals with noncancer effects, a "threshold" dose exists. Risks (for cancer) and hazards (for noncancer effects) are calculated for the reasonable maximum exposure (RME) for each pathway, a calculation that overestimates risks for the majority of the population in order to ensure that public health is protected. CR estimates represent the potential for cancer effects by estimating the probability of developing cancer over a lifetime due to site exposures. Noncancer hazards assume there is a level of chemical intake that is not associated with an adverse health effect even in sensitive individuals.

The following bulleted text summarize the results of the risk characterization. The exposure point concentrations (EPCs) used to calculate these risks and hazards are presented on Table 5-11.

- **Construction Workers.** Total CRs (5×10^{-8}) and TPH and non-TPH noncancer hazards (0.1 and 0.05, respectively) for combined exposures to soil and groundwater are below target health goals (see Table 5-12). Therefore, concentrations of the COPCs in soil and groundwater at the site are not present in concentrations that are a health concern for construction worker exposures.

- **On-Site Workers.** Total CRs (5×10^{-7}) and TPH and non-TPH noncancer hazards (0.04 and 0.6, respectively) for combined exposures to surface soil and groundwater vapors are below target health goals (see Table 5-13). Therefore, concentrations of the COPCs in surface soil and groundwater at the site are not present in concentrations that are a health concern for on-site worker exposures.

- **Child and Adult Residents.** Table 5-14 summarizes the results of the risk characterization for residential exposures to chemicals in soil and groundwater. Total CRs and non-TPH hazards for combined exposures to surface soil and groundwater vapors are below target health goals for child and integrated child/adult exposures. CRs were 1×10^{-6}; child non-TPH hazards were 0.08; and child/adult non-TPH hazards were 0.04. In addition, TPH hazard indices for exposures to groundwater vapors were also below target health goals for child (0.5) and integrated child/adult exposures (0.3). However, the child TPH HI of 2 for exposures to surface soil are slightly above the target health goal of 1. The exceedance above target health goals is due almost entirely to incidental ingestion of DRO in surface soil.

- **Elementary Child Trespasser.** Total CRs (7×10^{-8}) and TPH and non-TPH noncancer hazards (0.06 and 0.0002, respectively) for combined exposures to sediment and surface water of the East Canal of the airport ditch system are below target health goals (see Table 5-15). Therefore, concentrations of the COPCs in surface water and sediment are not present in the East Canal of the airport ditch in concentrations that are a health concern for on-site worker exposures.

- **Exposure to Free-Phase Petroleum Product.** Risks and hazards to free product cannot be quantified using standard risk assessment techniques. If free product is encountered in sufficient amounts, this could constitute a hazard. The presence of free product is generally assumed to present a situation where workers should take precautions to prevent exposure. Construction workers performing subsurface activities in the vicinity between Eagle Bay Housing Area and the East Canal of the airport ditch system, where depth to groundwater is less than 15 feet bgs (the maximum depth at which construction activities are expected to occur), could potentially contact free-phase petroleum during the course of their work. In the event that free product is encountered by construction workers, appropriate health and safety measures should be taken to minimize contact.

Because TPH chemicals in soil exceeded target health goals for child residential exposures and because there is sufficient free product remaining at the site that direct contact with free product could constitute a health risk, action-based alternative cleanup levels (ACLs) were calculated for DRO in soil as allowed under 18 AAC 75.340. The proposed action-based ACL is 6,111 mg/kg for DRO. This action-based ACL was calculated by defining a target health goal and then solving the basic risk assessment equations for concentration, rather than for risk or for hazard. The same site-specific information developed for calculating health risks was used in the action-based ACL calculations. Because only noncancer health effects are a concern, the ACL is protective of noncancer health end points.

Site-specific cleanup levels for groundwater were not calculated. While institutional controls are currently in place for groundwater, which restrict the use of groundwater as a drinking water source, the water is potentially potable (i.e., yield is sufficient and there is no saltwater intrusion). Therefore, the proposed groundwater cleanup levels for SWMU 62, New Housing Fuel Leak site are the Alaska DEC cleanup levels established for groundwater that is considered to be a reasonably expected potential future source of drinking water.

5.2 ECOLOGICAL

This section provides a summary of the ecological risk assessment conducted for this site. The complete, detailed ecological risk assessment is included as Appendix C of the FFS report (URS 2005a).

5.2.1 Ecological Risk Assessment Procedures

Ecological risk assessment procedures begin with determining whether a detailed ecological risk assessment of that site is required. A detailed ecological risk assessment of a given site is required whenever the potential for an ecological threat from chemicals exists. The decision on whether to perform a detailed ecological risk assessment or not is made during the problem formulation stage of the risk assessment process. Before a decision can be made on the need for a detailed ecological risk assessment of a given site, a determination is made regarding the following:

1. The presence of sensitive environments, critical habitats, or sensitive species at a site

2. The presence of complete exposure pathways which result in the exposure of ecological receptors to site contaminants

If it is determined that no sensitive environments, critical habitats or sensitive species are present at a given site, and complete exposure pathways cannot be identified, Alaska DEC guidance permits the ecological risk assessment process for that site to be terminated.

5.2.2 Problem Formulation

An ecological checklist (found in Appendix B of the Alaska DEC Risk Assessment Procedures Manual [ADEC 2000a] and included in Appendix C-II of the FFS [URS 2005a]) was completed, describing the location and characteristics (e.g., environmental setting, land use, environmental fate-and-transport, and ecological receptors) of specific environments within the boundaries of the SWMU 62, New Housing Fuel Leak site. Through this exercise, it was determined that no state or federal sensitive environment or critical habitat is found within the site boundaries.

An ecological conceptual site model (CSM) was also prepared for the SWMU 62, New Housing Fuel Leak site, describing the completeness and significance of exposure pathways by which ecological receptors may potentially be exposed to site contaminants. The CSM (included as Figure 5-2) revealed that no complete exposure pathways have been identified for any ecological receptors that warrant quantitative risk assessment. Several minor or insignificant exposure

pathways are present, none of which result in any ecologically significant exposure to contaminants at the site, and none of which requires quantitative evaluation.

5.2.3 Conclusion

Based on this assessment presented, it is concluded that no ecological threat exists for any ecological receptor from petroleum products released at the SWMU 62, New Housing Fuel Leak site. Therefore, no further ecological risk assessment is warranted for this site.

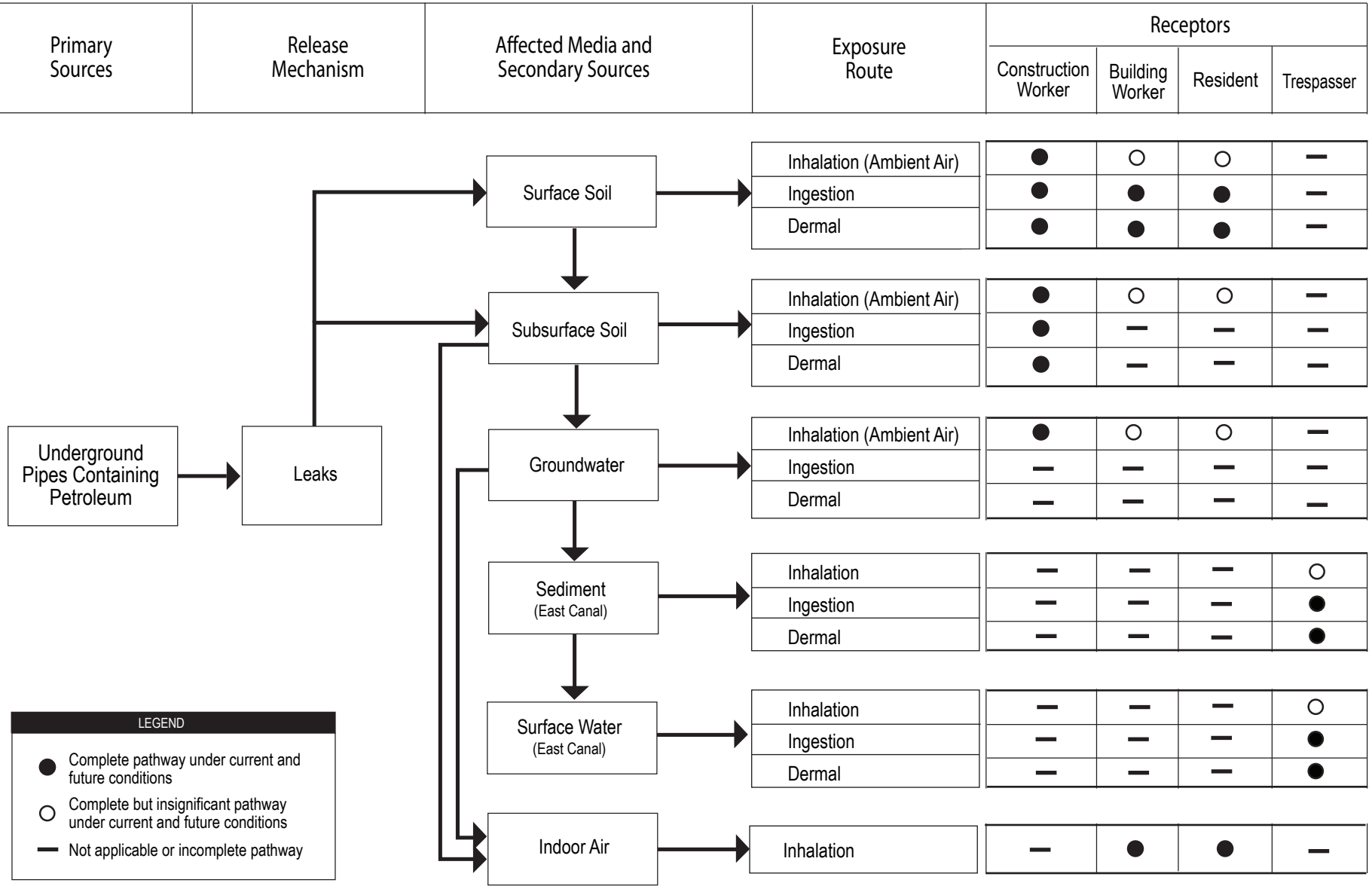

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Figure 5-1
Human Health Conceptual Site Model
SWMU 62, New Housing Fuel Leak Site

Adak Island, AK
DECISION DOCUMENT

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33759502_03.cdr

Primary Source	Primary Release Mechanism	Secondary Source	Secondary Release Mechanism	Tertiary Source	Tertiary Release Mechanism	Exposure Medium	Exposure Route	Potential Ecological Receptors									
								Terrestrial Biota				Aquatic Biota					
								Plants		Invertebrates		Macrophytes		Plankton		Invertebrates	
								Root Uptake	Shoot Sorption	Ingestion	Dermal Contact	Root Uptake	Shoot Sorption	Ingestion	Dermal Contact	Ingestion	Dermal Contact
ASTs, ags Pipes, Fuel Dispensers, Drums, FCTs, Fill Spouts on USTs, and/or Unknown	Spills/Leaks of Chemicals into Soil	On-Site Surface Soil	Dust Generation and Volitilization		Particulate and Volatile Emissions	Air	Inhalation	—	—	—	—	—	—	—	—	—	—
						On-Site Surface Soil (0-6 feet bgs)	Incidental Ingestion	—	—	—	—	—	—	—	—	—	—
							Dermal Contact/ Root Uptake		—	—	—	—	—	—	—	—	—
							Food Web	—	—	—	—	—	—	—	—	—	—
USTs, bgs Pipes, Disposal Area, and/or Unknown		On-Site Subsurface Soil	Overland Runoff			On-Site Subsurface Soil (>6 feet bgs)		—	—	○	○	—	—	—	—	—	—
							Incidental Ingestion	—	—	○	○	—	—	—	—	—	—
							Dermal Contact/ Root Uptake	—	—	○	○	—	—	—	—	—	—
			Leaching and Infiltration	Groundwater	Discharge to Drainage Ditch	East Canal Sweeper Creek Sweeper Cove Kuluk Bay surface water	Incidental Ingestion	○	○	○	○	○	○	○	○	○	○
								○	○	○	○	○	○	○	○	○	○
							Food Web	○	○	○	○	○	○	○	○	○	○
Storm and Wastewater Discharge	Spills/Leaks of Chemicals into Airport Ditch System					Sediments	Incidental Ingestion	○	○	○	○	○	○	○	○	○	○
			Slope Erosion				Dermal Contact/ Root Uptake	○	○	○	○	○	○	○	○	○	○
			Sedimentation, Sorption				Food Web	○	○	○	○	○	○	○	○	○	○

LEGEND

- ● Potentially Complete Pathway
- ○ Minor or Insignificant Pathway
- — Incomplete Pathway
- ags Above Ground Surface
- AST Above Ground Storage Tank
- bgs Below Ground Surface
- FCT Field Constructed Tank
- UST Underground Storage Tank

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Adak Island, AK
DECISION DOCUMENT

Figure 5-2
Ecological Conceptual Site Model
SWMU 62, New Housing Fuel Leak Site

Table 5-1
Construction Worker Exposures to Groundwater, Exposure Assumptions and Intake Equations

Equations:

Chemical intake (mg/kg-day) = CW * SIF

$$SIF_{derm} = \frac{CF1 \cdot CF2 \cdot SA \cdot EF \cdot ET \cdot ED \cdot PC}{BW \cdot AT}$$

$$SIF_{inh} = \frac{CF1 \cdot InhR \cdot EF \cdot ED \cdot VFw}{BW \cdot AT}$$

Where:

SIF_{derm} (L-mg/ug-kg-day) = summary intake factor for dermal contact with groundwater
SIF_{inh} (L-mg/ug-kg-day) = summary intake factor for inhalation of groundwater vapors

Parameter	Definition	Value	Units	Source
CW	Chemical concentration in	chemical specific	ug/L	analytical data
CF1	Conversion factor	1.00E-03	mg/ug	not applicable
CF2	Conversion factor	1.00E-03	L/cm^3	not applicable
SA	Skin surface area	3300	cm^2	default value, USEPA 2002c
PC	Dermal permeability constant	chemical specific	cm/hr	USEPA 2003b
InhR	Inhalation rate	20	m^3/day	default value, USEPA 2002c
VFw	Volatilization factor for water	0.01	L/m^3	site-specific, USEPA 1999a
EF	Exposure frequency	190	days/year	site-specific
ET	Exposure time	8	hours/day	site-specific
ED	Exposure duration	1	years	site-specific
BW	Body weight	70	kg	default value, USEPA 2002c
ATnc	Averaging time (noncarcinogen)	ED x 365 days/year	days	default value, USEPA 2002c
ATca	Averaging time (carcinogen)	25,550	days	default value, USEPA 2002c

Notes:

cm - centimeter
cm^2 - centimeters squared
cm^3 - cubic centimeters
hr - hour
kg - kilograms
L - liters
m^3 - cubic meters
mg - milligrams
ug - micrograms
USEPA - United States Environmental Protection Agency

Table 5-2
Construction Worker Exposures to Soil, Exposure Assumptions and Intake Equations

Equations:

Chemical intake (mg/kg-day) = CS * SIF

$$SIF_{ing} = \frac{IR \bullet CF \bullet EF \bullet ED}{BW \bullet AT}$$

$$SIF_{derm} = \frac{CF \bullet SA \bullet AF \bullet ABS \bullet EF \bullet ED}{BW \bullet AT}$$

$$SIF_{inh} = \frac{InhR \bullet EF \bullet ED \bullet (1/PEF)}{BW \bullet AT}$$

Where:

SIF_{ing} (day^{-1}) = summary intake factor for ingestion of soil
SIF_{derm} (day^{-1}) = summary intake factor for dermal contact with soil
SIF_{inh} (day^{-1}) = summary intake factor for inhalation of fugitive dust

Parameter	Definition	Value	Units	Source
CS	Chemical concentration in soil	chemical specific	mg/kg	analytical data
IR	Ingestion rate	330	mg/day	default value, USEPA 2002c
CF	Conversion factor	1.00E-06	kg/mg	not applicable
SA	Surface area	3300	cm^2	default value, USEPA 2002c
AF	Soil to skin adherence factor	0.3	mg/cm^2-day	default value, USEPA 2002c
ABS	Absorption factor	chemical specific	unitless	USEPA 2003b
InhR	Inhalation rate	20	m^3/day	default value, USEPA 2002c
PEF	Particulate emission factor	chemical specific	m^3/kg	site-specific, USEPA 2002c
EF	Exposure frequency	190	days/year	site-specific
ED	Exposure duration	1	years	site-specific
BW	Body weight	70	kg	default value, USEPA 2002c
ATnc	Averaging time (noncarcinogen)	ED x 365 days/year	days	default value, USEPA 2002c
ATca	Averaging time (carcinogen)	25,550	days	default value, USEPA 2002c

Notes:

cm^2 - centimeters squared
kg - kilograms
m^3 - cubic meters
mg - milligrams
USEPA - United States Environmental Protection Agency

Table 5-3
Building Worker Exposures to Vapors in Indoor Air
Exposure Assumptions and Intake Equations

Equations:

Chemical intake (mg/kg-day) = CA * SIF

$$SIF_{inh} = \frac{CF1 \bullet InhR \bullet EF \bullet ED \bullet ET}{BW \bullet AT}$$

Where:

SIF_{inh} (L-mg/ug-kg-day) = summary intake factor for inhalation of vapors from affected media

Parameter	Definition	Value	Units	Source
CA	Chemical concentration in air	chemical specific	$\mu g/m^3$	Calculated using the Johnson-Ettinger (1991) Model (USEPA 2003c) to estimate chemical movement from affected media (i.e., soil or groundwater) to air.
CF1	Conversion factor	1.00E-03	mg/μg	Not applicable
InhR	Inhalation rate	1.3	m^3/hour	Default value (USEPA 1997a)
EF	Exposure frequency	250	days/year	Default value (USEPA 1991)
ET	Exposure time	8	hours/day	Site-specific
ED	Exposure duration	25	years	Default value (USEPA 1991)
BW	Body weight	70	kg	Default value (USEPA 2002c)
ATnc	Averaging time for noncarcinogenic effects	ED x 365 days/year	days	Default value (USEPA 1991)
ATca	Averaging time for carcinogenic effects	25,550	days	Default value (USEPA 1991)

Notes:
cm^2 - square centimeter
cm^3 - cubic centimeter
hr - hour
kg - kilogram
L - liter
m^3 - cubic meter
mg - milligram
ug - microgram
USEPA - United States Environmental Protection Agency

Table 5-4
Building Worker Exposures to Surface Soil
Exposure Assumptions and Intake Equations

Equations:

Chemical intake (mg/kg-day) = CS * SIF

$$SIF_{ing} = \frac{IR \bullet CF \bullet EF \bullet ED}{BW \bullet AT}$$

$$SIF_{derm} = \frac{CF \bullet SA \bullet AF \bullet ABS \bullet EF \bullet ED}{BW \bullet AT}$$

Where:

SIF_{ing} (day^{-1}) = summary intake factor for ingestion of soil
SIF_{derm} (day^{-1}) = summary intake factor for dermal contact with soil

Parameter	Definition	Value	Units	Source
CS	Chemical concentration in soil	chemical specific	mg/kg	Analytical data
IR	Ingestion rate	100	mg/day	Default value (USEPA 2002c)
CF	Conversion factor	1.00E-06	kg/mg	Not applicable
SA	Surface area	3300	cm^2	Default value (USEPA 2002c)
AF	Soil to skin adherence factor	0.2	mg/cm^2-day	Default value (USEPA 2002c)
ABS	Absorption factor	chemical specific	unitless	USEPA 2003b
EF	Exposure frequency	250	days/year	Default value (USEPA 2002c)
ED	Exposure duration	25	year	Default value (USEPA 2002c)
BW	Body weight	70	kg	Default value (USEPA 2002c)
ATnc	Averaging time for noncarcinogenic effects	ED x 365 days/year	days	Default value (USEPA 1991)
ATca	Averaging time for carcinogenic effects	25,550	days	Default value (USEPA 1991)

Notes:
cm^2 - square centimeters
kg - kilograms
m^3 - cubic meters
mg - milligrams
USEPA - United States Environmental Protection Agency

Table 5-5
Residential Exposures to Vapors in Indoor Air
Exposure Assumptions and Intake Equations

Equations:

Chemical intake (mg/kg-day) = CA * SIF

$$SIF_{inh\text{-}nc} = \frac{CF1 \bullet InhRc \bullet EF \bullet EDc}{BWc \bullet ATnc}$$

$$SIF_{inh\text{-}ca} = \frac{[(InhRc \bullet EDc / BWc) + (InhRa \bullet EDa / BWa)] \bullet EF \bullet CF1}{ATca}$$

Where:

$SIF_{inh\text{-}nc}$ (L-mg/ug-kg-day) = summary intake factor for inhalation of vapors from affected media - noncarcinogenic effects
$SIF_{inh\text{-}ca}$ (L-mg/ug-kg-day) = summary intake factor for inhalation of vapors from affected media - carcinogenic effects

Parameter	Definition	Value	Units	Source
CA	Chemical concentration in air	Chemical-specific	ug/m^3	Calculated using the Johnson-Ettinger (1991) Model (USEPA 2003c) to estimate chemical movement from affected media (i.e., soil or groundwater) to air.
CF1	Conversion factor	1.00E-03	mg/ug	Not applicable
InhRc	Inhalation rate—child	10	m^3/day	Default value (USEPA 1998)
InhRa	Inhalation rate—adult	20	m^3/day	Default value (USEPA 1998)
EF	Exposure frequency	350	days/year	Default value (USEPA 1991)
EDc	Exposure duration—child	6	years	Default value (USEPA 1991)
EDa	Exposure duration—adult	24	years	Default value (USEPA 1991)
BWc	Body weight—child	15	kg	Default value (USEPA 1991)
Bwa	Body weight—adult	70	kg	Default value (USEPA 1991)
ATnc	Averaging time for noncarcinogenic effects	ED x 365 days/year	days	Default value (USEPA 1991)
ATca	Averaging time for carcinogenic effects	25,550	days	Default value (USEPA 1991)

Notes:
cm^2 - square centimeter
cm^3 - cubic centimeter
hr - hour
kg - kilogram
L - liter
m^3 - cubic meter
mg - milligram
ug - microgram
USEPA - United States Environmental Protection Agency

Table 5-6
Residential Exposures to Surface Soil
Exposure Assumptions and Intake Equations

Equations:

$$\text{Chemical intake (mg/kg-day)} = CS \bullet SIF$$

$$SIF_{ing\text{-}nc} = \frac{IRc \bullet CF \bullet EF \bullet EDc}{BWc \bullet ATnc}$$

$$SIF_{ing\text{-}ca} = \frac{[(IRc \bullet EDc / BWc) + (IRa \bullet EDa / BWa)] \bullet EF \bullet CF}{ATca}$$

$$SIF_{derm\text{-}nc} = \frac{CF \bullet SAc \bullet AFc \bullet ABS \bullet EF \bullet EDc}{BWc \bullet ATnc}$$

$$SIF_{derm\text{-}ca} = \frac{[(SAc \bullet AFc \bullet EDc / BWc) + (SAa \bullet AFa \bullet EDa / BWa)] \bullet ABS \bullet EF \bullet CF}{ATca}$$

Where:

$SIF_{ing\text{-}nc}$ (day^{-1}) = summary intake factor for ingestion of soil-noncarcinogenic effects
$SIF_{ing\text{-}ca}$ (day^{-1}) = summary intake factor for ingestion of soil-carcinogenic effects
$SIF_{derm\text{-}nc}$ (day^{-1}) = summary intake factor for dermal contact with soil-noncarcinogenic effects
$SIF_{derm\text{-}ca}$ (day^{-1}) = summary intake factor for dermal contact with soil-carcinogenic effects

Parameter	Definition	Value	Units	Source
CS	Chemical concentration in soil	chemical specific	mg/kg	Analytical data
IRc	Ingestion rate-child	200	mg/day	Default value (USEPA 2002a)
IRa	Ingestion rate-adult	100	mg/day	Default value (USEPA 2002a)
CF	Conversion factor	1.00E-06	kg/mg	Not applicable
SAc	Surface area-child	2,800	cm^2	Default value (USEPA 2002a)
SAa	Surface area-adult	5,700	cm^2	Default value (USEPA 2002a)
AFc	Soil to skin adherence factor-child	0.2	mg/cm^2-day	Default value (USEPA 2002a)
AFa	Soil to skin adherence factor-adult	0.07	mg/cm^2-day	Default value (USEPA 2002a)
ABS	Absorption factor	chemical specific	unitless	USEPA 2003b
EF	Exposure frequency	350	days/year	Default value (USEPA 1991)
EDc	Exposure duration-child	6	years	Default value (USEPA 1991)
EDa	Exposure duration-adult	24	years	Default value (USEPA 1991)
BWc	Body weight-child	15	kg	Default value (USEPA 1991)
BWa	Body weight-adult	70	kg	Default value (USEPA 1991)
ATnc	Averaging time for noncarcinogenic effects	ED x 365 days/year	days	Default value (USEPA 1991)
ATca	Averaging time for carcinogenic effects	25,550	days	Default value (USEPA 1991)

Notes:
cm^2 - square centimeter
derm - dermal
ing - ingestion
kg - kilogram
m^3 - cubic meter
mg - milligram
USEPA - United States Environmental Protection Agency

Table 5-7
Trespasser/Recreational Exposures to Surface Water, Exposure Assumptions and Intake Equations

Equations:

Chemical intake (mg/kg-day) = CW * SIF

$$SIF_{derm} = \frac{CF1 \cdot CF2 \cdot SA \cdot EF \cdot ET \cdot ED \cdot PC}{BW \cdot AT}$$

$$SIF_{ing} = \frac{IR \cdot CF1 \cdot CF2 \cdot ET \cdot EF \cdot ED}{BW \cdot AT}$$

Where:

SIF_{derm} (L-mg/ug-kg-day) = summary intake factor for dermal contact with groundwater
SIF_{ing} (L-mg/ug-kg-day) = summary intake factor for inhalation of groundwater vapors

Parameter	Definition	Value	Units	Source
CW	Chemical concentration in	chemical specific	ug/L	analytical data
CF1	Conversion factor	1.00E-03	mg/ug	not applicable
CF2	Conversion factor	1.00E-03	L/cm^3	not applicable
SA	Skin surface area	2314	cm^2	default value, USEPA 1997a
PC	Dermal permeability constant	chemical specific	cm/hr	USEPA 2003b
IR	Ingestion rate	30	mL/hr	default value, USEPA 1998
VFw	Volatilization factor for water	0.01	L/m^3	site-specific, USEPA 1999a
EF	Exposure frequency	190	days/year	site-specific
ET	Exposure time	5	hours/day	site-specific
ED	Exposure duration	1	years	site-specific
BW	Body weight	33	kg	default value, USEPA 1997a
ATnc	Averaging time (noncarcinogen)	ED x 365 days/year	days	default value, USEPA 1989
ATca	Averaging time (carcinogen)	25,550	days	default value, USEPA 1989

Notes:
cm - centimeter
cm^2 - centimeters squared
cm^3 - cubic centimeters
derm - dermal
hr - hour
ing - ingestion
kg - kilograms
L - liters
m^3 - cubic meters
mg - milligrams
ug - micrograms
mL - milliliter
USEPA - United States Environmental Protection Agency

Table 5-8
Trespasser/Recreational Exposures to Sediment, Exposure Assumptions and Intake Equations

Equations:

Chemical intake (mg/kg-day) = CSd * SIF

$$SIF_{ing} = \frac{IR \cdot CF \cdot EF \cdot ED}{BW \cdot AT}$$

$$SIF_{derm} = \frac{CF \cdot SA \cdot AF \cdot ABS \cdot EF \cdot ED}{BW \cdot AT}$$

Where:

SIF_{ing} (day^{-1}) = summary intake factor for ingestion of sediment
SIF_{derm} (day^{-1}) = summary intake factor for dermal contact with sediment

Parameter	Definition	Value	Units	Source
CSd	Chemical concentration in	chemical specific	mg/kg	analytical data
IR	Ingestion rate	300	mg/day	default value, USEPA 1999c
CF	Conversion factor	1.00E-06	kg/mg	not applicable
SA	Surface area	2,314	cm^2	site-specific, USEPA 1997a
AF	Soil to skin adherence factor	0.2	mg/cm^2-event	default value, USEPA 2003b
ABS	Absorption factor	chemical specific	unitless	USEPA 2003b
EF	Exposure frequency	7.5(ing)/21(derm)	events/year	site-specific
ED	Exposure duration	6	years	site-specific
BW	Body weight	33	kg	default value, USEPA 1997a
ATnc	Averaging time (noncarcinogen)	ED x 365 days/year	days	default value, USEPA 1989
ATca	Averaging time (carcinogen)	25,550	days	default value, USEPA 1989

Notes:

cm^2 - centimeters squared
kg - kilograms
m^3 - cubic meters
mg - milligrams
ing - ingestion
derm - dermal
USEPA - United States Environmental Protection Agency

Table 5-9
Carcinogenic Toxicity Criteria for the Chemicals of Potential Concern

Chemical	Oral Cancer: Slope Factor $(mg/kg\text{-}day)^{-1}$	Inhalation Cancer: Slope Factor $(mg/kg\text{-}day)^{-1}$	Tumor Type	EPA Cancer Classification[a]	Reference
2-Methylnaphthalene	None	None	NA	Not classified	NA
Benzene	0.055	0.029	Leukemia (human)	EPA Group A carcinogen	USEPA 2002a
Benzo(a)pyrene	7.3	3.1	Forestomach, larynx, and esophagus tumors (oral); Pharynx, larynx tumors (inhalation)	EPA Group B2 carcinogen	USEPA 2003a (oral) USEPA 1994 (inhalation)
Ethylbenzene	None	0.0039	Renal and testicular cancer (male rats)	EPA Group D carcinogen[b]	USEPA 2002a
Naphthalene	None	None	NA	EPA Group D carcinogen	USEPA 2002a
Toluene	None	None	NA	EPA Group D carcinogen	USEPA 2002a
Xylenes	None	None	NA	EPA Group D carcinogen	USEPA 2002a
DRO aliphatics	None	None	NA	Not classified	ADEC 2000b
DRO aromatics	None	None	NA	Not classified	ADEC 2000b
GRO aliphatic	None	None	NA	Not classified	ADEC 2000b
GRO aromatics	None	None	NA	Not classified	ADEC 2000b

Notes:
[a]EPA's Weight-of-Evidence Classification System:
Group A - human carcinogen (sufficient evidence in humans)
Group B1 - probable human carcinogen (limited human data available)
Group B2 - probable human carcinogen (sufficient evidence in animals, inadequate or no evidence in humans)
Group C - possible human carcinogen (limited evidence in animals)
Group D - not classifiable as to human carcinogenicity
[b]The IRIS file has not been updated yet to reflect the carcinogenicity of ethylbenzene. Therefore, the cancer classification will likely change.
ADEC - Alaska Department of Environmental Conservation
DRO - diesel-range organics
EPA - Environmental Protection Agency
GRO - gasoline-range organics
kg - kilogram
mg - milligram
NA - not applicable
SF - slope factor
USEPA - United States Environmental Protection Agency

Table 5-10
Noncarcinogenic Chronic and Subchronic Toxicity Criteria for the Chemicals of Potential Concern

Chemical	Chronic RfD (mg/kg-day)	Toxic Endpoint	Critical Study	Chronic RfD UF[a]	RfD Source	Adjustment from Chronic to Subchronic	Subchronic RfD (mg/kg-day)	EPA Subchronic Source[b]
Inhalation Exposures								
2-Methylnaphthalene	none[c]	--	--	--	NCEA-S-1400 (USEPA 2003d)	insufficient information	--	
Benzene	0.009	Decreased lymphocyte count	subchronic human occupational	300	IRIS	no adjustment for subchronic warranted, primary study is already occupational	0.009	
Benzo(a)pyrene	none[d]	--	--	--	--	--	--	
Ethylbenzene	0.29	Developmental toxicity	subchronic female rats	300	IRIS	Based on developmental effects during gestational exposures. No subchronic to chronic UF used; therefore, no subchronic value proposed.	0.29	
Naphthalene	0.00086	Nasal effects	chronic mouse	3,000	IRIS	remove adjustment from 5 to 7 days[e]	0.0043	
Toluene	0.11	Neurological effects	chronic human occupational	300	IRIS	no adjustment for subchronic warranted, primary study is already occupational	0.11	
Xylenes	0.029	Hyperactivity, decreased body weight, and increased mortality	subchronic male rats	300	IRIS	remove UF of 3 for subchronic to chronic	0.09	
DRO aliphatics	0.29	hepatic and hematological changes	NA	NA	ADEC 2000b	The petroleum fraction RfD values presented in ADEC guidance were not adjusted because of their status in State guidance and because of insufficient information on how those values were derived.	0.29	
DRO aromatics	0.06	Decreased body weight	NA	NA	ADEC 2000b		0.06	
GRO aliphatics	5.3	Neurotoxicity	NA	NA	ADEC 2000b		5.3	
GRO aromatics	0.11	Hepatotoxicity and nephrotoxicity	NA	NA	ADEC 2000b		0.11	
Oral Exposures								
2-Methylnaphthalene	0.009	pulmonary alveolar proteinosis	chronic male mice	1,000	NCEA-S-1400 (USEPA 2003d)	no adjustment for subchronic warranted because no UF applied for subchronic to chronic.	0.009	
Benzene	0.004	Decreased lymphocyte count	subchronic human occupational	300	IRIS	no adjustment for subchronic warranted, primary study is already occupational	0.004	
Benzo(a)pyrene	none[d]	--	--	--	--	--	--	
Ethylbenzene	0.10	Liver and kidney toxicity	subchronic mouse	1,000	IRIS	remove UF of 10 for subchronic to chronic	1	
Naphthalene	0.02	Decreased body weight	subchronic rat	3,000	IRIS	remove UF of 10 for subchronic to chronic	0.2	
Toluene	0.2	Changes in liver and kidney	subchronic rats	1,000	IRIS	remove UF of 10 for subchronic to chronic	2	*HEAST*
Xylenes	0.2	Hyperactivity, decreased body weight, and increased mortality	chronic rat	1,000	IRIS	remove adjustment from 5 to 7 days[e]	0.25	

Table 5-10 (Continued)
Noncarcinogenic Chronic and Subchronic Toxicity Criteria for the Chemicals of Potential Concern

Chemical	Chronic RfD (mg/kg-day)	Toxic Endpoint	Critical Study	Chronic RfD UF[a]	RfD Source	Adjustment from Chronic to Subchronic	Subchronic RfD (mg/kg-day)	EPA Subchronic Source[b]
Oral Exposures (Continued)								
DRO aliphatics	0.1	hepatic and hematological changes	NA	NA	ADEC 2000b	The petroleum fraction RfD values presented in ADEC guidance were not adjusted because of their status in State guidance and because of insufficient information on how those values were derived.	0.1	
DRO aromatics	0.04	Decreased body weight	NA	NA	ADEC 2000b		0.04	
GRO aliphatics	5.00	Neurotoxicity	NA	NA	ADEC 2000b		5.00	
GRO aromatics	0.2	Hepatotoxicity and nephrotoxicity	NA	NA	ADEC 2000b		0.2	

Notes

[a]EPA indicates that there are generally 5 areas of uncertainty where an application of a UF may be warranted

1 variation between species (applied when extrapolating from animal to human)
2 variation within species (applied to account for differences in human response and sensitive subpopulations)
3 use of a subchronic study to evaluate chronic exposure
4 use of a LOAEL, rather than a NOAEL
5 deficiencies in the data base

[b]If a subchronic value was obtained from a published source, rather than calculated, the source is listed in this column

[c]No inhalation criteria are available for this chemical and NCEA specifically states the route-to-route extrapolation from oral to inhalation is not recommended for this chemical (NCEA-S-1400, April 2003).

[e]This chemical is not a concern based on noncancer health effects. Therefore, there are no noncancer toxicity criteria for this chemical.

[e]EPA adjusted the 5-day per week exposure of the NOAEL to a 7-day NOAEL to account for continuous exposure (chronic), rather than subchronic, exposures

ADEC: Alaska Department of Environmental Conservation
DRO: diesel-range organics
EPA: Environmental Protection Agency
GRO: gasoline-range organics
IRIS: EPA's Integrated Risk Information System (on-line data base) (USEPA 2003a)
LOAEL: lowest-observed-adverse-effect-level
mg/kg-day: milligram per kilogram per day
NA: not applicable
NCEA: EPA's National Center for Environmental Assessment
NOAEL: no-observed-adverse-effect-level
RfD: Reference Dose
UF: Uncertainty factor

Table 5-11
Summary of Exposure Point Concentrations (EPCs)

Chemical of Potential Concern	Units	EPC [a]
Construction Worker Groundwater		
2-Methylnaphthalene	µg/L	11
Benzene	µg/L	15.4
Ethylbenzene	µg/L	91
Naphthalene	µg/L	22
Toluene	µg/L	133
Xylenes	µg/L	390
DRO (C_9-C_{24} aliphatics)	µg/L	32,302
DRO (C_9-C_{24} aromatics)	µg/L	16,151
GRO (C_6-C_8 aliphatics)	µg/L	1,145
GRO (C_6-C_8 aromatics)	µg/L	818
Construction Worker Soil		
DRO (C_9-C_{24} aliphatics)	mg/kg	1,600
DRO (C_9-C_{24} aromatics)	mg/kg	800
Residential Groundwater (Indoor Air)[b]		
2-Methylnaphthalene[c]	µg/L (µg/m^3)	0.18 (0.0004)
Benzene[c]	µg/L (µg/m^3)	3.56 (0.21)
Ethylbenzene[c]	µg/L (µg/m^3)	14.3 (0.84)
Naphthalene[c]	µg/L (µg/m^3)	11.8 J (0.0286)
Toluene[c]	µg/L (µg/m^3)	1.24 (0.077)
Xylenes[c]	µg/L (µg/m^3)	34.1 (1.74)
DRO (C_9-C_{24} aliphatics)	µg/L (µg/m^3)	[b]
DRO (C_9-C_{24} aromatics)	µg/L (µg/m^3)	[b]
GRO (C_6-C_8 aliphatics)[c]	µg/L (µg/m^3)	185 (2970)
GRO (C_6-C_8 aromatics)[c]	µg/L (µg/m^3)	132 (25.8)
Residential Surface Soil		
DRO (C_9-C_{24} aliphatics)	mg/kg	6,232
DRO (C_9-C_{24} aromatics)	mg/kg	3,116
On-site Worker Groundwater (Indoor Air)[b]		
2-Methylnaphthalene[c]	µg/L (µg/m^3)	32.5 (0.0027)
Benzene	µg/L (µg/m^3)	85 (0.168)
Ethylbenzene	µg/L (µg/m^3)	961 (2.07)
Naphthalene[c]	µg/L (µg/m^3)	66.6 (0.0063)

Table 5-11 (Continued)
Summary of Exposure Point Concentrations (EPCs)

Chemical of Potential Concern	Units	EPC [a]
Toluene	µg/L (µg/m^3)	1672 (3.52)
Xylenes	µg/L (µg/m^3)	4400 (8.54)
DRO (C_9-C_{24} aliphatics)	µg/L (µg/m^3)	[b]
DRO (C_9-C_{24} aromatics)	µg/L (µg/m^3)	[b]
GRO (C_6-C_8 aliphatics)	µg/L (µg/m^3)	11979 (514)
GRO (C_6-C_8 aromatics)	µg/L (µg/m^3)	8557 (53)
On-site Worker Surface Soil		
DRO (C_9-C_{24} aliphatics)[c]	mg/kg	13,600
DRO (C_9-C_{24} aromatics)[c]	mg/kg	6,800
Recreational/Trespasser Surface Water		
Benzene	µg/L	1.1
C9-C24 aliphatics	µg/L	1687
C9-C24 aromatics	µg/L	843
Recreational/Trespasser Sediment		
Benzo(a)pyrene	mg/kg	0.4
C9-C24 aliphatics	mg/kg	7,852
C9-C24 aromatics	mg/kg	3,926

[a] All EPCs are the 95 percent upper confidence limit of the mean, unless otherwise marked.
[b] The indoor air pathway is only complete for volatile chemicals. Indoor air EPCs were estimated using the Johnson-Ettinger Model for Vapor Intrusion from contaminated groundwater. Data from the wells in the closest proximity to the buildings were considered most representative of groundwater concentrations beneath the building. The model-predicted indoor air concentrations follow the groundwater concentrations in parentheses.
[c] This data set contains fewer than 10 samples; therefore the maximum detected concentration was used as the EPC. For groundwater, the maximum detected concentration from the most recent sampling investigation was used as the EPC.

DRO - diesel-range organics
EPC - exposure point concentration
GRO - gasoline-range organics
µg/L - micrograms of chemical per liter of water
µg/m^3 - micrograms of chemical per cubic meter of air
mg/kg - milligrams of chemicals per kilogram of soil

Table 5-12
Summary of Risks and Hazards for the Construction Worker

Chemicals of Potential Concern	Combined Groundwater and Soil		Groundwater						Surface Soil							
	Total		Inhalation		Dermal Contact		Total		Ingestion		Dermal Contact		Inhalation		Total	
	HI	CR	HI	CR	HI	CR	HI	CR	HI	CR	HI	CR	HI	CR	HI	CR
2-Methylnaphthalene	na	na	b	b	b	b	na	na	a	a	a	a	a	a	na	na
Benzene	0.01	5E-08	0.003	9E-09	0.01	4E-08	0.01	5E-08	a	a	a	a	a	a	na	na
Ethylbenzene	0.001	7E-09	0.0005	7E-09	0.0009	--	0.001	7E-09	a	a	a	a	a	a	na	na
Naphthalene	0.009	na	0.008	--	0.001	--	0.009	na	a	a	a	a	a	a	na	na
Toluene	0.002	na	0.002	--	0.0004	--	0.002	na	a	a	a	a	a	a	na	na
Xylenes	0.03	na	0.006	--	0.02	--	0.03	na	a	a	a	a	a	a	na	na
Non-TPH Total Hazard/Risk[1]	0.06	5E-08	0.02	2E-08	0.03	4E-08	0.05	5E-08	na	na	na	na	na	na	na	na
C9-C24 aliphatics	0.05	na	c	c	b	b	na	na	0.04	--	0.01	--	0.000002	--	0.05	na
C9-C24 aromatics	0.06	na	c	c	b	b	na	na	0.05	--	0.01	--	0.000004	--	0.06	na
C6-C8 aliphatics	0.0003	na	0.0003	--	b	b	0.0003	na	a	a	a	a	a	a	na	na
C6-C8 aromatics	0.01	na	0.01	--	b	b	0.01	na	a	a	a	a	a	a	na	na
TPH Total Hazard/Risk[1]	0.1	na	0.01	na	na	na	0.01	na	0.09	na	0.03	na	0.000006	na	0.1	na

[1]Risk and hazard estimates are presented to one significant figure. Total risk and hazard values were calculated by summing unrounded values. Therefore, the total values may not equal the sum of the rounded values.

a - Chemical not selected as a COPC in this media

b - Toxicity criteria are not available to quantify exposures to the chemical by this pathway.

c - This chemical is not considered volatile. The inhalation pathway is only complete for volatile chemicals.

-- - Chemical not associated with carcinogenic/non-carcinogenic effects by this pathway.

na - not applicable, no values to total

HI - hazard index

COPC - chemical of potential concern

CR - cancer risk

TPH - total petroleum hydrocarbon

Table 5-13
Summary of Risks and Hazards for the On-Site Worker Exposures

Chemicals of Potential Concern	Combined Groundwater and Soil		Groundwater		Surface Soil					
	Total		Inhalation of Indoor Air		Incidental Ingestion		Dermal Contact		Total	
	HI	CR	HI	CR	HI	CR	HI	CR	HI	CR
2-Methylnaphthalene	na	na	b	b	a	a	a	a	a	a
Benzene	0.002	2E-07	0.002	2E-07	a	a	a	a	a	a
Ethylbenzene	0.0007	3E-07	0.0007	3E-07	a	a	a	a	a	a
Naphthalene	0.0008	na	0.0008	--	a	a	a	a	a	a
Toluene	0.003	na	0.003	--	a	a	a	a	a	a
Xylenes	0.03	na	0.03	--	a	a	a	a	a	a
Non-TPH Total Hazard/Risk[1]	0.04	5E-07	0.04	5E-07	na	na	na	na	na	na
C9-C24 aliphatics	0.2	na	c	c	0.1	--	0.09	--	0.2	--
C9-C24 aromatics	0.3	na	c	c	0.2	--	0.1	--	0.3	--
C6-C8 aliphatics	0.01	na	0.01	--	a	a	a	a	a	a
C6-C8 aromatics	0.05	na	0.05	--	a	a	a	a	a	a
TPH Total Hazard/Risk[1]	0.6	na	0.06	na	0.3	na	0.2	na	0.5	na

[1]Risk and hazard estimates are presented to one significant figure. Total risk and hazard values were calculated by summing unrounded values. Therefore, the total values may not equal the sum of the rounded values.

a - Chemical not selected as a COPC in this media
b - Toxicity criteria are not available to quantify exposures to the chemical by this pathway.
c - This chemical is not considered volatile. The inhalation pathway is only complete for volatile chemicals.
-- - Chemical not associated with carcinogenic/non-carcinogenic effects by this pathway.
na - not applicable, no values to total
HI - hazard index
COPC - chemical of potential concern
CR - cancer risk
TPH - total petroleum hydrocarbon

Table 5-14
Summary of Risks and Hazards for the Child and Adult Residents

Chemicals of Potential Concern	Combined Groundwater and Soil			Groundwater			Surface Soil								
	Total			Inhalation of Indoor Air			Incidental Ingestion			Dermal Contact			Total		
	HI (child)	HI (child/adult)	CR (child/adult)	HI (child)	HI (child/adult)	CR (child/adult)	HI (child)	HI (child/adult)	CR (child/adult)	HI (child)	HI (child/adult)	CR (child/adult)	HI (child)	HI (child/adult)	CR (child/adult)
2-Methylnaphthalene	na	na	na	b	b	--	a	a	a	a	a	a	na	na	na
Benzene	0.01	0.008	9E-07	0.01	0.008	9E-07	a	a	a	a	a	a	na	na	na
Ethylbenzene	0.002	0.001	5E-07	0.002	0.001	5E-07	a	a	a	a	a	a	na	na	na
Naphthalene	0.02	0.01	na	0.02	0.01	--	a	a	a	a	a	a	na	na	na
Toluene	0.0004	0.0002	na	0.0004	0.0002	--	a	a	a	a	a	a	na	na	na
Xylenes	0.04	0.02	na	0.04	0.02	--	a	a	a	a	a	a	na	na	na
Non-TPH Total Hazard/Risk[1]	0.08	0.04	1E-06	0.08	0.04	1E-06	na	na	na	na	na	na	na	na	na
C9-C24 aliphatics	1	0.3	na	c	c	c	0.8	0.2	--	0.2	0.07	--	1	0.3	na
C9-C24 aromatics	1	0.4	na	c	c	c	1	0.3	--	0.3	0.09	--	1	0.4	na
C6-C8 aliphatics	0.4	0.2	na	0.4	0.2	--	a	a	a	a	a	a	na	na	na
C6-C8 aromatics	0.2	0.08	na	0.2	0.08	--	a	a	a	a	a	a	na	na	na
Hazard/Risk[1]	3	1	na	0.5	0.3	na	2	0.5	na	0.5	0.2	na	2	0.7	na

[1]Risk and hazard estimates are presented to one significant figure. Total risk and hazard values were calculated by summing unrounded values. Therefore, the total values may not equal the sum of the rounded values.

a - Chemical not selected as a COPC in this media

b - Toxicity criteria are not available to quantify exposures to the chemical by this pathway.

c - This chemical is not considered volatile. The inhalation pathway is only complete for volatile chemicals.

-- - Chemical not associated with carcinogenic/non-carcinogenic effects by this pathway.

na - not applicable, no values to total

HI - hazard index

COPC - chemical of potential concern

CR - cancer risk

TPH - total petroleum hydrocarbon

Table 5-15
Summary of Risks and Hazards for the Child Trespasser

Chemicals of Potential Concern	Combined Surface Water and Sediment		Surface Water						Sediment					
	Total		Ingestion		Dermal Contact		Total		Ingestion		Dermal Contact		Total	
	HI	CR	HI	CR	HI	CR	HI	CR	HI	CR	HI	CR	HI	CR
Benzene	0.0002	3E-09	0.00007	1E-09	0.00008	2E-09	0.0002	3E-09	b	b	b	b	na	na
Benzo(a)pyrene	na	7E-08	b	b	b	b	na	na	--	5E-08	--	3E-08	na	7E-08
Hazard/Risk[1]	0.0002	8E-08	0.00007	1E-09	0.00008	2E-09	0.0002	3E-09	na	5E-08	na	3E-08	na	7E-08
C9-C24 aliphatics	0.03	na	0.004	--	b	b	0.004	na	0.01	--	0.006	--	0.02	na
C9-C24 aromatics	0.03	na	0.006	--	b	b	0.006	na	0.02	--	0.008	--	0.03	na
TPH Total Hazard/Risk[1]	0.06	na	0.01	na	na	na	0.01	na	0.03	na	0.01	na	0.05	na

[1]Risk and hazard estimates are presented to one significant figure. Total risk and hazard values were calculated by summing unrounded values. Therefore, the total values may not equal the sum of the rounded values.

a - Chemical not selected as a COPC in this media

b - Toxicity criteria are not available to quantify exposures to the chemical by this pathway.

c - This chemical is not considered volatile. The inhalation pathway is only complete for volatile chemicals.

-- - Chemical not associated with carcinogenic/non-carcinogenic effects by this pathway.

na - not applicable, no values to total

HI - hazard index

COPC - chemical of potential concern

CR - cancer risk

TPH - total petroleum hydrocarbon

6.0 REMEDIAL ACTION OBJECTIVES AND CLEANUP LEVELS

This section describes the remedial action objectives (RAOs) and the cleanup levels established for the SWMU 62, New Housing Fuel Leak site.

6.1 REMEDIAL ACTION OBJECTIVES

Based on the human health risk assessment conducted for this site and the regulatory requirements, the following RAOs were developed for the protection of human health at the SWMU 62, New Housing Fuel Leak site:

- Prevent human exposure to petroleum hydrocarbons in surface soil that would result in adverse health effects.
- Reduce petroleum hydrocarbons in groundwater to concentrations less than or equal to the Alaska DEC groundwater cleanup levels established for groundwater used as a drinking water source
- Minimize exposure to free-phase product in soil, groundwater, and surface water
- Prevent migration of free product to surface water that would result in an exceedance of the Alaska DEC surface water quality standard (sheen only)

Based on the results of the ecological risk assessment discussed in Section 5, no ecological threat exists for any ecological receptor from petroleum products released at the SWMU 62, New Housing Fuel Leak site. Therefore, no RAOs were developed for ecological receptors at the site.

6.2 CLEANUP LEVELS

Chemical-specific screening criteria and cleanup levels for soil and groundwater have been established for petroleum-contaminated sites at the former Adak Naval Complex in accordance with Alaska DEC regulation 18 AAC Chapter 75. Screening criteria were used to estimate the potential extent of contamination. Cleanup levels are the specified concentrations for remediation. The soil and groundwater screening criteria and cleanup levels proposed for the SWMU 62, New Housing Fuel Leak site are provided in Table 6-1.

The Alaska regulations establish four methods for determining cleanup levels for soil [18 AAC 75.340]. The Alaska DEC Method Two cleanup levels, the most stringent cleanup levels for soil, were established to prevent migration of contaminants from soil to groundwater in the over

40 inches of rainfall zone (18 AAC 75.341, Tables B1 and B2). The Alaska DEC Method Two cleanup levels were used as screening criteria for SWMU 62, New Housing Fuel Leak site to estimate the potential extent of soil impacted by petroleum contamination at the site (see Section 4). (ACLs) are specified for remediation of soil and are based on Alaska DEC Method Four [18 AAC 75.340(a)(4)], which uses site-specific risk assessments to establish cleanup levels. Site-specific ACLs were calculated as discussed in the Section 5. The ACLs are established at concentrations such that risks from hazardous substances do not exceed the following target health goals:

- Cumulative carcinogenic risk of 1 in 100,000
- Cumulative noncarcinogenic HI of 1.0 (18 AAC 75.325(h)).

The Alaska regulations establish three methods for determining cleanup levels for groundwater [18 AAC 75.345]. The tabulated groundwater cleanup levels [18 AAC 75.345(b)(1), Table C] were used as screening criteria to estimate the potential extent of groundwater impacted by petroleum contamination at the site (see Section 4). Cleanup levels specified for remediation of groundwater at the SWMU 62, New Housing Fuel Leak site are also based on the tabulated groundwater cleanup levels because groundwater is considered to be a reasonably expected potential future source of drinking water.

The East Canal of the airport ditch system is the only surface water body impacted by releases from the SWMU 62, New Housing Fuel Leak site. For surface water bodies of the state, Alaska regulation 18 AAC Chapter 70 establishes water quality standards based on water use classes and subclasses. The canals of the airport ditch system, including the East Canal, fall within the fresh water class, and the secondary recreation subclass. The water quality standards established for this use class and subclass specify that petroleum hydrocarbons, oils and grease may not cause a film, sheen, or discoloration on the surface or floor of the water body or adjoining shorelines, and surface waters must be virtually free from floating oils [18 AAC 70.020(b)(5)(B)(ii)]. Based on the results of the risk assessment (see Section 5), no ecological threat exists for any ecological receptor from petroleum hydrocarbons released at the SWMU 62, New Housing Fuel Leak site. Therefore, no risk-based cleanup levels were calculated for surface water or sediment at the site.

6.3 EXTENT OF CONTAMINATION

The media of concern for which RAOs were established in Section 6.1 include soil, groundwater, and free-phase product. The extent of contamination for these media is summarized below.

The ACL discussed in Section 4 was used to delimit the area that exceeds acceptable risk for human exposure to petroleum hydrocarbons in surface soil. An ACL has been defined for DRO at a concentration of 6,111 mg/kg. One small area shown on Figure 6-1 was identified as

containing surface soil with DRO concentrations exceeding the ACL. The area exceeding the ACL is approximately 6,100 ft^2. Surface soil exceeding the ACL was found between 0 and 2 feet bgs. Based on the area and depths of the surface soil exceedances, the volume of soil exceeding the ACL was estimated to be 450 cy.

The extent of groundwater that exceeds Alaska DEC criteria established for groundwater used as drinking water source is delimited in Section 4 and shown on Figure 6-1. The Alaska DEC criteria established for groundwater not currently used for, or not reasonably expected to be used for drinking water at this site are:

- Benzene 5 µg/L (0.005 milligrams per liter [mg/L])
- Ethylbenzene 700 µg/L (0.7 mg/L)
- Toluene 1,000 µg/L (1 mg/L)
- DRO 1,500 µg/L (1.5 mg/L)
- GRO 1,300 µg/L (1.3 mg/L)

The areas that potentially exceed the Alaska DEC criteria for groundwater not used for drinking water total approximately 20 acres.

The approximate extent of free-product remaining on the site is also presented in Section 4. The estimated extent of residual free product for 2000 through 2003 is shown on Figure 4-1. During this time period, measurable thicknesses of free product were detected in three areas in the Eagle Bay Housing area and seven areas in the Sandy Cove Housing area as presented on Figure 4-1. These areas total approximately 5.7 acres. An estimated 1,400 to 6,900 gallons of recoverable free product may remain in the subsurface at the site.

LEGEND

- Fence
- Monitoring Well
- Abandoned Well
- Recovery Well
- Geoprobe Well
- Lost Well

- Extent of Groundwater Where Petroleum-Related Chemicals Exceed the Groundwater Cleanup Levels
- Extent of Surface Soil Where Petroleum-Related Chemicals Exceed the ACL for DRO
- Housing Unit Where Pipeline Leak Was Repaired

Perched

Perched

Perched

Observed Petroleum Seeps

Sandy Cove Housing

Eagle Bay Housing

Bayshore Highway

Main Road

Mechanic Road

East Canal

Sweeper Cove

Kuluk Bay

Raven Street

PAVED AREA

AIR TERMINAL BLDG

HIGH SCHOOL

ELEM. SCHOOL

FISH AND WILDLIFE HOUSING

U.S. NAVY	Adak Island, AK DECISION DOCUMENT	N 0 60 120 240 SCALE IN FEET	**Figure 6-1** **Extent of Surface Soil and Groundwater Contamination** **SWMU 62, New Housing Fuel Leak Site**

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Table 6-1
Soil and Groundwater Cleanup Levels, SWMU 62, New Housing Fuel Leak Site

Chemical	Soil		Groundwater
	Screening Criteria (Method Two)[a] (mg/kg)	Surface Soil ACL (Method Four)[b, c] (mg/kg)	Screening Criteria and Cleanup Levels (Table C)[a, b] (mg/L)
Total Petroleum Hydrocarbons			
DRO	230	6,111	1.5
GRO	260	NC	1.3
Volatile Organic Compounds			
Benzene	0.02	NC	0.005
Ethylbenzene	5	NC	0.7
Toluene	4.8	NC	1
Trichloroethene	0.02	NC	0.005

[a]Used as screening criteria to determine potential extent of contamination
[b]Used as cleanup levels for remediation
[c]Surface soil is soil less than two feet deep

Notes:
ACL - alternative cleanup level
DRO - diesel-range organics
GRO - gasoline-range organics
mg/kg - milligrams per kilogram
mg/L - milligram per liter
NC - not calculated, risk less than target health goal