APPENDIX D

GUIDELINES FOR ASSESSING CONSTITUENTS WITH SPECIAL CONSIDERATIONS

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D1.0 PETROLEUM HYDROCARBONS

Petroleum-impacted soil and groundwater shall be assessed for: (1) individual petroleum-related constituents using constituent-specific toxicity values and physical/chemical properties, **and** (2) petroleum hydrocarbon aliphatic and aromatic fractions using fraction-specific toxicity values and physical/chemical properties (EPA 2009; TPHCWG 1997). An overview of the components to be addressed for low, medium and high carbon range petroleum mixtures are listed in Table D-1. The components requiring evaluation for different types of petroleum releases are identified in Table D-2. These components are subject to modification based on the nature of the petroleum mixture released and other relevant site-specific considerations. The aliphatic and aromatic fraction carbon ranges are consistent with the equivalent carbon (EC) ranges defined by *Total Petroleum Hydrocarbon Working Group Series Volume 3, Selection of Representative TPH Fractions Based on Fate and Transport Considerations* (TPHCWG, 1997) and *Provisional Peer-Reviewed Toxicity Values for Complex Mixtures of Aliphatic and Aromatic Hydrocarbons Final* (EPA 2009). The physical/chemical properties for the fractions are given in Table D-3 (TPHCWG 1997). The toxicity values for the aliphatic and aromatic hydrocarbon fractions were obtained from *Provisional Peer-Reviewed Toxicity Values for Complex Mixtures of Aliphatic and Aromatic Hydrocarbons Final* (EPA 2009) and *Development of Fraction Specific Reference Doses (RfD) and Reference Concentrations (RfC) for Total Petroleum Hydrocarbons (TPH)* (TPHCWG 1997b) in accordance with Memorandum *Human Health Toxicity Values in Superfund Risk Assessment* (EPA 2003). The toxicity values are summarized in Table D-4 and the associated noncarcinogenic critical effects/targets are provided in Table D-5. Additional guidance on the evaluation of the carcinogenic polycyclic aromatic hydrocarbons is provided later in this appendix.

Ethanol

When a fuel containing ethanol (E10) is released to the environment, the Department may require that ethanol be included as a COC for the site investigation/RECAP assessment. In general, the assessment of ethanol shall include the collection of a groundwater sample from the most heavily impacted area. If warranted by site conditions, the department may require additional sampling to characterize the distribution of ethanol with in the AOI. When a fuel containing greater than 10% ethanol (e.g., E15, E20, E85, E95) is released to the environment, the Department may require that additional COC (e.g. methane) be addressed during site investigation/evaluation.

Analytical Methods

The analytical methods suggested for the identification and quantitation of the designated hydrocarbon fractions include the Massachusetts Department of Environmental Protection's VPH/EPH (volatile petroleum hydrocarbons/extractable petroleum hydrocarbon) Method and the Texas Commission on Environmental Quality Method 1006. When requesting these analyses, the data user must specify that the carbon ranges to be reported match those defined in this appendix. Alternate analytical methods such as EPA Method 1664 and 9071 (or equivalent method) are required for the characterization

of heavier petroleum hydrocarbon release ($C_{>35}$). For the analysis of PAH constituents, EPA SW846 Method 8310 or EPA SW846 Method 8270 may be used. The most recent version of these analytical methods, in accordance with the most recent revision of SW-846, shall be used. An EPA Method shall be used for the identification and quantitation of ethanol. It is the Submitter's responsibility that the method chosen will achieve SQL that are acceptable under the RECAP based on site-specific conditions, the COC present, and method-specific limitations. Data shall be obtained from a laboratory accredited by the State of Louisiana (or a laboratory exempt from accreditation) and shall meet the requirements presented in Section 2.2.

It will be necessary for releases currently being regulated under prior promulgated versions of RECAP to transition to compliance with the 2014 version of RECAP. Unless otherwise approved by the Department, an Area of Concern (AOC) currently being regulated under prior promulgated versions of RECAP may continue to comply with that specific version of RECAP until the current task/phase of the evaluation has been completed and approved by the Department. However, any further evaluation of the AOC shall be conducted in accordance with the requirements set forth in the 2014 version of RECAP unless otherwise approved by the Department.

Additive Health Effects

In accordance with EPA risk assessment guidance, each component shall be addressed as an individual COC of the mixture and the noncarcinogenic risk-based RS shall be adjusted to account for additive health effects based on: 1) health target/critical effect (i.e., mode of action) that serves as the basis for the RfD and/or RfC for each petroleum component; and 2) the site-specific combination of petroleum components under evaluation at the release site (EPA 1986; EPA 1989; EPA 2000). Refer to Table D-5 for the health targets/critical effects for the noncarcinogenic components. Refer to Section 2.5.2 for additional guidance on additivity.

Soil Saturation

The petroleum hydrocarbon concentration in soil shall not exceed: 1) a total sum of 5,800 mg/kg for aliphatics C_5-C_{10} and aromatics $C_{>8}$-C_{10}; 2) a total sum of 13,000 mg/kg for aliphatics $C_{>10}$-C_{16} and aromatics $C_{>10}$-C_{21}; and 3) a total sum of 30,000 mg/kg for aliphatics $C_{>16}$-C_{35} (and higher) and aromatics $C_{>21}$-C_{35} without Department approval (Fussel, et. al. 1981). Residual soil saturation points are known to vary depending on site-specific conditions (e.g., soil type, composition of the petroleum mixture, etc.) (Alaska, 2006; Brost and Devaull 2000; Fussel, et. al. 1981; Ohio EPA, 2010; Sanders 2009). Therefore, a concentration of petroleum hydrocarbons in soil greater than the $Soil_{sat}$ RECAP standards presented above may be considered acceptable if the following conditions are met: 1) the submitter demonstrates that NAPL is not present in the most heavily impacted soils within the AOI; 2) no other aesthetic or environmental concerns are identified based on site-specific conditions; <u>and</u> 3) the Department concurs with the findings and recommendations. Any variance in the applicability of the $Soil_{sat}$ is subject to Department approval and is contingent upon land use, the pathways of concern, characteristics of the soil and groundwater under evaluation, resource aesthetics, and other site-specific conditions.

Note: Corrective action for aesthetic considerations is not reimbursable by the Motor Fuels Trust Fund.

Table D-1 Petroleum Components/Constituents of Concern

ALIPHATIC HYDROCARBONS	AROMATIC HYDROCARBONS
Low Carbon Range Petroleum Hydrocarbons [1]	
Aliphatic Fraction C_5-C_8 [2]	Benzene
	Toluene
	Ethylbenzene
	Xylene
Medium Carbon Range Petroleum Hydrocarbons [1]	
Aliphatic Fraction $C_{>8}$-C_{10} [2]	Aromatic Fraction $C_{>8}$-C_{10} [2]
Aliphatic Fraction $C_{>10}$-C_{12} [2]	Aromatic Fraction $C_{>10}$-C_{12} [2]
Aliphatic Fraction $C_{>12}$-C_{16} [2]	Aromatic Fraction $C_{>12}$-C_{16} [2]
	Aromatic Fraction $C_{>16}$-C_{21} [2]
	Naphthalene
	2-Methylnaphthalene
High Carbon Range Petroleum Hydrocarbons [1,3]	
Aliphatic Fraction $C_{>16}$-C_{35} [2]	Aromatic Fraction $C_{>21}$-C_{35} [2]
	Benzo[a]anthracene
	Benzo[a]pyrene
	Benzo[b]fluoranthene
	Benzo[k]fluoranthene
	Chrysene
	Dibenzo[a,h]anthrancene
	Indeno[1,2,3-cd]pyrene

[1] *Provisional Peer-Reviewed Toxicity Values for Complex Mixtures of Aliphatic and Aromatic Hydrocarbons Final* (EPA 2009).
[2] Equivalent carbon number range as defined in TPHCWG, 1997a.
[3] Hydrocarbons $C_{>35}$ shall be addressed on a site-specific basis.

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Table D-2 Petroleum Components of Various Petroleum Mixtures

Component [1]	Gasoline	JP-4	JP-5	JP-7	JP-8	Kerosene	Diesel Light fuel oil	Heavy fuel oil	Crude oil	Highly refined base oils	Motor oil Lubricating oil	Unknown
Benzene	X	X							X [2]			X
Toluene	X	X							X [2]			X
Ethylbenzene	X	X							X [2]			X
Xylene	X	X							X [2]			X
cPAH[3]							X	X	X		X	X
Naphthalene [4]							X	X	X		X	X
2-Methylnaphthalene [4]							X	X	X		X	X
Lead (inorganic)	X[5]											X[5]
Metals											X[6]	X[5]
Ethanol [7]												
Methyl tertbutyl ether	X[5]											X[5]
1,2-Dibromoethane	X[5]											
1,2-Dichloroethane	X[5]											
Methyl ethyl ketone	X[5]											X[5]
Methyl isobutyl ketone	X[5]											X[5]
Aliphatic Fraction C_5 - C_8	X	X	X		X	X			X			X
Aliphatic Fraction $C_{>8}$ - C_{10}	X	X	X	X	X	X			X			X
Aliphatic Fraction $C_{>10}$ - C_{12}	X	X	X	X	X	X	X		X			X
Aliphatic Fraction $C_{>12}$ - C_{16}		X	X	X	X	X	X		X	X	X	X
Aliphatic Fraction $C_{>16}$ - C_{35}			X	X	X		X	X	X	X	X	X
Aromatic Fraction $C_{>8}$ - C_{10}	X	X	X	X	X	X			X			X
Aromatic Fraction $C_{>10}$ - C_{12} [4]		X	X	X	X	X	X		X			X
Aromatic Fraction $C_{>12}$ - C_{16} [4]		X	X	X	X	X	X		X	X	X	X
Aromatic Fraction $C_{>16}$ - C_{21}			X	X	X		X	X	X	X	X	X
Aromatic Fraction $C_{>21}$ - C_{35}								X	X	X	X	X
Petroleum Hydrocarbons $C_{>35}$								X	X	X	X	X

[1] *TPH Criteria Working Group Series Volume 2* (1998); *Toxicological Profile for Total Petroleum Hydrocarbons* (ATSDR 1999); *Provisional Peer-Reviewed Toxicity Values for Complex Mixtures of Aliphatic and Aromatic Hydrocarbons Final* (EPA 2009); under certain site-specific conditions, the Department may require that additional components be identified for evaluation; for petroleum mixtures not identified in Table D-2, hydrocarbon ranges and individual constituents shall be identified by the Submitter and approved by the Department.

[2]The inclusion of BTEX as COC for crude oil releases shall be determined by the Department based on the age of the release and the degree of weathering at the time of investigation/remediation activities; BTEX generally are not COC for older, weathered crude oil releases.

[3]Carcinogenic PAHs are benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, dibenzo[ah]anthracene, and indeno[1,2,3-cd]pyrene.

[4]In the determination of the AOIC and/or the CC, the concentration of naphthalene (EC = 11.69) shall be subtracted from the concentration of the aromatic $C_{>10}$ - C_{12} fraction and the concentration of 2-methylnaphthalene (EC=12.84) shall be subtracted from the concentration of the aromatic $C_{>12}$ - C_{16} fraction.

[5]When known or suspected to be present.

[6]Metals shall be identified as COC for releases of used motor oil.

[7] When a fuel containing ethanol (E10 or a greater percentage of ethanol) is released to the environment, the Department may require that ethanol be included as a COC.

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Table D-3 Chemical-Specific Parameters for Hydrocarbon Fractions

Fraction	Boiling Point (°C)	Molecular Weight (g/mole)	Solubility (mg/l)	Vapor Pressure (mm Hg)	Henry's Law Constant (unitless)	Koc (ml/g)
C_5-C_6 Aliphatics	5.1E+01	8.1E+01	3.6E+01	2.7E+02	3.3E+01	7.94E+02
$C_{>6}$-C_8 Aliphatics	9.6E+01	1.0E+02	5.4E+00	4.8E+01	5.0E+01	3.98E+03
$C_{>8}$-C_{10} Aliphatics	1.5E+02	1.3E+02	4.3E-01	4.8E+00	8.0E+01	3.16E+04
$C_{>10}$-C_{12} Aliphatics	2.0E+02	1.6E+02	3.4E-02	4.8E-01	1.2E+02	2.51E+05
$C_{>12}$-C_{16} Aliphatics	2.6E+02	2.0E+02	7.6E-04	3.7E-02	5.2E+02	5.01E+06
$C_{>16}$-C_{21} Aliphatics	3.2E+02	2.7E+02	1.3E-06	8.4E-04	4.9E+03	6.31E+08
$C_{>8}$-C_{10} Aromatics	1.5E+02	1.2E+02	6.5E+01	4.8E+01	4.8E-01	1.58E+03
$C_{>10}$-C_{12} Aromatics	2.0E+02	1.3E+02	2.5E+01	4.8E-01	1.4E-01	2.51E+03
$C_{>12}$-C_{16} Aromatics	2.6E+02	1.5E+02	5.8E+00	3.7E-02	5.3E-02	5.01E+03
$C_{>16}$-C_{21} Aromatics	3.2E+02	1.9E+02	6.5E-01	8.4E-04	1.3E-02	1.58E+04
$C_{>21}$-C_{35} Aromatics	3.4E+02	2.4E+02	6.6E-03	3.3E-07	6.7E-04	1.26E+05

TPH Criteria Working Group, 1997.

Fraction	Diffusivity in Air (DI_a) (cm^2/s)	Diffusivity in Water (DI_w) (cm^2/s)	Dermal Permeability Coefficient – Water (K_p) (cm/hr)	Dermal Absorption Factor – Soil (ABS) (unitless)
C_5-C_6 Aliphatics	7.3E-02	8.2E-06	2.0E-01	0
$C_{>6}$-C_8 Aliphatics	7.3E-02	8.2E-06	2.0E-01	0
$C_{>8}$-C_{10} Aliphatics	5.1E-02	6.8E-06	1.7E+00	0
$C_{>10}$-C_{12} Aliphatics	5.1E-02	6.8E-06	1.7E+00	0.1
$C_{>12}$-C_{16} Aliphatics	5.1E-02	6.8E-06	1.7E+00	0.1
$C_{>16}$-C_{21} Aliphatics	6.2E-02	7.2E-06	2.0E+00	0.1
$C_{>8}$-C_{10} Aromatics	5.6E-02	8.1E-06	6.9E-02	0
$C_{>10}$-C_{12} Aromatics	5.6E-02	8.1E-06	6.9E-02	0.1
$C_{>12}$-C_{16} Aromatics	5.6E-02	8.1E-06	6.9E-02	0.1
$C_{>16}$-C_{21} Aromatics	5.6E-02	8.1E-06	6.9E-02	0.1
$C_{>21}$-C_{35} Aromatics	2.8E-02	7.2E-06	3.1E-01	0.1

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Table D-4 Toxicity Values

ALIPHATIC HYDROCARBONS			AROMATIC HYDROCARBONS				
Low Carbon Range Petroleum Hydrocarbons [1]							
Component	Oral RfD (mg/kg-day)	Inhalation RfC (mg/m^3)	Component	Oral RfD (mg/kg-day)	Inhalation RfC (mg/m^3)	Oral CSF $((mg/kg\text{-}day)^{-1})$	IUR $((ug/m^3)^{-1})$
Aliphatic Fraction C_5-C_8 [2,3]	5.0E+00 [4]	6.0E-01[1]	Benzene [5]	4.0E-03	3.0E-02	5.5E-02	7.8E-06
			Toluene [5]	8.0E-02	5.0E+00	NA	NA
			Ethylbenzene [5]	1.0E-01	1.0E+00	NA	NA
			Xylene [5]	2.0E-01	1.0E-01	NA	NA
Medium Carbon Range Petroleum Hydrocarbons [1]							
Aliphatic Fraction $C_{>8}$-C_{10} [2]	1.0E-01[4]	1.0E-01[1]	Aromatic Fraction $C_{>8}$-C_{10} [2]	4.0E-02 [4]	1.0E-01[1]	NA	NA
Aliphatic Fraction $C_{>10}$-C_{12} [2]	1.0E-01 [4]	1.0E-01[1]	Aromatic Fraction $C_{>10}$-C_{12} [2]	4.0E-02 [4]	1.0E-01[1]	NA	NA
Aliphatic Fraction $C_{>12}$-C_{16} [2]	1.0E-01 [4]	1.0E-01[1]	Aromatic Fraction $C_{>12}$-C_{16} [2]	4.0E-02 [4]	1.0E-01[1]	NA	NA
			Aromatic Fraction $C_{>16}$-C_{21} [2]	3.0E-02 [4]	1.0E-01[1]	NA	NA
			Naphthalene [5]	2.0E-02	3.0E-03	NA	NA
			2-Methylnaphthalene[5]	4.0E-03	NA	NA	NA
High Carbon Range Petroleum Hydrocarbons [1]							
Aliphatic Fraction $C_{>16}$-C_{35} [2]	3.0E+00	NA	Aromatic Fraction [2] $C_{>21}$-C_{35}	4E-02 [1]	NA	NA	NA
			Benz[a]anthracene [6]	NA	NA	7.3E-01	NA
			Benzo[a]pyrene [5]	NA	NA	7.3E+00	NA
			Benzo[b]fluoranthene[6]	NA	NA	7.3E-01	NA
			Benzo[k]fluoranthene[6]	NA	NA	7.3E-02	NA
			Chrysene [6]	NA	NA	7.3E-03	NA
			Dibenzo[a,h]anthra-cene[6]	NA	NA	7.3E+00	NA
			Indeno[1,2,3-cd] pyrene[6]	NA	NA	7.3E-01	NA

Miscellaneous Components				
Component	Oral RfD (mg/kg-day)	Inhalation RfC (mg/m^3)	Oral CSF $((mg/kg\text{-}day)^{-1})$	IUR $((ug/m3)^{-1})$
Methyl tert-butyl ether	NA	3.0E+00 [5]	1.8E-03 [7]	NA
Methyl ethyl ketone [5]	6.0E-01	5.0E+00	NA	NA
Methyl isobutyl ketone	8.0E-02 [8]	3.0E+00 [5]	NA	NA
1,2-Dibromoethane [5]	9.0E-03	9.0E-03	2.0E+00	6.0E-04
1,2-Dichloroethane	NA	7.0E-03 [9]	9.1E-02 [5]	2.6E-05 [5]
Ethanol	5.7E+01 [10]	NA	NA	NA

NA = Toxicity Values are not available; refer to Section 2.4.1.

[1]*Provisional Peer-Reviewed Toxicity Values for Complex Mixtures of Aliphatic and Aromatic Hydrocarbons Final* (EPA 2009).

[2]Equivalent carbon number range as defined in TPHCWG, 1997a.

[3]If the n-hexane concentration is < 53% (as in commercial hexane) a RfC of 6.0 E-01 mg/m^3 shall be used. If the n-hexane concentration is > 53%, a RfC of 7.0E-01mg/m^3(critical effect peripheral neuropathy) shall be used (EPA 2009).

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[4]TPHCWG 1997b.
[5]Integrated Risk Information System , EPA 2015.
[6]EPA. 1993. *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons* (EPA/600/R-93/089).
[7]This toxicity value does not comply with Section 2.4.1; therefore it shall not be used for risk-based standards. This toxicity value shall only be used for GW_{3DW}, GW_{3NDW}, $Soil_{GW3DW}$ and $Soil_{GW3NDW}$.
[8]Health Effects Assessment Summary Tables, EPA 2015.
[9]Provisional Peer-Reviewed Toxicity Value, EPA 2015.
[10]Florida Department of Environmental Protection, Division of Waste Management. 2005.

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Table D-5 Petroleum Components Noncarcinogenic Critical Effects/Targets

Component	Noncarcinogenic Critical Effect/Target
Low Carbon Range Petroleum Mixtures	
Aliphatics C_5-C_8	Nasal effects [1]; kidney [2]
Toluene	Neurological system, kidney [3]
Ethylbenzene	Liver, kidney, fetus [3]
Xylene	Neurological system, decreased body weight, increased mortality [3]
Medium Carbon Range Petroleum Mixtures	
Aliphatic $C_{>8}$-C_{16}	Nasal effects; adrenal gland [1]; liver, hematological system [2]
Aromatics $C_{>8}$-C_{16}	Decreased body weight [1,2]
Aromatics $C_{>16}$-C_{21}	Decreased body weight [1]; kidney[2]
Naphthalene	Nasal effects, decreased body weight [3]
2-Methylnaphthalene	Lung [3]
High Carbon Range Petroleum Mixtures	
Aliphatics $C_{>16}$-C_{35}	Laxative effects [1]
Aromatics $C_{>21}$-C_{35}	Kidney, liver, hematological system [1]

Miscellaneous Components	Noncarcinogenic Critical Effect/Target
Methyl ethyl ketone	Fetal effects (decreased body weight, skeletal effects) [3]
Methyl isobutyl ketone	Fetal effects (decreased body weight, skeletal effects, increased mortality), liver, kidney, lethargy [3]
Methyl tert-butyl ether	Liver, kidney, periocular tissue [3]
Ethanol	Fetal effects (developmental effects) [4]

[1]EPA 2009
[2]TPHCWG 1997b
[3]*Integrated Risk Information System* (EPA 2015).
[4]Florida Department of Environmental Protection, Division of Waste Management. 2005.

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D2.0 CARCINOGENIC POLYCYCLIC AROMATIC HYDROCARBONS

Cancer Slope Factors. Seven Polycyclic Aromatic Hydrocarbons (PAH) constituents have been assigned a weight of evidence judgment of Group B2, probable human carcinogen. These carcinogenic PAH (cPAH) are benzo[a]pyrene, benz[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene. An oral cancer slope factor is currently available only for benzo[a]pyrene. The remaining cPAH shall be assessed using the benzo[a]pyrene oral cancer slope factor adjusted based on the "estimated order of potential potency" of the cPAH relative to the potency of benzo[a]pyrene. The relative potency factors are only applicable to the assessment of carcinogenic hazards associated with oral exposure to cPAH (*Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons*, EPA 1993).

The SS and MO-1 RS for cPAH in Tables 1, 2, and 3 are based on the potency factors listed in Table D-6 below. Screening standards and MO-1 RS for COC not listed in RECAP (Tables 1-3 and Appendix G) and site-specific MO-2 and MO-3 RS shall be developed using the most current toxicity information available. SS and MO-1 RS in Tables 1, 2, and 3 and Appendix G MO-2 RS are regulatory standards and cannot be re-calculated using revised toxicity information. These standards can only be revised through formal regulatory procedures.

Table D-6 Carcinogenic PAH Relative Potency Factors and Oral Slope Factors

cPAH	Relative Potency Factor[1]	Oral Slope Factor[2] $(mg/kg\text{-}day)^{-1}$
Benzo[a]pyrene	1.0	7.3E+00 [3]
Benz[a]anthracene	0.1	7.3E-01
Benzo[b]fluoranthene	0.1	7.3E-01
Benzo[k]fluoranthene	0.01	7.3E-02
Chrysene	0.001	7.3E-03
Dibenz[a,h]anthracene	1.0	7.3E+00
Indeno[1,2,3-cd]pyrene	0.1	7.3E-01

[1] *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons* (EPA/600/R-93/089), EPA 1993.
[2] *7.3E+00 $(mg/kg\text{-}day)^{-1}$ x relative potency factor.*
[3] Integrated Risk Information System, EPA 2015.

Potency Adjustments for Early-Life Exposure to cPAH. The cPAHs have been determined to have a mutagenic mechanism of action (MOA) for carcinogenesis, therefore, age-dependent adjustment factors (ADAFs) should be used to develop cancer slope factors that address differential potency in early life stages. Therefore, when assessing early-life exposure for the cPAHs for land uses involving multiple age receptors, default ADAFs shall be applied to the benzo[a]pyrene oral slope factor before applying the relative potency factors. Refer to Section D8.0 for additional guidance on addressing mutagens.

Anthropogenic Background. Polycyclic Aromatic Hydrocarbons (PAH) are ubiquitous in the environment due to various combustion processes such as automobile exhaust, industrial emissions, and natural events such as forest fires. They are also associated with industrial processes such as wood-treating operations, petroleum refining, and activities that produce used oils and waste fuels.

The benzo[a]pyrene equivalency (BAPE) approach is a tool that may be applied at an AOI to evaluate the cumulative occurrence of cPAH in surface soil relative to that typically resulting from anthropogenic sources in various land use settings. This approach may be used as an alternative to evaluating the occurrence of anthropogenic background levels of cPAH on an individual constituent basis, i.e., the screening of individual cPAH against the SO SS. The BAPE approach involves the conversion of the measured concentrations of cPAH to an equivalent concentration of BAP (i.e., equivalent with regard to carcinogenic potency). The resulting benzo[a]pyrene equivalent concentrations for the individual cPAH are then summed to yield the BAPE concentration for the cPAH mixture as follows:

$$C_{BAPE} = \sum (C_n \times RPF_n)$$

Where:

C_{BAPE} = the benzo[a]pyrene equivalent concentration in AOI surface soil
C_n = average concentration for the nth cPAH in surface soil
RPF_n = the relative potency factor for the nth cPAH (refer to Table D-6)

The C_{BAPE} for the AOI surface soil is then compared to the state default BAPE $Soil_{ssni}$ or $Soil_{ssi}$ or MO-1 $Soil_{ni}$ or $Soil_i$ for the assessment of anthropogenic background levels of cPAH in soil. cPAH concentrations remaining on site shall be protective of the soil to groundwater pathway.

Management Option 1 RECAP Standards are provided in Table D-7. A site-specific background BAPE may be developed for surface soil in accordance with Section 2.5.3.8.

Table D-7 MO-1 RECAP Standards for Soil for BAPE[1]

COC	Non-Urban $Soil_{ni}$ (mg/kg)	Urban $Soil_{ni}$ (mg/kg) [2,3]	$Soil_i$ (mg/kg)
BAPE	1.1E-01	1.2E+00	2.0E+00

[1]For the assessment of anthropogenic background levels of cPAH in surface soil
[2]Urban shall generally refer to a densely populated territory containing a minimum residential population of at least 50,000
[3]Consistent with urban anthropogenic background levels of cPAH in surface soil

Management Option 3. The BAPE approach may be used to evaluate site-related cPAH under MO-3. A site-specific BAPE identified to serve as the $Soil_{ni}$ or $Soil_i$ shall comply with the requirements in Section 2.5.1. cPAH concentrations remaining on site shall be protective of the soil to groundwater pathway. The BAPE AOIC shall be determined in accordance with Section 2.3.1.3 and the following equation:

$$C_{BAPE} = \sum (C_n \times RPF_n)$$

Where:
C_{BAPE} = the benzo[a]pyrene equivalent concentration in AOI surface soil
C_n = AOIC for n^{th} cPAH in surface soil
RPF_n = the relative potency factor for the nth cPAH (refer to Table D-6)

Analytical Methods. For the analysis of PAH constituents, EPA SW846 Method 8310 or EPA SW846 Method 8270 may be used. The most recent version of these analytical methods, in accordance with the most recent revision of SW-846, shall be used. It is the Submitter's responsibility that the method chosen will achieve SQL that are acceptable under the RECAP based on site-specific conditions, the COC present, and method-specific limitations. Data shall be obtained from a laboratory accredited by the State of Louisiana (or a laboratory exempt from accreditation) and shall meet the requirements presented in Section 2.2.

References

Agency for Toxic Substances and Disease Registry. 1995. *Toxiciolgical Profile for Polycyclic Aromatic Hydrocarbons.*

EPA. 1993. Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons (EPA/600/R-93/089).

EPA. 2015. Integrated Risk Information System.

Mielke, H.W. and G. Wang, C.R. Gonzales, B.Le, V.N. Quach, P.W. Mielke. 2001. *PAH and Metal Mixtures in New Orleans Soils and Sediments*. The Science of the Total Environment. 281 (2001) 217-227.

United States Census Bureau. 2015. Glossary, Definition of Urbanized Area. Census.gov.

Wang, G., H. W. Mielke, V. Quach, C. Gonzales, and Q. Zhang. 2004. *Determination of PAHs and Trace Metals in New Orleans Soils and Sediments*. Soil and Sediment Contamination, 13:313-327.

Wang, G., Q. Zhang, P. Ma, J. Rowden, H.W. Mielke, C. Gonzales, and E. Powell. 2008. *Sources and Distribution of PAHs in Urban Soils: Case Studies of Detroit and New Orleans*. Soil and Sediment Contamination, 17:547-563.

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D3.0 INORGANIC LEAD

Health risks associated with exposure to inorganic lead are not assessed using the traditional risk assessment methodology based on the use of toxicity values (RfD, RfC, SF). Rather, lead exposure is assessed using the Integrated Exposure Uptake Biokinetic Model (IEUBK) (pub. #9285.7-15-2, PB93-963511) or the Adult Lead Cleanup Level Model.

The IEUBK model is a pharmacokinetic model that integrates exposure from lead in air, water, soil, dust, diet, and paint. This model estimates blood lead levels associated with exposure under a residential scenario (child receptor) to determine an acceptable soil lead concentration for residential land use. Using standard EPA default parameters recommended in the Guidance Manual for IEUBK Model for Lead in Children (EPA 1994), the resulting soil concentration for lead is 400 mg/kg for a residential land use scenario. According to EPA guidance, it is expected that a soil lead concentration of 400 mg/kg will limit the probability that blood lead levels will exceed 10 ug/dl to no more than 5 percent for a child receptor under a residential exposure scenario. In accordance with EPA guidelines, the MO-1 and MO-2 risk-based $Soil_{ni}$ for lead has been set at 400 mg/kg. The final non-industrial RS applied at the AOI shall consider $Soil_{GW}$ and $Soil_{sat}$.

For industrial land use scenarios, lead exposure should be assessed using the Adult Lead Model in accordance with *Recommendations for the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil* (EPA 2003). This model focuses on estimating fetal blood lead concentrations in pregnant women exposed to lead contaminated soils in a commercial/industrial setting. In accordance with EPA guidelines, the Adult Lead Model and standard EPA default parameters recommended by EPA were used to develop the SO $Soil_{SSi}$, MO-1 $Soil_i$, and MO-2 $Soil_i$ of 800 mg/kg for lead. The final industrial RS applied at the AOI shall consider $Soil_{GW}$ and $Soil_{sat}$. The adult lead model and default assumptions are presented below.

Site-specific exposure data may be used under MO-3 for the assessment of lead exposure for residential and industrial land use scenarios. Under MO-2, site specific data may be used for the exposure concentration model inputs for air, drinking water, and soil/dust. In the absence of site-specific data, EPA default values shall be used.

Lead-Based Paint Sources. Remediation of soil impacted by lead-based paint is governed by the US Department of Housing and Urban Development (HUD) regulations, EPA regulations and the Louisiana state air regulations (LAC 33.III Chapter 28 §2811).

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Table D-8 Adult Lead Exposure Model Commercial/Industrial Land Use [1]

$$Soili(\mu g/g) = \frac{([PbB95\,fetal/(Rx(GSD_i)^{1.645})]) - PbB0)xAT_{s,d}}{BKSFx(IR_{s+d}xAF_{s,d}xEF_{s,d})}$$

Parameter	Definition (units)	Default
PbB_{95} fetal	95th Percentile PbB in Fetus (μg/dL)	10
R	Mean Ratio of Fetal to Maternal PbB	0.9
GSD_i	Individual Geometric Standard Deviation	2.3
PbB0	Baseline Blood Lead Value (μg/dL)	1.7
BKSF	Biokinetic Slope Factor (μg/dL per μg/day)	0.4
IR_{s+d}	Soil Ingestion Rate (including soil-derived indoor dust) (g/day)	0.05
$EF_{s,d}$	Exposure Frequency (same for soil and dust) (days/yr)	219
$AF_{s,d}$	Absorption Fraction (same for soil and dust)	0.12
$AT_{s,d}$	Averaging Time (same for soil and dust) (days)	365

[1] *Recommendations for the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil* EPA 540-R-03-001(EPA 2003); Memorandum Transmittal of *Update of the Adult Lead Methodology's Default Baseline Blood Lead Concentration and Geometric Standard Deviation Parameters*. EPA June 26, 2009. OSWER 9200.2-82; EPA Addressing Lead at Superfund Sites, Frequent Questions from Risk Assessors on the Adult Lead Methodology, Implementing the NHANES Update in the Adult Lead Model (EPA 2012).

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D4.0 2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN AND DIOXIN-LIKE COMPOUNDS

2,3,7,8-Tetrachlorodibenzo-*p*-dioxin (TCDD) and Dioxin-Like Compounds (DLC), including polychlorinated dibenzo-*p*-dioxins (PCDD), polychlorinated dibenzofurans (PCDF), and polychlorinated biphenyls (PCB), are structurally and toxicologically related halogenated dicyclic aromatic hydrocarbons. The Toxicity Equivalence Factor (TEF) Methodology, a component mixture method, shall be used to evaluate the risks associated with exposure to these mixtures using TCDD as the index chemical. Toxicity equivalent factors are consensus estimates of compound-specific toxicity/potency relative to the toxicity of TCDD. The TEF shall be used for all effects mediated through aryl hydrocarbon receptor binding by the DLCs including cancer and noncancer effects.

To apply TEFs to an environmental mixture of DLC, each individual compound's AOIC, CC, or exposure concentration is multiplied by its specific TEF, yielding the individual PCDD, PCDF, or PCB concentration that is equivalent to a concentration of TCDD. These TCDD equivalent concentrations are then summed to yield the total TCDD toxic equivalent (TEQ) AOIC or CC:

$$\text{Total TEQ AOIC or CC} = \sum_{n1} [PCDD_i \times TEF_i] + \sum_{n2} [PCDF_i \times TEF_i] + \sum_{n3} [PCB_i \times TEF_i]$$

where:

Parameter	Definition
Total TEQ AOIC or CC	Total Toxic Equivalent Concentration AOIC or CC
PCDD	Concentration of PCDD congener in medium
PCDF	Concentration of PCDF congener in medium
PCB	Concentration of PCB congener in medium
TEF	Congener-specific toxic equivalent factor (refer to Table D-10).

The Total TEQ AOIC, CC, or exposure concentration shall be compared to the medium-specific RS for TCDD.

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Table D-9 Human Health Toxicity Equivalent Factors (TEF)

Congener	TEF [1,2]
Polychlorinated Dibenzo-p-Dioxins	
2,3,7,8-TCDD	1
1,2,3,7,8-PentaCDD	1
1,2,3,4,7,8-HexaCDD	0.1
1,2,3,6,7,8-HexaCDD	0.1
1,2,3,7,8,9-HexaCDD	0.1
1,2,3,4,6,7,8-HeptaCDD	0.01
OctaCDD	0.0003
Polychlorinated Dibenzofurans	
2,3,7,8-TetraCDF	0.1
1,2,3,7,8-PentaCDF	0.03
2,3,4,7,8-PentaCDF	0.3
1,2,3,4,7,8-HexaCDF	0.1
1,2,3,6,7,8-HexaCDF	0.1
1,2,3,7,8,9-HexaCDF	0.1
2,3,4,6,7,8-HexaCDF	0.1
1,2,3,4,6,7,8-HeptaCDF	0.01
1,2,3,4,7,8,9-HeptaCDF	0.01
OctaCDF	0.0003
Non-Ortho Substituted Polychlorinated Biphenyls	
PCB 77 3,3',4,4'-TetraCB	0.0001
PCB 81 3,4,4',5-TetraCB	0.0003
PCB 126 3,3',4,4',5-PeCB	0.1
PCB 169 3,3',4,4',5,5'-HxCB	0.03
Mono-Ortho Substituted Polychlorinated Biphenyls	
PCB 105 2,3,3',4,4'-PeCB	0.00003
PCB 114 2,3,4,4',5-PeCB	0.00003
PCB 118 2,3',4,4',5-PeCB	0.00003
PCB 123 2',3,4,4',5-PeCB	0.00003
PCB 156 2,3,3',4,4',5-HxCB	0.00003
PCB 157 2,3,3',4,4',5'-HxCB	0.00003
PCB 167 2,3',4,4',5,5'-HxCB	0.00003
PCB 189 2,3,3',4,4',5,5'-HpCB	0.00003

[1]*The 2005 World Health Organization Re-evaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-like Compounds (*Martin van den Berg, Linda S. Birnbaum, Michael Denison, Mike De Vito, William Farland, Mark Feeley, Heidelore Fiedler, Helen Hakansson, Annika Hanberg, Laurie Haws, Martin Rose, Stephen Safe, Dieter Schrenk, Chiharu Tohyama, Angelika Tritscher, Jouko Tuomisto, Mats Tysklind, Nigel Walker, and Richard E. Peterson); *Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8-Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds* EPA/100/R-10/005. EPA 2010.

[2]For the Toxicity Equivalence Factor (TEF) Methodology, the most current TEF recommended by EPA shall be used to evaluate the risks associated with exposure to mixtures of TCDD and DLC for human health and ecological risk assessments.

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References

EPA. 2008. *Framework for Application of the Toxicity Equivalence Methodology for Polychlorinated Dioxins, Furans, and Biphenyls in Ecological Risk Assessment* EPA/100/R-08/004.

EPA. 2009. *National Primary Drinking Water Standards*. EPA 816-F-09-004, May 2009

EPA. 2010. *Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8-Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds* EPA/100/R-10/005.

EPA. 2012. *EPA's Reanalysis of Key Issues Related to Dioxin Toxicity and Response to NAS Comments, Volume 1*. In Support of Summary Information on the Integrated Risk Information System (IRIS) EPA/600/R-10/038F.

EPA. 2012. *Non-Cancer Toxicity Value for Dioxin and CERCLA/RCRA Cleanups*.

EPA. 2015. *Use of Dioxin TEFs in Calculating Dioxin TEQs at CERCLA and RCRA Sites*.

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D5.0 POLYCHLORINATED BIPHENYLS (PCBs)

Polychlorinated Biphenyls (PCBs) are a class of chemical compounds comprised of 209 congeners with varying degrees of chlorination. PCBs are generally released to the environment as commercial mixtures which are referred to as Aroclors (ATSDR 2000).

In general, PCB methods analyze for either Aroclor mixtures or individual PCB congeners. Analytical methods for Aroclors are often based on the comparison of PCB patterns in environmental samples with those of technical/commercial mixtures. However, degradation and weathering processes can result in a final pattern of PCBs in environmental and biological media that differs significantly from the original commercial formulation. Consequently, the Aroclor method may not accurately measure the presence of PCBs in environmental or biological media (EPA 2005). Analytical methods for individual PCB congeners are considered to be more accurate measures of the presence of PCBs in environmental and biological media. Also, since the toxicity of PCBs is congener-specific, these methods provide the best and most scientifically defensible basis for evaluating exposure and health risks associated with PCBs in the environment (EPA 2005). Before the selection of an analytical method, site-specific factors, project objectives, data quality objectives, and the intended end use of the data shall be considered. Depending on site-specific conditions, the use of the Aroclor method may be considered appropriate during the initial phases of investigation to determine the presence or absence of PCBs. Congener analysis is considered to be appropriate when weathering and biotransformation have occurred and when lower reporting limits are required (Bernhard et. al. 2001). The analytical protocol selected for the evaluation of PCB-impacted media shall be justified based on site-specific conditions and is subject to Department approval.

The evaluation of congener-specific data shall include an assessment of: 1) the Total TEQ Concentration for the 12 TCDD-like PBC congeners (refer to Section D4.0) and 2) the total PCB concentration (the sum of the concentrations detected for the 209 congeners minus the sum of the concentrations for the 12 dioxin-like congeners) (EPA 2013).

References

ATSDR. 2000. *Agency for Toxic Substances and Disease Registry Toxicological Profile for Polychlorinated Biphenyls.*

Bernhard, Teresa and Steve Petron. 2001. *Analysis of PBC Congeners vs. Aroclors in Ecological Risk Assessment.* Issue Paper.

EPA. 2005. *Memorandum: Response to Ecological Risk Assessment Forum Request for Information on the Benefits of PCB Congener-Specific Analyses*. David Cleverly. NCEA-C-1315. ERASC-002F.

EPA. 2015. *Integrated Risk Information System Polychlorinated Biphenyls*.

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D6.0 MUTAGENS

For chemicals that have been determined to have a mutagenic mode of action for carcinogenesis, chemical-specific information shall be used to develop cancer slope factors that address any potential for differential potency in early life stages, if appropriate data are available. Currently, vinyl chloride is the only chemical with appropriate dose-response data (i.e., slope factors and inhalation unit risks) for evaluating the differential susceptibility from early life exposure (EPA/635R-00/004, May 2000). For the other mutagens, default age-dependent adjustment factors (ADAF) shall be applied to the cancer slope factor for land uses involving multiple age receptors: a 10-fold adjustment for ages 0 - <2 years; a 3-fold adjustment for ages 2 - <16 years; and no adjustment for ages 16 years and older. These default ADAF address the potential for differential potency associated with exposure during early life (less than 16 years of age):

Table D-10 Residential Age-Dependent Adjustment Factors for Mutagens

Age (years)	Exposure Factors	Exposure Duration (years)	Default ADAF
0 - <2	Child	2	10
2 - <6	Child	4	3
6 - <16	Adult	10	3
16 - 26	Adult	10	1

Chemicals with a mutagenic mode of action for carcinogenesis that have been identified to date are listed in Table D-12.

Table D-11 Chemicals with a Mutagenic Mode of Action

Mutagen	CASRN
Acrylamide	79-06-1
Benzidine	92-87-5
Benzo[a]pyrene	50-32-8
Coke oven emissions	8007-45-2
Dibenz[a,h]anthracene	53-70-3
Dichloromethane	75-09-2
Diethylnitrosamine	55-18-5
Dimethylben[a]anthracene	57-97-6
Dimethylnitrosamine	62-75-9
Ethylnitrosourea	759-73-9
3-Methylchloanthrene	56-49-5
Methylnitrosourea	684-93-5
4,4'-Methylenebis(2-chloroaniline)	101-14-4
1,2-Dibromo-chloropropane	96-12-8
Safrole	94-59-7
Trichloroethylene	79-01-6
1,2,3-Trichloropropane	96-18-4
Urethane	51-79-6
Vinyl chloride	75-01-4

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For TCE, for land uses involving multiple age receptors, IRIS suggests that the kidney risk be assessed using the mutagenic equations and the liver and non-Hodgkin lymphoma (NHL) be addressed using the standard cancer equations.

When assessing early-life exposure for cPAHs, EPA recommends applying the default ADAF(s) to the benzo[a]pyrene slope factor before using relative potency factors to estimate risk from exposure to other PAHs (Science Policy Council's June 2006 memo on performing risk assessments that include carcinogens described in the Supplemental Guidance as having a mutagenic MOA (Communication II).

For additional information on addressing mutagens, refer to *Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens* EPA/630/R-03/003F March 2005; EPA Mid-Atlantic Regional Risk Assessment Screening Level User's Guide and FAQs.

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D7.0 NON-TRADITIONAL PARAMETERS

Non-traditional parameters include those constituents or physical/chemical parameters (e.g. chlorides, sulfates, pH, temperature, etc.) for which toxicity data are not available and thus cannot be evaluated using traditional risk assessment/RECAP methods. Non-traditional parameters shall be evaluated under MO-2 or MO-3. RS for these constituents (or physical/chemical parameters) shall consider, where appropriate and feasible, protection of human health, ecological receptors, livestock, crops, and vegetation; prevention of constituent migration and cross-media transfer; protection of beneficial uses of the medium of concern; protection of above ground and subsurface structures; and protection of resource aesthetics. Where appropriate, an environmental fate and transport analysis may be required by the Department to evaluate potential future impacts to health and/or the environment. An ecological checklist (RECAP Form 11) shall be completed to evaluate the need for an ecological risk assessment.

The evaluation of these parameters is highly dependent on professional judgment and all proposed RS shall be subject to Department approval. It is recommended that a workplan be submitted to the Department for approval prior to managing an AOI impacted by a non-traditional constituent or other parameter that may produce adverse environmental effects. A RS proposed for a non-traditional parameter shall be accompanied by appropriate supporting documentation and references. A RS for a non-traditional parameter shall not result in soil that exhibits hazardous waste characteristics of ignitability, corrosivity, or reactivity as defined in the Hazardous Waste Regulations (LAC 33:V). Prior to the development and application of a RS for a non-traditional parameter, the impacted medium under investigation shall be in declining conditions (i.e., the constituent mass is not increasing, the source of the release has been mitigated, and the area of constituent concentrations likely to be of concern is not expanding).

Non-traditional parameters shall be evaluated in accordance with the guidelines presented below as may be applicable.

1. Identify all available Applicable or Relevant and Appropriate Requirements (ARAR) (e.g., secondary MCL). Of the available ARAR, select the ARAR that is most appropriate for the evaluation of site-specific conditions and health and environmental concerns identified at the AOI. Where appropriate, consider the beneficial use of the medium of concern (e.g., groundwater used for irrigation);

2. Consider the protection of resource aesthetics (i.e., soil saturation level, water solubility, odor thresholds, taste, visual, etc.);

3. Consider all environmental fate and transport pathways especially those relating to exposure to human or ecological receptors and constituent migration and cross-media transfer;

4. Consider protection of vegetation (e.g., native surface cover) and/or the ability to grow crops;

5. Consider the Department-approved background concentration in accordance with Section 2.5.3.9 (e.g., for the evaluation of cross-media transfer, the naturally-occurring background chloride concentration of a receiving surface water body may be used as the SS or RS for the evaluation of chloride in a Groundwater 3 zone);

6. Based on the information obtained in steps 1, 2, 3, 4, and 5 identify a RS that adequately addresses the health and/or environmental concerns at the AOI;

7. Determine the AOIC or CC in accordance with Section 2.3; and

8. Compare the AOIC to the RS:

   If the AOIC is less than or equal to the RS, then typically no further action at this time shall be required for the medium of concern.

   If the AOIC is greater than the RS, then the AOI shall be further evaluated under a higher tier or the medium of concern shall be remediated to the RS.

If the SS or RS is less than the analytical quantitation limit, then a Department-approved quantitation limit shall serve as the SS or RS.

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