

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) 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.

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. 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.

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 as long as 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 to be conducted in accordance with the prior promulgated versions of RECAP.

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-3 for the health targets/critical effects for the noncarcinogenic components.

Soil Saturation

The petroleum hydrocarbon concentration in soil shall not exceed: 1) a total of 6,000 mg/kg for aliphatics C₆-C₁₀ and aromatics C_{>8}-C₁₀; 2) a total of 13,000 mg/kg for aliphatics C_{>10}-C₁₆ and aromatics C_{>10}-C₁₆; and 3) a total of 30,000 mg/kg for aliphatics C_{>16}-C₃₅ (and higher) and aromatics C_{>21}-C₃₅ without Department approval (Brost and Devaull 2000; Sanders 2009). Residual soil saturation points are known to vary depending on site-specific conditions (e.g., soil type, composition of the petroleum mixture, etc). 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; and 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

ALIPHATIC HYDROCARBONS	AROMATIC HYDROCARBONS
Low Carbon Range Petroleum Hydrocarbons ¹	
Aliphatic Fraction C ₅ -C ₈	Benzene
	Toluene
	Ethylbenzene
	Xylene
Medium Carbon Range Petroleum Hydrocarbons ¹	
Aliphatic Fraction C _{>8} -C ₁₀	Aromatic Fraction C _{>8} -C ₁₀
Aliphatic Fraction C _{>10} -C ₁₂	Aromatic Fraction C _{>10} -C ₁₂
Aliphatic Fraction C _{>12} -C ₁₆	Aromatic Fraction C _{>12} -C ₁₆
	Aromatic Fraction C _{>16} -C ₂₁
	Naphthalene
	2-Methylnaphthalene
High Carbon Range Petroleum Hydrocarbons ^{1,2}	
Aliphatic Fraction C _{>16} -C ₃₅	Aromatic Fraction C _{>21} -C ₃₅
	Benzo[a]anthracene
	Benzo[a]pyrene
	Benzo[b]fluoranthene
	Benzo[k]fluoranthene
	Chrysene
	Dibenzo[a,h]anthracene
	Indeno[1,2,3-cd]pyrene

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

²Hydrocarbons C_{>35} shall be addressed on a site-specific basis.

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							X	X	X		X	X
2-Methylnaphthalene							X	X	X		X	X
Lead (inorganic)	X ⁴											X ⁴
Metals											X ⁴	X ⁴
Methyl tertbutyl ether	X ⁴											X ⁴
1,2-Dibromoethane	X ⁴											
1,2-Dichloroethane	X ⁴											
Methyl ethyl ketone	X ⁴											X ⁴
Methyl isobutyl ketone	X ⁴											X ⁴
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
Aliphatic Fraction C ₁₂ - C ₁₆		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		X	X	X	X	X	X		X			X
Aromatic Fraction C ₁₂ - C ₁₆		X	X	X	X	X	X		X	X		X
Aromatic Fraction C ₁₆ - C ₂₁			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.

²The 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.

³Carcinogenic 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.

⁴When known or suspected to be present.

Table D-3 Physical/Chemical Properties for Hydrocarbon Fractions

Fraction	Boiling Point (°C)	Molecular Weight (g/mole)	Solubility (mg/l)	Vapor Pressure (atm)	Henry's Law Constant (unitless)	Koc (ml/g)
C ₅ -C ₆ Aliphatics	5.1E+01	8.1E+01	3.6E+01	3.5E-01	3.3E+01	7.94E+02
C _{>6} -C ₈ Aliphatics	9.6E+01	1.0E+02	5.4E+00	6.3E-02	5.0E+01	3.98E+03
C _{>8} -C ₁₀ Aliphatics	1.5E+02	1.3E+02	4.3E-01	6.3E-03	8.0E+01	3.16E+04
C _{>10} -C ₁₂ Aliphatics	2.0E+02	1.6E+02	3.4E-02	6.3E-04	1.2E+02	2.51E+05
C _{>12} -C ₁₆ Aliphatics	2.6E+02	2.0E+02	7.6E-04	4.8E-05	5.2E+02	5.01E+06
C _{>16} -C ₂₁ Aliphatics	3.2E+02	2.7E+02	1.3E-06	1.1E-06	4.9E+03	6.31E+08
C _{>8} -C ₁₀ Aromatics	1.5E+02	1.2E+02	6.5E+01	6.3E-03	4.8E-01	1.58E+03
C _{>10} -C ₁₂ Aromatics	2.0E+02	1.3E+02	2.5E+01	6.3E-04	1.4E-01	2.51E+03
C _{>12} -C ₁₆ Aromatics	2.6E+02	1.5E+02	5.8E+00	4.8E-05	5.3E-02	5.01E+03
C _{>16} -C ₂₁ Aromatics	3.2E+02	1.9E+02	6.5E-01	1.1E-06	1.3E-02	1.58E+04
C _{>21} -C ₃₅ Aromatics	3.4E+02	2.4E+02	6.6E-03	4.4E-10	6.7E-04	1.26E+05

TPH Criteria Working Group, 1997.

Table D-4 Toxicity Values

ALIPHATIC HYDROCARBONS			AROMATIC HYDROCARBONS				
Low Carbon Range Petroleum Hydrocarbons							
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-day) ⁻¹)	IUR ((ug/m ³)) ⁻¹
Aliphatic Fraction C ₅ -C ₈ ^{1,2,3}	NA ⁴	6.0E-01	Benzene ⁶	4.0E-03	3.0E-02	5.5E-02	7.8E-06
			Toluene ⁶	8.0E-02	5.0E+00	NA	NA
			Ethylbenzene ⁶	1.0E-01	1.0E+00	NA	NA
			Xylene ⁶	2.0E-01	1.0E-01	NA	NA
Medium Carbon Range Petroleum Hydrocarbons							
Aliphatic Fraction C _{>8} -C ₁₀ ^{1,2}	NA ⁵	1.0E-01	Aromatic Fraction C _{>8} -C ₁₀ ^{1,2}	NA ⁵	1.0E-01	NA	NA
Aliphatic Fraction C _{>10} -C ₁₂ ^{1,2}	NA ⁵	1.0E-01	Aromatic Fraction C _{>10} -C ₁₂ ^{1,2}	NA ⁵	1.0E-01	NA	NA
Aliphatic Fraction C _{>12} -C ₁₆ ^{1,2}	NA ⁵	1.0E-01	Aromatic Fraction C _{>12} -C ₁₆ ^{1,2}	NA ⁵	1.0E-01	NA	NA
			Aromatic Fraction C _{>16} -C ₂₁ ^{1,2}	NA ⁵	1.0E-01	NA	NA
			Naphthalene ⁶	2.0E-02	3.0E-03	NA	NA
			2-Methylnaphthalene ⁶	4.0E-03	NA	NA	NA
High Carbon Range Petroleum Hydrocarbons							
Aliphatic Fraction C _{>16} -C ₃₅ ^{1,2}	3.0E+00	NA	Aromatic Fraction ^{1,2} C _{>21} -C ₃₅	4E-02	NA	NA	NA
			Benz[a]anthracene ⁶	NA	NA	7.3E-01	NA
			Benzo[a]pyrene ⁶	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]anthracene 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-day) ⁻¹)	IUR ((ug/m ³)) ⁻¹
Methyl tert-butyl ether ^{6,7}	NA	3.0E+00	NA	NA
Methyl ethyl ketone ⁶	6.0E-01	5.0E+00	NA	NA
Methyl isobutyl ketone ^{6,8}	NA	3.0E+00	NA	NA
1,2-Dibromoethane ⁶	9.0E-03	9.0E-03	2.0E+00	6.0E-04
1,2-Dichloroethane ^{6,9}	NA	7.0E-03	9.1E-02	2.6E-05

NA = Tier 1 and Tier 2 Toxicity Values are not available.

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

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

³If the n-hexane concentration is < 53% (as in commercial hexane) a RfC of 6.0 E-01 mg/m³ shall be used. If the n-hexane concentration is > 53%, a RfC of 7.0E-01mg/m³(critical effect peripheral neuropathy) shall be used (EPA 2009).

⁴For GW_{3DW} and GW_{NDW}, Tier 3 chronic oral reference dose of 4.0E-02 mg/kg/day (Massachusetts DEP 2003) shall be used for aliphatics C₅-C₈.

⁵For GW_{3DW} and GW_{NDW}, Tier 3 chronic oral reference dose of 1.0E-02 mg/kg-d shall be used for aliphatics C_{>8-16} and a chronic oral reference dose of 3.0E-03 mg/kg-d shall be used for aromatics C_{>8-C₁₆} (PPRTV 2009).

⁶Integrated Risk Information System (EPA 2013).

⁷For GW_{3DW} and GW_{NDW}, Tier 3 oral slope factor of 1.8E-03 (mg/kg-d)⁻¹ shall be used (Mid-Atlantic Regional EPA 2013).

⁸For GW_{3DW} and GW_{NDW}, Tier 3 chronic oral reference dose of 8.0E-02 mg/kg-d shall be used (HEAST 2013).

⁹Provisional Peer-Reviewed Toxicity Value Database (EPA 2013).

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
Toluene	Neurological system ²
Ethylbenzene	Liver, kidney, fetus ²
Xylene	Neurological system, decreased body weight, increased mortality ²
Medium Carbon Range Petroleum Mixtures	
Aliphatic C _{>8-C₁₆}	Nasal effects; adrenal gland ¹
Aromatics C _{>8-C₂₁}	Decreased body weight ¹
Naphthalene	Nasal effects, decreased body weight ²
2-Methylnaphthalene	Lung ²
High Carbon Range Petroleum Mixtures	
Aliphatics C _{>16-C₃₅}	Laxative effects ¹
Aromatics C _{>21-C₃₅}	Kidney, liver, hematological system ¹
Miscellaneous Components	
Methyl ethyl ketone	Fetal effects (decreased body weight, skeletal effects) ²
Methyl isobutyl ketone	Fetal effects (decreased body weight, skeletal effects, increased mortality) ²
Methyl tert-butyl ether	Liver, kidney, periocular tissue ²

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

²*Integrated Risk Information System* (EPA 2013).

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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).

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

cPAH	Relative Potency Factor ¹	Oral Slope Factor ² (mg/kg-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.

²7.3E+00 (mg/kg-day)⁻¹ x relative potency factor.

³Integrated Risk Information System, EPA 2013.

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 urban 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 urban 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 of each individual cPAH in AOI surface soil (AOIC)

RPF_n = the relative potency factor for the cPAH

The C_{BAPE} for the AOI surface soil is then compared to the state default BAPE Screening Standard or MO-1 RECAP Standard to determine if the cPAH require further assessment.

Table D-7 Screening Standards for Soil for BAPE

COC	Soil _{ssni} (mg/kg)	Soil _{ssi} (mg/kg)
BAPE	1.2 ¹	3.0 ²

¹Within the acceptable cancer risk range; consistent with average urban background levels (Wang et al 2004; Wang et al 2008).

²Within the acceptable cancer risk range; consistent with range of urban background levels (Wang et al 2004; Wang et al 2008); consistent with EPA RODs for industrial/commercial land use.

Table D-8 MO-1 RECAP Standards for Soil for BAPE

COC	Soil _{ni} (mg/kg)	Soil _i (mg/kg)
BAPE	1.2 ¹	3.0 ¹

¹Within the acceptable cancer risk range; consistent with average urban background levels (Wang et al 2004; Wang et al 2008).

²Within the acceptable cancer risk range; consistent with range of urban background levels (Wang et al 2004; Wang et al 2008); consistent with EPA RODs for industrial/commercial land use.

Analytical Methods. For the analysis of PAH constituents, EPA SW846 Method 8310 or EPA SW846 Method 8270 may 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.

References

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

EPA. 2013. Integrated Risk Information System.

Wang, G., H. W. Mielke, V. Quach, C. Gonzles, 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.

D3.0 PRODUCED WATER

Produced water is defined in LAC 33:IX.I.708B, as “liquid and suspended particulate waste material generated by the processing of fluids brought to the surface in conjunction with recovery of oil or natural gas from underground geologic formations or with underground storage of hydrocarbons.” Potential parameters of concern for produced water releases are listed below. The composition of brines may vary and the final list of parameters of concern will be dependent on the nature of the brine released and site-specific conditions.

Table D-9 Constituents of Concern for Produced Water

Parameter	Notes
Sodium chloride	Refer to Section D4.0 of this appendix for detailed guidance on addressing sodium chloride
Total metals	arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver and zinc
Total Petroleum Hydrocarbons	Refer to Section D1.0 of this appendix for detailed guidance on addressing TPH
Benzene	
Toluene	
Ethylbenzene	
Xylene	
Polycyclic Aromatic Hydrocarbons	Refer to Sections D1.0, D2.0, and D8.0 of this appendix for detailed guidance on addressing PAHs

D4.0 SODIUM CHLORIDE

Sodium chloride (e.g., brine) is classified under RECAP as a non-traditional parameter since chemical-specific data essential for the development of Screening and RECAP Standards are not available. Therefore, where appropriate based on current land and/or groundwater classification and use, site-specific RECAP Standards for sodium chloride shall consider available ARARs; protection of human health; prevention of constituent migration and cross-media transfer; protection of the beneficial uses of the medium of concern; protection of resource aesthetics; and naturally-occurring salinity levels. The presence of sodium chloride in soil does not pose a risk to human health (TNRCC 2001; Bright and Addison 2002) therefore, a $Soil_{ni}$ or $Soil_i$ is not needed for site evaluation. All proposed SS and RS shall be accompanied by appropriate supporting documentation and references and shall be subject to Department approval. Depending on the source of the brine, other constituents may be present at the release site; these constituents should be addressed as typical COC under RECAP. Refer to Section D3.0 for the COC for produced water releases.

Screening Standards and MO-1 Standards have been identified for soil and groundwater and are considered to be appropriate for the first tier of screening at most sites. If background data indicate that native soil or groundwater conditions exceed the screening standards, and the Department concurs, then alternate limits may be approved for site management decisions. If the application of the SS, MO-1 RS, MO-2 RS, or MO-3 RS does not adequately address all of the concerns identified for the medium of concern, additional action may be required by the Department.

Table D-10 Groundwater Screening Standards for Sodium Chloride

Groundwater Protection	GW _{ss} (mg/l)
Chloride	250 ¹
Sodium	60 ²

¹Secondary MCL (EPA 2012).

²Aesthetic Guideline (EPA 2003).

Table D-11 Soil Screening Standards for Sodium Chloride

Soil Leachate Standards Protective of Groundwater	Soil _{LSS} ¹ (mg/l)
Chloride leachate standard	5000
Sodium leachate standard	1200

¹GW₁ multiplied by Summers default dilution factor of 20.

Table D-12 Management Option 1 Groundwater RECAP Standards for Sodium Chloride

Groundwater Protection (mg/l)	GW ₁	GW ₂	GW ₃
Chloride	250 ¹	250 ¹ x DF2	GW ₃ ² x DF3
Sodium	60 ³	60 ³ x DF2	60 ³ x DF3

¹Secondary MCL (EPA 2012).

²Based on site-specific POE; refer to LAC 33:IX Chapter 11 Table 3 Numerical Criteria and Designated Uses for the chloride criterion applicable to the POE.

³Aesthetic Guideline (EPA 2003).

Table D-13 Management Option 1 Soil RECAP Standards for Sodium Chloride

Soil Leachate Standards Protective of Groundwater	Soil _{LS} (mg/l)		
	GW1 Zone	GW2 Zone	GW3 Zone
Chloride (mg/l)	5000 ¹	5000 x DF2	GW ₃ ² x 20 x DF3
Sodium (mg/l)	1200 ¹	1200 x DF2	1200 x DF3

¹GW₁ multiplied by Summers dilution factor of 20.

²Based on site-specific POE; refer to LAC 33:IX Chapter 11 Table 3 Numerical Criteria and Designated Uses for the chloride criterion applicable to the POE.

MO-2 and MO-3 Site-Specific Standards for Sodium Chloride

Site-specific RS may be developed under MO-2 and/or MO-3. Where applicable based on groundwater classification and current land and groundwater use, site-specific standards for sodium chloride shall consider Applicable or Relevant and Appropriate Requirements (ARAR) (e.g., secondary MCL, surface water criterion and use designations); beneficial uses of the medium of concern; protection of resource aesthetics (e.g., soil properties, growth of native vegetation, drinking water taste thresholds, etc.); protection of ecological receptors; background salinity levels; and all environmental fate and transport pathways especially those relating to constituent migration and cross-media transfer. 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. Site-specific RS proposed to the Department shall be accompanied by appropriate supporting documentation and references and shall be subject to Department approval

Analytical Considerations

Electrical Conductivity (EC) (EPA Method 120.1, EPA Method 2510 or other EPA approved method), Sodium Absorption Ratio (SAR), and Exchangeable Sodium Percentage (ESP) shall be determined in accordance with *Laboratory Procedures for Analysis of Exploration and Production Waste*, Louisiana Department of Natural Resources Office of Conservation Injecting and Mining Division. For chlorides in groundwater or leachate, SW846 Method 9056 or other EPA approved Method shall be

used. For sodium in groundwater or leachate, SW846 6010, 6020, or 7000 or other EPA approved method shall be used. Electrical Conductivity (EC) readings collected in the field may be used to identify sample locations or in the development of a conceptual site model however, delineation of the AOI and identification of AOIC and/or CC shall be based on EC readings generated by an analytical laboratory and supported by the appropriate QA/QC data (refer to Section 2.2). The Synthetic Precipitation Leaching Procedure (SPLP) SW846 Method 1312 shall be used as the leach test. The leachable chlorides test included in the *Laboratory Procedures for Analysis of Exploration and Production Waste*, Louisiana Department of Natural Resources Office of Conservation Injecting and Mining Division is not an acceptable method for evaluating the soil to groundwater pathway under the RECAP.

NOTE: Where available methods allow, data meeting the requirements defined in RECAP Section 2.2 should be used for site management decisions. All methods and approaches used for site characterization are subject to Department approval.

References

Bright, Ph.D., Doug A. and Jan Addison, Ph.D. 2002. *Derivation of Matrix Soil Standards for Salt under the British Columbia Contaminated Sites Regulation.*

Environmental Protection Agency (EPA). 2012. *2012 Edition of the Drinking Water Standards and Health Advisories.* EPA 822-5-12-001.

Environmental Protection Agency. 2003. *Drinking Water Advisory: Consumer Acceptability Advice and Health Effects Analysis on Sodium.*

Louisiana Department of Natural Resources Office of Conservation, LAC 43:XIX Statewide Order 29-B.

Louisiana Department of Natural Resources Office of Conservation Injecting and Mining Division. *Laboratory Procedures for Analysis of Exploration and Production Waste*, (dnr.louisiana.gov/cons/conserin/LABMANUL.pdf)

Texas Natural Resource Conservation Commission, Toxicology & Risk Assessment Section Office of Permitting, Remediation & Registration 2001. *Evaluation of the Potential Health Impacts of Exposure to Iron, Calcium, Magnesium, Potassium, Sodium, and Phosphorus through Soil Ingestion.*

D5.0 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 value of 400 mg/kg is based on an assumed outdoor air concentration of 0.10 ug/m³ and a drinking water concentration of 4 ug/l (EPA 1994). 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).

Table D-14 Adult Lead Exposure Model Commercial/Industrial Land Use ¹

$$Soili(\mu\text{g} / \text{g}) = \frac{([PbB_{95\text{fetal}} / (R \times (GSD_i)^{1.645})] - PbB_0) \times AT_{s,d}}{BKSF \times (IR_{s+d} \times AF_{s,d} \times EF_{s,d})}$$

Parameter	Definition (units)	Default
PbB _{95 fetal}	95 th 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
PbB ₀	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

¹Recommendations 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).

D6.0 2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN AND DIOXIN-LIKE COMPOUNDS

2,3,7,8-Tetrachlorodibenzo-*p*-dioxin (TCDD) and Dioxin-Like Compounds (DLCs), including polychlorinated dibenzo-*p*-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and polychlorinated biphenyls (PCBs), are structurally and toxicologically related halogenated dicyclic aromatic hydrocarbons. The Toxicity Equivalence Factor (TEF) Methodology shall be used to evaluate the risks associated with exposure to mixtures of TCDD and DLCs for human health and ecological risk assessments. To apply TEFs to an environmental mixture of DLCs, 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:

$$\text{Total TEQ AOIC or CC} = \sum_{n1} [\text{PCDD}_i \times \text{TEF}_i] + \sum_{n2} [\text{PCDF}_i \times \text{TEF}_i] + \sum_{n3} [\text{PCB}_i \times \text{TEF}_i]$$

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

Table D-15 Human Health Toxicity Equivalent Factors (TEF) ¹

Congener	TEF
<i>Polychlorinated Dibenzo-p-Dioxins</i>	
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
<i>Polychlorinated Dibenzofurans</i>	
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
<i>Non-Ortho Substituted Polychlorinated Biphenyls</i>	
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
<i>Mono-Ortho Substituted Polychlorinated Biphenyls</i>		
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
<i>Di-Ortho Substituted Polychlorinated Biphenyls</i>		
PCB 170	2,2',3,3',4,4',5-HpCB	0.0001
PCB180	2,2',3,4,4',5,5'-HpCB	0.00001

¹The 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; EPA Mid-Atlantic Regional Screening Levels User's Guide November 2012.

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

Table D-16 Screening Standards for 2,3,7,8-TCDD

	Soil _{SSni} (ng/kg)	Soil _{SSI} (ng/kg)	Soil _{SSGW} (ng/kg)	GW _{SS} (ug/l)
2,3,7,8-TCDD (Total TEQ)	50 ¹	664 ¹	900	3.0E-05 ²

¹Final Non-Cancer Dioxin Reassessment, EPA 2012; EPA Superfund, Non-Cancer Toxicity Value for Dioxin and CERCLA/RCRA Cleanups, Questions and Answers on use of the 2,3,7,8-TCDD Reference Dose released on February 12, 2012.

²MCL (EPA 2012).

Table D-17 MO-1 Standards for 2,3,7,8-TCDD

	Soil _{ni} (ng/kg)	Soil _i (ng/kg)	Soil _{GW} (ng/kg)	Soil _{sat}	GW ₁ (ug/l)	GW ₂ (ug/l)	GW _{3DW} (ug/l)	GW _{3NDW} (ug/l)	Water _{sol} (ug/l)
2,3,7,8-TCDD (Total TEQ)	50 ¹	664 ¹	900 ²	NA	3.0E-05 ³	3.0E-05 ³	3.0E-05 ⁴	3.0E-05 ⁴	2.0E-01

¹Final Non-Cancer Dioxin Reassessment, EPA 2012; EPA Superfund, Non-Cancer Toxicity Value for Dioxin and CERCLA/RCRA Cleanups, Questions and Answers on use of the 2,3,7,8-TCDD Reference Dose released on February 12, 2012.

²Applicable to all groundwater classifications; Soil_{GW3} multiplied by the highest MO-1 DF is less than Soil_{GW2}. The Soil_{GW} may be multiplied by a DF2 for groundwater classifications 2 and 3.

³MCL (EPA 2012).

⁴GW₃ multiplied by the highest MO-1 DF is less than the GW₂; the GW₂ may be multiplied by a DF2 for groundwater classifications 2 and 3.

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. 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. 2013. *Use of Dioxin TEFs in Calculating Dioxin TEQs at CERCLA and RCRA Sites*.

D7.0 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 D6.0) 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. 2013. *Integrated Risk Information System Polychlorinated Biphenyls*.

D8.0 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 for evaluating the differential susceptibility from early life exposure (EPA/635R-00/004, May 2000). If appropriate chemical-specific data are not available, then the default age-dependent adjustment factors (ADAFs) 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 ADAFs address the potential for differential potency associated with exposure during early life (less than 16 years of age):

Table D-18 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 - 30	Adult	14	1

Chemicals with a mutagenic mode of action for carcinogenesis that have been identified to date are listed in Table D-18.

Table D-19 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

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.

D9.0 NITROGENOUS COMPOUNDS

Inorganic nitrogenous compounds such as ammonia, nitrite, and nitrate are common COCs at fertilizer facilities. When ammonia (NH₃) is released to the environment, it is generally converted to ammonium (NH₄) in relatively short period of time. Ammonium is then converted to nitrite. Nitrite is subsequently converted to nitrate. Nitrate is more stable in the environment than nitrite and is very mobile in the soil and groundwater. Therefore, the primary nitrogenous COC of concern at fertilizer sites is nitrate. For soils, leaching of nitrate to groundwater is the pathway of greatest concern.

It is important to note that when relatively large volumes of ammonia are released to the environment, the pH of the soil and groundwater become elevated which results in a significant proportion of the ammoniated nitrogen remaining in the unionized form (NH₃). These site conditions dramatically slow the ultimate conversion of ammonia to nitrate resulting in relatively high concentrations of ammonia in the soil and groundwater. In order to account for the fact that ammonia and nitrite will ultimately be transformed to nitrate (i.e., these COC serve as a continuing source of nitrate), it is particularly important to include these constituents in the site investigation/evaluation. Therefore, the most comprehensive approach to site investigation/evaluation of nitrogenous constituents at fertilizer sites is to quantify the total concentration of inorganic nitrogen (ammonia-N + nitrate-N + nitrite-N) in impacted media.

Table D-20 Soil Screening Standards for Nitrogenous Compounds

Nitrogenous Compounds	Soil Leachate SS (mg/l)	GW _{SS} (mg/l)
Total Nitrogen (ammonia-N + nitrate-N + nitrite-N)	200 ¹	10 ²

¹MCL of 10 mg/l for nitrate + nitrite (as nitrogen) x Summers DF of 20.

²SDWA MCL for nitrate + nitrite (as nitrogen) (EPA 2012).

Table D-21 Management Option 1 Soil Standards for Nitrogenous Compounds

Soil (mg/kg)	Soil _{ni}	Soil _i	Soil _{sat}
Nitrate	1E+05 ¹	1E+05 ¹	NA ²
Nitrite	7800	1E+05 ¹	NA

¹Aesthetic limit

²Not Applicable

Table D-22 Management Option 1 Soil Leachate Standards for Nitrogenous Compounds

Soil Protective of Groundwater	Soil Leachate Standards (mg/l)			
	GW1 Zone	GW2 Zone	GW3DW Zone	GW3NDW Zone
Total Leachable Nitrogen (ammonia-N + nitrate-N + nitrite-N)	200 ¹	200 ¹ x DF2	200 ² x DF3	4500 ³ x DF3
Total Leachable Nitrogen as nitrite (nitrite-N)	--	--	--	290 ⁴ x DF3

¹MCL of 10 mg/l for nitrate + nitrite (as nitrogen) x Summers DF of 20.

²GW_{3DW} for nitrate + nitrite (as nitrogen) x Summers DF of 20.

³GW_{3NDW} for nitrate (as nitrogen) x Summers DF of 20.

⁴GW_{3NDW} for nitrite (as nitrogen) x Summers DF of 20.

Table D-23 Management Option 1 Groundwater Standards for Nitrogenous Compounds

Groundwater (mg/l)	GW ₁	GW ₂	GW _{3DW}	GW _{3NDW}
Total Nitrogen (ammonia-N + nitrate-N + nitrite-N)	10 ¹	10 ¹ x DF2	10 ² x DF3	230 ³ x DF3
Nitrite-N	--	--	--	15 ⁴ x DF3

¹MCL of 10 mg/l for nitrate + nitrite (as nitrogen).

²GW_{3DW} for nitrate + nitrite (as nitrogen).

³GW_{3NDW} for nitrate (as nitrogen).

⁴GW_{3NDW} for nitrite (as nitrogen).

Refer to Appendix A for documentation on the development of the MO-1 GW_{3DW} and GW_{3NDW} standards.

Table D-24 Analytical Methods for Nitrogenous Compounds

Parameter	Method*
Ammonia nitrogen (NH ₃ ⁻ -N)	EPA Method 350.1
Nitrite nitrogen (NO ₂ ⁻ -N)	EPA Method 353.2
Nitrate nitrogen (NO ₃ ⁻ -N)	EPA Method 353.2

*Comparable methods may be acceptable to the Department

MO-2 and MO-3 Standards

Site-specific RS may be developed under MO-2 and/or MO-3. Where applicable based on groundwater classification and land use, site-specific standards for total nitrogen and individual nitrogenous constituents shall consider protection of human health and ecological receptors, Applicable or Relevant and Appropriate Requirements (ARAR) (e.g., MCL); beneficial use of the medium of concern; protection of resource aesthetics (e.g., soil saturation level, soil properties, water solubility, native surface cover); and all environmental fate and transport pathways especially those relating to exposure to human or ecological receptors and constituent migration and cross-media transfer. 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. Site-specific RS proposed to the Department shall be accompanied by appropriate supporting documentation and references and shall be subject to Department approval.

D10.0 SULFATE

Sulfate is classified under RECAP as a non-traditional parameter since essential chemical-specific data are not available for the development of Screening and RECAP Standards using standard RECAP methods. Screening Standards and MO-1 Standards have been identified for soil and groundwater and are considered to be appropriate for the first tier of screening at most sites.

Table D-25 Screening Standard for Groundwater

Groundwater Parameter	GW _{ss} (mg/l)
Sulfate	250 ¹

¹Secondary MCL (EPA 2012).

Table D-26 Screening Standard for Soil Leachate

Soil Parameter	Soil _{LSS} (mg/l)
Sulfate leachate standard	5,000 ¹

¹GW₁ multiplied by Summers dilution factor of 20.

Table D-27 Management Option 1 Groundwater Standards

Groundwater Parameter (mg/l)	GW ₁	GW ₂	GW ₃
Sulfate	250 ¹	250 ¹ x DF2	GW ₃ ² x DF3

¹Secondary MCL; Environmental Protection Agency 2012 *Edition of the Drinking Water Standards and Health Advisories*. EPA 822-5-12-001..

²Based on site-specific POE; refer to LAC 33:IX *Chapter 11 Table 3 Numerical Criteria and Designated Uses* for the sulfate criterion applicable to the POE.

Table D-28 Management Option 1 Standards for Soil Leachate

Soil Parameter	Soil Leachate Standards (mg/l)		
	GW1 Zone	GW2 Zone	GW3 Zone
Sulfate (mg/l)	5,000 ¹	5,000 ¹ x DF2	GW ₃ x 20 x DF3

¹GW₁ multiplied by Summers dilution factor of 20.

²Based on site-specific POE; refer to LAC 33:IX *Chapter 11 Table 3 Numerical Criteria and Designated Uses* for the sulfate criterion applicable to the POE.

MO-2 and MO-3 Site-Specific Standards

Site-specific RS may be developed under MO-2 and/or MO-3. Where applicable based on groundwater classification and land use, site-specific standards for sulfate shall consider Applicable or Relevant and Appropriate Requirements (ARAR) (e.g., secondary MCL, surface water criterion and use designations; beneficial use of the medium of concern; protection of resource aesthetics (e.g., soil properties, drinking water taste thresholds, native surface cover, etc.); protection of ecological receptors; background levels; and all

environmental fate and transport pathways especially those relating to constituent migration and cross-media transfer. 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. Site-specific RS proposed to the Department shall be accompanied by appropriate supporting documentation and references and shall be subject to Department approval

Analytical Considerations

The recommended method for the analysis of sulfate is EPA SW846 Method 9056. All methods and approaches used for site characterization are subject to Department approval.

References

Environmental Protection Agency (EPA). *2012 Edition of the Drinking Water Standards and Health Advisories*. EPA 822-5-12-001.

LDEQ. 2012. *LAC 33:IX Chapter 11 Table 3 Numerical Criteria and Designated Uses*.

D11.0 ACIDIC AND CAUSTIC COC

pH is a measure of the concentration of hydrogen ions and is a useful indicator of the relative acidity or alkalinity of an environmental medium following the release of an acidic or caustic substance. The pH scale ranges from 0 to 14. A pH of 7 is neutral while a pH less than 7 is acidic and a pH greater than 7 is basic (alkaline). A change of one unit on this scale represents a tenfold change in pH. pH is defined as the negative logarithm of the hydrogen ion concentration:

$$\text{pH} = -\log [\text{H}^+]$$

pH is classified under RECAP as a non-traditional parameter since essential chemical-specific data are not available for the development of Screening and RECAP Standards using standard RECAP methods. Screening Standards and MO-1 Standards have been identified for soil and groundwater and are considered to be appropriate for the first tier of screening at most sites.

Table D-29 pH Screening Standard for Groundwater

Groundwater pH	GWss
pH	6.5 – 8.5 ¹

¹Secondary MCL range (EPA 2012).

Table D-30 pH Screening Standard for Soil

Soil pH	Soil _{LSS}
pH leachate standard	5.2 – 7.2 ¹
pH	6 - 7 ²

¹Secondary MCL pH values were converted to [H⁺], multiplied by a Summers dilution factor of 20, then the resulting [H⁺] was converted back to a pH value.

²USDA 1998.

Table D-31 Management Option 1 pH Standards for Groundwater

Groundwater pH	GW ₁	GW ₂	GW ₃
pH	6.5-8.5 ¹	Site-Specific ²	Site-Specific ³

¹Secondary MCL range (EPA 2012).

²To determine the site-specific GW₂: 1) convert the Secondary MCL pH values to [H⁺]; 2) multiply the [H⁺] by the site-specific Domenico DF2; and 3) take $-\log [\text{H}^+]$ to determine the pH value of the site-specific GW₂.

³To determine the site-specific GW₃: 1) refer to LAC 33:IX Chapter 11 Table 3 Numerical Criteria and Designated Uses and identify the pH criterion applicable to the POE; 2) convert the pH criterion to [H⁺]; 3) multiply the [H⁺] by the site-specific Domenico DF3; and 4) take $-\log [\text{H}^+]$ to determine the pH value of the site-specific GW₃.

Table D-32 Management Option 1 pH Standards for Soil

Soil pH	Soil _{ni}	Soil _i	Soil _{AG}
pH	6-7 ¹	5.5 – 7.3 ²	6.6 – 7.3 ³

¹Acceptable for direct contact (EPA); best pH range for the growth of most plants (USDA 1998).

²pH values < 5.5 adversely effect soil microbes, nutrient availability, plant growth; increase heavy metal mobility and toxicity; and are corrosive to concrete (USDA 1998; Texas A&M).

³Acceptable for plant growth, microbes, nutrient availability.

Table D-33 Management Option 1 Standards for Soil Leachate

Soil pH	Soil Leachate Standards		
	GW1 Zone	GW2 Zone	GW3 Zone
pH	5.2 – 7.2 ¹	6.5 -8.5 ²	GW ₃ ³

¹Secondary MCL pH values were converted to [H⁺], multiplied by a Summers dilution factor of 20, then the resulting [H⁺] was converted back to a pH value.

²Secondary MCL pH value shall be converted to [H⁺], multiplied by a Summers dilution factor of 20 and a site-specific Domenico DF2, then the resulting [H⁺] was converted back to a pH value.

³To determine the site-specific GW₃; 1) refer to LAC 33:IX Chapter 11 Table 3 Numerical Criteria and Designated Uses and identify the pH criterion applicable to the POE; 2) converted the pH criterion to [H⁺], 3) multiplied the [H⁺] by Summer’s DF of 20 and the site-specific Domenico DF3; 4) take the –log [H⁺] to convert to a site-specific GW₃ pH value.

MO-2 and MO-3 Site-Specific Standards

Where deemed appropriate, a higher tier of assessment may be used to allow for consideration of site-specific conditions in the selection of RECAP standards. Based on the environmental medium under evaluation and land and/or groundwater use, site-specific RECAP Standards for pH shall consider, available ARARs; protection of the beneficial use of the medium and potential receptors associated with that use; prevention of constituent migration and cross-media transfer; protection of resource aesthetics; and naturally-occurring pH levels. In addition the RS shall consider literature recommendations and guidelines applicable to site-specific conditions. A RS for pH shall not result in an environmental medium that exhibits hazardous waste characteristics of corrosivity as defined in the Hazardous Waste Regulations (LAC 33:V). All proposed RS shall be accompanied by appropriate supporting documentation and references and shall be subject to Department approval.

Analytical Considerations

pH readings collected in the field may be used to identify sample locations or in the development of a conceptual site model however, delineation of the AOI and identification of AOIC and/or CC shall be based on pH readings generated by an analytical laboratory and supported by the appropriate QA/QC data (refer to Section 2.2). pH shall determined by EPA SW846 Method 9045, EPA Method 150.1, or other approved EPA Method. All methods and approaches used for site characterization are subject to Department approval.

References

EPA 2012 *Edition of the Drinking Water Standards and Health Advisories*. EPA 822-S-12-001.

Texas A&M. The Agricultural Program. *Soil Acidity and Liming*. L.A. Redmon, M.L. McFarland, V.A. Haby, and D.H. Bade.

USDA. 1998. Natural Resources Conservation Service. *Soil Quality Indicators: pH*.

D12.0 OTHER NON-TRADITIONAL PARAMETERS

Other non-traditional parameters include those constituents or physical/chemical parameters for which toxicity data are not available and thus cannot be evaluated using traditional risk assessment/RECAP methods. Non-traditional parameters not specifically addressed in this appendix 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 18) shall be completed to evaluate the need for an ecological risk assessment.

The evaluation of these parameters is highly dependent on professional judgement 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).

Under most site conditions it is not necessary to develop a Soil_{ni} or Soil_i for iron, calcium, magnesium, potassium, sodium, or phosphorus (TNRCC Interoffice Memorandum October 9, 2001 *Evaluation of the Potential Health Impacts of Exposure to Iron, Calcium, Magnesium, Potassium, Sodium, and Phosphorus through Soil Ingestion*). However, where warranted, the soil levels protective of groundwater and resources aesthetics shall be considered in the development of a soil RS.

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 RS for the evaluation of chloride in a Groundwater 3 zone); and
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.

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.

D13.0 CONSTITUENTS AND HAZARDS NOT ADDRESSED UNDER RECAP

Constituents and hazards not addressed by the RECAP regulation are listed below along with a reference to the applicable regulation or agency.

1. Asbestos; refer to LAC 33:III Air.
2. Radiation including Naturally-Occurring Radioactive Materials (NORM); refer to LAC 33:XV Radiation Protection.
3. Soils impacted by lead-based paint; refer to LAC 33.III Chapter 28 §2811.
4. Infectious Agents; refer to LDHH.