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 those 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 Assessments* (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 (http://www.state.ma.us/dep/bwsc/vph_eph.htm) and the Texas Commission on Environmental Quality Method 1006 (http://www.tnrcc.state.tx.us/permitting/analysis.htm#5035). 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 2013 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 2013 version of RECAP unless otherwise approved by the Department to be conducted in accordance with ~~a~~ 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.

Aesthetic Cap

For soil present from surface to a depth of 15 feet bgs, the total concentration of petroleum hydrocarbons present in soil within the Area of Investigation (AOI) shall be less than or equal to 10,000 ppm. The total petroleum hydrocarbon concentration in soil shall be determined by summing the AOIC for each aliphatic and aromatic hydrocarbon fraction detected within the soil AOI. This total petroleum hydrocarbon concentration shall be less than or equal to 10,000 ppm.

For soils present a depth greater than 15 feet bgs, a total concentration of petroleum hydrocarbons greater than 10,000 ppm may be considered acceptable if the following conditions are met: 1) the SPLP results indicate that the total concentration of petroleum hydrocarbons present in soil is protective of groundwater; 2) no other environmental concerns are identified based on site-specific conditions; 3) NAPL is not present; <u>and</u> 4) the Department concurs with the findings and recommendations.

For groundwater, the total petroleum hydrocarbon concentration in groundwater shall be determined by summing the compliance concentrations (CC) for each aliphatic and aromatic hydrocarbon fraction detected within the groundwater AOI/plume. This total petroleum hydrocarbon concentration shall be less than or equal to 10,000 ppm.

Any variance in the applicability of the 10,000 ppm cap is subject to Department approval and is contingent upon land use, the pathways of concern, the characteristics of the medium under evaluation, and other site-specific conditions.

The Submitter may be required to remediate to petroleum hydrocarbon concentrations that are lower than the concentrations specified by this Program if compliance with MO-1, MO-2, or MO-3 RS results in a visual or odor nuisance that compromises the aesthetic value and/or land use of the site. For example, for a release of diesel fuel in an industrial area, where all the indicator constituents for petroleum-impacted soils are met and the hydrocarbon concentrations for the fractions are less than or equal to the RS but a

constant, objectionable odor or visual nuisance is evident, the submitter may recommend and complete excavation of the affected soils to aesthetically acceptable concentrations. This new clean up goal would be governed by the aesthetic appearance and odor of the soil only, **not a revised risk-based RS**. The proposed aesthetic concentration and plan to address the soils are subject to Department approval. 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]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]Hydrocarbons $C_{>35}$ 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]
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.

[2] As warranted based on the degree of weathering at the time of investigation/remediation activities.

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

[4] When 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 Aliphatic and Aromatic Fraction Chronic Toxicity Values

Fraction [1,2]	Oral Chronic Reference Dose (mg/kg-day)	Inhalation Chronic Reference Concentration (mg/m^3)	
Low Carbon Range Petroleum Mixtures			
Aliphatics $C_{>5}$-C_8 [3]	NA [4]	6.0E-01	
Medium Carbon Range Petroleum Mixtures			
Aliphatics $C_{>8}$-C_{16}	NA	1.0E-01	
Aromatics $C_{>8}$-C_{21}	NA	1.0E-01	
High Carbon Range Petroleum Mixtures			
Aliphatics $C_{>16}$-C_{35}	3.0E+00	NA	
Aromatics $C_{>21}$-C_{35}	4.0E-02	NA	

[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, 1997.

[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).

[4]NA = Not Available.

Table D-5 Petroleum Components Noncarcinogenic Critical Effects/Targets

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

[1]Critical effects/targets for toluene, ethylbenzene, xylene, naphthalene, and 2-methylnaphthalene applicable to MO-1 and Appendix G RECAP Standards; critical effects/targets for site-specific MO-2 and MO-3 RS shall be based on the most current RfD and RfC.

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

[3]*Integrated Risk Information System* (EPA 2013).

References

Total Petroleum Hydrocarbon Criteria Working Group Series, (John B. Gustafson, Ph.D.; Joan Griffith Tell, Ph.D. and Doug Orem). 1997. Volume 3 *Selection of Representative TPH Fractions Based on Fate and Transport Considerations*

U.S. EPA (U.S. Environmental Protection Agency). 1986. *Guidelines for the Health Risk Assessment of Chemical Mixtures*. Fed. Reg. 51(185):34014–34025.

U.S. EPA (U.S. Environmental Protection Agency). 1989. *Risk Assessment Guidance for Superfund Volume I. Human Health Evaluation Manual (Part A)*. U.S. Environmental Protection Agency, Washington, DC. EPA540189002.

U.S. EPA (U.S. Environmental Protection Agency). 2000. *Supplementary Guidance for Conducting Health Risk Assessment of Chemical Mixtures*. U.S. Environmental Protection Agency, Risk Assessment Forum, Washington, DC. EPA/630/R-00/002.

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) include 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] $(mg/kg\text{-}day)^{-1}$
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 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]

[1]Within the acceptable cancer risk range; consistent with average urban background levels (Wang et al 2004; Wang et al 2008).
[2]Within the acceptable cancer risk range; consistent with range of urban background levels (Wang et al 2004; Want et al 2008); consistent with EPA RODs for industrial/commerical 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]

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

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

References

EPA. 2003. *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 the environmental medium under evaluation and land and/or groundwater use, site-specific RECAP Standards for sodium chloride shall consider available ARARs; protection of human health, ecological receptors, livestock, agricultural crops, and native vegetation; prevention of constituent migration and cross-media transfer; protection of beneficial uses of the medium of concern; protection of resource aesthetics; and naturally-occurring salinity levels. 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 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 Parameters	GWss (mg/l)
Chloride	250 [1]
Sodium	60 [2]

[1]Secondary MCL (EPA 2012).
[2]Aesthetic Guideline (EPA 2003).

Table D-11 Soil Screening Standards for Sodium Chloride

Soil to Groundwater Pathway	$Soil_{SS}$ [1] (mg/l)
Chloride leachate standard	5000
Sodium leachate standard	1200

Agricultural Land Use[2]	$Soil_{SSAG}$ [3]			
Crop [4]	Chloride [5]		Sodium [6]	
	(mg/kg)	EC (dS/m)	ESP (%)	SAR
Citrus [7]	830	1.3	<15	<12
Corn [7,8]	1100	1.7	<15	<12
Cotton [7]	6200	7.7	<15	<12
Rice [7]	1900	3.0	<15	<12
Soybean [7]	3200	5.0	<15	<12
Strawberry [7,8]	640	1.0	<15	<12
Sugarcane [7,9]	1100	1.7	<15	<12
Sweet potato [7]	960	1.5	<15	<12
Tomato [7,8]	1600	2.5	<15	<12

[1] GW_1 multiplied by Summers default dilution factor of 20.
[2] Refer to Appendix E.
[3] In general, the screening standards for agricultural land use ($Soil_{SSAG}$) are applicable to the root zone which typically includes from ground surface to 3 to 4 feet below ground surface (Oklahoma 2006; Kansas 2004).
[4] Screening standards for crops not listed in Table D-11 shall be obtained from state agency, federal agency, or agricultural cooperative extension service guidance or recommendations, or other defensible scientific reference and proposed to the Department for approval.
[5] Chlorides may be evaluated as total chlorides (mg/kg) or as electrical conductivity (EC-solution phase).
[6] Exchangeable sodium percentage (ESP-solid phase); Sodium adsorption ratio (SAR-solution phase); LDNR, LAC 43:XIX; Utah 1996.
[7] Tanji and Kielen 2003.
[8] USDA.
[9] Viator, G. et. al. 2006; Viator, S. et. al. 2011.

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

Groundwater Parameters (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

[1] Secondary MCL (EPA 2012).
[2] Based 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.
[3] Aesthetic Guideline (EPA 2003).

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

Soil to Groundwater Pathway	Soil Leachate Standards (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

Agricultural Land Use[3]	$Soil_{AG}$ [4]			
Crop [5]	Chloride [6]		Sodium [7]	
	(mg/kg)	EC (dS/m)	ESP (%)	SAR
Citrus [8]	830	1.3	<15	<12
Corn [8,9]	1100	1.7	<15	<12
Cotton [8]	6200	7.7	<15	<12
Rice [8]	1900	3.0	<15	<12
Soybean [8]	3200	5.0	<15	<12
Strawberry [8,9]	640	1.0	<15	<12
Sugarcane [8,10]	1100	1.7	<15	<12
Sweet potato [9]	960	1.5	<15	<12
Tomato [8,9]	1600	2.5	<15	<12

[1] GW_1 multiplied by Summers dilution factor of 20.
[2] Based 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.
[3] Refer to Appendix E.
[4] In general, RECAP standards for agricultural land use ($Soil_{AG}$) are applicable to the root zone which typically includes from ground surface to 3 to 4 feet below ground surface (Oklahoma 2006; Kansas 2004).
[5] MO-1 RECAP standards for crops not listed in Table D-13 shall be obtained from from state agency, federal agency, or agricultural cooperative extension service guidance or recommendations, or other defensible scientific reference and proposed to the Department for approval.
[6] Chlorides may be evaluated as total chlorides (mg/kg) or as electrical conductivity (EC-solution phase).
[7] Exchangeable sodium percentage (ESP-solid phase); Sodium adsorption ratio (SAR-solution phase); LDNR, LAC 43:XIX; Utah 1996.
[8] Tanji and Kielen 2003.
[9] USDA.
[10] Viator, G., et. al. 2006; Viator, S., et. al. 2011.

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

Where deemed appropriate, a higher tier of assessment may be used to allow for consideration of site-specific conditions in the selection of soil and groundwater standards. The identification of site-specific MO-2 and MO-3 standards is discussed below.

Groundwater

The appropriate groundwater standards for sodium chloride are dependent on: 1) the groundwater classification (refer to RECAP Section 2.3.2.1) of the zone of interest; and 2) groundwater uses such as household residential use, irrigation of agricultural crops, livestock watering, etc.

Groundwater Classification 1:

The identification of the GW_1 RS shall include consideration of: 1) the secondary MCL of 250 mg/l for chlorides; 2) the EPA drinking water advisory limit of 60 mg/l for sodium; 3) the naturally-occurring background concentrations of chloride and sodium; and/or 4) other ARAR deemed to be appropriate based on site-specific conditions and/or groundwater use (and the Department concurs).

Groundwater Classification 2:

The identification of the GW_2 RS shall include consideration of: 1) the secondary MCL of 250 mg/l for chlorides; 2) the EPA drinking water advisory limit of 60 mg/l for sodium; 3) the naturally-occurring background concentrations of chloride and sodium; and/or 4) other ARAR deemed to be appropriate based on site-specific conditions and/or groundwater use (and the Department concurs). If the zone is classified as a GW2 aquifer solely based on the presence of an agricultural water supply well (i.e., the yield and/or TDS meet the requirements of a GW3 zone), then a GW2 may be identified based on the protection of the agricultural use of the groundwater (e.g., irrigation, livestock watering, etc). Refer to agricultural groundwater use below for further guidance.

Groundwater Classification 3:

The GW_3 RS for chloride shall be based on the chloride surface water criterion (refer to LAC 33:IX Chapter 11 Table 3 Numerical Criteria and Designated Use) designated for the nearest downgradient surface water body (POE).

Agricultural Groundwater Use:

- ***Irrigation***

  The groundwater standard for the irrigation of agricultural crops shall be based on the type of crop and the type of irrigation system under consideration. The parameters that shall serve as groundwater standards for the irrigational use of groundwater include, Electrical Conductivity (EC), sodium concentration, and/or chloride concentration. If deemed appropriate by the Department other parameters may be identified as groundwater standards.

- ***Livestock Water Supply***

For groundwater used for watering livestock, a water salinity (Total Soluble Salts) limit protective of all classes of livestock and poultry under consideration shall serve as the groundwater standard.

- ***Aquaculture Water Supply***

For groundwater used for aquaculture, a water salinity limit protective of all types aquaculture under consideration shall serve as the groundwater standard.

Soil

Under RECAP, soil standards consider the protection of human health, groundwater, and aesthetics. 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. The soil RS for sodium chloride shall generally consider protection of aesthetics (ability of soil to support native surface cover at a minimum) and the protection of groundwater. Based on site-specific conditions, other concerns shall be addressed as warranted including agricultural land use and protection of ecological receptors.

Residential, Commercial, and Industrial Land Uses

The identification of sodium chloride soil standards for residential, commercial, or industrial land use shall consider the protection of groundwater and soil aesthetics. The soil to groundwater pathway shall be evaluated using a leachate test. Leachate test results shall be evaluated as appropriate for the groundwater classification of the zone of concern. In residential areas, soil sodium and chloride levels in the root zone should be supportive of landscaping vegetation such as grasses used for lawns. In undeveloped areas of commercial/industrial land use, sodium chloride concentrations should be reduced in the root zone to levels that will support the growth of wild vegetation native to the area. The protection of soil aesthetics in developed industrial or commercial areas is likely not to be a concern.

Agricultural Land Use

The identification of sodium and chloride soil standards for agricultural land use shall address all applicable land uses such as the protection of groundwater and the protection of agricultural crops and aquaculture. RECAP Standards for agricultural land use shall include the identification of soil limits for electrical conductivity (EC-solution phase), the exchangeable sodium percentage (ESP-solid phase), and sodium adsorption ratio (SAR-solution phase) that are specific to the crops under consideration at the AOI. The EC, ES,

and SAR standards shall be met within the root zone which generally includes from ground surface to a depth of 3to 4 feet bgs (Oklahoma 2006; Kansas 2004). For crops with root zones below 3 ft bgs, the EC, ESP and SAR standards shall be met to the depth recommended in the scientific literature for the protection of the crop of interest. In general for agricultural land use, the use of a 95%UCL-AM concentration is not appropriate for demonstrating compliance with the RS. Compliance with the standards shall be required throughout the root zone within the AOI to ensure crop protection across the designated planting area.

The soil to groundwater pathway shall be evaluated for sodium chloride using a leachate test. Leachate test results shall be evaluated as appropriate for the groundwater classification of the zone of concern.

If the Submitter can show that higher limits for EC, SAR, and ESP can be justified for future land use or that background analyses indicate that native soil conditions exceed the SS or RS, and the Department concurs, then alternate limits may be approved for site management decisions.

Wetlands

Soil in an elevated, freshwater wetland area where the AOI is not normally inundated, the following soil standards shall apply: EC < 8mmho/cm, SAR < 14, and ESP < 25 [Louisiana Department of Natural Resources Office of Conservation, LAC 43:XIX Statewide Order 29-B Chapter 3 Pollution Control - Onsite Storage, Treatment and Disposal of Exploration and Production Waste (E&P Waste) Generated from the Drilling and Production of Oil and Gas Wells (Oilfield Pit Regulations)]. If the Submitter can show that higher limits for EC, SAR, and ESP can be justified for future land use or that background analyses indicate that native soil conditions exceed the recommended criteria, and the Department concurs, then alternate limits may be approved for site management decisions.

Soil in a submerged freshwater wetland area is not required to meet EC, SAR or ESP limits. [Louisiana Department of Natural Resources Office of Conservation, LAC 43:XIX Statewide Order 29-B Chapter 3 Pollution Control - Onsite Storage, Treatment and Disposal of Exploration and Production Waste (E&P Waste) Generated from the Drilling and Production of Oil and Gas Wells (Oilfield Pit Regulations)].

Note: Evaluation of brine releases to wetland environments should include consideration of sodium chloride levels protective of ecological receptors for all impacted media.

Analytical Considerations

Electrical Conductivity (EC), Sodium Absorption Ratio (SAR), 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.

NOTE: Where available methods allow, data meeting the requirements defined in RECAP Section 2.4 should be used for site management decisions.

References

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Viator, S., J. Flanagan, a. Granger, B. Herbert, B Joffrion, B Legendre and R. Louque. 2011. *Influence of Soil Salinity on Sugarcane.* Louisiana Agriculture magazine Fall 2011.

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/m^3 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 non-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 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. 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]

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

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).

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:

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

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

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

Congener	TEF
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
Di-Ortho Substituted Polychlorinated Biphenyls		
PCB 170	2,2',3,3',4,4',5-HpCB	0.0001
PCB180	2,2',3,4,4',5,5'-HpCB	0.00001

[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; 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]

[1]Final 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.
[2]MCL (EPA 2012).

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.). 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-17 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-18 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.

D9.0 NITROGENOUS COMPOUNDS

Inorganic nitrogenous compounds such as ammonia, nitrite, and nitrate are common COCs at fertilizer facilities. When ammonia (NH_3) is released to the environment, it is generally converted to ammonium (NH_4) 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 typically 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 (NH_3). 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 + nitrate-N) in impacted media.

Table D-19 Screening Standards for Nitrogenous Compounds

Nitrogenous Compounds	Soil Leachate SS (mg/l)	GW_{SS} (mg/l)
Total Nitrogen (ammonia-N + nitrate-N + nitrate-N)	200 [1]	10 [2]

[1]MCL of 10 mg/l for nitrate + nitrite (as nitrogen) x Summers DF of 20.
[2]SDWA MCL for nitrate + nitrite (as nitrogen) (EPA 2012).

Table D-20 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

[1]Aesthetic limit
[2]Not Applicable

Table D-21 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 + nitrate-N)	200 [1]	200 [1] x DF2	200 [2] x DF3	4500 [3] x DF3
Total Leachable Nitrogen as nitrate (nitrite-N)	--	--	--	290 [4] x DF3

[1]MCL of 10 mg/l for nitrate + nitrite (as nitrogen) x Summers DF of 20.
[2]GW_{3DW} for nitrate + nitrite (as nitrogen) x Summers DF of 20.
[3]GW_{3NDW} for nitrate (as nitrogen) x Summers DF of 20.
[4]GW_{3NDW} for nitrite (as nitrogen) x Summers DF of 20.

Table D-22 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 + nitrate-N)	10 [1]	10 [1] x DF2	10 [2] x DF3	227 [3] x DF3
Nitrite-N	--	--	--	14.5 [4] x DF3

[1]MCL of 10 mg/l for nitrate + nitrite (as nitrogen).
[2]GW_{3DW} for nitrate + nitrite (as nitrogen).
[3]GW_{3NDW} for nitrate (as nitrogen).
[4]GW_{3NDW} for nitrite (as nitrogen).

Refer to Appendix A for documentation on the development of the MO-1 GW_{3DW} and $GW3_{NDW}$ standards.

Table D-23 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 (e.g., groundwater used for irrigation, watering livestock, aquaculture, etc.); protection of resource aesthetics (e.g., soil saturation level, soil properties, water solubility, odor thresholds, taste, visual, etc.), protection of vegetation (e.g., native surface cover) and/or the ability to grow crops (e.g.,

agricultural land use); 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-24 Screening Standard for Groundwater

Groundwater Parameter	GWss (mg/l)
Sulfate	250 [1]

[1]Secondary MCL (EPA 2012).

Table D-25 Screening Standard for Soil Leachate

Soil Parameter	$Soil_{SS}$ (mg/l)
Sulfate leachate standard	5,000 [2]

[2]GW_1 multiplied by Summers dilution factor of 20.

Table D-26 Management Option 1 Groundwater Standards

Groundwater Parameter	GW_1 (mg/l)	GW_2 (mg/l)	GW_3 (mg/l)
Sulfate	250 [1]	250 [1] x DF2	GW_3 [2] x DF3

[1]Secondary MCL; Environmental Protection Agency (EPA). *2012 Edition of the Drinking Water Standards and Health Advisories*. EPA 822-5-12-001.
[2]Based 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-27 Management Option 1 Standards for Soil Leachate

Soil Parameter	Soil Leachate Standards (mg/l)		
	GW1 Zone	GW2 Zone	GW3 Zone
Sulfate	5,000 [1]	5,000 [1] x DF2	GW_3 x 20 x DF3

[1]GW_1 multiplied by Summers dilution factor of 20.
[2]Based 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

Where deemed appropriate, a higher tier of assessment may be used to allow for consideration of site-specific conditions in the selection of soil and groundwater standards. Based on the environmental medium under evaluation and land and/or groundwater use, site-specific RECAP Standards for sulfate 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 sulfate levels. All proposed RS shall be accompanied by appropriate supporting documentation and references and shall be subject to Department approval.

Groundwater

The appropriate groundwater standard for sulfate is dependent on: 1) the groundwater classification (refer to RECAP Section 2.3.2.1) of the zone of interest; and 2) groundwater uses such as household residential use, livestock watering, or other beneficial use.

Groundwater Classification 1:

The identification of the GW_1 RS shall include consideration of: 1) the secondary MCL of 250 mg/l for sulfate; the naturally-occurring background concentrations of sulfate; and/or 3) other ARAR deemed to be appropriate based on site-specific conditions and/or groundwater use (and the Department concurs)

Groundwater Classification 2:

The identification of the GW_2 RS shall include consideration of: 1) the secondary MCL of 250 mg/l for sulfate; 2) the naturally-occurring background concentrations of sulfate; and/or 3) other ARAR deemed to be appropriate based on site-specific conditions and/or groundwater use (and the Department concurs). If the zone is classified as a GW2 aquifer solely based on the presence of an agricultural water supply well (i.e., the yield and/or TDS meet the requirements of a GW3 zone), then a GW2 may be identified based on the protection of the agricultural use of the groundwater (e.g., irrigation, livestock watering, etc). Refer to agricultural groundwater use below for further guidance.

Groundwater Classification 3:

The GW_3 RS for sulfate shall be based on the surface water criterion (refer to LAC 33:IX Chapter 11 Table 3 Numerical Criteria and Designated Use) for sulfate identified for the nearest downgradient surface water body (POE).

Agricultural Groundwater Use:

For groundwater used for watering livestock, sulfate and total soluble salt guidelines protective of all classes of livestock and poultry under consideration shall serve as the groundwater standard. For other agricultural uses, the groundwater RS shall be protective of the use(s) under consideration.

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:

$$pH = - \log [H^+]$$

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-28 pH Screening Standard for Groundwater

Groundwater pH	GWss
pH	6.5 – 8.5 [1]

[1]Secondary MCL range (EPA 2012).

Table D-29 pH Screening Standard for Soil

Soil pH	$Soil_{SS}$
pH	6 -7 [2]
pH leachate standard	5.2 – 7.2 [1]

[1]Secondary 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.

[2]USDA 1998.

Table D-30 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]

[1]Secondary MCL range (EPA 2012).

[2]To determine the site-specific GW_2: 1) convert the Secondary MCL pH values to $[H^+]$; 2) multiply the $[H^+]$ by the site-specific Domenico DF2; and 3) take $-\log [H^+]$ to determine the pH value of the site-specific GW_2.

[3]To determine the site-specific GW_3: 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 $-\log [H^+]$ to determine the pH value of the site-specific GW_3.

Table D-31 Management Option 1 pH Standards for Soil

Soil pH	$Soil_{ni}$	$Soil_{i}$	$Soil_{AG}$
pH	6-7 [1]	> 5.5 [2]	6.6 – 7.3 [3]

[1]Acceptable for direct contact (EPA); best pH range for the growth of most plants (USDA 1998).
[2]pH 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).
[3]Acceptable for plant/crop growth, microbes, nutrient availability.

Table D-32 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]

[1]Secondary 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.
[2]Secondary MCL pH value shall be 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.
[3]To determine the site-specific GW_3; 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 GW_3 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 ignitability, corrosivity, or reactivity 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.

Site-specific soil RS for agricultural land use, nurseries, and areas of landscaping, etc shall consider the preferred soil pH range for the crops/vegetation present at the AOI.

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 2001) 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 2.13 (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.