Appendix I

Ecological Effects Evaluation

1. Ecological Effects Evaluation

Soil, sediment, and surface water data in the downstream areas was analyzed for a variety of constituents including volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), and metals, as described in Section 2 of the Downstream Areas Data Assessment Report (main report). The data collected was evaluated by comparison to background as well as based on effects on ecological receptors consistent with the Downstream Areas Remedial Sampling Plan (DARSP; ARCADIS 2013), as discussed in Section 5 of the main report. The ecological evaluation involved comparison of data to ecological screening values (ESVs) as well as calculating sample-specific toxic units (TUs) to evaluate the combined effect of PAHs in sediment and surface water on aquatic receptors. This appendix provides the technical basis for the selection of ESVs as well as the methods used to estimate the TUs. Examples to illustrate the TU calculations are provided in Tables I-1 through I-3, and step-by-step calculation sheets are provided in Attachment I-1.

1.1 Ecological Screening Values

ESVs are constituent concentrations in environmental media below which risk to ecological receptors exposed to those media is considered *de minimus* (i.e., if there are no exceedances of the ESV, the constituent(s) being screened is eliminated from any further risk evaluation). However, the reverse is not true; concentrations exceeding ESVs do not necessarily imply that ecological risk exist, rather, it indicates that additional ecological risk evaluation is warranted. ESVs were identified from literature sources based on the hierarchy recommended by the Arkansas Department of Environmental Quality (ADEQ) as described in the DARSP (ARCADIS 2013), which was approved by the ADEQ on July 12, 2013. ESVs were identified for individual constituents where available and are summarized in Table 5-2 of the report. Further, as discussed in the DARSP (ARCADIS 2013), the ecotoxicity of PAHs as a mixture was evaluated. This is because PAHs occur in the environment as mixtures rather than individual constituents, and they generally act through a common mechanism of action (i.e., non-specific narcosis). Narcosis "results in the degradation of cell membranes, which could result in mild toxic effects or mortality, depending upon the exposure," and the effects of narcotic compounds are approximately additive (USEPA 2009). Therefore, the ecological toxicity of PAHs is the result of the cumulative effects of the various PAHs in a mixture. To evaluate PAH mixture, consistent with agency recommendations (USEPA 2001, 2007a), PAHs were summed based on their molecular weight into two groups: low-molecular weight (LMW) PAHs to include PAHs with three or less benzene rings and high-molecular weight (HMW) PAHs to include PAHs with four or more benzene rings. PAHs that were not detected in a particular sample were not included in the sums.

Many PAHs were analyzed for in the downstream area, therefore it was imperative to identify those that will be used in PAHs sums for comparison to ESVs for sums. A list 43 PAH compounds were analyzed for in soil and subsurface sediment samples; while a list of 88 PAH compounds was analyzed for in surface sediment samples. Over half of these PAHs are heterocyclic PAHs that contain sulfur, nitrogen, or oxygen atoms in their rings—and were analyzed for forensic purposes only. The heterocyclic PAH derivatives are not used in the sums that were compared to ESV based on sums as the ESVs were based on non-

heterocyclic PAHs. Table 5-3 of the report lists the PAHs used in the summations for soils and sediments. For soils and subsurface sediments, the summations include 38 PAH compounds: the priority pollutant list of PAH compounds (16), two additional non-alkylated PAHs (or parent compounds), and 20 alkylated forms of parent PAH compounds. For surface sediments, the summations include 40 PAH compounds: the priority pollutant list of PAH compounds (16), four additional non-alkylated PAHs (or parent compounds), and 20 alkylated forms of parent PAH compounds. USEPA guidance (USEPA 2001, 2007a, 2009) does not define the specific PAHs or the number of PAHs to be included in the PAH summations. It is noteworthy, the available ESVs for LMW, HMW, and total PAHs were derived using data for a relatively low number of PAH compounds. To be conservative, this screen was conducted by comparing (to the ESVs) the sums of substantially larger numbers of PAHs than those for which the ESVs were developed. The remaining sections describe the identification of ESVs by medium.

1.1.1 Soil

Soil ESVs were obtained from the following sources in order of hierarchy, consistent with the DARSP (ARCADIS 2013):

1. USEPA Ecological Soil Screening Levels (EcoSSLs; USEPA 2013a), including those for PAHs (USEPA 2007a)

2. USEPA Region 4 Screening Values[1] (USEPA 2011)

3. USEPA Region 5 Screening Values (USEPA 2003a)

4. National Oceanic and Atmospheric Administration (NOAA) Screening Quick Reference Tables (SQuiRTs; Buchman 2008)

5. Canadian Council of Ministers of the Environment (CCME [2008])

ESVs for soil are summarized in Table 5-2 of the main report. The ESVs for VOCs were identified from either Region 4 or 5. These ESVs were based on various endpoints; however, they are considered

[1] The USEPA Region 4 soil ESVs used in this evaluation are the October 2011 values provided to ARCADIS by the agency referenced herein as USEPA 2011. ARCADIS was notified that USEPA Region 4 is in the process of revising the ESVs to reflect more recent recommendations by USEPA. The revised USEPA Region 4 ESVs default to USEPA EcoSSLs where available. The revised ESVs also contain updated ESVs for some organic compounds. Attached to this report is the current USEPA Region 4 ESV table provided to ARCADIS, along with the associated correspondence (Attachment I-2). In addition, a comparison between the 2001 and the revised 2911 USEPA Region 4 soil ESVs is included in Attachment I-3.

conservative. For metals (except for mercury) and for PAHs, the soil ESVs were obtained from the most current USEPA EcoSSLs, available on the EcoSSL website (USEPA 2013a). USEPA EcoSSLs are available for the protection of up to four endpoints: plants, soil invertebrates, bird, and mammals (USEPA 2013a). The lowest EcoSSL value, from those for the four endpoints, was selected as the ESV for each constituent, as shown in Table 5-2 of the report.

The EcoSSLs that were used for the protection of plants and invertebrates are conservative. They were derived from plant and soil invertebrate chronic toxicity test data (USEPA 2005a) from studies where the bioavailability of the constituents is higher than what would be expected in a natural setting. For example, the data used to derive the plant EcoSSL for nickel are all from studies where the soil bioavailability index was 2, which corresponds to "relatively high or very high bioavailability" (USEPA 2007b).

Likewise, the assumptions used to derive EcoSSLs for the protection of avian and mammalian species are also conservative. EcoSSLs for those species are calculated by combining dietary uptake models and conservative toxicity thresholds (i.e., toxicity reference values [TRVs]) that rely on generic receptor exposure assumptions that may not reflect site receptors or conditions. For example, the EcoSSL for vanadium is based on vanadium effects on birds (USEPA 2005b), and the TRV used to calculate that EcoSSL is based on toxicity studies with the domestic chicken (*Gallus domesticus*), which has been shown to be more sensitive to vanadium than naturally-occurring species observed at the site such as mallard ducks (*Anas platyrhynchos*) (Rattner et al. 2006).

Bioaccumulation factors used to derive EcoSSLs for wildlife are selected to be conservative as well. For example, the HMW PAH EcoSSL (USEPA 2007a) , which was based on mammalian receptors, uses a bioaccumulation factor of 2, which is 2 orders of magnitude higher than what is generally seen in the field (Jager et al. 2003). Where such high bioaccumulation models have been used to estimate risk adverse effects were not documented in the field when concentrations exceeded the EcoSSLs (Kapustka 2004). In addition, the EcoSSLs currently available from USEPA (2013a) do not account for bioavailability, although it has become clear that bioavailability plays an important role in uptake and toxicity (Interstate Technology & Regulatory Council [ITRC] 2011) and efforts are underway to update the EcoSSLs (Sample et al. 2013) to incorporate bioavailability among other recent technical advances. Currently EcoSSLs assume that bioavailability from food and incidentally ingested soil to be 100%. This is highly conservative because it has been shown that the relative bioavailabilities of constituents are typically lower. For example, the relative bioavailability of vanadium in soil is approximately 8% (United States Department of Defense 2003), and as such, the Vanadium EcoSSL that uses 100% is very conservative.

To evaluate the combined ecotoxicological contributions of PAHs in soil, total LMW PAH and total HMW PAH concentrations in site soil data[2] were compared to the LMW and HMW PAH ESVs. Although the ESVs for both LMW and HMW PAHs are based on single compound toxicity studies, USEPA (2007a) recommends these values to screen PAHs in soil. For conservatism, the initial soil screen was conducted on the sum of 16 priority pollutant PAHs, two additional non-alkylated PAHs not included in the priority pollutant list (benzo(e)pyrene and perylene), and 20 alkylated PAHs. The PAHs are presented in what is referred to as the Long List in Table 5-3 of the report which sums 40 PAHs for surface sediments and 38 PAHs for subsurface sediments and soils since benzo(a)fluoranthene and benzo(b)fluorene were not analyzed.

1.1.2 Sediment

Sediment ESVs were obtained from the following sources in order of hierarchy, consistent with the DARSP (ARCADIS 2013):

1. USEPA Region 4 Sediment Screening Levels (USEPA 2001)
2. USEPA Region 3 Freshwater Sediment Screening Values (USEPA 2006)
3. USEPA Region 5 Screening Values (USEPA 2003a)
4. USEPA ECOTOX Thresholds (USEPA 2013b)
5. NOAA SQuiRTs (Buchman 2008)
6. CCME (2008)

The ESVs for sediment are summarized in Table 5-2 of the report. There are some detected constituents for which sediment ESVs were not available from the sources listed above and therefore, are not evaluated herein: barium, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, 2-phenylbutane, n-butylbenzene, n-propylbenzene, and p-isopropyltoluene (Cymene).

For PAH mixtures, the sediment ESVs from Region 4 are based on practical quantitation limits for LMW PAHs. There is a high degree of uncertainty associated with the available sediment ESVs from Region 4 for PAHs; the 330 µg/kg ESV for individual PAHs and total LMW PAHs is based on a PQL (i.e., does not have

[2]Naphthalene and pyrene were analyzed by USEPA Method 8260 and the Modified Method 8270 SIM. For the calculation of the sums and the toxic units, data from Method 8260 were used because it is the more precise method for those analytes.

ecological significance), and the 655 µg/kg ESV for total HMW PAHs is based on a toxic effect level (TEL). TELs are derived from associations observed between measures of adverse biological effects and the concentrations of analytes measured in sediments that may contain multiple constituents. Using a TEL to derive an ESV may not reflect a constituent-specific response threshold due to unknown co-contaminant and constituent mixture issues, and does not incorporate site-specific factors that influence bioavailability (MacDonald et al. 2000; DiToro et al. 1991). Specifically, the Region 4 ESV for HMW PAHs is based on a TEL measured in estuarine sediment where six of the non-alkylated HMW PAHs were measured and summed (USEPA 2001, MacDonald 1994). Because PAHs are present in mixtures, it is likely that the same sediment in which those six PAHs were measured could have contained many more individual PAHs. In addition, if the PAHs had been measured and summed, the TEL would likely have been higher. Therefore, the use of the sediment ESVs from Region 4 leads to some uncertainty.

Sediment ESVs were used as a first conservative step in screening site sediment data for potential toxicological effects. PAH data were summed in two ways to compare to the ESVs. First, a conservative approach was conducted using the sum of priority pollutants, four additional alkylated PAHs that are not on the priority pollutant list, and the 20 alkylated PAHs for a total of 40 PAHs (referred to hereafter as the long list). A second approach summed the priority pollutant list plus 1- and 2-methlynaphthelene for a total of 18 PAHs (referred to hereafter as "Priority+2" List). The methylnaphthalenes were included in this shorter list for conservatism. Table 5-3 of the report lists the PAHs used in each sum[3]. Both of these sums are conservative since the ESVs were based on data for a much shorter list of PAHs.

1.1.3 Surface Water

Surface water data collected concurrently with the soil and sediment data per the DARSP are presented in this report. Surface water data collected per the DASRP were compared to surface water ESVs. Surface water ESVs were identified using the following hierarchy:

1. Arkansas Pollution Control and Ecology Commission Regulation No. 2 Standards dated August 26, 2011.

2. USEPA National Recommended Water Quality Criteria for Freshwater Aquatic Life Chronic Continuous Criteria (USEPA 2013c)

3. USEPA Region 4 Screening Values (USEPA 2001)

4. USEPA Region 3 Freshwater Screening Values (USEPA 2006)

[3] Naphthalene and pyrene were analyzed for via two USEPA Method 8260 and also the Modified Method 8270 SIM. In the calculation of the sums and the toxic unit, data from Modified Method 8270 SIM were used.

5. USEPA Region 5 Screening Values (USEPA 2003a)

6. NOAA SQuiRTs (Buchman 2008)

7. CCME (2008)

8. Oak Ridge National Laboratory (Suter and Tsao 1996)

Surface water ESVs used in the ecological screen are presented in Table 5-2 of the report. An ESV was not available for carbazole which was detected in surface water; however, carbazole was not detected in the crude oil and therefore, eliminated from further evaluation.

1.2 Toxic Unit Calculations

In addition to comparing PAH mixtures to the ESVs, the mixtures in sediment and surface water were evaluated by estimating sample TUs based on USEPA's guidance for evaluating the toxicity of PAH mixtures (USEPA 2003b). This guidance provides methods to evaluate PAHs by estimating TUs using equilibrium partitioning (EqP) and identifies benchmarks that are causally linked to specific PAHs, applicable across various geochemical environments and appropriately protective of benthic organisms. Thus, using TUs to evaluate PAHs is considered to have less uncertainty than the ESV comparison discussed above (i.e., those based on a PQL or TEL). Using a TU approach allows for evaluating the additive effect of PAHs. Since it is well understood that toxicity of PAHs is attributable to the concentration of PAHs in water or interstitial porewater, the TU can be calculated by comparing the water or porewater concentrations of PAHs to their final chronic values (FCVs), which are protective of aquatic life. FCVs developed using the National Water Quality Criteria Guidelines are provided for 34 individual PAHs4 (USEPA 2003b) and therefore the TU were calculated for those PAHs as seen in equation below:

$$TU = \frac{[PAH_1]}{FCV_1} + \frac{[PAH_2]}{FCV_2} + \ldots + \frac{[PAH_n]}{FCV_n}$$

The TU is analogous to a hazard quotient (HQ). If the HQ (total TU) is equal to or less than one in a given sediment sample, potential risk from concentration of the PAH mixture in that sample is considered acceptable for the protection of benthic organisms (USEPA 2003b, 2009, 2012). If the TU exceeds one, potential risk from concentration of the PAH mixture in that sample may not be acceptable for the protection of benthic organisms and may need further evaluation.

[4] While USEPA (2003b) presents FCVs for 34 PAHs, site data for 35 PAHs were used because data for 1-methylnaphthalene and 2-methylnaphthalene were reported individually in addition to C1-methylnaphthalene.

1.2.1 Sediment

It has been well established that PAH toxicity is related to the amount of organic carbon in sediment, which governs the bioavailability of PAHs to benthic organisms (Swartz 1999; USEPA 2003b, 2012). Based on this, the organic-carbon normalized sediment concentration is a reasonable approximation of the interstitial concentration. USEPA (2003b) provide methods for estimating the interstitial/dissolved water concentrations using what is referred to as a one-carbon model that relies on the binding capacity of organic carbon in sediment for PAHs. In this model, all organic carbon is treated equally, or as a single type of carbon. More recently, USEPA issued guidance to provide a summary of procedures for determining the freely dissolved concentrations of nonionic organic chemicals (including PAHs) for deriving sediment TUs (USEPA 2012). The 2012 guidance specifically addressed how interstitial water dissolved concentrations can be measured or estimated. It discusses estimation methods based on the one-carbon model, previously described by USEPA (USEPA 2003b), as well as a two-carbon model.

The one-carbon partitioning model incorporates the partitioning of PAHs to naturally occurring organic carbon (OC) and can be used to estimate the dissolved concentration (C_d) of each PAH ([PAH_x]) using the measured PAH bulk sediment concentration (C_{sed}) of individual PAHs. OC is a measure of natural organic carbon such as vegetative debris, humic and fulvic acids, and decayed remains of plants and animals. However, it has become widely recognized that various types of carbon have differing capacity for binding PAHs (and other narcotic chemicals; USEPA 2012). One such type of carbon that has been shown to have a significant binding capacity is black carbon (BC) such as coke, charcoal, and soot, which originates from combustion sources and are known to have extremely high sorption capacities (USEPA 2012; Accardi-Dey and Gschwend 2002, 2003; Burgess 2009, Ghosh 2007, Hauck et al. 2007, Hawthorne et al. 2007, ITRC 2011, Lohmann et al. 2005). Therefore, whereas the one-carbon partitioning model is useful to assess PAHs in sediment, the presence of BC in sediments may make this approach overly conservative because estimated dissolved concentrations will be higher than what actually occur. Alternatively, the two-carbon model can accommodate the presence of both natural OC and BC and more accurately estimate dissolved concentrations in the presence of BC.

To assess sediment in the downgradient area of the site, PAHs in surface sediment (i.e., the biologically active zone) were evaluated based on their cumulative effects and bioaccessibility to benthic invertebrates consistent with USEPA guidance (USEPA 2003b, 2012). Sample-specific TUs were initially calculated using the one-carbon model for all sediment samples. Where a specific PAH was not detected, its concentration was set at zero. If the TU result using the one-carbon model was below one, the sample was not further evaluated. If the TU was above one, the TU using the two-carbon model was calculated. The models are presented below and sample calculations for sediment are presented in Tables I-1 and I-2 for the one- and two-carbon models respectively, with step-by-step calculation sheets provided in Attachment I-1.

One-carbon model

In the one-carbon model, the C_d of each PAH ([PAH_x]) is estimated using the equation presented below (USEPA 2003b):

$C_d = C_{sed} / f_{OC}$

Where:
C_{sed} = concentration of each PAH in sediment (micrograms per kilogram dry weight [dw]; measured value)
C_d = concentration of freely dissolved PAH in pore water (micrograms per liter; estimated value)
f_{OC} = fraction of organic carbon (set at total organic carbon [TOC]; measured value)

Two-carbon model

The two-carbon model can be used to better estimate the Cd of each PAH (PAHx) using the following relationship (USEPA 2012; Accardi-Dey and Gschwend 2002):

$C_{sed}/C_d = f_{OC} \times K_{OC} + f_{BC} \times K_{BC}C_{pw}^{n-1}$

Where:
C_{sed} = concentration of each PAH in sediment (micrograms per kilogram dw; measured value)
C_d = concentration of freely dissolved PAH in pore water (micrograms per liter; estimated value)
f_{OC} = fraction of organic carbon exclusive of BC in sediment (kilogram [kg] OC/kg dw); f_{OC} exclusive of BC calculated from the difference between TOC and BC (from measured values)
f_{BC} = fraction of BC in sediment (kg BC/kg dw) (measured value)
K_{BC} = BC – pore water partition coefficient (liters per kilogram [L/kg] BC) for each individual PAH. PAH-specific K_{BC}s were calculated based on a regression equation from Koelmans et al. 2006 ($LogK_{BC} = 0.6997LogK_{ow} + 2.8219$). This regression equation was selected because it was derived using values from various laboratory and field studies obtained from the literature
K_{OC} = OC – water partition coefficient (L/kg OC) for each individual PAH (USEPA 2003b)
n = Freundlich coefficient for sorption to BC (unitless) (0.7; Hauck et al. 2007)

The equation is used, via an iterative approach, to estimate the freely dissolved PAH concentration by solving for C_d.

1.2.2 Surface Water

To evaluate the combined toxic contributions of PAHs in a mixture in surface water, the sum of the quotients of the actual measured PAH concentrations in surface water to the water FCVs for each individual PAH (i.e., the TU) was calculated. A sample calculation TU calculation for surface water is presented in Table I-3, with a step-by-step calculation sheet provided in Attachment I-1.

2. References

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Tables

Table I-1

Example for Calculating the Toxic Unit in Sediment Using the One-Carbon Model

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

Analyte	Final Chronic Value (FCV)[1]	SED-DA-045		
		Concentration in Sediment (C_{sed})	Concentration in Sediment (C_{sed})	Toxic Unit (TU)[2]
	(µg/goc)	(µg/dry kg)	(µg/goc)	(unitless)
Organic Carbon				
Total Organic Carbor (%)	--	4.64	--	--
Fraction Organic Carbon (foc)	--	0.0464	--	--
PAHs - Non-alkylated				
Acenaphthene	491	26.8	0.58	0.001
Acenaphthylene	452	30.7	0.66	0.001
Anthracene	594	38	0.82	0.001
Benzo(a)anthracene	841	60	1.29	0.002
Benzo(a)pyrene	965	90.9	1.96	0.002
Benzo(b)fluoranthene	979	142	3.06	0.003
Benzo(e)pyrene	967	171	3.69	0.004
Benzo(g,h,i)perylene	1095	189	4.07	0.004
Benzo(j)+(k)Fluoranthene	981	41.4	0.89	0.0009
Chrysene/Triphenylene	844	275	5.93	0.007
Dibenz(a,h)anthracene	1123	32.6	0.70	0.0006
Fluoranthene	707	126 J	2.72	0.004
Fluorene	538	179	3.86	0.007
Indeno[1,2,3-cd]pyrene	1115	50.8	1.09	0.001
Naphthalene	385	44.6	0.96	0.002
Perylene	967	133	2.87	0.003
Phenanthrene	596	669	14.42	0.02
Pyrene	697	193	4.16	0.006
PAHs - Alkylated				
1-Methylnaphthalene	446	371	8.00	0.02
2-Methylnaphthalene	447	492	10.60	0.02
C1-Chrysenes	929	922	19.87	0.02
C1-Fluoranthenes/Pyrenes	770	1032	22.24	0.03
C1-Fluorenes	611	714	15.39	0.03
C1-Phenanthrenes/Anthracenes	670	2302	49.61	0.07
C2-Chrysenes	1008	1336	28.79	0.03
C2-Fluorenes	686	2021	43.56	0.06
C2-Naphthalenes	510	2538	54.70	0.1
C2-Phenanthrenes/Anthracenes	746	4461	96.14	0.1
C3-Chrysenes	1112	1095	23.60	0.02
C3-Fluorenes	769	2244	48.36	0.06
C3-Naphthalenes	581	4265	91.92	0.2
C3-Phenanthrenes/Anthracenes	829	4853	104.59	0.1
C4-Chrysenes	1214	753	16.23	0.01
C4-Naphthalenes	657	4045	87.18	0.1
C4-Phenanthrenes/Anthracenes	913	3212	69.22	0.08
			Total Toxic Unit ($TU_{34\text{-}1C}$)[3]	1.2

Table I-1
Example for Calculating the Toxic Unit in Sediment Using the One-Carbon Model

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

Notes:
1. FCVs from USEPA 2003.
2. The analyte-specific TU is the ratio of Csed (µg/goc) to the FCV (µg/goc).
3. The sample $TU_{34\text{-}1C}$ is the summation of the toxic unit values for 34 PAHs and PAH classes using the one-carbon model.
   A TU equal to 1 or less indicates that risk to benthic receptors is not likely.
   A TU above 1 indicates that more evaluation is necessary to evaluate potential risk to the benthic receptors.

< = less than the limit of quantitation
FCV = final chronic value
µg/kg = micrograms per kilogram
µg/goc = micrograms per gram of organic carbon
PAH = polycyclic aromatic hydrocarbon
TOC = total organic carbon
TU = toxic unit
USEPA = United States Environmental Protection Agency

Reference:
USEPA. 2003. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks for the Protection of Benthic Organisms: PAH Mixtures. Environmental Protection Agency, Office of Research and Development. EPA-600-R-02-013.

Table I-2
Example for Calculating the Toxic Unit in Sediment Using the Two-Carbon Model

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

Analyte	Analyte-Specific Physical Parameters				SED-DA-045		
	Final Chronic Value (FCV)[1] (µg/L)	log K_{OW} (unitless)	log K_{OC} (unitless)	Log K_{BC} (unitless)	PAH Concentration in Sediment (C_{sed}) (µg/dry kg)	Estimated Dissovled PAH Concentration (C_d) [2] (µg/L)	Toxic Unit (TU) [3] (unitless)
Organic Carbon							
Total Organic Carbon (%; measured value)	--	--	--	--	4.64	--	--
Black Carbon (%; measured value)	--	--	--	--	0.24 J	--	--
Organic Carbon (%; calculated value)	--	--	--	--	4.4	--	--
Fraction of Organic Carbon (f_{OC}) (unitless)	--	--	--	--	0.0440	--	--
Fraction of Black Carbon (f_{BC}) (unitless)	--	--	--	--	0.0024	--	--
PAHs - Non-alkylated							
Acenaphthene	55.85	4.012	3.944	5.6284	26.8	0.0050	0.00009
Acenaphthylene	306.9	3.223	3.168	5.0761	30.7	0.0373	0.0001
Anthracene	20.73	4.534	4.457	5.9938	38	0.0024	0.0001
Benzo(a)anthracene	2.227	5.673	5.577	6.7911	60	0.0003	0.0001
Benzo(a)pyrene	0.9573	6.107	6.003	7.0949	90.9	0.0002	0.0002
Benzo(b)fluoranthene	0.6774	6.266	6.16	7.2062	142	0.0003	0.0004
Benzo(e)pyrene	0.9008	6.135	6.031	7.1145	171	0.0005	0.0005
Benzo(g,h,i)perylene	0.4391	6.507	6.397	7.3749	189	0.0002	0.0005
Benzo(j)+(k)Fluoranthene	0.6415	6.291	6.184	7.2237	41.4	0.0000	0.00008
Chrysene/Triphenylene	2.042	5.713	5.616	6.8191	275	0.0024	0.001
Dibenz(a,h)anthracene	0.2825	6.713	6.599	7.5191	32.6	0.0000	0.00005
Fluoranthene	7.109	5.084	4.998	6.3788	126 J	0.0036	0.0005
Fluorene	39.3	4.208	4.137	5.7656	179	0.0428	0.001
Indeno[1,2,3-cd]pyrene	0.275	6.722	6.608	7.5254	50.8	0.0000	0.00009
Naphthalene	193.5	3.356	3.299	5.1692	44.6	0.0456	0.0002
Perylene	0.9008	6.135	6.031	7.1145	133	0.0003	0.0004
Phenanthrene	19.13	4.571	4.494	6.0197	669	0.1063	0.006
Pyrene	10.11	4.922	4.839	6.2654	193	0.0092	0.0009
PAHs - Alkylated							
1-Methylnaphthalene	75.37	3.837	3.772	5.5059	371	0.2638	0.004
2-Methylnaphthalene	72.16	3.857	3.792	5.5199	492	0.3653	0.005
C1-Chrysenes	0.8557	6.14	6.036	7.118	922	0.0044	0.005
C1-Fluoranthenes/Pyrenes	4.887	5.287	5.197	6.5209	1032	0.0363	0.007
C1-Fluorenes	13.99	4.72	4.64	6.124	714	0.0823	0.006
C1-Phenanthrenes/Anthracenes	7.436	5.04	4.955	6.348	2302	0.1778	0.02
C2-Chrysenes	0.4827	6.429	6.32	7.3203	1336	0.0037	0.008
C2-Fluorenes	5.305	5.2	5.112	6.46	2021	0.1046	0.02
C2-Naphthalenes	30.24	4.3	4.227	5.83	2538	1.0914	0.04
C2-Phenanthrenes/Anthracenes	3.199	5.46	5.367	6.642	4461	0.1558	0.05
C3-Chrysenes	0.1675	6.94	6.822	7.678	1095	0.0009	0.005
C3-Fluorenes	1.916	5.7	5.603	6.81	2244	0.0381	0.02
C3-Naphthalenes	11.1	4.8	4.719	6.18	4265	0.6655	0.06
C3-Phenanthrenes/Anthracenes	1.256	5.92	5.82	6.964	4853	0.0604	0.05
C4-Chrysenes	0.07062	7.36	7.235	7.972	753	0.0002	0.003
C4-Naphthalenes	4.048	5.3	5.21	6.53	4045	0.1989	0.05
C4-Phenanthrenes/Anthracenes	0.5594	6.32	6.213	7.244	3212	0.0145	0.03
						Total Toxic Unit ($TU_{34\text{-}2C}$)[4]	**0.4**

Table I-2
Example for Calculating the Toxic Unit in Sediment Using the Two-Carbon Model

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

Notes:

1. FCV obtained from USEPA 2003.
2. Dissolved concentrations were estimated using an iterative approach to solve for C_d as specified in the calculation sheet.

   where:

   C_{sed} = sediment concentration

   C_d = estimated dissolved (porewater) concentration

   f_{BC} = fraction black carbon

   f_{oc} = fraction organic carbon

   K_{BC} = BC – pore water partition coefficient for each individual PAH (liters per kg BC; Koelmans et al. 2006)

   K_{oc} = Organic carbon – water partition coefficient for each individual PAH (liter per kg organic carbon; USEPA 2003)

   n = freundlich coefficient (0.7; Hauck et al. 2007)
3. The analyte-specific TU is the ratio of C_d (µg/L) to the FCV (µg/L).
4. The sample $TU_{34\text{-}2C}$ is the summation of the toxic unit values for 34 PAHs and PAH classes using the two-carbon model.

   A TU equal to 1 or less indicates that risk to benthic receptors is not likely.

   A TU above 1 indicates that more evaluation is necessary to evaluate potential risk to the benthic receptors.

FCV = final chronic value

K_{ow} = Octanol-Water Partition Coefficient

µg/kg = micrograms per kilogram

µg/L = microgram per liter

PAH = polycyclic aromatic hydrocarbon

TOC = total organic carbon

TU = toxic unit

USEPA = United States Environmental Protection Agency

References:

Koelmans, A.A., M.T.O. Jonker, G. Cornelissen, T.D. Buchelli, P.C.M. Van Noort, and Ö. Gustafsson. 2006. Black Carbon: the reverse of its dark side. Chemosphere 63:365-377.

Hauck, M, M.A.J. Huijbregts, A.A. Koelmans, C.T.A. Moermond, M.J. Van Den Heuvel-Greve, K. Veltman, A.J. Hendriks, and A.D. Vethaak. 2007. Including Sorption to Black Carbon in Modeling Bioaccumulation of Polycyclic Aromatic Hydrocarbons: Uncertainty Analysis and Comparison to Field Data. Environ. Sci. Technol., 41:2738-2744.

USEPA. 2003. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks for the Protection of Benthic Organisms: PAH Mixtures. Environmental Protection Agency, Office of Research and Development. EPA-600-R-02-013. November 2003.

Table I-3
Example for Calculating the Toxic Unit in Surface Water

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

Analyte	Final Chronic Value (FCV)[1] (µg/L)	WS-027DA	
		PAH Concentration in Surface Water (µg/L)	Toxic Unit[2]
PAH - Non-alkylated			
Acenaphthene	55.85	0.007 J	0.0001
Acenaphthylene	306.9	0.01403	0.00005
Anthracene	20.73	0.02447	0.001
Benzo(a)anthracene	2.227	0.02539	0.01
Benzo(a)pyrene	0.9573	0.03475	0.04
Benzo(b)fluoranthene	0.6774	0.0998	0.1
Benzo(e)pyrene	0.9008	0.05995	0.07
Benzo(g,h,i)perylene	0.4391	0.04914	0.1
Benzo(j)+(k)fluoranthene	0.6415	0.0329	0.05
Chrysene/Triphenylene	2.042	0.05438	0.03
Dibenz(a,h)anthracene	0.2825	0.01382 J	0.05
Fluoranthene	7.109	0.06456 J	0.009
Fluorene	39.3	0.01793 J	0.0005
Indeno[1,2,3-cd]pyrene	0.275	0.04343	0.2
Naphthalene	193.5	0.02145 J	0.0001
Perylene	0.9008	0.105	0.1
Phenanthrene	19.13	0.04238 J	0.002
Pyrene	10.11	0.04978	0.005
PAH - Alkylated			
1-Methylnaphthalene	75.37	0.018	0.0002
2-Methylnaphthalene	72.16	0.0234	0.0003
C1-Chrysenes	0.8557	< 0.0017 U	0
C1-Fluoranthenes/Pyrenes	4.887	0.04319	0.009
C1-Fluorenes	13.99	0.02402	0.002
C1-Phenanthrenes/Anthracenes	7.436	0.09511	0.01
C2-Chrysenes	0.4827	< 0.0017 U	0
C2-Fluorenes	5.305	< 0.0017 U	0
C2-Naphthalenes	30.24	0.0684	0.002
C2-Phenanthrenes/Anthracenes	3.199	0.13961	0.04
C3-Chrysenes	0.1675	< 0.0017 U	0
C3-Fluorenes	1.916	< 0.0017 U	0
C3-Naphthalenes	11.1	0.07578 J	0.007
C3-Phenanthrenes/Anthracenes	1.256	0.06738 J	0.05
C4-Chrysenes	0.07062	< 0.0017 U	0
C4-Naphthalenes	4.048	0.05307 J	0.01
C4-Phenanthrenes/Anthracenes	0.5594	0.04496 J	0.08
		Total Toxic Unit (TU_{34})[3]	1.0

Notes:

1. FCVs from USEPA 2003.

2. The analyte-specific toxic unit is calculated by dividing the concentration in water by the FCV.

3. The sample TU_{34} is the summation of the toxic unit values for 34 PAHs and PAH classes. A TU equal to 1 or less indicates that risk to benthic receptors is not likely. A TU above 1 indicates that more evaluation is necessary to evaluate potential risk to the benthic receptors.

< = less than the limit of quantitation

FCV = final chronic value

µg/kg = micrograms per kilogram

µg/L = micrograms per liter

PAH = polycyclic aromatic hydrocarbon

TOC = total organic carbon

TU = toxic unit

USEPA = United States Environmental Protection Agency

Reference:

USEPA. 2003. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks for the Protection of Benthic Organisms: PAH Mixtures. Environmental Protection Agency, Office of Research and Development. EPA-600-R-02-013. November 2003.

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Attachment I-1

Toxic Unit Step-Wise Calculation Sheets

Toxic Unit Calculation Sheet for Sediment using the One-Carbon Model

Objective

To evaluate the combined toxic contributions of PAHs in sediment, the summation of the toxic unit values was determined for 34 PAHs and PAH classes using the one-carbon model. A sample calculation TU calculation for sediment is presented in Table I-1.

$$C_d = \frac{C_{sed}}{f_{OC}}$$

After the C_d is calculated, the toxic unit (TU) calculation is completed using the following equation:

$$TU = \frac{[PAH_1]}{FCV_1} + \frac{[PAH_2]}{FCV_2} + \ldots + \frac{[PAH_n]}{FCV_n}$$

Where:

TU = toxic unit
FCV = final chronic value (USEPA 2003)
PAH_n = The C_d result for each individual PAH
C_{sed} = concentration of each PAH in sediment (micrograms per kilogram [µg/kg] dry weight; measured value)
C_d = Dissolved concentration - TOC-normalized concentration of each PAH in sediment (µg/gram of organic carbon [µg/goc]; calculated value)
f_{OC} = fraction of organic carbon (set at total organic carbon [TOC]; measured value)

Refer to Section 1.2.1 of Appendix I for references on the one-carbon model equation and input values.

Example

A sample calculation is provided for Sample ID SED-DA-045(0-0.5) in Table I-1. Below is a step-by-step calculation for phenanthrene, in this same sample, estimated using the following input parameters and sample results:

FCV = 596 µg/goc
C_{sed} = 669 µg/kg
f_{OC} = 0.0464

Toxic Unit Calculation Sheet for Sediment using the One-Carbon Model

Step 1. Calculate C_d.

$$C_d = \frac{669\ \mu g/kg}{0.0464\ x\ 1000}$$

$$C_d = 14.42\ \mu g/goc$$

Where, 1000 is conversion factor from kg to gram.

Step 2. Calculate PAH-specific TU for phenanthrene, which has a FCV of 596 µg/g_{oc}.

$$\text{PAH specific TU} = \frac{C_d}{FCV}$$

$$\text{PAH specific TU} = \frac{14.42\ \mu g/goc}{596\ \mu g/goc} = 0.0242 = 0.02$$

Note: Result is shown to one significant digit on calculation sheets, but all digits are included in total TU calculations.

Step 3. Repeat for each individual PAH and add each PAH-specific TUs to find a total TU for the sample.

Toxic Unit Calculation Sheet for Sediment using the Two-Carbon Model

Objective

The two-carbon model can be used to better estimate the C_d of each PAH (PAHx) using the relationship below (USEPA 2012; Accardi-Dey and Gschwend 2002). The C_d is the concentration of freely dissolved PAH in porewater (micrograms per liter [µg /L], which is an estimated value). Porewater concentrations were identified iteratively, using the "Goal Seek" feature in Excel, based on the following relationship:

$$\frac{C_{sed}}{C_d} = f_{OC} \times K_{OC} + f_{BC} \times K_{BC} C_d^{\,n-1}$$

Where:

C_{sed} = concentration of each PAH in sediment (micrograms per kilogram [µg/kg] dry weight; measured value)
f_{OC} = fraction of organic carbon exclusive of BC in sediment (kilogram [kg] OC/kg dw); f_{OC} exclusive of BC calculated from the difference between TOC and BC (from measured values)
f_{BC} = fraction of BC in sediment (kg BC/kg dw) (measured value)
K_{BC} = BC – pore water partition coefficient (liters per kilogram [L/kg] BC) for each individual PAH. PAH-specific K_{BC}s were calculated based on a regression equation from Koelmans et al. 2006 ($LogK_{BC} = 0.6997 LogK_{ow} + 2.8219$). This regression equation was selected because it was derived using values from various laboratory and field studies obtained from the literature
K_{OC} = OC – water partition coefficient (L/kg OC) for each individual PAH (USEPA 2003b)
n = Freundlich coefficient for sorption to BC (unitless) (0.7; Hauck et al. 2007)

After the C_d is calculated, the toxic unit (TU) calculation is completed using the following equation:

$$TU = \frac{[PAH_1]}{FCV_1} + \frac{[PAH_2]}{FCV_2} + \ldots + \frac{[PAH_n]}{FCV_n}$$

Where:

TU = toxic unit
FCV = final chronic value (USEPA 2003)
PAH_n = result for each individual PAH

Refer to Section 1.2.1 of Appendix I for references on the two-carbon model equation and input values.

Example with Assumptions

A sample calculation is provided for Sample ID SED-DA-045(0-0.5) in Table I-2. Below is a step-by-step calculation for phenanthrene, in this same sample, estimated using the following input parameters and sample results:

C_{sed} = 669 µg/kg
TOC = 4.64% = 0.0464
BC =0.24% = 0.0024
FCV = 19.13 µg/L

Toxic Unit Calculation Sheet for Sediment using the Two-Carbon Model

Step 1. Calculate K_{OC} and K_{BC}, using the log K_{OC} and log K_{BC} values.

$$K_{OC} = 10^{\wedge} \log K_{OC}$$

$$K_{BC} = 10^{\wedge} \log K_{BC}$$

For phenanthrene with a log K_{OC} = 4.494 and a log K_{BC} = 6.0197

$$K_{OC} = 10^{\wedge} 4.494 = 31{,}189$$

$$K_{BC} = 10^{\wedge} 6.0197 = 1{,}046{,}405$$

Step 2. Calculate f_{OC}, which is the fraction of organic carbon exclusive of BC in sediment (i.e., total organic carbon minus black carbon)

$$f_{OC} = f_{TOC} - f_{BC}$$

$$f_{OC} = 0.0464 - 0.0024 = 0.044$$

Step 3. Use an iterative process (e.g., "Goal Seek" in Excel) to solve for the freely dissolved PAH concentration, C_d (µg/L).

$$C_{sed}/C_d = f_{OC} \times K_{OC} + f_{BC} \times K_{BC} C_d^{\,n-1}$$

$$669\ \mu g/kg / C_d = 0.044 \times 31{,}189 + 0.0024 \times 1{,}046{,}405\ C_d^{\,0.7-1}$$

Equation is solved if **C_d = 0.1063 µg/L**

Step 5. Calculate PAH-specific TU for phenanthrene, which has a final chronic value (FCV) of 19.13 µg/L.

$$\text{PAH specific TU} = \frac{Cd}{FCV}$$

$$\text{PAH specific TU} = \frac{0.1063\ \mu g/L}{19.13\ \mu g/L} = 0.0056 = 0.006$$

Note: Result is shown to one significant digit on calculation sheets, but all digits are included in total TU calculations.

Step 6. Repeat for each individual PAH and add each PAH-specific TUs to find a total TU for the sample.

Toxic Unit Calculation Sheet for Surface Water

Objective

To evaluate the combined toxic contributions of PAHs in a mixture in surface water, the sum of the quotients of the actual measured PAH concentrations in surface water to the water FCVs for each individual PAH (i.e., the TU) was calculated. A sample calculation TU calculation for surface water is presented in Table I-3.

$$TU = \frac{[PAH_1]}{FCV_1} + \frac{[PAH_2]}{FCV_2} + \ldots + \frac{[PAH_n]}{FCV_n}$$

Where:

TU = toxic unit
FCV = final chronic value (USEPA 2003)
PAH_n = result for each individual PAH

Example

A sample calculation is provided for WS-027DA in Table I-3. Below is a step-by-step calculation for phenanthrene, in this same sample, estimated using the following input parameters and sample results:

FCV = 19.13 µg/L
PAH = 0.04238 µg/L

Step 1. Calculate TU for individual PAH.

$$TU = \frac{[PAH]}{FCV}$$

$$TU = \frac{0.04238\ \mu g/L}{19.13\ \mu g/L}$$

$$TU = 0.002$$

Note: Result is shown to one significant digit on calculation sheets, but all digits are included in total TU calculations.

Step 2. Repeat for each individual PAH and add each PAH-specific TUs to find a total TU for the sample.

Attachment I-2

USEPA Region 4 ESV Table

From: Brett Thomas [mailto:Thomas.Brett@epamail.epa.gov]
Sent: Tuesday, July 03, 2012 8:22 AM
To: Fontenot, Lance
Cc: Meredith Anderson
Subject: Fw: Ecological Screening Levels

Lance,

Sorry for the delay in response. I think the hierarchy you have below should be good. I am forwarding a
link to our Region 4 Guidelines, as they moved, and an updated Region 4 soil screening table, as this has
not yet been incorporated into the online RAGS version. The update was to incorporate the Eco SSL
screening values. So I guess at this point, use the Region 4 values where they are available, and then
move down the hierarchy for compounds not covered by the Region 4 guidelines. Sounds like that is what
you are proposing.

http://www.epa.gov/region04/superfund/programs/riskassess/ecolbul.html

Also, the soil screening table has been revised but not yet included in the Guidelines document. Here is
the revised Table:

(See attached file: Revised Region 4 screening values for soil Oct 2011.xlsx)

Thanks. Hope all is well there.

Brett Thomas, Ph.D.
Ecological Risk Technical Support
Superfund Division, EPA Region 4
61 Forsyth Street, SW
Atlanta, GA 30303
(T) (404) 562-8751
(F) (404) 562-8896

Hi Brett. I am adding some minor revisions to the work plan for Hattiesburg and wanted to check with you to see
current Region 4 preference for surface water, sediment and soil screening levels. Will the hierarchy below
work? Any suggestions would be appreciated. I also noticed that Region 5 actually has a much larger selection of
soil screening values for wildlife. Do you think the Region 5 values would suffice for our screening effort of the
numerous Appendix 9 constituents?
Thanks,
Lance
---

* ?USEPA Region 4 “Ecological Risk Assessment Bulletins - Supplement to RAGS” website (USEPA
2001b); and
* ?USEPA Ecological Soil Screening Levels website; and
* ?USEPA Region 5 Ecological Screening Levels.

Table 4. Recommended Ecological Screening Values for Soil (mg/kg dry weight)

CONSTITUENT	CAS #	TAL	TCL	Ecological Screening Value	Source	Receptor
INORGANIC COMPOUNDS						
Aluminum	7429-90-5	●		Narrative statement	[1]	
Antimony	7440-36-0	●		0.27	[1]	a
Arsenic	7440-38-2	●		18	[1]	b
Barium	7440-39-3	●		330	[1]	c
Beryllium	7440-41-7	●		21	[1]	a
Boron	7440-42-8			0.5	[2]	b
Cadmium	7440-43-9	●		0.36	[1]	a
Chromium III (total)	16065-83-1	●		26	[1]	d
Chromium VI (hexavalent)	18540-29-9			130	[1]	a
Cobalt	7440-48-4	●		13	[1]	b
Copper	7440-50-8	●		28	[1]	d
Iron	7439-89-6	●		Narrative statement	[1]	
Lanthanum	7439-91-0			50	[2]	d
Lead	7439-92-1	●		11	[1]	d
Lithium	7439-93-2			2	[2]	b
Manganese	7439-96-5	●		220	[1]	b
Mercury (total)	7439-97-6	●		0.1	[2]	c
Methyl mercury(1+), Ion	22967-92-6			0.67	[3]	f
Molybdenum	7439-98-7			2	[2]	b
Nickel	7440-02-0	●		38	[1]	b
Selenium	7782-49-2	●		0.52	[1]	b
Silver	7440-22-4	●		4.2	[1]	d
Technetium	7440-26-8			0.2	[2]	b
Thallium	7440-28-0	●		1	[4]	f
Tin	7440-31-5			50	[2]	b
Titanium	7440-32-6			1000	[2]	e
Tungsten	7440-33-7			400	[2]	e
Uranium	7440-61-1			5	[2]	b
Vanadium	7440-62-2	●		7.8	[1]	d
Zinc	7440-66-6	●		46	[1]	d
PESTICIDES						
Aldrin	309-00-2		●	0.00006	[4]	f
Atrazine	1912-24-9		●	0.0002	[4]	f
Azinphos-methyl	86-50-0			0.000005	[4]	f
a-BHC	319-84-6		●	0.003	[4]	f
b-BHC	319-85-7		●	0.009	[4]	f
g-BHC (Lindane)	58-89-9		●	0.00005	[4]	f
BHC total (a-BHC/b-BHC/g-BHC)	--			0.01	[4]	f
Carbaryl	63-25-2			0.00003	[4]	f
Carbofuran	1563-66-2			0.00002	[4]	f
Chlordane	57-74-9		●	0.00003	[4]	f
DDD	72-54-8		●	see total		
DDE	72-55-9		●	see total		
DDT	50-29-3		●	see total		
DDT/DDE/DDD (total)	--		●	0.021	[1]	a
Dieldrin	60-57-1		●	0.0049	[1]	a
Endrin	72-20-8		●	0.00004	[4]	f

Drins total (aldrin/dieldrin/endrin)	--			0.005	[4]	f
Endosulfan	115-29-7		●	0.00001	[4]	f
Heptachlor	76-44-8		●	0.0007	[4]	f
Heptachlor epoxide	1024-57-3		●	0.0000002	[4]	f
Maneb	12427-38-2			0.002	[4]	f
Organotin compounds	--			0.001	[4]	f
MCPA (4-chloro-2-methyl phenoxy acetic acid)	94-74-6			0.00005	[4]	f
POLYCHLORINATED BIPHENYLS (PCBs)						
PCB toxic equivalents (TEQ)				0.000004	[5]	f
PCBs (sum)	1336-36-3		●	0.02	[4]	f
SEMIVOLATILE ORGANIC COMPOUNDS (SVOCs)						
2-Chloroacetamide	79-07-2			2	[2]	c
3-Chlorophenol	108-43-0			7	[2]	b
3,4-Dichlorophenol	95-77-2			20	[2]	b,c
2,4,5-Trichlorophenol	95-95-4		●	4	[2]	b
2,4,6-Trichlorophenol	88-06-2		●	10	[2]	c
2,3,4,5-Tetrachlorophenol	4901-51-3			20	[2]	c
Phenol	108-95-2		●	0.05	[4]	f
Pentachlorophenol (PCP)	87-86-5		●	2.1	[1]	d
Chlorophenols[1] (each)	--			0.05	[5]	f
Nonchlorinated phenols[2] (each)	--			0.1	[5]	f
Chlorophenols (sum)	--		●	0.01	[4]	f
Cresol (3-methylphenol)	1319-77-3			0.05	[4]	f
Cresols (sum)	--			0.05	[4]	f
4-Nitrophenol	100-02-7		●	7	[2]	c
2,4-Dinitrophenol	51-28-5		●	20	[2]	b
Nonylphenol (and its ethoxylates)	25154-52-3			5.7	[5]	f
Monochloroaniline				0.005	[4]	f
Dichloroaniline				0.005	[4]	f
3-Chloroaniline (3-Aminochlorobenzene)	108-42-9			20	[2]	b
Hexachlorobenzene	118-74-1		●	0.05	[5]	f
Pentachlorobenzene	608-93-5			0.05	[5]	f
Hexachlorocyclopentadiene	77-47-4		●	10	[2]	b
2,4-Dichloroaniline	554-00-7			100	[2]	c
3,4-Dichloroaniline	95-76-1			20	[2]	c
2,4,5-Trichloroaniline	634-93-5			20	[2]	bc
2,3,5,6-Tetrachloroaniline	3481-20-7			20	[2]	bc
Pentachloroaniline	527-20-8			100	[2]	c
1,1'-Biphenyl	92-52-4		●	60	[2]	b
N-Nitrosodiphenylamine	86-30-6		●	20	[2]	b
Nitrobenzene	98-95-3		●	40	[2]	c
POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)						
2-Methylnaphthalene*	91-57-6		●	See LMWPAHs		
Acenaphthene*	83-32-9		●	See LMW PAHs		
Acenaphthylene*	208-96-8		●	See LMW PAHs		
Anthracene*	120-12-7		●	See LMW PAHs		
Benzo(a)anthracene**	56-55-3		●	See HMWPAHs		
Benzo(a)pyrene**	50-32-8		●	See HMWPAHs		
Benzo(b)fluoranthene**	205-99-2		●	See HMWPAHs		
Benzo(k)fluoranthene**	207-08-9		●	See HMWPAHs		
Benzo(ghi)perylene**	191-24-2		●	See HMWPAHs		

Chrysene**	218-01-9		●	See HMWPAHs		
Dibenzo(a,h)anthracene**	53-70-3		●	See HMWPAHs		
Fluoranthene**	206-44-0		●	See HMWPAHs		
Fluorene*	86-73-7		●	See LMW PAHs		
Indeno(1,2,3-cd)pyrene**	193-39-5		●	See HMWPAHs		
Naphthalene*	91-20-3		●	See LMW PAHs		
Phenanthrene*	85-01-8		●	See LMW PAHs		
Pyrene**	129-00-0		●	See HMWPAHs		
TOTAL PAHs						
Low Molecular Weight (LMW)* PAHs	130498-29-2		NA	29	[1]	c
High Molecular Weight (HMW)** PAHs	130498-29-2		NA	1.1	[1]	a
PHTHALATE ESTERS						
Diethylphthalate	84-66-2		●	100	[2]	b
Dimethylphthalate	131-11-3		●	200	[2]	c
Di-n-butyl phthalate	84-74-2		●	200	[2]	b
Phthalates (sum)	--			0.1	[4]	f
VOLATILE ORGANIC COMPOUNDS						
Acrylonitrile	107-13-1			0.000007	[4]	f
Vinyl chloride	75-01-4		●	0.01	[4]	f
Dichloromethane (Methylene chloride)	75-09-2		●	0.4	[4]	f
Trichloromethane (chloroform)	67-66-3		●	0.02	[4]	f
Tetrachloromethane (Carbon tetrachloride)	56-23-5		●	0.4	[4]	f
1,1-Dichloroethane	75-34-3		●	0.02	[4]	f
1,2-Dichloroethane	107-06-2		●	0.02	[4]	f
1,1-Dichloroethene	75-35-4		●	0.1	[4]	f
1,2-Dichloroethene	540-59-0		●	0.2	[4]	f
1,1,1-Trichloroethane	71-55-6		●	0.07	[4]	f
1,1,2-Trichloroethane	79-00-5		●	0.4	[4]	f
Dichloropropane	78-87-5		●	0.002	[4]	f
1,2-Dichloropropane	78-87-5		●	0.1	[5]	f
Cis-1,4-dichloro-2-butene	1476-11-5			1,000	[2]	e
Trans-1,4-dichloro-2-butene	110-57-6			1,000	[2]	e
Trichloroethene	79-01-6		●	0.1	[4]	f
Tetrachloroethene	127-18-4		●	0.002	[4]	f
Aliphatic chlorinated hydrocarbons[3] (each)	--			0.1	[5]	f
Aliphatic nonchlorinated (each)	--			0.3	[5]	f
Cyclohexanone	108-94-1			0.1	[4]	f
Benzene	71-43-2		●	0.01	[4]	f
Chlorobenzenes[4] (each)				0.05	[5]	f
Chlorobenzene	108-90-7		●	0.1	[5]	f
1,2-Dichlorobenzene	95-50-1		●	0.1	[5]	f
1,3-Dichlorobenzene	541-73-1		●	0.1	[5]	f
1,4-Dichlorobenzene	106-46-7		●	0.1	[5]	f
Ethylbenzene	100-41-4		●	0.03	[4]	f
Chlorobenzenes (sum)			●	0.03	[4]	f
Catechol (o-Dihydroxybenzene)	120-80-9			0.05	[4]	f
Resorcinol (m-Dihydroxybenzene)	108-46-3			0.05	[4]	f
Hydroquinone (p-Dihydroxybenzene)	123-31-9			0.05	[4]	f
Styrene (Vinyl benzene)	100-42-5		●	0.3	[4]	f
Toluene	108-88-3		●	0.01	[4]	f
Pyridine	110-86-1			0.1	[4]	f
Furan	110-00-9			NA	[2]	b

Tetrahydrofuran	109-99-9			0.1	[4]	f
Tetrahydrothiophene	110-01-0			0.1	[4]	f
Xylenes	1330-20-7		•	0.1	[3,4]	f
OTHER CHEMICALS						
Bromide				20	[4]	bc
Bromine (total)	7726-95-6			10	[2]	c
Fluoride				500	[4]	bc
Fluorine (total)	7782-41-4			30	[2]	e
Iodine	7553-56-2			4	[2]	b
Sulfur (elemental)	7704-34-9			500	[5]	f
Cyanide (free)	57-12-5		•	0.9	[5]	f
Cyanide, complex (total)	--		•	5	[4]	f
Phthalic acid esters (each)				30	[5]	f
Quinoline	91-22-5			0.1	[5]	f
Thiophene	110-02-1			0.1	[5]	f
Thiocyanates (sum)	--			1	[4]	f
Ethylene glycol	107-21-1			960	[5]	f
Mineral oil	8042-47-5			50	[4]	f
pH (standard units)				6 - 8	[5]	f

Notes:

The ecological screening value (ESV) is the lowest value reported for the protection of ecological receptors
a = ESV for the protection of mammalian wildlife
b = ESV for the protection of terrestrial plants
c = ESV for the protection of soil invertebrates
d = ESV for the protection of avian wildlife
e = ESV for the protection of microbes
f = ESV for the protection of all ecological receptors

*LMWPAHs have less than 4 rings
**HMWPAHs have 4 or more rings
CAS = Chemical abstracts service
NA = No data available
TAL = Target analyte list (inorganics)
TCL = Target compound list (organics)

[1]Chlorophenols include:
chlorophenol isomers (ortho, meta, para)
dichlorophenols (2,6- 2,5- 2,4- 3,5- 2,3- 3,4-)
trichlorophenols (2,4,6- 2,3,6- 2,4,5- 2,3,4- 3,4,5-)
tetrachlorophenols (2,3,5,6- 2,3,4,5- 2,3,4,6-)

[2] Nonchlorinated aliphatic compounds include:
2,4-dimethylphenol
2,4,-dinitrophenol
2-methyl 4,6-dinitrophenol
phenol
cresol

[3]Aliphatic chlorinated hydrocarbons include:
chloroform
dichloroethane (1,1- 1,2-), dichloroethene (1,2- 1,2-)
dichloromethane
1,2-dichloropropane, 1,2-dichloropropene (cis and trans)
1,1,2,2-tetrachloroethane, tetrachloroethene
carbon tetrachloride
trichloroethane (1,1,1- 1,1,2-), trichloroethene

[4] Chlorobenzenes include:
all trichloroebnzene isomers
all tetrachlorobenzene isomers
pentachlorobenzene

Sources:

[1] USEPA (2007 or latest revision): Ecological Soil Screening Levels. http://www.epa.gov/ecotox/ecossl/
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[4] MHSPE (Ministry of Housing, Spatial Planning and Environment). 2000. Intervention Values and Target Values Soil Quality Standards. Directorate-General for Environmental Protection, Department of Soil Protection, The Hague, The Netherlands. February 4, 2000
[5] CCME. 2007. Canadian Soil Quality Guidelines for the Protection of Environment and Human Health. Canadian Council of Ministers of the Environment. Update 7. September 2007.
Winnipeg, Manitoba. http://www.ec.gc.ca/CEQG-RCQE/English/Ceqg/Soil/default.cfm

Attachment I-3

Comparison of USEPA Region 4 Soil ESVs

Comparison of USEPA Region 4 Soil ESVs

1. Region 4 Soil Ecological Screening Values

This attachment provides a comparison of the Draft Region 4 Soil Screening Levels revised by U.S. Environmental Protection Agency (USEPA) in October 2011 (USEPA 2011) to the Region 4 Soil Screening Levels published in November 2001 (USEPA 2001). Although the Draft 2011 Ecological Screening Values (ESVs) have not been published by USEPA Region 4, USEPA Region 4 staff have been distributing them and requesting that they be used (see Attachment I-2). Further, the source documents for the ESVs are publicly available. The Draft USEPA 2011 ESVs represent a more current understanding of the science. The 2011 USEPA Region 4 ESVs default to USEPA Ecological Soil Screening Levels where available. Further, the 2011 ESVs contain updated ESVs for some organic compounds. The 2011 USEPA Region 4 ESV table provided to ARCADIS is provided in Attachment I-2, along with the associated correspondence (USEPA 2011). This attachment also compares the Draft revised 2011 USEPA Region 4 soil ESVs to the 2001 ESVs for constituents whose ESV was based on a Region 4 value in this report. Further, this attachment shows the comparison of detected levels of those constituents in the soil to the 2001 USEPA Region 4 soil ESVs.

2. Comparison of 2001 and 2011 Ecological Screening Values

The USEPA Region 4 ESVs are based on contaminant levels associated with a low probability of unacceptable risks to ecological receptors. As these numbers are based on conservative endpoints and sensitive ecological effects data, they represent a preliminary screening of site contaminant levels to determine if there is a need to conduct further investigations at the site (USEPA 2001). For the assessment of the data collected during as part of the Downstream Areas Remedial Sampling Plan (ARCADIS 2013), the ESVs for one metal (mercury) and some volatile organic compounds (VOCs) were identified from Region 4. There was no change in the Region 4 ESV (0.1 milligram per kilogram) for mercury. However, the 2001 ESVs for following VOCs were updated in 2011 (USEPA 2011):

Analyte	CAS Number	2001 Region 4 ESVs	Revised 2011 Region 4 ESVs	Units	Detected in Crude Oil?	Detected in Soil Samples?
Benzene	71-43-2	50	10	µg/kg	Yes	Yes
Ethylbenzene	100-41-4	50	30	µg/kg	Yes	No
Methylene Chloride	75-09-2	2000	400	µg/kg	No	No
Toluene	108-88-3	50	10	µg/kg	Yes	Yes
Trichloroethene	79-01-6	1	100	µg/kg	No	Yes
Xylene (Total)	1330-20-7	50	100	µg/kg	Yes	No

Note:

µg/kg = micrograms per kilogram

Comparison of USEPA Region 4 Soil ESVs

The above comparison indicates that the associated ESVs for benzene, ethylbenzene, methylene chloride, and toluene were lowered in 2011, and the associated ESVs for trichloroethene and total xylenes were raised in 2011.

3. Summary of Screening Assessment

As described in Section 2 above, the ESVs for seven VOCs were revised in 2011. Of these, only three VOCs (benzene, toluene, and trichloroethene) were detected in soil samples from the drainage ways and Dawson Cove. The screening of the detected VOCs in the soil samples against the 2001 USEPA Region 4 soil ESVs is included in the attached screening tables. The screening of the detected VOCs in the soil samples against the 2011 revised ESVs is included in Tables 6-2 and 6-3 of the report. The screening of detected VOCs in the soils against the 2001 ESVs indicates exceedances only for trichloroethene, which was above the ESV of 1 µg/kg. There were no other exceedances of the 2001 ESVs. The following table summarizes the screening of detected VOCs in soil samples to the to the 2001 and 2011 USEPA Region 4 soil ESVs.

Drainage Ways

Analyte	Frequency of Detection	Range of Detected Values (µg/kg)	2001 ESV Screening		2011 ESV Screening	
			2001 ESV (µg/kg)	Numbers Above ESV	2011 ESV (µg/kg)	Numbers Above ESV
Benzene	3/45 (7%)	0.6 - 34	50	0	10	1
Toluene	6/45 (13%)	1 - 5	50	0	10	0
Trichloroethene	21/45 (47%)	1 - 4	1	15	100	0

Dawson Cove

Analyte	Frequency of Detection	Range of Detected Values (µg/kg)	2001 ESV Screening		2011 ESV Screening	
			2001 ESV (µg/kg)	Numbers Above ESV	2011 ESV (µg/kg)	Numbers Above ESV
Toluene	0/54 (0%)	-	50	0	10	0
Trichloroethene	30/54 (56%)	1 - 5	1	22	100	0

This comparison of the screening results indicates that the more conservative approach is to screen the soil samples against the 2011 ESVs, which was done in the report. Although trichloroethene results exceed the 2001 soil ESV, this analyte is not a typical petroleum hydrocarbon constituent, and there was no need to

further evaluate this analyte. Therefore, using the revised 2011 USEPA Region 4 soil ESVs was a conservative screening evaluation of soils.

4. References

ARCADIS. 2013. Downstream Areas Remedial Sampling Plan. Mayflower Pipeline Incident, Mayflower, Arkansas. July.

USEPA. 2001. Region 4 Ecological Risk Assessment Bulletins - Supplement to RAGS. Available at: http://www.epa.gov/region4/superfund/programs/riskassess/ecolbul.html

USEPA. 2011. USEPA Region 4 Soil Ecological Screening Values - Oct 2011 draft values, obtained by personal communication from Mr. Brett Thomas, USEPA Region 4 and Lance Fontenot, ARCADIS electronic mail dated July 2012.

Attachment I-3
Drainage Way Soil Sampling Results Screened against 2001 USEPA Region 4 Soil ESVs

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

					Location	SO-DA-001	SO-DA-001	SO-DA-001	SO-DA-002	SO-DA-002	SO-DA-002	SO-DA-003	SO-DA-003	SO-DA-003	SO-DA-003	SO-DA-004	SO-DA-004	SO-DA-004
					Depths (ft)	0-0.5 ft	0.5-1 ft	1-1.5 ft	0-0.5 ft	0.5-1 ft	1-1.5 ft	0-0.5 ft	0-0.5 ft	0.5-1 ft	1-1.5 ft	0-0.5 ft	0.5-1 ft	1-1.5 ft
					Sample Date	8/13/2013	8/13/2013	8/13/2013	8/13/2013	8/13/2013	8/13/2013	8/13/2013	8/13/2013	8/13/2013	8/13/2013	8/13/2013	8/13/2013	8/13/2013
					Sample ID	SO-DA-001(0.0-0.5)	SO-DA-001(0.5-1.0)	SO-DA-001(1.0-1.5)	SO-DA-002(0.0-0.5)	SO-DA-002(0.5-1.0)	SO-DA-002(1.0-1.5)	SO-DA-003(0.0-0.5)	SO-DA-DUP-06-081313FD	SO-DA-003(0.5-1.0)	SO-DA-003(1.0-1.5)	SO-DA-004(0.0-0.5)	SO-DA-004(0.5-1.0)	SO-DA-004(1.0-1.5)
Analyte[1]	CAS Number	Units	Is Analyte Screened Further?[2]	2001 USEPA Region 4 Soil ESV[3]														
VOCs																		
Benzene	71-43-2	µg/kg	**Yes**	50		< 5 U	< 6 U	< 5 U	< 6 U	< 6 U	< 6 U	0.7 J	0.7 J	< 5 U	< 6 U	< 5 U	< 6 U	< 5 U
Toluene	108-88-3	µg/kg	**Yes**	50		2 J	2 J	< 5 U	< 6 U	< 6 U	< 6 U	1 J	1 J	< 5 U	< 6 U	< 5 U	< 6 U	< 5 U
Trichloroethene	79-01-6	µg/kg	No	1		**3 J**	**4 J**	**3 J**	**2 J**	**3 J**	< 6 U	**2 J**	**3 J**	1 J	**2 J**	**3 J**	< 6 U	< 5 U

Attachment I-3
Drainage Way Soil Sampling Results Screened against 2001 USEPA Region 4 Soil ESVs

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

					Location Depths (ft) Sample Date Sample ID	SO-DA-005 0-0.5 ft 8/13/2013 SO-DA-005(0.0-0.5)	SO-DA-005 0.5-1 ft 8/13/2013 SO-DA-005(0.5-1.0)	SO-DA-005 1-1.5 ft 8/13/2013 SO-DA-005(1.0-1.5)	SO-DA-006 0-0.5 ft 8/13/2013 SO-DA-006(0.0-0.5)	SO-DA-006 0.5-1 ft 8/13/2013 SO-DA-006(0.5-1.0)	SO-DA-006 1-1.5 ft 8/13/2013 SO-DA-006(1.0-1.5)	SO-DA-007 0-0.5 ft 8/2/2013 SO-DA-007(0.0-0.5)	SO-DA-007 0.5-1 ft 8/2/2013 SO-DA-007(0.5-1.0)	SO-DA-007 1-1.5 ft 8/2/2013 SO-DA-007(1.0-1.5)	SO-DA-008 0-0.5 ft 8/2/2013 SO-DA-008(0.0-0.5)	SO-DA-008 0.5-1 ft 8/2/2013 SO-DA-008(0.5-1.0)	SO-DA-008 1-1.5 ft 8/2/2013 SO-DA-008(1.0-1.5)	SO-DA-009 0-0.5 ft 8/2/2013 SO-DA-009(0.0-0.5)
Analyte[1]	**CAS Number**	**Units**	**Is Analyte Screened Further?[2]**	**2001 USEPA Region 4 Soil ESV[3]**														
VOCs																		
Benzene	71-43-2	µg/kg	**Yes**	50		< 5 U	< 6 U	< 6 U	< 6 U	< 6 U	0.6 J	< 5 U	< 5 U	< 5 U	< 5 U	< 6 U	< 5 U	< 6 U
Toluene	108-88-3	µg/kg	**Yes**	50		< 5 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 5 U	< 5 U	< 5 U	< 5 U	< 6 U	< 5 U	< 6 U
Trichloroethene	79-01-6	µg/kg	No	1		< 5 U	**3 J**	**3 J**	**4 J**	**3 J**	**3 J**	< 5 U	< 5 U	< 5 U	< 5 U	1 J	< 5 U	< 6 U

Attachment I-3
Drainage Way Soil Sampling Results Screened against 2001 USEPA Region 4 Soil ESVs

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

				Location	SO-DA-009	SO-DA-009	SO-DA-010	SO-DA-010	SO-DA-010	SO-DA-010	SO-DA-011	SO-DA-011	SO-DA-011	SO-DA-012	SO-DA-012	SO-DA-012	SO-DA-013
				Depths (ft)	0.5-1 ft	1-1.5 ft	0-0.5 ft	0-0.5 ft	0.5-1 ft	1-1.5 ft	0-0.5 ft	0.5-1 ft	1-1.5 ft	0-0.5 ft	0.5-1 ft	1-1.5 ft	0-0.5 ft
				Sample Date	8/2/2013	8/2/2013	8/2/2013	8/2/2013	8/2/2013	8/2/2013	8/2/2013	8/2/2013	8/2/2013	8/1/2013	8/1/2013	8/1/2013	8/1/2013
				Sample ID	SO-DA-009(0.5-1.0)	SO-DA-009(1.0-1.5)	SO-DA-010(0.0-0.5)	SO-DA-DUP-02-080213FD	SO-DA-010(0.5-1.0)	SO-DA-010(1.0-1.5)	SO-DA-011(0.0-0.5)	SO-DA-011(0.5-1.0)	SO-DA-011(1.0-1.5)	SO-DA-012(0.0-0.5)	SO-DA-012(0.5-1.0)	SO-DA-012(1.0-1.5)	SO-DA-013(0.0-0.5)
Analyte[1]	**CAS Number**	**Units**	**Is Analyte Screened Further?[2]**	**2001 USEPA Region 4 Soil ESV[3]**													
VOCs																	
Benzene	71-43-2	µg/kg	**Yes**	50	< 5 U	< 6 U	< 6 U	< 8 U	< 5 U	< 6 U	< 6 U	< 5 U	< 5 U	< 6 U	< 5 U	< 5 U	< 5 U
Toluene	108-88-3	µg/kg	**Yes**	50	< 5 U	< 6 U	1 J	2 J	< 5 U	< 6 U	2 J	< 5 U	< 5 U	< 6 U	< 5 U	< 5 U	< 5 U
Trichloroethene	79-01-6	µg/kg	No	1	< 5 U	**2 J**	< 6 U	< 8 U	< 5 U	< 6 U	< 6 U	< 5 U	< 5 U	< 6 U	< 5 U	< 5 U	1 J

Attachment I-3
Drainage Way Soil Sampling Results Screened against 2001 USEPA Region 4 Soil ESVs

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

				Location	SO-DA-013	SO-DA-013	SO-DA-014	SO-DA-014	SO-DA-014	SO-DA-014	SO-DA-015	SO-DA-015	SO-DA-015
				Depths (ft)	0.5-1 ft	1-1.5 ft	0-0.5 ft	0-0.5 ft	0.5-1 ft	1-1.5 ft	0-0.5 ft	0.5-1 ft	1-1.5 ft
				Sample Date	8/1/2013	8/1/2013	8/1/2013	8/1/2013	8/1/2013	8/1/2013	8/1/2013	8/1/2013	8/1/2013
				Sample ID	SO-DA-013(0.5-1.0)	SO-DA-013(1.0-1.5)	SO-DA-014(0.0-0.5)	SO-DA-DUP-01-080113FD	SO-DA-014(0.5-1.0)	SO-DA-014(1.0-1.5)	SO-DA-015(0.0-0.5)	SO-DA-015(0.5-1.0)	SO-DA-015(1.0-1.5)
Analyte[1]	CAS Number	Units	Is Analyte Screened Further?[2]	2001 USEPA Region 4 Soil ESV[3]									
VOCs													
Benzene	71-43-2	µg/kg	**Yes**	50	< 5 U	< 5 U	< 6 U	< 6 U	< 5 U	< 4 U	34 J	< 6 U	< 6 U
Toluene	108-88-3	µg/kg	**Yes**	50	< 5 U	< 5 U	< 6 U	< 6 U	< 5 U	< 4 U	< 310 U	5 J	< 6 U
Trichloroethene	79-01-6	µg/kg	No	1	1 J	1 J	< 6 U	**2 J**	1 J	**2 J**	< 310 U	< 6 U	< 6 U

Attachment I-3
Drainage Way Soil Sampling Results Screened against 2001 USEPA Region 4 Soil ESVs

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

Notes:

1. For analytes that were detected in soil samples collected under the Downstream Areas Remedial Sampling Plan (ARCADIS 2013), but were not detected in crude oil samples, the data and associated ESVs are presented, if available, for completeness; however, the analytes were not evaluated further. In addition, only the PAHs associated with the risk screening (as discussed in Section 5) are presented in this table. Complete analytical data are included in Appendix F.
2. As discussed in Section 5 of the report, analytes are screened further if the analyte is associated with the crude oil at concentrations that could have resulted in the observed concentrations in soil. The following screening is utilized:
   Bold = Analyte above the soil ESV but not highlighted since the analyte was not detected in the crude oi
   Highlight = Analyte above the soil ESV
3. USEPA Region 4 Soil ESVs published in November 2001. Available at: http://www.epa.gov/region4/superfund/programs/riskassess/ecolbul.html

Acronyms and Abbreviations:

-- = not available or not applicable
ESV = ecological screening value
ft = foot/feet
µg/kg = micrograms per kilogram
USEPA = U.S. Environmental Protection Agency
VOC = volatile organic compound

Laboratory Data Qualifiers:

< = less than the reporting limit
J = The compound was positively identified; however, the associated numerical value is an estimated concentration only.
U = Compound was not detected.

Reference:

ARCADIS. 2013. Downstream Areas Remedial Sampling Plan. Mayflower Pipeline Incident, Mayflower, Arkansas. July

Attachment I-3
Dawson Cove Soil Sampling Results Screened against 2001 USEPA Region 4 Soil ESVs

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

			Location	SO-DA-016	SO-DA-016	SO-DA-016	SO-DA-017	SO-DA-017	SO-DA-017	SO-DA-018	SO-DA-018	SO-DA-018	SO-DA-018	SO-DA-019	SO-DA-019
			Depths (ft)	0-0.5 ft	0.5-1 ft	1-1.5 ft	0-0.5 ft	0.5-1 ft	1-1.5 ft	0-0.5 ft	0-0.5 ft	0.5-1 ft	1-1.5 ft	0-0.5 ft	0.5-1 ft
			Sample Date	8/6/2013	8/6/2013	8/6/2013	8/6/2013	8/6/2013	8/6/2013	8/6/2013	8/6/2013	8/6/2013	8/6/2013	8/8/2013	8/8/2013
			Sample ID	SO-DA-016(0.0-0.5)	SO-DA-016(0.5-1.0)	SO-DA-016(1.0-1.5)	SO-DA-017(0.0-0.5)	SO-DA-017(0.5-1.0)	SO-DA-017(1.0-1.5)	SO-DA-018(0.0-0.5)	SO-DA-DUP-03-080613FD	SO-DA-018(0.5-1.0)	SO-DA-018(1.0-1.5)	SO-DA-019(0.0-0.5)	SO-DA-019(0.5-1.0)
Chemical	**Units**	**Is Analyte Screened Further?[2]**	**2001 USEPA Region 4 Soil ESV[3]**												
VOCs															
Toluene	µg/kg	**Yes**	50	< 7 U	< 5 U	< 5 U	< 7 U	< 5 U	< 5 U	< 6 U	< 6 U	< 5 U	< 5 U	< 6 U	< 6 U
Trichloroethene	µg/kg	No	1	< 7 U	< 5 U	< 5 U	< 7 U	< 5 U	< 5 U	< 6 U	< 6 U	< 5 U	1 J	< 6 U	< 6 U

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Dawson Cove Soil Sampling Results Screened against 2001 USEPA Region 4 Soil ESVs

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

				Location	SO-DA-019	SO-DA-019	SO-DA-019	SO-DA-019	SO-DA-020	SO-DA-020	SO-DA-020	SO-DA-021	SO-DA-021	SO-DA-021	SO-DA-021	SO-DA-021
				Depths (ft)	1-1.5 ft	1.5-2 ft	2-3 ft	3-4 ft	0-0.5 ft	0.5-1 ft	1-1.5 ft	0-0.5 ft	0.5-1 ft	1-1.5 ft	1.5-2 ft	2-3 ft
				Sample Date	8/8/2013	8/8/2013	8/8/2013	8/8/2013	8/7/2013	8/7/2013	8/7/2013	8/8/2013	8/8/2013	8/8/2013	8/8/2013	8/8/2013
				Sample ID	SO-DA-019(1.0-1.5)	SO-DA-019(1.5-2.0)	SO-DA-019(2.0-3.0)	SO-DA-019(3.0-4.0)	SO-DA-020(0.0-0.5)	SO-DA-020(0.5-1.0)	SO-DA-020(1.0-1.5)	SO-DA-021(0.0-0.5)	SO-DA-021(0.5-1.0)	SO-DA-021(1.0-1.5)	SO-DA-021(1.5-2.0)	SO-DA-021(2.0-3.0)
Chemical	**Units**	**Is Analyte Screened Further?[2]**	**2001 USEPA Region 4 Soil ESV[3]**													
VOCs																
Toluene	µg/kg	**Yes**	50	< 5 U	< 6 U	< 6 U	< 9 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 5 U	< 5 U	< 7 U
Trichloroethene	µg/kg	No	1	< 5 U	1 J	1 J	< 9 U	1 J	1 J	1 J	< 6 U	< 6 U	**2 J**	**2 J**	**2 J**	

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Dawson Cove Soil Sampling Results Screened against 2001 USEPA Region 4 Soil ESVs

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

			Location	SO-DA-021	SO-DA-022	SO-DA-022	SO-DA-022	SO-DA-022	SO-DA-023	SO-DA-023	SO-DA-023	SO-DA-023	SO-DA-023	SO-DA-023
			Depths (ft)	3-4 ft	0-0.5 ft	0-0.5 ft	0.5-1 ft	1-1.5 ft	0-0.5 ft	0-0.5 ft	0.5-1 ft	1-1.5 ft	1.5-2 ft	2-3 ft	3-4 ft
			Sample Date	8/8/2013	8/7/2013	8/7/2013	8/7/2013	8/7/2013	8/8/2013	8/8/2013	8/8/2013	8/8/2013	8/8/2013	8/8/2013	8/8/2013
			Sample ID	SO-DA-021(3.0-4.0)	SO-DA-022(0.0-0.5)	SO-DA-DUP-04-080713FD	SO-DA-022(0.5-1.0)	SO-DA-022(1.0-1.5)	SO-DA-023(0.0-0.5)	SO-DA-DUP-05-080813FD	SO-DA-023(0.5-1.0)	SO-DA-023(1.0-1.5)	SO-DA-023(1.5-2.0)	SO-DA-023(2.0-3.0)	SO-DA-023(3.0-4.0)
Chemical	**Units**	**Is Analyte Screened Further?[2]**	**2001 USEPA Region 4 Soil ESV[3]**												
VOCs															
Toluene	µg/kg	**Yes**	50	< 6 U	< 7 U	2 J	< 6 U	< 7 U	< 7 U	< 6 U	< 5 U	< 5 U	< 6 U	< 5 U	< 6 U
Trichloroethene	µg/kg	No	1	**2 J**	**2 J**	< 6 U	**2 J**	**3 J**	**5 J**	**3 J**	**2 J**	**2 J**	**3 J**	**2 J**	**4 J**

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Dawson Cove Soil Sampling Results Screened against 2001 USEPA Region 4 Soil ESVs

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

			Location	SO-DA-024	SO-DA-024	SO-DA-024	SO-DA-025	SO-DA-025	SO-DA-025	SO-DA-026	SO-DA-026	SO-DA-026	SO-DA-027	SO-DA-027	SO-DA-027
			Depths (ft)	0-0.5 ft	0.5-1 ft	1-1.5 ft	0-0.5 ft	0.5-1 ft	1-1.5 ft	0-0.5 ft	0.5-1 ft	1-1.5 ft	0-0.5 ft	0.5-1 ft	1-1.5 ft
			Sample Date	8/8/2013	8/8/2013	8/8/2013	8/7/2013	8/7/2013	8/7/2013	8/11/2013	8/11/2013	8/11/2013	8/8/2013	8/8/2013	8/8/2013
			Sample ID	SO-DA-024(0.0-0.5)	SO-DA-024(0.5-1.0)	SO-DA-024(1.0-1.5)	SO-DA-025(0.0-0.5)	SO-DA-025(0.5-1.0)	SO-DA-025(1.0-1.5)	SO-DA-026-(0.0-0.5)	SO-DA-026-(0.5-1.0)	SO-DA-026-(1.0-1.5)	SO-DA-027(0.0-0.5)	SO-DA-027(0.5-1.0)	SO-DA-027(1.0-1.5)
Chemical	**Units**	**Is Analyte Screened Further?[2]**	**2001 USEPA Region 4 Soil ESV[3]**												
VOCs															
Toluene	µg/kg	**Yes**	50	< 5 U	< 5 U	< 6 U	< 8 U	< 5 U	< 5 U	< 6 U	< 6 U	< 7 U	< 6 U	< 5 U	< 6 U
Trichloroethene	µg/kg	No	1	**5 J**	**3 J**	**2 J**	< 8 U	1 J	< 5 U	**4 J**	1 J	**2 J**	**2 J**	**2 J**	**3 J**

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Dawson Cove Soil Sampling Results Screened against 2001 USEPA Region 4 Soil ESVs

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

			Location	SO-DA-028	SO-DA-028	SO-DA-028	SO-DA-029	SO-DA-029	SO-DA-029	SO-DA-032	SO-DA-032	SO-DA-032
			Depths (ft)	0-0.5 ft	0.5-1 ft	1-1.5 ft	0-0.5 ft	0.5-1 ft	1-1.5 ft	0-0.5 ft	0.5-1 ft	1-1.5 ft
			Sample Date	8/11/2013	8/11/2013	8/11/2013	8/11/2013	8/11/2013	8/11/2013	8/7/2013	8/7/2013	8/7/2013
			Sample ID	SO-DA-028-(0.0-0.5)	SO-DA-028-(0.5-1.0)	SO-DA-028-(1.0-1.5)	SO-DA-029-(0.0-0.5)	SO-DA-029-(0.5-1.0)	SO-DA-029-(1.0-1.5)	SO-DA-032(0.0-0.5)	SO-DA-032(0.5-1.0)	SO-DA-032(1.0-1.5)
Chemical	**Units**	**Is Analyte Screened Further?[2]**	**2001 USEPA Region 4 Soil ESV[3]**									
VOCs												
Toluene	µg/kg	**Yes**	50	< 9 U	< 5 U	< 5 U	< 7 U	< 6 U	< 5 U	< 8 U	< 5 U	< 7 U
Trichloroethene	µg/kg	No	1	< 9 U	< 5 U	**2 J**	< 7 U	< 6 U	< 5 U	< 8 U	< 5 U	< 7 U

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Dawson Cove Soil Sampling Results Screened against 2001 USEPA Region 4 Soil ESVs

Downstream Areas Data Assessment Report
ExxonMobil Environmental Services Company
Mayflower Pipeline Incident Response, Mayflower, Arkansas

Notes:

1. For analytes that were detected in soil samples collected under the Downstream Areas Remedial Sampling Plan (ARCADIS 2013), but were not detected in crude oil samples, the data and associated ESVs are presented, if available, for completeness; however, the analytes were not evaluated further. In addition, only the PAHs associated with the risk screening (as discussed in Section 5) are presented in this table. Complete analytical data are included in Appendix F.
2. As discussed in Section 5 of the report, analytes are screened further if the analyte is associated with the crude oil at concentrations that could have resulted in the observed concentrations in soil. The following screening is utilized:
   Bold = Analyte above the soil ESV but not highlighted since the analyte was not detected in the crude oi
   Highlight = Analyte above the soil ESV
3. USEPA Region 4 Soil ESVs published in November 2001. Available at: http://www.epa.gov/region4/superfund/programs/riskassess/ecolbul.htm

Acronyms and Abbreviations:

-- = not available or not applicable
ESV = ecological screening value
ft = foot/feet
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USEPA = U.S. Environmental Protection Agency
VOC = volatile organic compound

Laboratory Data Qualifiers:

< = less than the reporting limit
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Reference:

ARCADIS. 2013. Downstream Areas Remedial Sampling Plan. Mayflower Pipeline Incident, Mayflower, Arkansas. July