



Memorandum

To: Keegan Roberts, John Wondolleck

From: Todd Burgesser

Date: October 8, 2015

Subject: An Evaluation of Chemicals of Natural Origin on Reported Total Petroleum Hydrocarbon Concentrations at the Santa Susana Field Laboratory

This paper addresses the efficacy of EPA analytical Method 8015M to accurately report petroleum related chemicals termed Total Petroleum Hydrocarbons (TPH) in Area IV soils¹. The California Department of Toxic Substances has identified 5 milligram/kilogram (mg/kg) as the proposed soil cleanup standard for TPH. As described in this memorandum, this cleanup standard is neither technically achievable nor defensible.

The data used in this evaluation are from Area IV soil samples collected from May 2014 to June 2014 as part of the Phase 3 data gap soil sampling efforts. Based on the reporting of elevated TPH results in samples collected from Area IV locations with no history of facility operations, CDM Smith directed the contracted laboratories (EMAX and Lancaster) to prepare two extracts from each soil sample, and to perform a “cleanup” on one of the extracts prior to analysis. This cleanup was intended to aid in identifying the presence of organic matter that could be mistakenly reported in sample results as TPH. Each sample extract (with and without the cleanup step) was analyzed and reported separately. This exercise used SW-846 Method 3630 as the extract cleanup method and SW-846 Method 8015M as the analytical method for both TPH analyses of the extracts.

EPA SW-846 Method 8015M for TPH uses a gas chromatograph (GC) for compound separation and a flame ionization detector (FID) for compound detection. The FID is not very selective and will produce a signal for any compound that contains a carbon atom in the sample extract. Chemical quantitation is accomplished by integrating the area underneath the peaks between specific retention times (a range). This procedure is not compound specific and does not rely on pattern recognition, such as is done for the analysis of PCBs, resulting in non-TPH compounds contributing to the reported result. This means that the method reports the presence of any chemical within the analyzed-for carbon range, including naturally occurring organic matter (NOM) chemicals that are not TPH related. Additional preparation of the sample extract is required to remove chemicals not TPH related in order to determine the presence of TPH.

¹ Also termed Extractable Fuel Hydrocarbons (EFH)

In an attempt to more accurately quantify TPH in soil samples, additional sample extract preparation is required to remove NOM prior to analyses. EPA SW-846 sample preparation Method 3630 uses silica gel to remove polar molecules from the extract (TPH chemicals are primarily non-polar). Silica gel is a regenerative adsorbent with weakly acidic properties containing sodium silicate and sulfuric acid. Silica gel functions by separating compounds based on their polarity, in effect removing potentially naturally occurring polar organic materials and retaining fuel hydrocarbons and other non-polar chemicals for analysis.

Analytical Procedure

A total of 186 soil samples were subjected to the SW 846 8015/3630 dual extract analyses. Soil samples were prepared for analysis by the contracted laboratories (EMAX and Lancaster Laboratories) by extracting an aliquot of soil (25 to 30 grams) with methylene chloride. The methylene chloride extract was then concentrated down to a volume of 10 milliliters (mL). The extract was split with one half analyzed directly by SW-846 method 8015M and the other half of the extract subjected to a silica gel cleanup followed by 8015M analysis.

Data Analysis

TPH is a mixture of chemicals that are identified by the number of carbon atoms each compound contains. The lighter weight compounds have fewer carbon atoms and the heavier compounds have a greater number of carbon atoms. The first column of Table 1 lists the carbon ranges used in this analysis of TPH.

The results of the soil analyses are consistent with knowledge of the site, particularly the results of the soil treatability studies. The lighter (less carbon) compounds have either degraded or volatilized from Area IV soils, while the heavier compounds have remained. TPH of carbon ranges 8-11 and 12-14 was reported in only 6 and 3 of 186 samples, respectively. However, for the heavier compounds (those with carbon ranges greater than 15), TPH was reported in 57, 143, and 136 of 186 samples, respectively.

Table 1 also includes a summary of the calculated NOM concentration contained in the Area IV soil samples. The NOM concentration was calculated by subtracting the post-silica gel cleanup step analysis results from the pre-cleanup step analysis results. The difference reflects the non-TPH contribution of the 8015 analysis of the sample.

The data presented in the last four columns of Table 1 include all data that had detections above the method reporting limit (MRL). The calculated NOM contributions for individual samples are provided in Tables 2 through 6 for each of the carbon ranges.

Table 1 Summary of TPH Results					
Parameter	Total Number of Soil Samples	Number of Samples with TPH Reported Above MDL (no extract cleanup)	Average NOM concentration (Result without cleanup – with cleanup) (mg/kg)	Minimum Reported NOM concentration (Result without cleanup – with cleanup) (mg/kg)	Maximum Reported NOM concentration (Result without cleanup – with cleanup) (mg/kg)
C8-C11	186	6	5	2	13
C12-C14	186	3	3	2	3.5
C15-C20	186	57	8	1	68
C21-C30	186	143	22	0	260
C30-C40	186	136	38	0	300

The hydrocarbons that were removed during the extract cleanup step are presumed to be naturally occurring hydrocarbons of a polar nature. This presumption is based on the acceptable recoveries of spiked hydrocarbons in the matrix spike and matrix spike duplicate samples analyzed. Non-polar NOM are not removed during this cleanup procedure and may be contributing to the total mass of TPH reported. Based on these results the silica gel cleanup procedure is effective in removing some of the polar compounds that are not TPH, but non-polar compounds may still be contributing to the total TPH reported in the site soil samples.

Although this evaluation confirmed the removal of some NOM in site soils using the silica gel cleanup, some questions still remain regarding the reliance of data produced by these methods and laboratories in support of soil cleanup levels. The current look-up-table (LUT) value for TPH is 5 mg/kg and background levels for TPH were not established. Significant quantities of non-polar NOM compounds may remain in sample extracts following the silica gel cleanup and contribute to the “TPH” concentrations reported by the laboratories.

Method precision limits between laboratories using the silica gel cleanup have not been established. SW-846 Method 8015C does not provide specific details/requirements to the user regarding instrument conditions, sample quantitation procedures and extract cleanup methods to allow for acceptable inter-laboratory precision when analyzing environmental samples to approaching the LUT of 5 mg/kg.

During the soil treatability study (bio-remediation) soils were analyzed at predetermined intervals to estimate degradation rates after the soils had been augmented with various supplements. EMAX laboratories analyzed the samples collected at day zero and day 126, Lancaster Laboratories Inc. (LLI) analyzed 24 samples collected on day 244. As expected the sample collected on day 126 showed decreased concentration or relatively no change in total TPH when compared to day 0. On

day 244 (the samples analyzed by LLI) showed significant increases of TPH (between 1.9 and 11 times greater) when compared to days zero and 126. These increases are due in significant part to inconsistencies in the method used and indicate a serious lack of inter-laboratory precision. As a result, California Polytechnic State University (Cal Poly) conducted a study (Nelson, et. al, 2015) intended in part to evaluate the silica gel cleanup method followed by the laboratory (EMAX) contracted to perform TPH analysis for the soil treatability studies. Cal Poly was not able to replicate results reported by EMAX for the five site soils tested. Nelson et al, 2015 concluded that "Reliable TPH measurements near background TPH levels or near the 5 mg/kg look-up table value for Area IV would be nearly impossible". Although both laboratories contracted to perform chemical analyses for the Department of Energy (DOE) have been certified to perform this method in the state of California this method used for this analysis does not rigorous enough ensure acceptable inter-laboratory precision.

Conclusion

The results of the comparison of sample extract pre-cleanup and post-cleanup TPH analysis in Area IV soils demonstrates that SW846 Method 8015M is not compound specific or adequate enough to allow quantification of TPH in soil near 5 mg/kg concentrations. Use of Method 3630 to remove polar compounds from the soil extract demonstrates a strong contribution of naturally occurring matter to the analytical results. In addition, use of the silica gel cleanup step by two laboratories has shown poor inter-laboratory precision and poor effectiveness of removing a significant portion of non-polar natural organic material from site soil extracts. The maximum calculated possible NOM result of 300 mg/kg should be considered the minimum LUT value for site soils. However, there remains a large technical uncertainty whether at this concentration the methods are accurately reporting the actual TPH concentration in soil.

Nelson, Y.M., Cronin, S., Cochran, K., and Varni, A., 2015. Chemical Characterization of Residual Fuel Hydrocarbons in Soils at the Santa Susana Field Laboratory, Final Report. July 31.

Table 2 Carbon Range C8 to C11 Results – Detections Only			
Sample ID	Result TPH (C8-C11) without Cleanup mg/kg	Result TPH with Cleanup (C8-C11) mg/kg	NOM (Difference)
FDG2-SL-612-SA5D-SB-0.0-0.5	13 J	5.1 U	13
FDG2-SL-565-NBZ-SB-0.0-0.5	6.4	5.1 U	6.4
FDG2-SL-625-SA8-SB-0.0-0.5	3.8 J	5.1 U	3.8
STS-SPT-SO-SRBS1116-SA6-0.0-0.5-A	2.6 J	5.1 U	2.6
SL-699-SA5B-TR-0.5	7.9	5.6	2.3
FDG2-SL-613-SA5D-SB-0.0-0.5	2.1 J	5.2 U	2.1

Table 3 Carbon Range C12 to C14 Results – Detections Only			
Sample ID	Result TPH (C12-C14) without Cleanup mg/kg	Result TPH (C12-C14) with Cleanup mg/kg	NOM (Difference)
FDG2-SL-626-SA8-SB-4.0-5.0	6.8	3.3 J	3.5
SL-699-SA5B-TR-0.5	7.6	4.6 J	3
FDG2-SL-565-NBZ-SB-0.0-0.5	2.4 J	5.1 U	2.4

NOM - Naturally Occurring Material

Table 4 Carbon Range C15 to C20 Results – Detections Only			
Sample ID	Result TPH (C15-C20) without Cleanup mg/kg	Result TPH (C15-C20) with Cleanup mg/kg	NOM (Difference)
STS-SPT-SO-SL311-SA6-0.0-0.5-DUP	96	28	68
STS-SPT-SO-SL311-SA6-0.0-0.5-B	41	5 U	41
STS-SPT-SO-SL311-SA6-0.0-0.5-D	170	140	30
FDG2-SL-568-NBZ-SB-0.0-0.5	27	5.3 U	27
STS-SPT-SO-SL311-SA6-0.0-0.5-A	74	49	25
FDG2-SL-612-SA5D-SB-0.0-0.5	20 J	5.1 U	20
SL-699-SA5B-TR-0.5	36	16	20

Table 4 Carbon Range C15 to C20 Results – Detections Only			
Sample ID	Result TPH (C15-C20) without Cleanup mg/kg	Result (TPH (C15-C20) with Cleanup mg/kg	NOM (Difference)
FDG2-SL-566-NBZ-SB-0.0-0.5	23 J	5.5	17.5
FDG2-SL-573-NBZ-SB-0.0-0.5	14 J	5 U	14
FDG2-SL-885-SA5D-SB-0.0-0.5	13 J	10 U	13
FDG2-SL-571-NBZ-SB-0.0-0.5	11 J	5.3 U	11
FDG2-SL-626-SA8-SB-4.0-5.0	16	5.1 J	10.9
FDG2-SL-613-SA5D-SB-0.0-0.5	9.1	5.2 U	9.1
STS-SPT-SO-SL311-SA6-0.0-0.5-C	63	55	8
FDG2-SL-631-SA8-SB-4.5-5.0	7.5	5.5 U	7.5
FDG2-SL-572-NBZ-SB-0.0-0.5	7.3	5 U	7.3
FDG2-SL-565-NBZ-SB-0.0-0.5	6.7	5.1 U	6.7
FDG2-SL-560-NBZ-SB-0.0-0.5	5.6	5.1 U	5.6
FDG2-SL-625-SA8-SB-0.0-0.5	5.1 J	5.1 U	5.1
FDG2-SL-930-SA8-SB-4.0-5.0	4.8 J	5.5 U	4.8
FDG2-SL-575-NBZ-SB-0.0-0.5	4.5 J	5 U	4.5
FDG2-SL-631-SA8-SB-0.0-0.5	4.5 J	5.3 U	4.5
SL-503-SA5C-TR-0.5	4.3 J	5.3 U	4.3
FDG2-SL-574-NBZ-SB-0.0-0.5	4.2 J	5.1 U	4.2
FDG2-SL-628-SA8-SB-0.0-0.5	4.2 J	5.2 U	4.2
FDG2-SL-561-NBZ-SB-0.0-0.5	4.1 J	5 U	4.1
FDG2-SL-582-NBZ-SB-0.0-0.5	3.7 J	5.2 U	3.7
FDG2-SL-630-SA8-SB-4.0-5.0	3.7 J	5.5 U	3.7
FDG2-SL-564-NBZ-SB-0.0-0.5	3.6 J	5.1 U	3.6
FDG2-SL-585-NBZ-SB-0.0-0.5	3.5 J	5.1 U	3.5
FDG2-SL-630-SA8-SB-7.0-8.0	3.4 J	5.4 U	3.4
SL-529-SA5B-TR-11.0	7.9 J	4.6 J	3.3
FDG2-SL-562-NBZ-SB-0.0-0.5	3.3 J	6.2 U	3.3
FDG2-SL-630-SA8-SB-0.0-0.5	3.3 J	5.2 U	3.3
SL-699-SA5B-TR-3.0	3.3 J	5.3 U	3.3
STS-SPT-SO-SL225-SA5B-0.0-0.5-B	3.2 J	5.1 U	3.2
FDG2-SL-584-SA5D-SB-0.0-0.5	3.1 J	5.2 U	3.1
SL-686-SA6-TR-0.5	3.1 J	5.1 U	3.1
FDG2-SL-577-NBZ-SB-0.0-0.5	3 J	5.1 U	3

Table 4 Carbon Range C15 to C20 Results – Detections Only			
Sample ID	Result TPH (C15-C20) without Cleanup mg/kg	Result (TPH (C15-C20) with Cleanup mg/kg	NOM (Difference)
STS-SPT-SO-SL225-SA5B-0.0-0.5-D	3 J	5.1 U	3
FDG2-SL-631-SA8-SB-7.0-8.0	2.9 J	6 U	2.9
STS-PHY-SO-02_LS_C-0.0-1.5	2.9 J	5.2 U	2.9
STS-PHY-SO-08_SM_BB-0.0-1.5	2.9 J	5.1 U	2.9
FDG2-SL-576-NBZ-SB-0.0-0.5	2.8 J	5.1 U	2.8
FDG2-SL-623-SA8-SB-0.0-0.5	2.8 J	5.4 U	2.8
FDG2-SL-629-SA8-SB-0.0-0.5	2.8 J	5.1 U	2.8
FDG2-SL-581-NBZ-SB-0.0-0.5	2.6 J	5.3 U	2.6
FDG2-SL-567-NBZ-SB-0.0-0.5	2.4 J	5.1 U	2.4
FDG2-SL-626-SA8-SB-0.0-0.5	2.3 J	5.1 U	2.3
FDG2-SL-694-SA6-SB-0.0-0.5	2.3 J	5 U	2.3
FDG2-SL-878-SA5A-SB-0.0-0.5	2.3 J	5.1 U	2.3
SL-605-SA5C-TR-0.5	2.3 J	5.3 U	2.3
FDG2-SL-691-SA6-SB-0.0-0.5	2.2 J	5 U	2.2
FDG2-SL-614-SA5D-SB-0.0-0.5	2.1 J	5.1 U	2.1
FDG2-SL-624-SA8-SB-0.0-0.5	2.1 J	5.1 U	2.1
STS-PHY-SO-18_CB_A-0.0-1.5	7.6	6.3	1.3
STS-SPT-SO-SRBS1116-SA6-0.0-0.5-DUP	14	13	1

NOM - Naturally Occurring Material

Table 5 Carbon Range C21 to C30 Results – Detections Only			
Sample ID	Result TPH (C21-C30) without Cleanup mg/kg	Result TPH with Cleanup (C21-C30) mg/kg	NOM (Difference)
STS-SPT-SO-SL311-SA6-0.0-0.5-A	800	540	260
STS-SPT-SO-SL311-SA6-0.0-0.5	660	500	160
STS-SPT-SO-SL311-SA6-0.0-0.5-D	1100	940	160
FDG2-SL-566-NBZ-SB-0.0-0.5	210	61	149
FDG2-SL-612-SA5D-SB-0.0-0.5	140	10	130
STS-SPT-SO-SL311-SA6-0.0-0.5-B	500	370	130

Table 5 Carbon Range C21 to C30 Results – Detections Only			
Sample ID	Result TPH (C21-C30) without Cleanup mg/kg	Result TPH with Cleanup (C21-C30) mg/kg	NOM (Difference)
FDG2-SL-568-NBZ-SB-0.0-0.5	130	4.9 J	125.1
STS-SPT-SO-SL311-SA6-0.0-0.5-C	610	500	110
STS-SPT-SO-SL311-SA6-0.0-0.5-DUP	650	540	110
FDG2-SL-885-SA5D-SB-0.0-0.5	150	55	95
FDG2-SL-573-NBZ-SB-0.0-0.5	100	27	73
FDG2-SL-626-SA8-SB-4.0-5.0	69	5.3 U	69
FDG2-SL-571-NBZ-SB-0.0-0.5	71	12	59
FDG2-SL-572-NBZ-SB-0.0-0.5	62	14	48
FDG2-SL-560-NBZ-SB-0.0-0.5	59	12	47
FDG2-SL-613-SA5D-SB-0.0-0.5	48	2.2 J	45.8
FDG2-SL-625-SA8-SB-0.0-0.5	49	3.9 J	45.1
FDG2-SL-565-NBZ-SB-0.0-0.5	45	3.3 J	41.7
SL-699-SA5B-TR-0.5	64	23	41
FDG-SL-836-SA5B-SB-19.0-20.0	130	94	36
FDG2-SL-631-SA8-SB-4.5-5.0	36	3 J	33
FDG2-SL-561-NBZ-SB-0.0-0.5	44	16	28
FDG2-SL-628-SA8-SB-0.0-0.5	27	3.9 J	23.1
FDG2-SL-631-SA8-SB-0.0-0.5	25	2.3 J	22.7
STS-SPT-SO-SL225-SA5B-0.0-0.5-B	48	26	22
FDG2-SL-574-NBZ-SB-0.0-0.5	25	3.9 J	21.1
SL-529-SA5B-TR-11.0	49	28	21
FDG2-SL-564-NBZ-SB-0.0-0.5	23	2.5 J	20.5
FDG2-SL-629-SA8-SB-0.0-0.5	24	3.8 J	20.2
SL-503-SA5C-TR-0.5	20	5.3 U	20
FDG2-SL-582-NBZ-SB-0.0-0.5	22	3 J	19
FDG2-SL-569-NBZ-SB-0.0-0.5	18	5 U	18
FDG2-SL-585-NBZ-SB-0.0-0.5	18	5.1 U	18
SL-686-SA6-TR-0.5	30	12	18
FDG2-SL-630-SA8-SB-0.0-0.5	21	3.3 J	17.7
FDG2-SL-878-SA5A-SB-0.0-0.5	24	6.5	17.5
FDG2-SL-874-SA5A-SB-4.0-5.0	16	5.4 U	16
FDG2-SL-876-SA5A-SB-0.0-0.5	32	16	16

Table 5 Carbon Range C21 to C30 Results – Detections Only			
Sample ID	Result TPH (C21-C30) without Cleanup mg/kg	Result TPH with Cleanup (C21-C30) mg/kg	NOM (Difference)
FDG2-SL-930-SA8-SB-4.0-5.0	35	19	16
STS-SPT-SO-SL225-SA5B-0.0-0.5-D	49	33	16
FDG2-SL-577-NBZ-SB-0.0-0.5	18	2.1 J	15.9
SL-730-SA5A-TR-0.5	18	2.1 J	15.9
FDG2-SL-584-NBZ-SB-0.0-0.5	22	6.8	15.2
FDG2-SL-630-SA8-SB-7.0-8.0	24	8.8	15.2
SL-529-SA5B-TR-0.5	33	18	15
STS-SPT-SO-SL225-SA5B-0.0-0.5	38	23	15
STS-SPT-SO-SL225-SA5B-0.0-0.5-DUP	40	25	15
FDG2-SL-576-NBZ-SB-0.0-0.5	18	3.1 J	14.9
SL-587-SA5A-TR-0.5	29	15	14
SL-707-SA5B-TR-0.5	14	5.1 U	14
STS-SPT-SO-SL225-SA5B-0.0-0.5-A	35	21	14
FDG2-SL-623-SA8-SB-0.0-0.5	13	5.4 U	13
FDG2-SL-691-SA6-SB-0.0-0.5	13	5 U	13
SL-611-SA8-TR-0.5	42	29	13
STS-SPT-SO-SL225-SA5B-0.0-0.5-C	33	20	13
FDG2-SL-567-NBZ-SB-0.0-0.5	16	3.1 J	12.9
FDG2-SL-586-NBZ-SB-0.0-0.5	12	5.1 U	12
FDG2-SL-624-SA8-SB-0.0-0.5	12	5.1 U	12
FDG2-SL-630-SA8-SB-4.0-5.0	26	14	12
STS-PHY-SO-02_LS_C-0.0-1.5	59	47	12
STS-SPT-SO-SRBS1116-SA6-0.0-0.5-DUP	110	98	12
FDG2-SL-562-NBZ-SB-0.0-0.5	14	2.6 J	11.4
FDG2-SL-628-SA8-SB-4.0-5.0	15	3.7 J	11.3
FDG2-SL-614-SA5D-SB-0.0-0.5	14	2.8 J	11.2
FDG2-SL-1174-SA5A-SB-4.0-5.0	11	5.4 U	11
FDG2-SL-586-SA5D-SB-0.0-0.5	11	5.2 U	11
STS-PHY-SO-08_SM_BB-0.0-1.5	51	40	11
FDG2-SL-878-SA5A-SB-4.0-5.0	13	2.1 J	10.9
FDG-SL-798-SA5B-SB-0.0-0.5	19	8.5	10.5
FDG2-SL-575-NBZ-SB-0.0-0.5	20	9.8	10.2

Table 5 Carbon Range C21 to C30 Results – Detections Only			
Sample ID	Result TPH (C21-C30) without Cleanup mg/kg	Result TPH with Cleanup (C21-C30) mg/kg	NOM (Difference)
FDG2-SL-875-SA5A-SB-0.0-0.5	16	5.8	10.2
FDG2-SL-692-SA6-SB-0.0-0.5	10	5.1 U	10
SL-651-SA5C-TR-0.5	10	5.2 U	10
FDG2-SL-694-SA6-SB-0.0-0.5	9.9	5 U	9.9
FDG2-SL-695-SA6-SB-0.0-0.5	9.7	5 U	9.7
FDG2-SL-583-NBZ-SB-0.0-0.5	9.5	5 U	9.5
FDG2-SL-1175-SA5A-SB-2.0-3.0	13	3.6 J	9.4
SL-699-SA5B-TR-3.0	9.4	5.3 U	9.4
FDG2-SL-584-SA5D-SB-0.0-0.5	30	21	9
FDG2-SL-631-SA8-SB-7.0-8.0	8.9	6 U	8.9
FDG2-SL-581-NBZ-SB-0.0-0.5	8.6	5.3 U	8.6
FDG2-SL-693-SA6-SB-0.0-0.5	12	3.4 J	8.6
FDG2-SL-626-SA8-SB-0.0-0.5	8.5	5.1 U	8.5
FDG2-SL-582-NBZ-SB-3.0-3.5	8.1	5.5 U	8.1
SL-611-SA8-TR-10.5	8.1	5.6 U	8.1
STS-PHY-SO-02_LS_D-0.0-1.0	8.1	5 U	8.1
FDG2-SL-576-NBZ-SB-2.0-3.0	7.8	5.2 U	7.8
SL-570-SA6-TR-0.5	7.5	5.2 U	7.5
FDG2-SL-563-NBZ-SB-0.0-0.5	7.2	5.1 U	7.2
FDG2-SL-875-SA5A-SB-2.0-3.0	33	26	7
SL-636-SA5A-TR-0.5	13	6	7
SL-529-SA5B-TR-2.0	10	3.2 J	6.8
SL-693-SA5B-TR-0.5	6.8	5.1 U	6.8
FDG2-SL-877-SA5A-SB-0.0-0.5	6.7	5 U	6.7
STS-PHY-SO-06_PG_B-0.0-1.0	6.7	5.1 U	6.7
SL-693-SA5B-TR-3.0	6.5	5.2 U	6.5
SL-529-SA5B-TR-3.0	14	7.7	6.3
SL-653-SA5C-TR-15.0	6.3	5.2 U	6.3
SL-605-SA5C-TR-0.5	10	3.9 J	6.1
SL-611-SA8-TR-5.0	6.1	5.5 U	6.1
SL-548-SA8-TR-0.5	6	5.5 U	6
STS-PHY-SO-08_SM_CC-0.0-1.0	19	13	6

Table 5 Carbon Range C21 to C30 Results – Detections Only			
Sample ID	Result TPH (C21-C30) without Cleanup mg/kg	Result TPH with Cleanup (C21-C30) mg/kg	NOM (Difference)
FDG2-SL-570-NBZ-SB-0.0-0.5	5.6	5 U	5.6
FDG-SL-842-SA5B-SB-4.0-5.0	5.6	5.3 U	5.6
SL-646-SA5C-TR-0.5	5.6	5.1 U	5.6
STS-PHY-SO-01_BE_D-0.0-1.5	5.6	5.1 U	5.6
STS-PHY-SO-04_MF_B-0.0-1.0	13	7.8	5.2
SL-605-SA5C-TR-5.0	8.5	3.5 J	5
SL-693-SA5B-TR-5.0	5 J	5.3 U	5
STS-SPT-SO-SRBS1116-SA6-0.0-0.5-D	54	49	5
SL-636-SA5A-TR-3.5	4.8 J	5.3 U	4.8
STS-PHY-SO-17_NM_D-0.0-1.5	4.8 J	5.1 U	4.8
FDG2-SL-585-SA5D-SB-0.0-0.5	7.3	2.7 J	4.6
SL-534-SA8-TR-0.5	4.6 J	5.2 U	4.6
SL-651-SA5C-TR-5.0	4.6 J	5.2 U	4.6
STS-PHY-SO-23_YS_D-0.0-1.5	4.4 J	5.1 U	4.4
STS-PHY-SO-08_SM_D-0.0-1.0	4 J	5 U	4
STS-PHY-SO-308_SM_CC-0.0-1.0	15	11	4
STS-PHY-SO-35_NG_C-0.0-1.0	6.7	2.9 J	3.8
FDG-SL-841-SA5B-SB-4.0-5.0	3.7 J	5.5 U	3.7
SL-605-SA5C-TR-10.0	3.5 J	5.5 U	3.5
SL-655-SA5C-TR-0.5	3.5 J	5.3 U	3.5
STS-PHY-SO-35_NG_D-0.0-1.0	3.5 J	5.3 U	3.5
FDG-SL-836-SA5B-SB-15.0-16.0	3.4 J	5.9 U	3.4
SL-651-SA5C-TR-10.0	3.2 J	5.3 U	3.2
SL-707-SA5B-TR-3.0	3.2 J	5.2 U	3.2
STS-SPT-SO-SRBS1116-SA6-0.0-0.5-C	45	42	3
SL-848-SA8-TR-5.0	2.9 J	5.7 U	2.9
STS-PHY-SO-18_CB_D-0.0-1.0	6.6	3.9 J	2.7
FDG-SL-842-SA5B-SB-0.0-0.5	4.9 J	2.3 J	2.6
STS-PHY-SO-06_PG_D-0.0-1.0	12	9.7	2.3
SL-646-SA5C-TR-5.0	2.3 J	5.2 U	2.3
STS-PHY-SO-23_YS_C-0.0-0.5	7.3	5.2	2.1
STS-PHY-SO-23_YS_A-0.0-1.5	18	16	2

Table 5 Carbon Range C21 to C30 Results – Detections Only			
Sample ID	Result TPH (C21-C30) without Cleanup mg/kg	Result TPH with Cleanup (C21-C30) mg/kg	NOM (Difference)
STS-SPT-SO-SRBS1116-SA6-0.0-0.5	34	32	2
STS-SPT-SO-SRBS1116-SA6-0.0-0.5-B	60	58	2
FDG2-SL-628-SA8-SB-14.0-15.0	4.1 J	2.4 J	1.7
STS-PHY-SO-35_NG_A_0.0-1.0	5.1	3.4 J	1.7
STS-PHY-SO-35_NG_B_0.0-1.0	7	5.4	1.6
STS-PHY-SO-04_MF_D-0.0-1.5	6.1	4.9 J	1.2
STS-PHY-SO-02_LS_B-0.0-1.0	14	13	1
STS-PHY-SO-17_NM_BB-0.0-1.0	12	11	1
STS-PHY-SO-01_BE_A-0.0-1.5	15	15	0

Table 6 Carbon Range C21 to C30 Results – Detections Only			
Sample ID	Result TPH (C30-C40) without Cleanup mg/kg	Result (TPH (C30-C40) with Cleanup mg/kg	NOM (Difference)
FDG2-SL-566-NBZ-SB-0.0-0.5	400	100	300
FDG2-SL-573-NBZ-SB-0.0-0.5	320	56	264
FDG2-SL-568-NBZ-SB-0.0-0.5	260	8.3 J	251.7
FDG2-SL-885-SA5D-SB-0.0-0.5	350	100	250
FDG2-SL-612-SA5D-SB-0.0-0.5	250	26	224
FDG2-SL-571-NBZ-SB-0.0-0.5	140	10 J	130
FDG-SL-836-SA5B-SB-19.0-20.0	310	210	100
FDG2-SL-561-NBZ-SB-0.0-0.5	99	7.2 J	91.8
FDG2-SL-560-NBZ-SB-0.0-0.5	96	5 J	91
STS-SPT-SO-SL311-SA6-0.0-0.5	300	210	90
FDG2-SL-572-NBZ-SB-0.0-0.5	98	14	84
STS-SPT-SO-SL311-SA6-0.0-0.5-B	200	120	80
FDG2-SL-613-SA5D-SB-0.0-0.5	82	4.2 J	77.8
FDG2-SL-625-SA8-SB-0.0-0.5	86	8.3 J	77.7
FDG2-SL-631-SA8-SB-4.5-5.0	80	7.4 J	72.6
FDG2-SL-582-NBZ-SB-0.0-0.5	73	6.2 J	66.8

Table 6 Carbon Range C21 to C30 Results – Detections Only			
Sample ID	Result TPH (C30-C40) without Cleanup mg/kg	Result (TPH (C30-C40) with Cleanup mg/kg	NOM (Difference)
FDG2-SL-876-SA5A-SB-0.0-0.5	90	25	65
STS-PHY-SO-08_SM_BB-0.0-1.5	98	34	64
FDG2-SL-565-NBZ-SB-0.0-0.5	61	4.8 J	56.2
SL-529-SA5B-TR-11.0	110	58	52
SL-587-SA5A-TR-0.5	87	37	50
SL-730-SA5A-TR-0.5	50	10 U	50
STS-PHY-SO-02_LS_C-0.0-1.5	100	51	49
FDG2-SL-878-SA5A-SB-0.0-0.5	53	4.6 J	48.4
STS-SPT-SO-SL225-SA5B-0.0-0.5-DUP	81	34	47
FDG2-SL-629-SA8-SB-0.0-0.5	46	10 U	46
FDG2-SL-628-SA8-SB-0.0-0.5	51	5.5 J	45.5
SL-686-SA6-TR-0.5	55	10	45
SL-529-SA5B-TR-0.5	83	40	43
SL-699-SA5B-TR-0.5	65	22	43
STS-SPT-SO-SL225-SA5B-0.0-0.5-B	79	36	43
STS-SPT-SO-SL225-SA5B-0.0-0.5	72	30	42
FDG2-SL-631-SA8-SB-0.0-0.5	46	4.6 J	41.4
FDG2-SL-875-SA5A-SB-0.0-0.5	58	17	41
FDG2-SL-577-NBZ-SB-0.0-0.5	40	10 U	40
FDG2-SL-585-NBZ-SB-0.0-0.5	40	10 U	40
FDG2-SL-930-SA8-SB-4.0-5.0	61	21	40
STS-SPT-SO-SL311-SA6-0.0-0.5-DUP	260	220	40
FDG2-SL-630-SA8-SB-7.0-8.0	50	11	39
FDG2-SL-567-NBZ-SB-0.0-0.5	37	10 U	37
FDG2-SL-569-NBZ-SB-0.0-0.5	37	10 U	37
FDG2-SL-584-NBZ-SB-0.0-0.5	36	10 U	36
FDG2-SL-576-NBZ-SB-0.0-0.5	35	10 U	35
FDG2-SL-626-SA8-SB-4.0-5.0	35	11 U	35
SL-503-SA5C-TR-0.5	35	11 U	35
FDG2-SL-574-NBZ-SB-0.0-0.5	38	5.7 J	32.3
FDG2-SL-562-NBZ-SB-0.0-0.5	32	12 U	32
FDG2-SL-874-SA5A-SB-4.0-5.0	31	11 U	31

Table 6 Carbon Range C21 to C30 Results – Detections Only			
Sample ID	Result TPH (C30-C40) without Cleanup mg/kg	Result (TPH (C30-C40) with Cleanup mg/kg	NOM (Difference)
FDG2-SL-575-NBZ-SB-0.0-0.5	46	16	30
FDG2-SL-586-NBZ-SB-0.0-0.5	30	10 U	30
FDG2-SL-630-SA8-SB-0.0-0.5	35	5.2 J	29.8
FDG-SL-798-SA5B-SB-0.0-0.5	38	8.9 J	29.1
SL-636-SA5A-TR-0.5	43	14	29
STS-PHY-SO-06_PG_D-0.0-1.0	35	6.1 J	28.9
FDG2-SL-630-SA8-SB-4.0-5.0	42	14	28
FDG2-SL-878-SA5A-SB-4.0-5.0	28	10 U	28
FDG2-SL-614-SA5D-SB-0.0-0.5	36	8.2 J	27.8
FDG2-SL-695-SA6-SB-0.0-0.5	27	10 U	27
FDG2-SL-694-SA6-SB-0.0-0.5	26	10 U	26
SL-611-SA8-TR-0.5	56	30	26
FDG2-SL-564-NBZ-SB-0.0-0.5	30	4.4 J	25.6
FDG2-SL-582-NBZ-SB-3.0-3.5	24	11 U	24
FDG2-SL-693-SA6-SB-0.0-0.5	24	10 U	24
FDG2-SL-628-SA8-SB-4.0-5.0	28	4.6 J	23.4
FDG2-SL-583-NBZ-SB-0.0-0.5	23	10 U	23
FDG2-SL-584-SA5D-SB-0.0-0.5	48	25	23
FDG2-SL-692-SA6-SB-0.0-0.5	23	10 U	23
STS-SPT-SO-SL225-SA5B-0.0-0.5-D	60	37	23
STS-SPT-SO-SRBS1116-SA6-0.0-0.5-DUP	96	73	23
FDG2-SL-1175-SA5A-SB-2.0-3.0	36	14	22
FDG2-SL-586-SA5D-SB-0.0-0.5	22	10 U	22
FDG2-SL-1174-SA5A-SB-4.0-5.0	21	11 U	21
FDG2-SL-576-NBZ-SB-2.0-3.0	21	10 U	21
FDG2-SL-581-NBZ-SB-0.0-0.5	21	11 U	21
FDG2-SL-624-SA8-SB-0.0-0.5	21	10 U	21
STS-PHY-SO-08_SM_CC-0.0-1.0	28	7.2 J	20.8
FDG2-SL-623-SA8-SB-0.0-0.5	20	11 U	20
SL-707-SA5B-TR-0.5	20	10 U	20
STS-PHY-SO-23_YS_A-0.0-1.5	20	10 U	20
FDG2-SL-691-SA6-SB-0.0-0.5	19	10 U	19

Table 6 Carbon Range C21 to C30 Results – Detections Only			
Sample ID	Result TPH (C30-C40) without Cleanup mg/kg	Result (TPH (C30-C40) with Cleanup mg/kg	NOM (Difference)
SL-570-SA6-TR-0.5	19	10 U	19
STS-PHY-SO-35_NG_C-0.0-1.0	19	10 U	19
STS-SPT-SO-SL225-SA5B-0.0-0.5-A	45	26	19
FDG2-SL-875-SA5A-SB-2.0-3.0	85	67	18
SL-636-SA5A-TR-3.5	18	11 U	18
SL-651-SA5C-TR-0.5	18	10 U	18
STS-PHY-SO-01_BE_A-0.0-1.5	25	7.2 J	17.8
STS-PHY-SO-17_NM_BB-0.0-1.0	27	9.4 J	17.6
FDG2-SL-877-SA5A-SB-0.0-0.5	17	10 U	17
SL-529-SA5B-TR-3.0	33	16	17
SL-548-SA8-TR-0.5	17	11 U	17
STS-PHY-SO-04_MF_D-0.0-1.5	17	10 U	17
STS-SPT-SO-SL225-SA5B-0.0-0.5-C	45	28	17
FDG2-SL-563-NBZ-SB-0.0-0.5	16	10 U	16
STS-PHY-SO-308_SM_CC-0.0-1.0	24	8.1 J	15.9
FDG2-SL-626-SA8-SB-0.0-0.5	15	10 U	15
SL-848-SA8-TR-5.0	15	11 U	15
STS-PHY-SO-06_PG_B-0.0-1.0	15	10 U	15
FDG2-SL-631-SA8-SB-7.0-8.0	14	12 U	14
SL-693-SA5B-TR-0.5	14	10 U	14
SL-693-SA5B-TR-5.0	14	11 U	14
STS-PHY-SO-01_BE_D-0.0-1.5	14	10 U	14
SL-611-SA8-TR-10.5	13	11 U	13
SL-693-SA5B-TR-3.0	13	10 U	13
SL-699-SA5B-TR-3.0	13	11 U	13
STS-PHY-SO-35_NG_A_0.0-1.0	13	10 U	13
STS-PHY-SO-35_NG_B_0.0-1.0	13	10 U	13
FDG2-SL-585-SA5D-SB-0.0-0.5	18	5.7 J	12.3
FDG2-SL-570-NBZ-SB-0.0-0.5	12	10 U	12
FDG-SL-842-SA5B-SB-4.0-5.0	12	11 U	12
SL-611-SA8-TR-5.0	12	11 U	12
STS-PHY-SO-02_LS_D-0.0-1.0	12	10 U	12

Table 6 Carbon Range C21 to C30 Results – Detections Only			
Sample ID	Result TPH (C30-C40) without Cleanup mg/kg	Result (TPH (C30-C40) with Cleanup mg/kg	NOM (Difference)
STS-PHY-SO-18_CB_A-0.0-1.5	110	98	12
STS-PHY-SO-18_CB_D-0.0-1.0	12	10 U	12
SL-534-SA8-TR-0.5	11	10 U	11
SL-646-SA5C-TR-0.5	11	10 U	11
STS-PHY-SO-08_SM_D-0.0-1.0	11	10 U	11
SL-605-SA5C-TR-0.5	16	5.1 J	10.9
FDG-SL-842-SA5B-SB-0.0-0.5	9.8 J	10 U	9.8
STS-PHY-SO-17_NM_D-0.0-1.5	9.8 J	10 U	9.8
FDG-SL-841-SA5B-SB-4.0-5.0	9.3 J	11 U	9.3
SL-653-SA5C-TR-15.0	9.1 J	10 U	9.1
SL-605-SA5C-TR-5.0	14	5 J	9
STS-SPT-SO-SRBS1116-SA6-0.0-0.5-D	59	50	9
SL-529-SA5B-TR-2.0	14	5.2 J	8.8
SL-651-SA5C-TR-5.0	8.8 J	10 U	8.8
SL-605-SA5C-TR-10.0	8.4 J	11 U	8.4
STS-PHY-SO-35_NG_D-0.0-1.0	7.4 J	11 U	7.4
STS-PHY-SO-23_YS_D-0.0-1.5	6.5 J	10 U	6.5
STS-PHY-SO-02_LS_B-0.0-1.0	12	5.9 J	6.1
STS-PHY-SO-23_YS_C-0.0-0.5	11	5.5 J	5.5
SL-534-SA8-TR-5.0	5 J	11 U	5
SL-655-SA5C-TR-0.5	5 J	11 U	5
STS-SPT-SO-SRBS1116-SA6-0.0-0.5	50	45	5
STS-PHY-SO-04_MF_B-0.0-1.0	10	8.8 J	1.2
STS-SPT-SO-SRBS1116-SA6-0.0-0.5-C	53	53	0

NOM - Naturally Occuring Material