**Supplementary material**

**evaluating incremental sampling methodology for Petroleum hydrocarbon plume estimates and remediation strategies**

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**Supplemental 1** Visual supporting information for site location, conceptual site design, and core sampling.

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**Fig. 1. Locator map from Google Maps showing the approximate locations (200 km apart) of Saskatoon and Raymore in Saskatchewan, Canada.**



**Fig. 2. Example of the conceptual site modeling using historical data to decide Investigation Areas, Single Borehole Decision Units, and Decision Unit Layers.**



**Fig. 3. Top) An example diagram of the spacing and number of samples taken from one DU Layer using ISM. The samples are combined in one bottle of methanol and then subsampled to send one sample for analysis. Bottom) A depiction of the typical number of samples taken from a DU Layer using Phase II/Discrete methods. The samples are put into individual vials with methanol and two samples are sent for analysis, or only one depending of photo‑ionization detector (PID) readings.**

**Supplemental 2** Chebychev 95UCL (95% Upper Confidence Limit) data (mg contaminant/kg soil) for all measured petroleum hydrocarbons in the Investigation Areas (IAs) for each Decision Unit Layer (DUL) (only including IAs that were sampled for ISM and Phase II together) and for DULs across the site (ITRC, 2012).

**95UCL calculation:**

The 95% Upper Confidence Limit calculations used a Chebychev 95UCL to deal with the high variability in sample data. The excel file with the built-in calculator from the ISM document from ITRC was used (found at: <http://www.itrcweb.org/ISM-1/4_2_2_UCL_Calculation_Method.html>) (ITRC, 2012). The calculation used is as follows:

† acceptable level of potential decision error; α (95% = 0.05).

**Table S1. Saskatoon site Investigation Area 1 Chebychev 95% UCL hydrocarbon values, means, standard deviation (mg/kg), and coefficient of variance (CV; %) for each Decision Unit Layer (DUL).**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **Contaminant Concentration (mg kg-1)** | | | | | |
|  |  | **Benzene** | **F1+BTEX** | **F1-BTEX** | **F2** | **F3** | **F4** |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ISM DUL 1 (0 - 1.5 m) | 95UCL | 36 | 3920 | 3170 | 1910 | 929 | ND† |
|  | Mean | 11 | 1200 | 967 | 423 | 195 | ND |
|  | Standard Dev. | 9.8 | 1081.6 | 973.7 | 592.1 | 291.7 | ND |
|  | CV | 90 | 90 | 90 | 140 | 150 | ND |
| ISM DUL 2  (1.5 - 4.5 m) | 95UCL | 26 | 819 | 451 | 375 | 365 | ND |
|  | Mean | 10 | 295 | 183 | 128 | 110 | ND |
|  | Standard Dev. | 6.2 | 208.1 | 106.5 | 98.2 | 101.5 | ND |
|  | CV | 60 | 71 | 58 | 77 | 92 | ND |
| ISM DUL 3 (4.5 - 7.5 m) | 95UCL | 7 | 73 | 53 | 63 | 477 | 136 |
|  | Mean | 3 | 22 | 16 | 23 | 159 | 25 |
|  | Standard Dev. | 2.0 | 20.3 | 14.6 | 15.7 | 126.5 | 43.9 |
|  | CV | 80 | 92 | 89 | 67 | 78 | 170 |
| Investigation Area (ISM) | 95UCL Mean | 23 | 1610 | 1223 | 784 | 590 | 45 |
|  |  |  |  |  |  |  |  |
| Discrete DUL 1 (0 - 1.5 m) | 95UCL | 14 | 1690 | 1310 | 3920 | 2320 | ND |
|  | Mean | 4 | 377 | 329 | 746 | 433 | ND |
|  | Standard Dev. | 4.1 | 520.0 | 391.5 | 1259.6 | 750.6 | ND |
|  | CV | 110 | 138 | 119 | 169 | 173 | ND |
| Discrete DUL 2 (1.5 - 4.5 m) | 95UCL | 134 | 6640 | 4740 | 435 | 250 | ND |
|  | Mean | 31 | 1397 | 977 | 170 | 47 | ND |
|  | Standard Dev. | 41.0 | 2084.2 | 1496.9 | 105.3 | 80.8 | ND |
|  | CV | 131 | 149 | 153 | 62 | 173 | ND |
| Discrete DUL 3 (4.5 - 7.5 m) | 95UCL | 16 | 214 | 207 | 639 | 347 | ND |
|  | Mean | 4 | 40 | 65 | 124 | 95 | ND |
|  | Standard Dev. | 4.7 | 69.3 | 56.3 | 204.8 | 100.4 | ND |
|  | CV | 111 | 173 | 87 | 166 | 106 | ND |
| Investigation Area (Discrete) | 95UCL Mean | 55 | 2850 | 2090 | 1660 | 973 | ND |
|  |  |  |  |  |  |  |  |
| Phase II ESA | 95UCL | 52 | 1940 | 1220 | 334 | 226 | ND |
|  | Mean | 17 | 674 | 417 | 126 | 62 | ND |
|  | Standard Dev. | 13.7 | 504.7 | 318.7 | 82.8 | 65.2 | ND |
|  | CV | 80 | 75 | 76 | 66 | 105 | ND |

† ND = value below instrument detection limit or no data available.

**Table S2. Saskatoon site Investigation Area 2 Chebychev 95% UCL hydrocarbon values, means, standard deviation (mg/kg), and coefficient of variance (CV; %) for each Decision Unit Layer (DUL).**

|  |  |  |
| --- | --- | --- |
|  |  | **Contaminant Concentration (mg kg-1)** |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **Benzene** | **F1+BTEX** | **F1-BTEX** | **F2** | **F3** | **F4** |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ISM DUL 1 (0 - 1.5 m) | 95UCL | 1 | 34 | 322 | 39 | 152 | ND† |
|  | Mean | 1 | 6 | 60 | 12 | 45 | ND |
|  | Standard Dev. | 0.3 | 11.0 | 103.9 | 10.7 | 42.3 | ND |
|  | CV | 173 | 173 | 173 | 92 | 94 | ND |
| ISM DUL 2  (1.5 - 4.5 m) | 95UCL | 19 | 6410 | 1110 | 972 | 483 | ND |
|  | Mean | 4 | 1219 | 228 | 220 | 122 | ND |
|  | Standard Dev. | 6.2 | 2061.9 | 348.9 | 298.7 | 143.4 | ND |
|  | CV | 163 | 169 | 153 | 136 | 118 | ND |
| ISM DUL 3  (4.5 - 7.5 m) | 95UCL | 3 | 102 | 98 | 39 | 129 | ND |
|  | Mean | 1 | 24 | 18 | 12 | 24 | ND |
|  | Standard Dev. | 0.7 | 31.2 | 31.8 | 10.7 | 41.6 | ND |
|  | CV | 90 | 132 | 173 | 92 | 173 | ND |
|  |  |  |  |  |  |  |  |
| Investigation Area (ISM) | 95UCL Mean | 8 | 2180 | 509 | 350 | 254 | ND |
|  |  |  |  |  |  |  |  |
| Discrete DUL 1 (0 - 1.5 m) | 95UCL | 4 | 179 | 174 | 12100 | 1070 | 482 |
|  | Mean | 1 | 33 | 51 | 2280 | 350 | 90 |
|  | Standard Dev. | 1.4 | 57.7 | 48.8 | 3914.2 | 286.7 | 155.9 |
|  | CV | 173 | 174 | 95 | 172 | 82 | 173 |
| Discrete DUL 2 (1.5 - 4.5 m) | 95UCL | 64 | 6410 | 5720 | 441 | 4250 | ND |
|  | Mean | 12 | 1220 | 1067 | 137 | 837 | ND |
|  | Standard Dev. | 20.7 | 2061.4 | 1847.5 | 121.0 | 1355.0 | ND |
|  | CV | 172 | 169 | 173 | 89 | 162 | ND |
| Discrete DUL 3 (4.5 - 7.5 m) | 95UCL | 9 | 400 | 376 | 602 | 290 | 136 |
|  | Mean | 2 | 89 | 89 | 118 | 87 | 25 |
|  | Standard Dev. | 2.8 | 123.3 | 114.4 | 192.1 | 80.8 | 43.9 |
|  | CV | 129 | 138 | 129 | 162 | 93 | 173 |
| Investigation Area (Discrete) | 95UCL Mean | 26 | 2330 | 2090 | 4390 | 1870 | 206 |
|  |  |  |  |  |  |  |  |
| Phase II ESA | 95UCL | 14 | 613 | 551 | 781 | 351 | ND |
|  | Mean | 4 | 190 | 170 | 227 | 99 | ND |
|  | Standard Dev. | 3.8 | 168.2 | 151.3 | 220.3 | 100.0 | ND |
|  | CV | 87 | 89 | 89 | 97 | 101 | ND |

† ND = value below instrument detection limit or no data available.

**Table S3. Raymore site Investigation Area 1 Chebychev 95% UCL hydrocarbon values, means, standard deviation (mg/kg), and coefficient of variance (CV; %) for each Decision Unit Layer (DUL).**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **Contaminant Concentration (mg kg-1)** | | | | | | | |
|  |  | **Benzene** | | **F1+BTEX** | | **F1-BTEX** | **F2** | **F3** | **F4** |
| ISM DUL 1 (0 - 1.5 m) | 95UCL | 34 | 5530 | | 5000 | | 5300 | 1700 | ND† |
|  | Mean | 6 | 1038 | | 938 | | 1050 | 421 | ND |
|  | Standard Dev. | 111.0 | 1786.1 | | 1612.8 | | 1690.4 | 506.1 | ND |
|  | CV | 172 | 172 | | 172 | | 161 | 120 | ND |
| ISM DUL 2 (1.5 - 4.5 m) | 95UCL | 10 | 786 | | 732 | | 357 | 196 | ND |
|  | Mean | 2 | 147 | | 137 | | 67 | 37 | ND |
|  | Standard Dev. | 3.4 | 254.0 | | 236.7 | | 115.5 | 63.5 | ND |
|  | CV | 166 | 173 | | 173 | | 173 | 173 | ND |
| ISM DUL 3 (4.5 – 6.0 m) | 95UCL | ND | ND | | ND | | ND | 164 | ND |
|  | Mean | ND | ND | | ND | | ND | 31 | ND |
|  | Standard Dev. | ND | ND | | ND | | ND | 53.1 | ND |
|  | CV | ND | ND | | ND | | ND | 173 | ND |
| Investigation Area (ISM) | 95UCL Mean | 15 | 2110 | | 1910 | | 1887 | 685 | ND |
|  |  |  |  | |  | |  |  |  |
| Discrete DUL 1 (0 - 1.5 m) | 95UCL | 20 | 2280 | | 2110 | | 5590 | 3030 | ND |
|  | Mean | 4 | 470 | | 437 | | 1733 | 883 | ND |
|  | Standard Dev. | 6.4 | 720.9 | | 663.4 | | 1530.8 | 852.0 | ND |
|  | CV | 173 | 153 | | 152 | | 88 | 96 | ND |
| Discrete DUL 2 (1.5 - 4.5 m) | 95UCL | 64 | 4470 | | 4290 | | 2320 | 661 | ND |
|  | Mean | 12 | 833 | | 800 | | 433 | 123 | ND |
|  | Standard Dev. | 20.8 | 1443.4 | | 1385.6 | | 750.6 | 213.6 | ND |
|  | CV | 173 | 173 | | 173 | | 173 | 173 | ND |
| Discrete DUL 3 (4.5 – 6.0 m) | 95UCL | 0 | ND | | ND | | ND | 643 | 179 |
|  | Mean | 0 | ND | | ND | | ND | 120 | 33 |
|  | Standard Dev. | 0.04 | ND | | ND | | ND | 207.9 | 57.7 |
|  | CV | 173 | ND | | ND | | ND | 173 | 173 |
| Investigation Area (Discrete) | 95UCL Mean | 28 | 2250 | | 2130 | | 2640 | 1440 | 60 |
|  |  |  |  | |  | |  |  |  |
| Phase II ESA | 95UCL | 24 | 2000 | | 2130 | | 4310 | 1880 | ND |
|  | Mean | 5 | 408 | | 433 | | 1018 | 428 | ND |
|  | Standard Dev. | 9.0 | 730.9 | | 780.7 | | 1511.70 | 664.6 | ND |
|  | CV | 198 | 179 | | 181 | | 149 | 156 | ND |

† ND = value below instrument detection limit or no data available.

**Table S4. Saskatoon site wide Chebychev 95% UCL hydrocarbon values, means, standard deviation (mg/kg), and coefficient of variance (CV; %) for each Decision Unit Layer (DUL).**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | **Contaminant Concentration (mg kg-1)** | | |
| **DUL, Contaminant** | **Analysis Performed** | **ISM**† | **Discrete**† | **Phase II**† |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1, Benzene | 95UCL | 16 | 6.0 | ND‡ |
|  | Mean | 4 | 2 | ND |
|  | Standard Dev. | 7.7 | 2.9 | ND |
|  | CV | 180 | 170 | ND |
| 2, Benzene | 95UCL | 15 | 59 | 31 |
|  | Mean | 5 | 16 | 10 |
|  | Standard Dev. | 6.5 | 28.0 | 12.2 |
|  | CV | 120 | 170 | 130 |
| 3, Benzene | 95UCL | 4 | 8 | ND |
|  | Mean | 1 | 2 | ND |
|  | Standard Dev. | 1.6 | 3.4 | ND |
|  | CV | 130 | 140 | ND |
| 1, F1+BTEX | 95UCL | 1758 | 671 | ND |
|  | Mean | 452 | 157 | ND |
|  | Standard Dev. | 847.1 | 333.8 | ND |
|  | CV | 190 | 210 | ND |
| 2, F1+BTEX | 95UCL | 624 | 3573 | 1204 |
|  | Mean | 207 | 981 | 379 |
|  | Standard Dev. | 270.9 | 1681.9 | 463.7 |
|  | CV | 130 | 170 | 120 |
| 3, F1+BTEX | 95UCL | 52 | 179 | ND |
|  | Mean | 17 | 49 | ND |
|  | Standard Dev. | 22.5 | 84.5 | ND |
|  | CV | 130 | 170 | ND |
| 1, F1-BTEX | 95UCL | 1417 | 542 | ND |
|  | Mean | 365 | 129 | ND |
|  | Standard Dev. | 683.1 | 267.9 | ND |
|  | CV | 190 | 210 | ND |
| 2, F1-BTEX | 95UCL | 490 | 2858 | 757 |
|  | Mean | 154 | 783 | 245 |
|  | Standard Dev. | 218.0 | 1346.3 | 287.4 |
|  | CV | 140 | 170 | 120 |
| 3, F1-BTEX | 95UCL | 44 | 166 | ND |
|  | Mean | 13 | 44 | ND |
|  | Standard Dev. | 20.4 | 79.0 | ND |
|  | CV | 160 | 180 | ND |
| 1, F2 | 95UCL | 753 | 1485 | ND |
|  | Mean | 163 | 302 | ND |
|  | Standard Dev. | 383.0 | 767.3 | ND |
|  | CV | 240 | 250 | ND |
| 2, F2 | 95UCL | 425 | 4591 | 290 |
|  | Mean | 130 | 936 | 103 |
|  | Standard Dev. | 191.2 | 2371.5 | 105.1 |
|  | CV | 150 | 250 | 100 |
| 3, F2 | 95UCL | 35 | 370 | ND |
|  | Mean | 13 | 118 | ND |
|  | Standard Dev. | 14.1 | 163.7 | ND |
|  | CV | 110 | 140 | ND |
| 1, F3 | 95UCL | 391 | 1289 | ND |
|  | Mean | 114 | 516 | ND |
|  | Standard Dev. | 179.8 | 501.8 | ND |
|  | CV | 160 | 100 | ND |
| 2, F3 | 95UCL | 254 | 1628 | 148 |
|  | Mean | 87 | 346 | 47 |
|  | Standard Dev. | 108.3 | 831.6 | 56.7 |
|  | CV | 130 | 240 | 120 |
| 3, F3 | 95UCL | 243 | 194 | ND |
|  | Mean | 96 | 87 | ND |
|  | Standard Dev. | 95.7 | 69.6 | ND |
|  | CV | 100 | 80 | ND |
| 1, F4 | 95UCL | ND | 304 | ND |
|  | Mean | ND | 105 | ND |
|  | Standard Dev. | ND | 129.5 | ND |
|  | CV | ND | 120 | ND |
| 2, F4 | 95UCL | ND | ND | ND |
|  | Mean | ND | ND | ND |
|  | Standard Dev. | ND | ND | ND |
|  | CV | ND | ND | ND |
| 3, F4 | 95UCL | 51 | ND | ND |
|  | Mean | 10 | ND | ND |
|  | Standard Dev. | 26.9 | ND | ND |
|  | CV | 280 | ND | ND |

† ISM and the discrete sample from the ISM core used 8 co-located Single Borehole DU’s to Phase II borings. Phase II data used 0 borings from DUL 1, 6 borings from DUL 2, and 1 boring from DUL 3.  
‡ ND = value below instrument detection limit or no data available.

**Table S5. Raymore site wide Chebychev 95% UCL hydrocarbon values, means, standard deviation (mg/kg), and coefficient of variance (CV; %) for each Decision Unit Layer (DUL).**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **DUL, Contaminant** | **Contaminant** | **ISM**† | **Discrete**† | **Phase II**† |
|  |  | ‑‑‑‑‑‑‑‑‑‑‑‑‑‑‑‑‑‑‑ mg kg‑1‑‑‑‑‑‑‑‑‑‑‑‑‑‑‑‑‑‑ | | |
| 1, Benzene | 95UCL | 17 | 8 | 0.2 |
|  | Mean | 3 | 2 | 0.1 |
|  | Standard Dev. | 7.8 | 4.2 | 0.04 |
|  | CV | 240 | 270 | 50 |
| 2, Benzene | 95UCL | 5 | 39 | 32 |
|  | Mean | 1 | 7 | 6. |
|  | Standard Dev. | 2.4 | 16.1 | 10.4 |
|  | CV | 240 | 220 | 170 |
| 3, Benzene | 95UCL | ND‡ | 0.05 | ND |
|  | Mean | ND | 0.01 | ND |
|  | Standard Dev. | ND | 0.03 | ND |
|  | CV | ND | 250 | ND |
| 1, F1+BTEX | 95UCL | 2769 | 1002 | 194 |
|  | Mean | 519 | 201 | 111 |
|  | Standard Dev. | 1264.5 | 486.2 | 26.9 |
|  | CV | 240 | 240 | 20 |
| 2, F1+BTEX | 95UCL | 393 | 2679 | 2679 |
|  | Mean | 73 | 500 | 500 |
|  | Standard Dev. | 179.6 | 1118.0 | 866.0 |
|  | CV | 250 | 220 | 170 |
| 3, F1+BTEX | 95UCL | ND | ND | ND |
|  | Mean | ND | ND | ND |
|  | Standard Dev. | ND | ND | ND |
|  | CV | ND | ND | ND |
| 1, F1-BTEX | 95UCL | 2501 | 926 | 192 |
|  | Mean | 469 | 187 | 112 |
|  | Standard Dev. | 1142.1 | 448.5 | 26.2 |
|  | CV | 240 | 240 | 20 |
| 2, F1-BTEX | 95UCL | 367 | 2572 | 2858 |
|  | Mean | 68 | 480 | 533 |
|  | Standard Dev. | 167.4 | 1073.3 | 923.8 |
|  | CV | 250 | 220 | 170 |
| 3, F1-BTEX | 95UCL | ND | ND | ND |
|  | Mean | ND | ND | ND |
|  | Standard Dev. | ND | ND | ND |
|  | CV | ND | ND | ND |
| 1, F2 | 95UCL | 2685 | 2852 | 6559 |
|  | Mean | 525. | 743 | 2200 |
|  | Standard Dev. | 1214.0 | 1280.4 | 1414.2 |
|  | CV | 230 | 170 | 60 |
| 2, F2 | 95UCL | 179 | 1393 | 1554 |
|  | Mean | 33 | 260 | 290 |
|  | Standard Dev. | 81.7 | 581.4 | 502.3 |
|  | CV | 250 | 220 | 170 |
| 3, F2 | 95UCL | ND | ND | ND |
|  | Mean | ND | ND | ND |
|  | Standard Dev. | ND | ND | ND |
|  | CV | ND | ND | ND |
| 1, F3 | 95UCL | 918 | 1512 | 1904 |
|  | Mean | 237 | 417 | 1250 |
|  | Standard Dev. | 382.6 | 664.3 | 212.1 |
|  | CV | 160 | 160 | 20 |
| 2, F3 | 95UCL | 98 | 397 | 554 |
|  | Mean | 18 | 74 | 103 |
|  | Standard Dev. | 44.9 | 165.5 | 179.0 |
|  | CV | 250 | 220 | 170 |
| 3, F3 | 95UCL | 116 | 591 | ND |
|  | Mean | 31 | 153 | ND |
|  | Standard Dev. | 47.8 | 245.8 | ND |
|  | CV | 160 | 160 | ND |
| 1, F4 | 95UCL | ND | 58 | ND |
|  | Mean | ND | 11 | ND |
|  | Standard Dev. | ND | 29 | ND |
|  | CV | ND | 270 | ND |
| 2, F4 | 95UCL | ND | ND | ND |
|  | Mean | ND | ND | ND |
|  | Standard Dev. | ND | ND | ND |
|  | CV | ND | ND | ND |
| 3, F4 | 95UCL | ND | 167 | ND |
|  | Mean | ND | 43 | ND |
|  | Standard Dev. | ND | 69.8 | ND |
|  | CV | ND | 160 | ND |

† ISM and the discrete sample from the ISM core used 8 co-located Single Borehole DU’s to Phase II borings. Phase II data used 0 borings from DUL 1, 6 borings from DUL 2, and 1 boring from DUL 3.

‡ ND = value below instrument detection limit or no data available.

**Supplemental 3** Total amounts of soil used for analysis for ISM, discrete, and Phase II methods.

**Table S6. Amount of soil (g) used to process or analyze samples on a site wide scale per Decision Unit Layer for Saskatoon site.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Decision Unit Layer** | **Contaminant** | **ISM**† | **Discrete**‡ | **Phase II**‡ |
| 1 | Benzene | 360 | 60 | 10 |
| 2 | Benzene | 360 | 60 | 30 |
| 3 | Benzene | 360 | 60 | 5 |
| 1 | CCME F1 | 360 | 60 | 10 |
| 2 | CCME F1 | 360 | 60 | 30 |
| 3 | CCME F1 | 360 | 60 | 5 |
| 1 | CCME F2 | 1080 | 30 | 30 |
| 2 | CCME F2 | 1080 | 30 | 15 |
| 3 | CCME F2 | 1080 | 30 | 5 |
| 1 | CCME F3 | 1080 | 30 | 30 |
| 2 | CCME F3 | 1080 | 30 | 15 |
| 3 | CCME F3 | 1080 | 30 | 5 |
| 1 | CCME F4 | 1080 | 30 | 30 |
| 2 | CCME F4 | 1080 | 30 | 15 |
| 3 | CCME F4 | 1080 | 30 | 5 |

† Amount of soil was homogenized and then subsampled.  
‡ Discrete and Phase II methods sample from unhomogenized soil.

**Table S7. Amount of soil (g) used to process or analyze samples on a site wide scale per Decision Unit Layer for Raymore site.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Decision Unit Layer** | **Contaminant** | **ISM**† | **Discrete**‡ | **Phase II**‡ |
| 1 | Benzene | 360 | 60 | 10 |
| 2 | Benzene | 360 | 60 | 15 |
| 3 | Benzene | 360 | 60 | 5 |
| 1 | CCME F1 | 360 | 60 | 10 |
| 2 | CCME F1 | 360 | 60 | 15 |
| 3 | CCME F1 | 360 | 60 | 5 |
| 1 | CCME F2 | 1080 | 30 | 10 |
| 2 | CCME F2 | 1080 | 30 | 15 |
| 3 | CCME F2 | 1080 | 30 | 5 |
| 1 | CCME F3 | 1080 | 30 | 10 |
| 2 | CCME F3 | 1080 | 30 | 15 |
| 3 | CCME F3 | 1080 | 30 | 5 |
| 1 | CCME F4 | 1080 | 30 | 10 |
| 2 | CCME F4 | 1080 | 30 | 15 |
| 3 | CCME F4 | 1080 | 30 | 5 |

† Amount of soil was homogenized and then subsampled.  
‡ Discrete and Phase II methods sample from non‑homogenized soil.

**Supplemental 4** Percent differences between ISM, discrete, and Phase II sampling methods using the 95UCL data.

**Table S8. Percent difference between 95% Chebychev Confidence Intervals for each sampling method for designated Investigation Area (IA).**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **IA and Sample Type** | **Benzene** | **F1+BTEX** | **F1-BTEX** | **F2** | **F3** | **F4** |
| Saskatoon IA 1 |  |  |  |  |  |  |
| ISM vs. Phase II ESA | 76.5 | 19.1 | 0.32 | 80.5 | 89.2 | 200 |
| Discrete vs. Phase II ESA | 5.69 | 37.7 | 52.5 | 133 | 125 | ND† |
| ISM vs. Discrete | 81.3 | 55.8 | 52.3 | 71.9 | 49.0 | 200 |
|  |  |  |  |  |  |  |
| Saskatoon IA 2 |  |  |  |  |  |  |
| ISM vs. Phase II ESA | 58.9 | 112 | 7.94 | 76.3 | 31.9 | ND |
| Discrete vs. Phase II ESA | 59.4 | 117 | 117 | 140 | 137 | 200 |
| ISM vs. Discrete | 109 | 6.52 | 122 | 171 | 152 | 200 |
|  |  |  |  |  |  |  |
| Raymore IA 1 |  |  |  |  |  |  |
| ISM vs. Phase II ESA | 48.8 | 5.15 | 11.1 | 78.2 | 93.0 | ND |
| Discrete vs. Phase II ESA | 15.0 | 11.7 | 0.14 | 48.3 | 26.0 | 200 |
| ISM vs. Discrete | 61.8 | 6.60 | 11.0 | 33.1 | 71.3 | 200 |

† ND = value below instrument detection limit or no data available.

**Table S9. Saskatoon site wide percent difference between 95% Chebychev Confidence Intervals for each sampling method.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Decision Unit Layer** | **Contaminant** | **ISM samples vs. discrete samples** | **ISM samples vs. Phase II samples** | **Discrete samples vs. Phase II samples** |
| 1 | Benzene | 90.9 | ND† | ND |
| 2 | Benzene | 118.9 | 69.6 | 62.5 |
| 3 | Benzene | 66.7 | ND | ND |
| 1 | F1+BTEX | 89.5 | ND | ND |
| 2 | F1+BTEX | 140.5 | 63.5 | 99.2 |
| 3 | F1+BTEX | 110.0 | ND | ND |
| 1 | F1-BTEX | 89.3 | ND | ND |
| 2 | F1-BTEX | 141.5 | 42.8 | 116.2 |
| 3 | F1-BTEX | 116.2 | ND | ND |
| 1 | F2 | 65.4 | ND | ND |
| 2 | F2 | 166.1 | 37.8 | 176.2 |
| 3 | F2 | 165.4 | ND | ND |
| 1 | F3 | 106.9 | ND | ND |
| 2 | F3 | 146.0 | 52.7 | 166.7 |
| 3 | F3 | 22.4 | ND | ND |
| 1 | F4 | ND | ND | ND |
| 2 | F4 | ND | ND | ND |
| 3 | F4 | ND | ND | ND |

† ND = value below instrument detection limit or no data available.

**Table S10. Raymore site wide percent difference between 95% Chebychev Confidence Intervals for each sampling method.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Decision Unit Layer** | **Contaminant** | **ISM samples vs. discrete samples** | **ISM samples vs. Phase II samples** | **Discrete samples vs. Phase II samples** |
| 1 | Benzene | 72.0 | 195 | 190 |
| 2 | Benzene | 155 | 146 | 19.7 |
| 3 | Benzene | ND† | ND | ND |
| 1 | F1+BTEX | 93.7 | 174 | 135 |
| 2 | F1+BTEX | 149 | 149 | 0 |
| 3 | F1+BTEX | ND | ND | ND |
| 1 | F1-BTEX | 91.9 | 172 | 131 |
| 2 | F1-BTEX | 150 | 155 | 10.5 |
| 3 | F1-BTEX | ND | ND | ND |
| 1 | F2 | 6.00 | 83.8 | 78.8 |
| 2 | F2 | 155 | 159 | 10.9 |
| 3 | F2 | ND | ND | ND |
| 1 | F3 | 48.9 | 69.9 | 23.0 |
| 2 | F3 | 121 | 140 | 33.0 |
| 3 | F3 | 134 | ND | ND |
| 1 | F4 | ND | ND | ND |
| 2 | F4 | ND | ND | ND |
| 3 | F4 | ND | ND | ND |

† ND = value below instrument detection limit or no data available.

**Supplemental 5** Raw data collected during study.

**Table S11. Compiled petroleum hydrocarbon data (mg/kg) collected from the Phase II (PII) analysis and the ISM analysis for Raymore and Saskatoon sites.**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Site** | **Invest. Area** | **DU Layer** | **Borehole** | **Depth** | **Sample ID** | **Sample Type** | **Benzene** | **Benzene PII** | **F1+BTEX** | **F1+BTEX PII** | **F1-BTEX** | **F1-BTEX PII** | **F2** | **F2 PII** | **F3** | **F3 PII** | **F4** | **F4 PII** |
| Raymore | 3 | 1 | S15-02 | 0-1.5 | 1 | D | ND† | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 3 | 1 | S15-02 | 0-1.5 | 1 | P | ND | ND | ND | ND | ND | ND | ND | ND | 160.0 | ND | ND | ND |
| Raymore | 3 | 1 | S15-02 | 0-1.5 | 1 | W | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 3 | 2 | S15-02 | 1.5-4.5 | 2 | D | ND | ND\* | ND | ND\* | ND | ND\* | ND | ND\* | ND | ND\* | ND | ND\* |
| Raymore | 3 | 2 | S15-02 | 1.5-4.5 | 2 | P | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 3 | 2 | S15-02 | 1.5-4.5 | 2 | W | ND | ND | ND | ND | ND | ND | ND | ND | 53.0 | ND | ND | ND |
| Raymore | 3 | 3 | S15-02 | 4.5-6.0 | 3 | D | ND | ND | ND | ND | ND | ND | ND | ND | 560.0 | ND | 160.0 | ND |
| Raymore | 3 | 3 | S15-02 | 4.5-6.0 | 3 | P | ND | ND | ND | ND | ND | ND | ND | ND | 93.0 | ND | ND | ND |
| Raymore | 3 | 3 | S15-02 | 4.5-6.0 | 3 | W | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 1 | 1 | S15-04 | 0-1.5 | 4 | D | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 1 | 1 | S15-04 | 0-1.5 | 4 | P | ND | ND | ND | ND | ND | ND | ND | ND | 63.0 | ND | ND | ND |
| Raymore | 1 | 1 | S15-04 | 0-1.5 | 4 | W | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 1 | 2 | S15-04 | 1.5-4.5 | 5 | D | ND | ND\* | ND | ND\* | ND | ND\* | ND | ND\* | ND | ND\* | ND | ND\* |
| Raymore | 1 | 2 | S15-04 | 1.5-4.5 | 5 | P | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 1 | 2 | S15-04 | 1.5-4.5 | 5 | W | ND | ND | 15.0 | ND | 15.0 | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 1 | 3 | S15-04 | 4.5-6 | 6 | D | ND | ND | ND | ND | ND | ND | ND | ND | 360.0 | ND | 100.0 | ND |
| Raymore | 1 | 3 | S15-04 | 4.5-6 | 6 | P | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 1 | 3 | S15-04 | 4.5-6 | 6 | W | ND | ND | 24.0 | ND | 24.0 | ND | ND | ND | 120.0 | ND | ND | ND |
| Raymore | 1 | 1 | S15-05 | 0-1.5 | 7 | D | ND | 0.1 | 110.0 | 130.0 | 110.0 | 130.0 | 2300.0 | 3200.0 | 1700.0 | 1400.0 | ND | ND\* |
| Raymore | 1 | 1 | S15-05 | 0-1.5 | 7 | P | 0.1 | ND | 13.0 | ND | 13.0 | ND | 150.0 | ND | 200.0 | ND | ND | ND |
| Raymore | 1 | 1 | S15-05 | 0-1.5 | 7 | W | 0.1 | ND | 19.0 | ND | 19.0 | ND | 200.0 | ND | 210.0 | ND | ND | ND |
| Raymore | 1 | 2 | S15-05 | 1.5-3.75 | 8 | D | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 1 | 2 | S15-05 | 1.5-3.75 | 8 | P | 0.1 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 1 | 2 | S15-05 | 1.5-3.75 | 8 | W | 0.2 | ND | 19.0 | ND | 19.0 | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 1 | 3 | S15-05 | 3.75-5.0 | 9 | D | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 1 | 3 | S15-05 | 3.75-5.0 | 9 | P | ND | ND | ND | ND | ND | ND | ND | ND | 92.0 | ND | ND | ND |
| Raymore | 1 | 3 | S15-05 | 3.75-5.0 | 9 | W | ND | ND | 19.0 | ND | 19.0 | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 1 | 1 | S15-06 | 0-1.5 | 10 | D | 11.0 | ND | 1300.0 | ND | 1200.0 | ND | 2900.0 | ND | 950.0 | ND | ND | ND |
| Raymore | 1 | 1 | S15-06 | 0-1.5 | 10 | P | 19.0 | ND | 3100.0 | ND | 2800.0 | ND | 3000.0 | ND | 1000.0 | ND | ND | ND |
| Raymore | 1 | 1 | S15-06 | 0-1.5 | 10 | W | 22.0 | ND | 4100.0 | ND | 3600.0 | ND | 3800.0 | ND | 1700.0 | ND | 160 | ND |
| Raymore | 1 | 2 | S15-06 | 1.5-4.5 | 11 | D | 36.0 | 18.0 | 2500.0 | 1500.0 | 2400.0 | 1600.0 | 1300.0 | 870.0 | 370.0 | 310.0 | ND | ND\* |
| Raymore | 1 | 2 | S15-06 | 1.5-4.5 | 11 | P | 5.9 | ND | 440.0 | ND | 410.0 | ND | 200.0 | ND | 110.0 | ND | ND | ND |
| Raymore | 1 | 2 | S15-06 | 1.5-4.5 | 11 | W | 7.6 | ND | 690.0 | ND | 640.0 | ND | 330.0 | ND | 170.0 | ND | ND | ND |
| Raymore | 1 | 3 | S15-06 | 4.5-6 | 12 | D | 0.1 | ND\* | ND | ND\* | ND | ND\* | ND | ND\* | ND | ND\* | ND | ND\* |
| Raymore | 1 | 3 | S15-06 | 4.5-6 | 12 | P | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 1 | 3 | S15-06 | 4.5-6 | 12 | W | 0.0 | ND | 29.0 | ND | 29.0 | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 4 | 1 | S15-10 | 0-1.5 | 13 | D | ND | ND\* | ND | ND\* | ND | ND\* | ND | ND\* | 270.0 | ND\* | 76.0 | ND\* |
| Raymore | 4 | 1 | S15-10 | 0-1.5 | 13 | P | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 4 | 1 | S15-10 | 0-1.5 | 13 | W | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 4 | 2 | S15-10 | 1.5-4.5 | 14 | D | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 4 | 2 | S15-10 | 1.5-4.5 | 14 | P | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 4 | 2 | S15-10 | 1.5-4.5 | 14 | W | ND | ND | ND | ND | ND | ND | ND | ND | 63.0 | ND | ND | ND |
| Raymore | 4 | 3 | S15-10 | 4.5-6 | 15 | D | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 4 | 3 | S15-10 | 4.5-6 | 15 | P | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 4 | 3 | S15-10 | 4.5-6 | 15 | W | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 2 | 1 | S15-08 | 0-1.5 | 16 | D | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 2 | 1 | S15-08 | 0-1.5 | 16 | P | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 2 | 1 | S15-08 | 0-1.5 | 16 | W | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 2 | 2 | S15-08 | 1.5-4.5 | 17 | D | ND | ND\* | ND | ND\* | ND | ND\* | ND | ND\* | ND | ND\* | ND | ND\* |
| Raymore | 2 | 2 | S15-08 | 1.5-4.5 | 17 | P | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 2 | 2 | S15-08 | 1.5-4.5 | 17 | W | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 2 | 3 | S15-08 | 4.5-6 | 18 | D | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 2 | 3 | S15-08 | 4.5-6 | 18 | P | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| Raymore | 2 | 3 | S15-08 | 4.5-6 | 18 | W | ND | ND | 52.0 | ND | 52.0 | ND | ND | ND | 280.0 | ND | ND | ND |
| 11th & W | 1 | 1 | S15-01 | 0-1.5 | 19 | D | 3.5 | ND | 160.0 | ND | 130.0 | ND | 37.0 | ND | ND | ND | ND | ND |
| 11th & W | 1 | 1 | S15-01 | 0-1.5 | 19 | P | 14.0 | ND | 1500.0 | ND | 1200.0 | ND | 170.0 | ND | ND | ND | ND | ND |
| 11th & W | 1 | 1 | S15-01 | 0-1.5 | 19 | W | 5.5 | ND | 620.0 | ND | 460.0 | ND | 110.0 | ND | ND | ND | ND | ND |
| 11th & W | 1 | 2 | S15-01 | 1.5-4.5 | 20 | D | 78.0 | 7.8 | 3800.0 | 930.0 | 2700.0 | 480.0 | 250.0 | 65.0 | ND | ND\* | ND | ND\* |
| 11th & W | 1 | 2 | S15-01 | 1.5-4.5 | 20 | P | 14.0 | ND | 490.0 | ND | 280.0 | ND | 85.0 | ND | 200.0 | ND | ND | ND |
| 11th & W | 1 | 2 | S15-01 | 1.5-4.5 | 20 | W | 11.0 | ND | 490.0 | ND | 340.0 | ND | 37.0 | ND | ND | ND | ND | ND |
| 11th & W | 1 | 3 | S15-01 | 4.5-7.5 | 21 | D | ND | ND | ND | ND | ND | ND | 11.0 | ND | 84.0 | ND | ND | ND |
| 11th & W | 1 | 3 | S15-01 | 4.5-7.5 | 21 | P | 0.7 | ND | ND | ND | ND | ND | 11.0 | ND | 120.0 | ND | ND | ND |
| 11th & W | 1 | 3 | S15-01 | 4.5-7.5 | 21 | W | 0.6 | ND | ND | ND | ND | ND | ND | ND | 54.0 | ND | ND | ND |
| 11th & W | 1 | 1 | S15-02 | 0-1.5 | 22 | D | 8.2 | ND | 970.0 | ND | 780.0 | ND | 2200.0 | ND | 1300.0 | ND | ND | ND |
| 11th & W | 1 | 1 | S15-02 | 0-1.5 | 22 | P | 19.0 | ND | 2100.0 | ND | 1700.0 | ND | 1100.0 | ND | 530.0 | ND | ND | ND |
| 11th & W | 1 | 1 | S15-02 | 0-1.5 | 22 | W | 17.0 | ND | 1900.0 | ND | 1500.0 | ND | 1900.0 | ND | 910.0 | ND | ND | ND |
| 11th & W | 1 | 2 | S15-02 | 1.5-4.5 | 23 | D | 14.0 | 33.0 | 310.0 | 1000.0 | 230.0 | 700.0 | 210.0 | 220.0 | 140.0 | 130.0 | ND | ND\* |
| 11th & W | 1 | 2 | S15-02 | 1.5-4.5 | 23 | P | 14.0 | ND | 320.0 | ND | 200.0 | ND | 240.0 | ND | 130.0 | ND | ND | ND |
| 11th & W | 1 | 2 | S15-02 | 1.5-4.5 | 23 | W | 8.6 | ND | 300.0 | ND | 220.0 | ND | 290.0 | ND | 180.0 | ND | ND | ND |
| 11th & W | 1 | 3 | S15-02 | 4.5-7.5 | 24 | D | 9.2 | ND | 120.0 | ND | 98.0 | ND | 360.0 | ND | 200.0 | ND | ND | ND |
| 11th & W | 1 | 3 | S15-02 | 4.5-7.5 | 24 | P | 2.3 | ND | 26.0 | ND | 21.0 | ND | 41.0 | ND | 56.0 | ND | ND | ND |
| 11th & W | 1 | 3 | S15-02 | 4.5-7.5 | 24 | W | 2.0 | ND | 31.0 | ND | 25.0 | ND | 45.0 | ND | ND | ND | ND | ND |
| 11th & W | 1 | 1 | S15-03 | 0-1.5 | 25 | D | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 11th & W | 1 | 1 | S15-03 | 0-1.5 | 25 | P | ND | ND | ND | ND | ND | ND | ND | ND | 54.0 | ND | ND | ND |
| 11th & W | 1 | 1 | S15-03 | 0-1.5 | 25 | W | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 11th & W | 1 | 2 | S15-03 | 1.5-4.5 | 26 | D | 1.7 | 11.0 | 81.0 | 93.0 | 77.0 | 72.0 | 51.0 | 92.0 | ND | 56.0 | ND | ND\* |
| 11th & W | 1 | 2 | S15-03 | 1.5-4.5 | 26 | P | 3.2 | ND | 76.0 | ND | 69.0 | ND | 58.0 | ND | ND | ND | ND | ND |
| 11th & W | 1 | 2 | S15-03 | 1.5-4.5 | 26 | W | 2.2 | ND | 62.0 | ND | 57.0 | ND | 22.0 | ND | ND | ND | ND | ND |
| 11th & W | 1 | 3 | S15-03 | 4.5-7.5 | 27 | D | 3.3 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 11th & W | 1 | 3 | S15-03 | 4.5-7.5 | 27 | P | 4.6 | ND | 40.0 | ND | 28.0 | ND | 18.0 | ND | 300.0 | ND | 76.0 | ND |
| 11th & W | 1 | 3 | S15-03 | 4.5-7.5 | 27 | W | 3.3 | ND | 36.0 | ND | 26.0 | ND | 11.0 | ND | ND | ND | ND | ND |
| 11th & W | 2 | 1 | S15-04 | 0-1.5 | 28 | D | 2.5 | ND | 100.0 | ND | 97.0 | ND | 66.0 | ND | 79.0 | ND | ND | ND |
| 11th & W | 2 | 1 | S15-04 | 0-1.5 | 28 | P | 0.5 | ND | 19.0 | ND | 18.0 | ND | 21.0 | ND | 51.0 | ND | ND | ND |
| 11th & W | 2 | 1 | S15-04 | 0-1.5 | 28 | W | 0.7 | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 11th & W | 2 | 2 | S15-04 | 1.5-4.5 | 29 | D | 36.0 | 6.7 | 3600.0 | 250.0 | 3200.0 | 220.0 | 6800.0 | 240.0 | 2400.0 | 97.0 | ND | ND\* |
| 11th & W | 2 | 2 | S15-04 | 1.5-4.5 | 29 | P | 11.0 | ND | 710.0 | ND | 630.0 | ND | 560.0 | ND | 280.0 | ND | ND | ND |
| 11th & W | 2 | 2 | S15-04 | 1.5-4.5 | 29 | W | 4.6 | ND | 310.0 | ND | 280.0 | ND | 660.0 | ND | 290.0 | ND | ND | ND |
| 11th & W | 2 | 3 | S15-04 | 4.5-7.5 | 30 | D | 1.2 | ND | 38.0 | ND | 35.0 | ND | 230.0 | ND | 100.0 | ND | ND | ND |
| 11th & W | 2 | 3 | S15-04 | 4.5-7.5 | 30 | P | 1.0 | ND | 12.0 | ND | ND | ND | 14.0 | ND | 72.0 | ND | ND | ND |
| 11th & W | 2 | 3 | S15-04 | 4.5-7.5 | 30 | W | 0.8 | ND | 12.0 | ND | 10.0 | ND | 41.0 | ND | 52.0 | ND | ND | ND |
| 11th & W | 2 | 1 | S15-05 | 0-1.5 | 31 | D | ND | ND | ND | ND | ND | ND | 15.0 | ND | 650.0 | ND | 270.0 | ND |
| 11th & W | 2 | 1 | S15-05 | 0-1.5 | 31 | P | ND | ND | ND | ND | ND | ND | 14.0 | ND | 84.0 | ND | ND | ND |
| 11th & W | 2 | 1 | S15-05 | 0-1.5 | 31 | W | ND | ND | ND | ND | ND | ND | 34.0 | ND | 84.0 | ND | ND | ND |
| 11th & W | 2 | 2 | S15-05 | 1.5-4.5 | 32 | D | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 11th & W | 2 | 2 | S15-05 | 1.5-4.5 | 32 | P | 0.5 | ND | 58.0 | ND | 55.0 | ND | 100.0 | ND | 86.0 | ND | ND | ND |
| 11th & W | 2 | 2 | S15-05 | 1.5-4.5 | 32 | W | 0.8 | ND | 110.0 | ND | 99.0 | ND | 150.0 | ND | 130.0 | ND | ND | ND |
| 11th & W | 2 | 3 | S15-05 | 4.5-7.5 | 33 | D | 5.4 | 6.6 | 230.0 | 320.0 | 220.0 | 290.0 | 340.0 | 440.0 | 160.0 | 200.0 | ND | ND\* |
| 11th & W | 2 | 3 | S15-05 | 4.5-7.5 | 33 | P | 1.4 | ND | 59.0 | ND | 55.0 | ND | 21.0 | ND | ND | ND | ND | ND |
| 11th & W | 2 | 3 | S15-05 | 4.5-7.5 | 33 | W | 0.9 | ND | 29.0 | ND | 27.0 | ND | 66.0 | ND | 86.0 | ND | ND | ND |
| 11th & W | 2 | 1 | S15-06 | 0-1.5 | 34 | D | ND | ND | ND | ND | ND | ND | 26.0 | ND | 320.0 | ND | 76.0 | ND |
| 11th & W | 2 | 1 | S15-06 | 0-1.5 | 34 | P | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 11th & W | 2 | 1 | S15-06 | 0-1.5 | 34 | W | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 11th & W | 2 | 2 | S15-06 | 1.5-4.5 | 35 | D | 0.2 | ND\* | 60.0 | ND\* | 57.0 | ND\* | 180.0 | ND\* | 110.0 | ND\* | ND | ND\* |
| 11th & W | 2 | 2 | S15-06 | 1.5-4.5 | 35 | P | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 11th & W | 2 | 2 | S15-06 | 1.5-4.5 | 35 | W | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 11th & W | 2 | 3 | S15-06 | 4.5-6.0 | 36 | D | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 11th & W | 2 | 3 | S15-06 | 4.5-6.0 | 36 | P | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 11th & W | 2 | 3 | S15-06 | 4.5-6.0 | 36 | W | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 11th & W | 3 | 1 | S15-08 | 0-1.5 | 37 | D | ND | ND | 12.0 | ND | 11.0 | ND | 74.0 | ND | 1100.0 | ND | 300.0 | ND |
| 11th & W | 3 | 1 | S15-08 | 0-1.5 | 37 | P | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 11th & W | 3 | 1 | S15-08 | 0-1.5 | 37 | W | ND | ND | ND | ND | ND | ND | ND | ND | 72.0 | ND | ND | ND |
| 11th & W | 3 | 2 | S15-08 | 1.5-4.5 | 38 | D | ND | ND\* | ND | ND\* | ND | ND\* | ND | ND\* | 56.0 | ND\* | ND | ND\* |
| 11th & W | 3 | 2 | S15-08 | 1.5-4.5 | 38 | P | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 11th & W | 3 | 2 | S15-08 | 1.5-4.5 | 38 | W | ND | ND | 25.0 | ND | 25.0 | ND | ND | ND | ND | ND | ND | ND |
| 11th & W | 3 | 3 | S15-08 | 4.5-6.0 | 39 | D | ND | ND | ND | ND | ND | ND | ND | ND | 88.0 | ND | ND | ND |
| 11th & W | 3 | 3 | S15-08 | 4.5-6.0 | 39 | P | ND | ND | ND | ND | ND | ND | ND | ND | 130.0 | ND | ND | ND |
| 11th & W | 3 | 3 | S15-08 | 4.5-6.0 | 39 | W | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 11th & W | 4 | 1 | S15-11 | 0-1.5 | 40 | D | ND | ND | 13.0 | ND | 12.0 | ND | ND | ND | 680.0 | ND | 190.0 | ND |
| 11th & W | 4 | 1 | S15-11 | 0-1.5 | 40 | P | ND | ND | ND | ND | ND | ND | ND | ND | 190.0 | ND | ND | ND |
| 11th & W | 4 | 1 | S15-11 | 0-1.5 | 40 | W | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 11th & W | 4 | 2 | S15-11 | 1.5-4.5 | 41 | D | ND | ND\* | ND | ND\* | ND | ND\* | ND | ND\* | 63.0 | ND\* | ND | ND\* |
| 11th & W | 4 | 2 | S15-11 | 1.5-4.5 | 41 | P | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 11th & W | 4 | 2 | S15-11 | 1.5-4.5 | 41 | W | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| 11th & W | 4 | 3 | S15-11 | 4.5-6.0 | 42 | D | ND | ND | ND | ND | ND | ND | ND | ND | 66.0 | ND | ND | ND |
| 11th & W | 4 | 3 | S15-11 | 4.5-6.0 | 42 | P | ND | ND | ND | ND | ND | ND | ND | ND | 86.0 | ND | ND | ND |
| 11th & W | 4 | 3 | S15-11 | 4.5-6.0 | 42 | W | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |

† ND = value below instrument detection limit or no data available.  
ND\* = Data point collected and analyzed from Phase II was ND, other ND are place holder for no data collection.

**Table S12. Location data and petroleum hydrocarbon data (mg/kg) used to make plume figure (Fig 2. In manuscript).**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  | **Concentration (ppm)** | | | | | |
|  |  |  |  | **Benzene** | | **CCME F1** | | **CCME F2** | |
| **Borehole** | **Latitude** | **Longitude** | **Depth (m)** | **ISM** | **Phase II** | **ISM** | **Phase II** | **ISM** | **Phase II** |
| 1 | 52.11657 | -106.7061 | 0-1.5 | 14 | 7.8 | 1200 | 480 | 170 | 0 |
| 2 | 52.1165 | -106.706 | 0-1.5 | 19 | 33 | 1700 | 700 | 1100 | 0 |
| 3 | 52.11641 | -106.7061 | 0-1.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 52.11643 | -106.7064 | 0-1.5 | 0.54 | 0 | 18 | 0 | 21 | 0 |
| 5 | 52.11636 | -106.7065 | 0-1.5 | 0 | 0 | 0 | 0 | 14 | 0 |
| 6 | 52.11626 | -106.7063 | 0-1.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 52.11629 | -106.7066 | 0-1.5 | ND† | 0 | ND | 0 | ND | 230 |
| 8 | 52.11624 | -106.7067 | 0-1.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 52.1164 | -106.7066 | 0-1.5 | ND | 0 | ND | 0 | ND | 0 |
| 10 | 52.11637 | -106.7068 | 0-1.5 | ND | 0 | ND | 0 | ND | 0 |
| 11 | 52.11623 | -106.7069 | 0-1.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 52.11657 | -106.7061 | 1.5-4.5 | 14 | 7.8 | 280 | 480 | 85 | 65 |
| 2 | 52.1165 | -106.706 | 1.5-4.5 | 14 | 33 | 200 | 700 | 240 | 220 |
| 3 | 52.11641 | -106.7061 | 1.5-4.5 | 3.2 | 11 | 69 | 72 | 58 | 92 |
| 4 | 52.11643 | -106.7064 | 1.5-4.5 | 11 | 6.7 | 630 | 220 | 560 | 240 |
| 5 | 52.11636 | -106.7065 | 1.5-4.5 | 0.48 | 0 | 55 | 0 | 100 | 0 |
| 6 | 52.11626 | -106.7063 | 1.5-4.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 52.11629 | -106.7066 | 1.5-4.5 | ND | 0 | ND | 0 | ND | 0 |
| 8 | 52.11624 | -106.7067 | 1.5-4.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 52.1164 | -106.7066 | 1.5-4.5 | ND | 0.2 | ND | 25 | ND | 1700 |
| 10 | 52.11637 | -106.7068 | 1.5-4.5 | ND | 0 | ND | 0 | ND | 0 |
| 11 | 52.11623 | -106.7069 | 1.5-4.5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 52.11657 | -106.7061 | 4.5-6.0 | 0.67 | 0 | 0 | 0 | 11 | 0 |
| 2 | 52.1165 | -106.706 | 4.5-6.0 | 2.3 | 0 | 21 | 0 | 41 | 0 |
| 3 | 52.11641 | -106.7061 | 4.5-6.0 | 4.6 | 11 | 28 | 72 | 18 | 0 |
| 4 | 52.11643 | -106.7064 | 4.5-6.0 | 0.99 | 0 | 0 | 0 | 14 | 0 |
| 5 | 52.11636 | -106.7065 | 4.5-6.0 | 1.4 | 6.6 | 55 | 290 | 21 | 440 |
| 6 | 52.11626 | -106.7063 | 4.5-6.0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 52.11629 | -106.7066 | 4.5-6.0 | ND | 0 | ND | 0 | ND | 0 |
| 8 | 52.11624 | -106.7067 | 4.5-6.0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 52.1164 | -106.7066 | 4.5-6.0 | ND | 0 | ND | 0 | ND | 0 |
| 10 | 52.11637 | -106.7068 | 4.5-6.0 | ND | 0 | ND | 0 | ND | 0 |
| 11 | 52.11623 | -106.7069 | 4.5-6.0 | 0 | 0 | 0 | 0 | 0 | 0 |

† ND = value below instrument detection limit or no data available.

**Table S13. Number of pixels for each plume map layer for Phase II ESA and ISM results (Fig. 2. In manuscript). Pixel size = 0.14972 m.**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Depth Increment** | | |
| **PII** | **1 (m)** | **3 (m)** | **5 (m)** |
| Benzene | 63127 | 82504 | 49529 |
| F1 | 34331 | 63153 | 45427 |
| F2 | 632 | 56852 | 7207 |
| **ISM** |  |  |  |
| Benzene | 65247 | 77870 | 82593 |
| F1 | 49270 | 70145 | 2140 |
| F2 | 5412 | 31908 | 0 |

**Table S14. Plume volume (m3) data and percent difference (%) results for Fig. 2. In manuscript.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Depth Increment** | | |  |  |  |
| **PII** | **1 (m)** | **3 (m)** | **5 (m)** | **Total plume volume (m3)** | **% Difference between ISM and Phase II Plume** | |
| Benzene | 2123 | 5548 | 1665 | 9336 | **Benzene** | -8.54 |
| F1 | 1154 | 4247 | 1527 | 6929 | **F1** | 7.49 |
| F2 | 21 | 3823 | 242 | 4087 | **F2** | 75.57 |
| **ISM** |  |  |  |  |  |  |
| Benzene | 2194 | 5237 | 2777 | 10208 |  |  |
| F1 | 1657 | 4717 | 72 | 6446 |  |  |
| F2 | 182 | 2146 | 0 | 2328 |  |  |

**Table S15. Petroleum hydrocarbon data (mg/kg) collected from laboratory experiment comparing 1 ISM sample to the mean of 30 discrete samples from the same core.**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Core#\_Sample** | **F1 C6-C10 (mg/kg)** | **Benzene (mg/kg)** | **Toluene (mg/kg)** | **Ethylbenzene (mg/kg)** | **Xylenes 1 (mg/kg)** | **Xylenes 2 (mg/kg)** | **BTEX total (mg/kg)** | **F1-BTEX (mg/kg)** |
| 1\_ISM | ND† | ND | ND | ND | ND | ND | ND | ND |
| 1\_1‡ | 0.81 | ND | ND | ND | ND | ND | ND | 0.81 |
| 1\_10 | 1.22 | ND | ND | ND | ND | ND | ND | 1.22 |
| 1\_11 | 1.88 | ND | ND | ND | ND | ND | ND | 1.88 |
| 1\_12 | 0.76 | ND | ND | ND | ND | ND | ND | 0.76 |
| 1\_13 | 0.83 | ND | ND | ND | ND | ND | ND | 0.83 |
| 1\_14 | 0.65 | ND | ND | ND | ND | ND | ND | 0.65 |
| 1\_15 | 0.45 | ND | ND | ND | ND | ND | ND | 0.45 |
| 1\_16 | 1.67 | ND | ND | ND | 0.12 | ND | 0.12 | 1.54 |
| 1\_17 | 0.40 | ND | ND | ND | ND | ND | ND | 0.40 |
| 1\_18 | 1.22 | ND | ND | ND | ND | ND | ND | 1.22 |
| 1\_19 | 5.85 | ND | ND | 0.70 | 1.07 | 1.96 | 3.73 | 2.13 |
| 1\_2 | 8.39 | ND | 0.95 | 0.99 | 1.27 | 2.84 | 6.06 | 2.34 |
| 1\_20 | 2.13 | ND | ND | ND | ND | ND | ND | 2.13 |
| 1\_21 | 0.75 | ND | ND | ND | 0.07 | ND | 0.07 | 0.67 |
| 1\_22 | 1.60 | ND | ND | ND | ND | ND | ND | 1.60 |
| 1\_23 | 0.05 | ND | ND | ND | ND | ND | ND | 0.05 |
| 1\_24 | ND | ND | ND | ND | ND | ND | ND | ND |
| 1\_25 | 2.80 | ND | ND | 0.33 | 0.68 | ND | 1.00 | 1.80 |
| 1\_3 | ND | ND | ND | ND | ND | ND | ND | ND |
| 1\_4 | ND | ND | ND | ND | ND | ND | ND | ND |
| 1\_5 | 1.65 | ND | ND | ND | ND | ND | ND | 1.65 |
| 1\_6 | 0.61 | ND | ND | ND | ND | ND | ND | 0.61 |
| 1\_7 | 0.79 | ND | ND | ND | ND | ND | ND | 0.79 |
| 1\_8 | 0.49 | ND | ND | ND | ND | ND | ND | 0.49 |
| 1\_9 | 0.84 | ND | ND | ND | ND | ND | ND | 0.84 |
| 2\_ISM | 78.97 | 15.30 | 7.22 | 5.22 | 1.00 | 5.64 | 34.37 | 44.60 |
| 2\_1 | ND | ND | ND | ND | ND | ND | ND | ND |
| 2\_10 | 22.59 | 1.38 | 2.11 | 1.00 | 0.05 | 2.57 | 7.12 | 15.47 |
| 2\_11 | 21.72 | 1.24 | 2.69 | 1.97 | 1.26 | 2.63 | 9.79 | 11.94 |
| 2\_12 | 26.34 | 1.41 | 2.13 | 0.61 | ND | 1.75 | 5.91 | 20.43 |
| 2\_13 | 14.67 | 1.89 | 2.33 | 0.83 | ND | 1.88 | 6.92 | 7.75 |
| 2\_14 | 31.81 | 4.18 | 2.37 | 0.56 | ND | ND | 7.11 | 24.70 |
| 2\_15 | 23.06 | 6.05 | 2.99 | 1.63 | 0.22 | 1.80 | 12.68 | 10.38 |
| 2\_16 | 42.24 | 8.37 | 4.03 | 3.10 | 0.17 | 3.67 | 19.34 | 22.90 |
| 2\_17 | 55.01 | 10.19 | 4.96 | 5.05 | 1.80 | 3.49 | 25.49 | 29.52 |
| 2\_18 | 102.56 | 15.17 | 8.00 | 6.69 | 0.19 | 8.47 | 38.51 | 64.05 |
| 2\_19 | 36.71 | 8.67 | 3.84 | 3.42 | 0.08 | 3.66 | 19.67 | 17.04 |
| 2\_2 | 2.43 | ND | ND | ND | 0.24 | ND | 0.24 | 2.20 |
| 2\_20 | 261.77 | 35.53 | 19.32 | 16.31 | 1.02 | 18.17 | 90.35 | 171.42 |
| 2\_21 | 295.76 | 40.92 | 24.63 | 18.86 | 2.58 | 20.97 | 107.96 | 187.80 |
| 2\_22 | 370.90 | 42.28 | 31.85 | 21.68 | 4.01 | 21.66 | 121.48 | 249.42 |
| 2\_23 | 190.30 | 28.45 | 14.65 | 13.74 | 3.47 | 12.22 | 72.52 | 117.78 |
| 2\_24 | 464.57 | 80.34 | 37.03 | 27.78 | 7.20 | 26.74 | 179.10 | 285.48 |
| 2\_25 | 25.47 | 5.31 | 2.05 | 1.78 | 0.56 | 1.38 | 11.08 | 14.40 |
| 2\_26 | 44.05 | 14.67 | 3.68 | 4.41 | 1.79 | 1.50 | 26.05 | 18.00 |
| 2\_27 | 44.78 | 14.87 | 3.91 | 4.17 | 1.49 | 1.89 | 26.32 | 18.46 |
| 2\_28 | 82.10 | 21.49 | 6.61 | 6.96 | 2.49 | 3.15 | 40.69 | 41.41 |
| 2\_29 | 88.82 | 18.32 | 6.47 | 6.25 | 2.67 | 2.66 | 36.38 | 52.44 |
| 2\_3 | 2.33 | ND | ND | ND | ND | ND | ND | 2.33 |
| 2\_30 | 110.27 | 23.62 | 7.72 | 6.97 | 2.37 | 5.36 | 46.04 | 64.23 |
| 2\_4 | 2.17 | ND | ND | ND | 0.16 | ND | 0.16 | 2.01 |
| 2\_5 | 12.98 | ND | ND | ND | 0.27 | ND | 0.27 | 12.70 |
| 2\_6 | 0.42 | ND | ND | 0.61 | ND | ND | 0.61 | ND |
| 2\_7 | 17.48 | 1.24 | ND | 0.34 | ND | ND | 1.59 | 15.90 |
| 2\_8 | 13.32 | ND | ND | 0.42 | ND | ND | 0.42 | 12.90 |
| 2\_9 | 45.36 | 1.41 | 2.49 | 1.50 | 0.18 | 4.21 | 9.79 | 35.57 |
| 3\_ISM | 220.09 | 34.82 | 12.33 | 13.55 | 16.37 | 3.09 | 80.17 | 139.92 |
| 3\_1 | 322.51 | 42.57 | 18.32 | 16.30 | 12.44 | 2.45 | 92.08 | 230.43 |
| 3\_10 | 392.49 | 49.60 | 20.65 | 22.52 | 28.23 | 12.95 | 133.95 | 258.54 |
| 3\_11 | 174.42 | 24.46 | 10.96 | 13.64 | 16.44 | 4.87 | 70.38 | 104.04 |
| 3\_12 | 885.65 | 115.12 | 47.79 | 45.67 | 55.51 | 6.29 | 270.38 | 615.26 |
| 3\_13 | 231.38 | 31.57 | 13.39 | 13.96 | 23.59 | 8.93 | 91.45 | 139.93 |
| 3\_14 | 164.38 | 38.97 | 8.96 | 11.92 | 20.11 | 1.62 | 81.59 | 82.79 |
| 3\_15 | 383.57 | 80.21 | 18.03 | 17.89 | 22.90 | 10.41 | 149.44 | 234.13 |
| 3\_16 | 442.55 | 61.32 | 26.34 | 22.83 | 23.29 | 14.82 | 148.59 | 293.95 |
| 3\_17 | 96.79 | 25.23 | 5.26 | 7.81 | 13.05 | 2.99 | 54.33 | 42.46 |
| 3\_18 | 86.47 | 21.96 | 4.95 | 6.98 | 11.00 | 2.98 | 47.87 | 38.60 |
| 3\_19 | 114.74 | 29.57 | 6.87 | 8.59 | 16.24 | 5.90 | 67.18 | 47.57 |
| 3\_2 | 161.34 | 22.75 | 8.97 | 8.51 | 8.99 | 3.86 | 53.09 | 108.25 |
| 3\_20 | 98.58 | 21.43 | 6.14 | 7.27 | 14.45 | 5.08 | 54.37 | 44.21 |
| 3\_21 | 973.07 | 144.00 | 54.99 | 44.14 | 40.25 | 28.22 | 311.60 | 661.46 |
| 3\_22 | 195.44 | 31.46 | 10.96 | 11.48 | 12.42 | 3.84 | 70.15 | 125.29 |
| 3\_23 | 219.91 | 36.59 | 14.39 | 14.00 | 9.53 | 8.32 | 82.83 | 137.09 |
| 3\_24 | 108.50 | 31.43 | 4.15 | 8.95 | 10.59 | 1.61 | 56.73 | 51.77 |
| 3\_25 | 51.88 | 20.12 | 3.65 | 5.76 | 3.62 | ND | 33.15 | 18.72 |
| 3\_26 | 43.61 | 17.06 | 2.35 | 6.10 | 4.14 | ND | 29.64 | 13.96 |
| 3\_27 | 38.87 | 9.89 | ND | 4.73 | 3.60 | ND | 18.22 | 20.66 |
| 3\_28 | 60.42 | 18.54 | 3.30 | 6.92 | 7.05 | 2.70 | 38.51 | 21.91 |
| 3\_29 | 58.79 | 17.06 | 4.09 | 5.63 | 3.72 | 1.43 | 31.93 | 26.85 |
| 3\_3 | 201.91 | 24.27 | 9.23 | 14.08 | 22.15 | 6.11 | 75.84 | 126.07 |
| 3\_30 | 35.56 | 13.58 | 2.02 | 4.19 | 4.13 | ND | 23.91 | 11.65 |
| 3\_4 | 82.21 | 18.74 | 3.78 | 6.44 | 10.15 | 3.89 | 42.99 | 39.22 |
| 3\_5 | 112.46 | 26.37 | 5.86 | 9.34 | 14.15 | 3.99 | 59.72 | 52.74 |
| 3\_6 | 131.43 | 18.02 | 6.98 | 8.48 | 12.54 | 3.56 | 49.58 | 81.85 |
| 3\_7 | 219.02 | 45.20 | 12.82 | 14.39 | 22.75 | 3.00 | 98.18 | 120.85 |
| 3\_8 | 264.28 | 35.46 | 14.12 | 15.75 | 20.53 | 1.97 | 87.84 | 176.44 |
| 3\_9 | 503.61 | 64.02 | 28.34 | 29.05 | 28.41 | 3.55 | 153.37 | 350.24 |

† ND = value below instrument detection limit or no data available.  
‡ Samples that are numbers indicate the discrete sample taken from the core.

**References**

ITRC (Interstate Technology Regulatory Council). 2012. Incremental sampling methodology. ISM-1. Washington, D.C.: Interstate Technology & Regulatory Council, Incremental Sampling Methodology Team. [www.itrcweb.org](http://www.itrcweb.org).