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# Z-Area Vault 4

## Phase 2 Soil Sample Analytical Data Report

ERD-EN-2008-0083

December 2008

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## **EXECUTIVE SUMMARY**

Soil and gravel samples were collected from the most contaminated area, next to Cell E, of four areas of radiological soil contamination at Z-Area Vault 4, which had been previously sampled in Phase 1.

Sample results indicate that significant cesium-137 (Cs-137) contamination outside the Cell E wall is spatially restricted in all directions. More than 99% of the Cs-137 which leaked onto gravel adjacent to the vault wall remains within 2 feet of its original location. At most, only 0.1% of the leaked cesium has seeped into the ground deeper than 12 inches, and soil samples collected from depths greater than 24 inches have essentially no Cs-137.

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## 1.0 PURPOSE

The objective of this document is to report analytical data results of soil samples collected during Phase 2 of the investigation of wet spots associated with the Saltstone Disposal Facility Vault 4. Phase 2 soil samples were obtained adjacent to Cell E. Analytical results from Phase 1, upon which the Phase 2 sample locations were based, were reported in a previous document (Kubilius, 2008).

## 2.0 PHASE 1 SUMMARY

Phase 1 sampling was conducted in early 2008, and included soil samples beneath wet spots on the exterior wall of Cells E, F, J, and L. The objective was to determine contaminant concentrations at two locations associated with each wet spot: (1) in the gravel immediately beneath the wet spot, and (2) in soil just off the edge of the concrete footer (mud mat), two feet away from the first location.

Soil and gravel samples were collected per the Vault 4 Soil Sample Collection Plan, Revision 0 (Liner, 2008a) from four locations adjacent to the vault and from one background sample. The four vault locations were selected to test active wet spots at Vault 4 Cells E, F, J, and L. At each location, three samples were collected. Two samples were collected from the gravel immediately against the vault wall, representing depth intervals of 0 to 3 inches, and 3 to 12 inches. A third sample was collected from soil two or three feet away from the vault wall, in the dirt backfill beyond the edge of the vault footer, at a nominal depth interval of 12 to 24 inches.

Analytical results of Phase 1 sampling were reported in Kubilius (2008), and are summarized here:

- The ground surface adjacent to all four cells is contaminated with fission products.
- Over 99% of the radioactivity is attributable to cesium-137.
- The ground surface next to cells E and F is more contaminated than the soil near cells J and L.
- The spatial extent of contamination is limited: most contamination is restricted to the uppermost 3 inches of gravel, with much lower levels found at greater depth, or away from the wall.

## 3.0 PHASE 2 SAMPLING APPROACH

Phase 2 soil sampling (Liner, 2008b) took place in July 2008. There were two objectives:

- Investigate the spatial extent of the most contaminated area sampled by Phase 1. This is the location ZV4-002, at Cell E.
- Obtain additional iodine-129 (I-129) data.

In order to better understand the lateral extent of contamination at Cell E, 10 soil samples were collected from the 0 to 3 inch depth interval, at spacings of 1 ft along the edge of the Vault 4 concrete footer in both directions from the Phase 1 location ZV4-002, and additionally 13 measurements at spacings of one foot out away from the vault, to the edge of the Contamination Area. These samples were analyzed in the field for Cs-137 by the ISOCS (In Situ Object Counting System) field gamma ray detector. Samples were brought to the detector, which was located about 100 meters east of Vault 4, in an area of low background. ISOCS analytical results are considered to be qualitative, rather than quantitative.

All Phase 2 sampling for quantitative laboratory analysis was conducted within a 7 ft x 6 ft area, surrounding the locations of the previously sampled ZV4-002 at Cell E, which was the most contaminated sample location from Phase 1 (**Figure 1**). The extent of contamination was investigated laterally with stepout samples in various directions from the original ZV4-002; and vertically by collecting samples down to 72 inches depth at each location, as opposed to a 24 inch depth in Phase 1.

Step-out samples were collected on three sides of the Phase 1 location: along the edge of the concrete footer, and out beyond it (**Figure 2**). The original Phase 1 location, ZV4-002, was resampled in Phase 2, and called ZV4-006. Sample locations ZV4-008 and ZV4-009 are at the edge of the concrete footer, on either side of ZV4-006, at the same distance from the vault as ZV4-006. ZV4-010 is 4 feet farther out from the vault from ZV4-006. The locations of ZV4-008 and ZV4-010, were chosen to be in relatively less-contaminated areas, based on the ISOCS data. However, these locations do not represent the edge of the contaminated area; Cs-137 concentrations increase beyond ZV4-008 and -010.

The sampled depths at all these locations are 0 to 3 inches, 24 to 48 inches, and 48 to 72 inches.

Vertical development of contamination was investigated by collecting samples at various depths in Phase 2, immediately adjacent to the location of the Phase 1 12 to 24 inch sample (at the edge of the concrete footer). Phase 2 depths at this location (ZV4-006) are 0 to 3 inches, 24 to 48 inches, and 48 to 72 inches (**Figure 3**).

All samples from ZV4-006, -008, -009, and -010 were analyzed for nitrate and a limited suite of radiological constituents, including gross alpha, nonvolatile beta, C-14, Sr-90, Tc-99, Sb-125, I-129, and Cs-137. In addition, the 3 to 12 inch and 12 to 24 inch depth intervals from ZV4-002 (Phase 1 location) were resampled for I-129. Samples were sent to GEL laboratory in Charleston, SC. Because the presence of Cs-137 can interfere with the identification of I-129,

the laboratory was instructed to chemically remove cesium from the sample aliquots prior to counting I-129.

## 4.0 PHASE 2 RESULTS

Laboratory analytical results of Phase 2 sampling are shown in **Table 1**, together with corresponding data from Phase 1. For some samples, two or three separate analyses were performed: the regular sample, the laboratory duplicate, and/or the field duplicate. In some cases, the regular result is higher than the duplicate(s); in other cases it is lower. For samples shown in Table 1, only the *regular* sample result is reported.

Nearly all radioactivity is due to Cs-137, with lesser contributions from Sb-125, Sr-90, Tc-99, and I-129. Iodine-129 was detected in one Phase 2 sample, but due to interference from Cs-137/Ba-137m, its quantity is uncertain. Alpha activity is consistent with natural levels. Nitrate is present at levels exceeding background, but less than the highest detections in Phase 1.

Some analytical results in Table 1 are accompanied by the letters J or R. J indicates that the analyte is judged to be present in the sample at a concentration above the detection limit, and *the result is accepted as a valid detection, but the concentration is uncertain*. Reasons for the uncertainty vary from sample to sample, and may include: concentration below the practical quantitation limit, matrix interference from another analyte, detection of the analyte in the associated method blank, duplicate relative percent difference exceedance, or holding time exceedance. R indicates that the analytical result is rejected, and therefore *it is not known whether the analyte is present* in the sample. Reasons for rejection may include excessive matrix interference from another analyte, identification criteria not met, or excessive holding time exceedance.

### 4.1 CESIUM-137

Qualitative Cs-137 data from the ISOCS is shown in **Figure 4**. Two conclusions are evident. First, surface contamination is widespread inside the CA; all 23 ISOCS samples show Cs-137 concentrations significantly above background. Second, the highest ISOCS result, 857 pCi/g, collected three feet away from the wall, is much lower than the 209,000 pCi/g result obtained next to the wall in Phase 1. This indicates that contamination due to the current wet spot is spatially limited.

The lateral distribution of Phase 2 laboratory Cs-137 results in surface samples is shown in **Figure 5**. The maximally contaminated sample from Phase 1 is shown with a concentration of 209,000 pCi/g. All four stepout samples show Cs-137 results above site background, with samples 2 feet from the vault varying between 8 and 1,050 pCi/g; the sample 6 ft from the wall shows 6 pCi/g. However, when comparing the stepouts with the original 209,000 pCi/g, it is evident that most contamination is localized quite close to the vault wall.

Vertical Cs-137 distribution is presented in **Table 1** and illustrated in **Figure 6**. It can be seen that most Cs-137 contamination has moved less than 3 inches into the ground, and almost none has migrated more than 2 feet deep. This low mobility is consistent with behavior at other SRS waste units.

## 4.2 NITRATE

The concentration distribution of soil nitrate as nitrogen in units of mg/kg, is presented in Table 1, and illustrated in **Figures 7** (lateral) and **8** (vertical). Nitrate has moved farther from its point of origin than Cs-137 has; Figure 7 indicates that the maximum nitrate concentration in the Cell E samples is in the 12-24 inch interval (ZV4-002 & -006) or in the 24-48 inch interval (ZV4-008 and -009). However, at three of four Cell E locations, nitrate concentrations in the deepest interval (48-72 inches) are lower, and consistent with site background levels. The relatively high mobility shown by nitrate at Vault 4 is consistent with its chemical properties.

## 4.3 IODINE-129

In Phase 1, iodine-129 was detected in one sample at Cell F (ZV4-003, 3-12 inches depth). In many of the remaining samples, large Cs-137 peaks interfered with instrument identification of iodine-129. In these samples (see Table 1), it is not possible to say whether or not I-129 is present. Therefore, for Phase 2, the laboratory was instructed to perform chemical separation so that a pure iodine extract could be quantitated. However, the lab initially failed to perform the required separation, and as discussed in Section 4.0, most I-129 analyses in Phase 2 which contain large Cs-137 peaks are likewise inconclusive.

After the lab's error was recognized, GEL did perform the chemical separation and re-analyzed all Phase 2 samples. No I-129 was detected in any sample. However, these re-analyses were not performed until 56 days after sample collection, and I-129, because of its volatility, has a holding time of 28 days. Because of the significant holding time exceedance, the re-analysis of each sample is regarded as inconclusive. Therefore, only the first analytical results are reported in Table 1.

One I-129 sample result was rejected by the laboratory, but is accepted in this report as a valid detection. It is the 3-12 inch depth sample from ZV4-002, phase 2 (ZV4SS-0000038 in Table 1). The laboratory rejected the result due to failed abundance (identification criteria not met). The large I-129 peak at 29.6 keV was observed by the instrument, but the smaller two peaks at 33.6 and 39.6 keV were not seen. The lab's identification criteria ("75% summed abundance") requires that at least two of the three peaks be visible, but only one was actually seen by the instrument. However, in samples with high concentrations of Cs-137, peak interference may prevent the two smaller peaks from being found. This was confirmed by the matrix spike sample for ZV4SS-0000038, in which the instrument failed to recognize the two smaller iodine peaks, despite the known presence of I-129 in the sample. Therefore the recognition of the large 29.6 keV peak is here regarded as sufficient evidence for the presence of iodine-129 in samples with high Cs-137. The analysis is accepted as an I-129 detection. Due to significant interference

from Cs-137, the reported concentration of 69 pCi/g is uncertain, and the result is qualified with J.

## 5.0 REFERENCES

Kubilius, W., 2008. *Z-Area Vault 4 Phase 1 Soil Sample Analytical Data Report*, ERD-EN-2008-0056, Revision 0, July 2008

Liner, K., 2008a. *Z-Area Industrial Solid Waste Landfill Disposal Facility Vault 4 Soil Sample Collection Plan*, SRS-REG-2008-00007, Revision 0, 1/29/08

Liner, K., 2008b. *Z-Area Industrial Solid Waste Landfill Disposal Facility Vault 4 Soil Sample Collection Plan*, SRS-REG-2008-00007, Revision 1, 5/5/08

USEPA, 1996. *Soil Screening Guidance: User's Guide*, EPA/540/R-96/018, April 2006



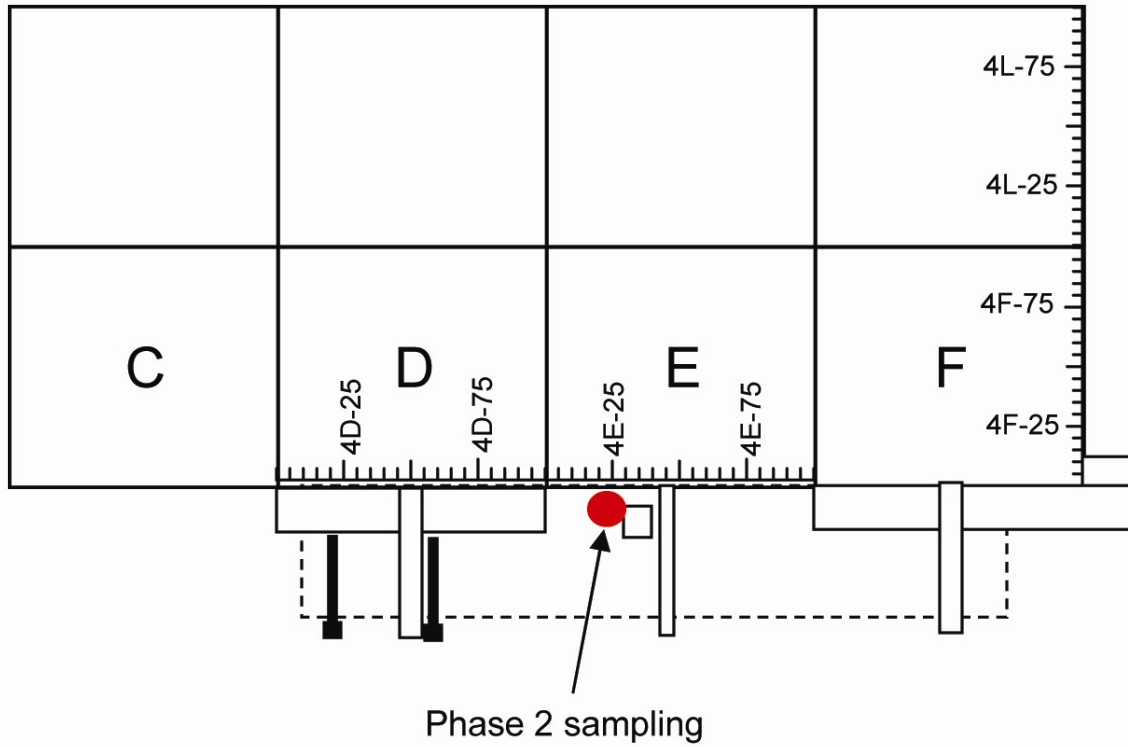


Figure 1. Location of Phase 2 sampling at Saltstone Vault 4, Cell E.

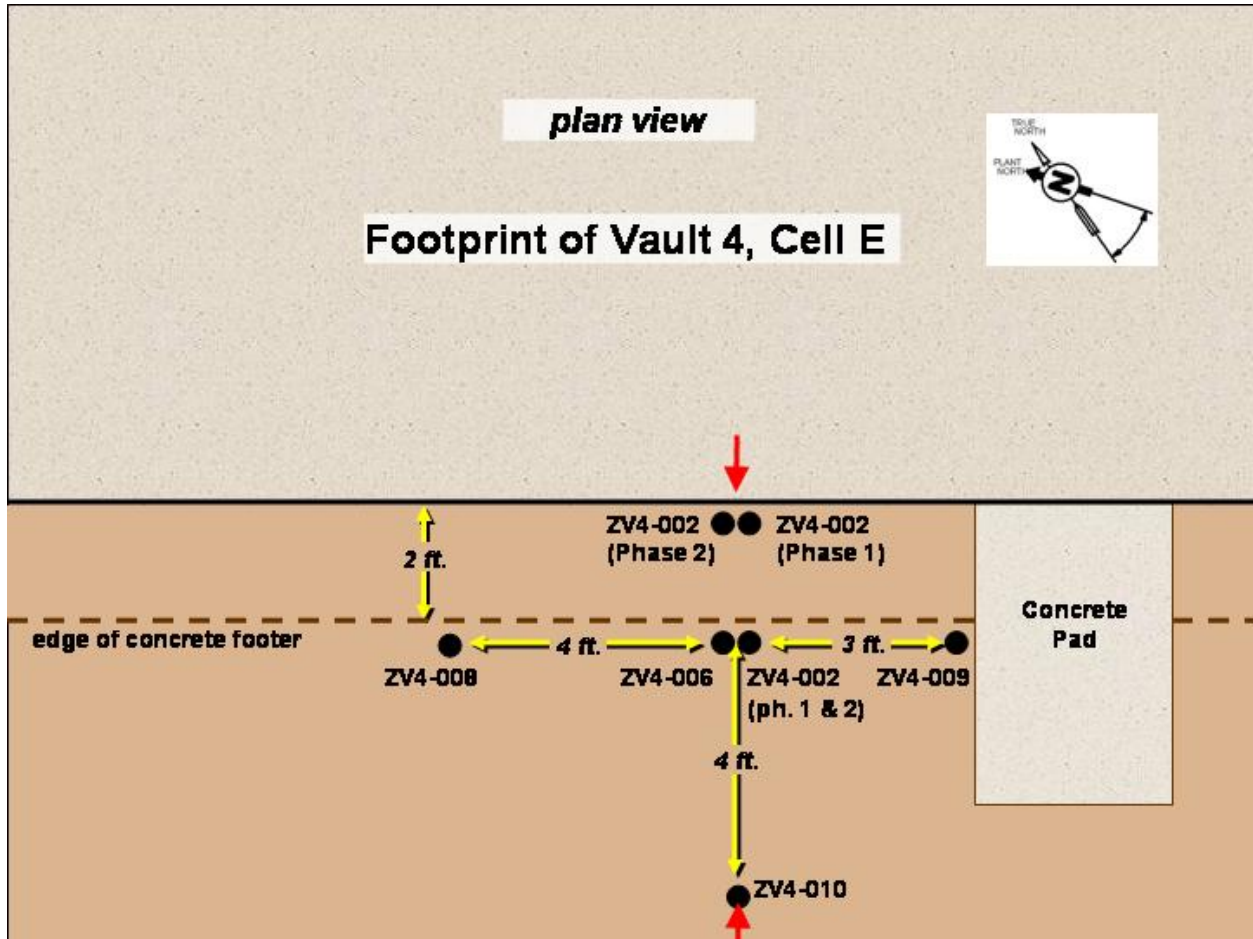


Figure 2. Sample locations, Phase 2. Red arrows indicate line of cross section for Figures 6 and 8.

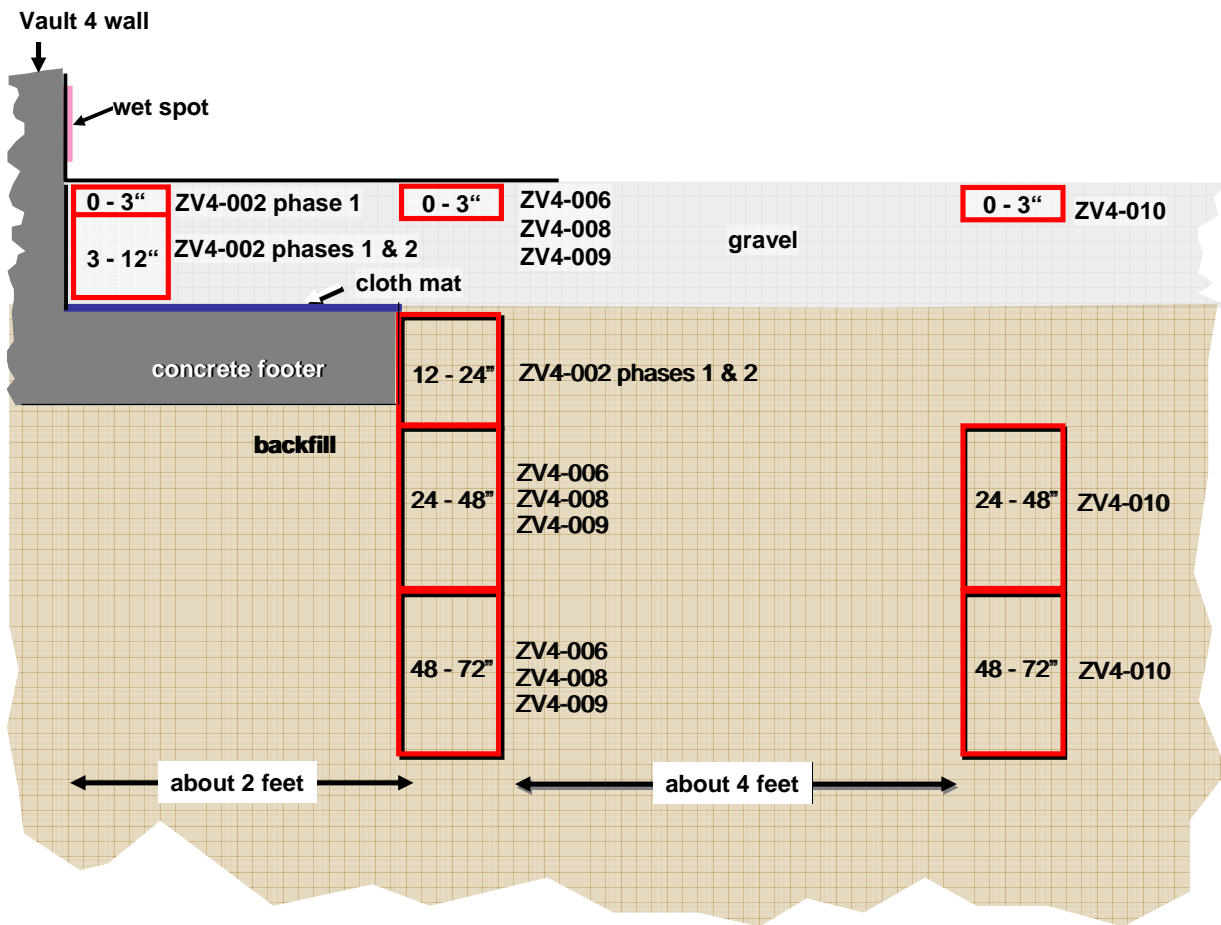


Figure 3. Sample depths, Phase 2

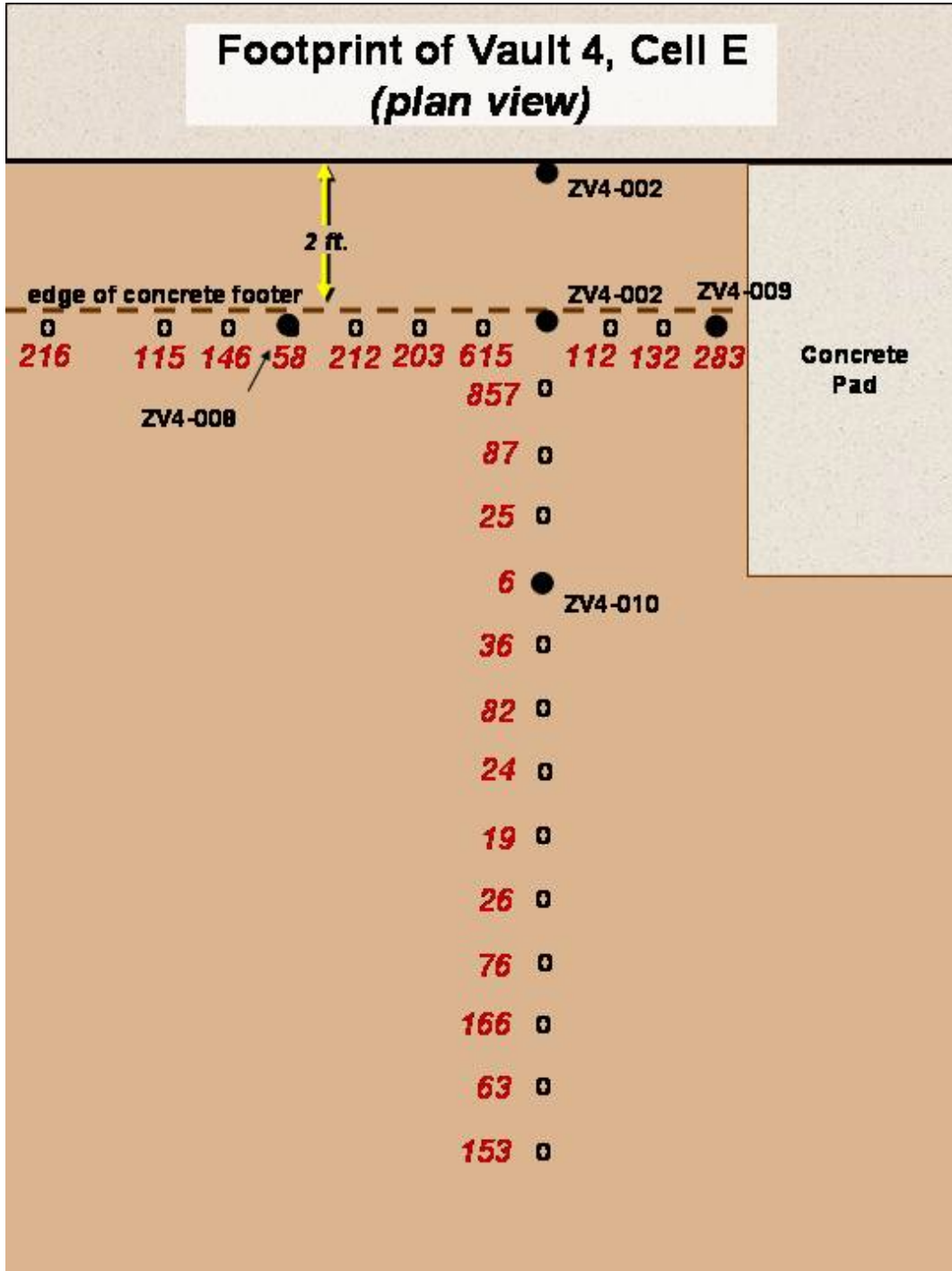


Figure 4. Qualitative surface Cs-137 concentrations (pCi/g), obtained with the ISOCS instrument.

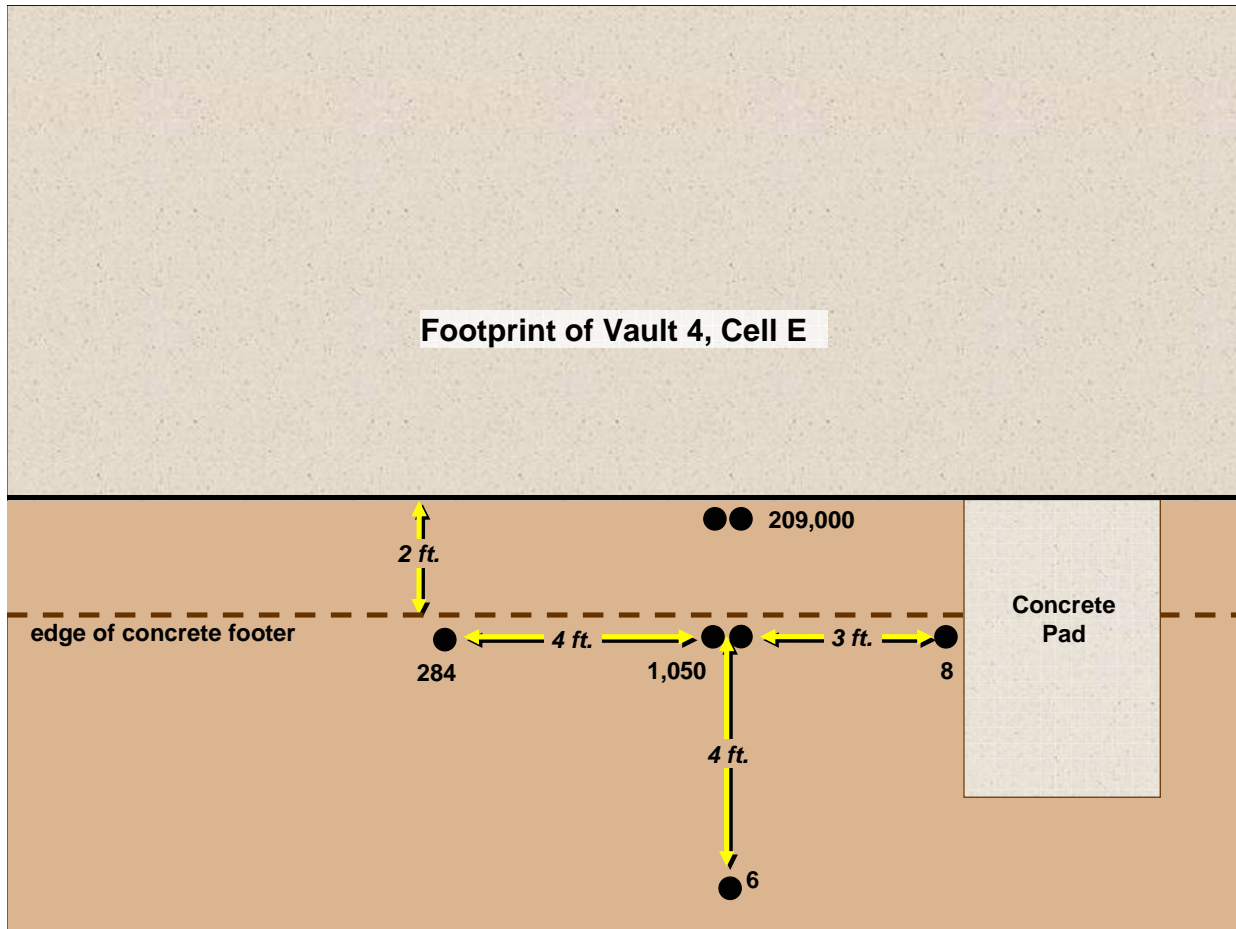


Figure 5. Cesium-137 concentrations, pCi/g, in surface soil samples (0 to 3 inch depth) at Cell E.

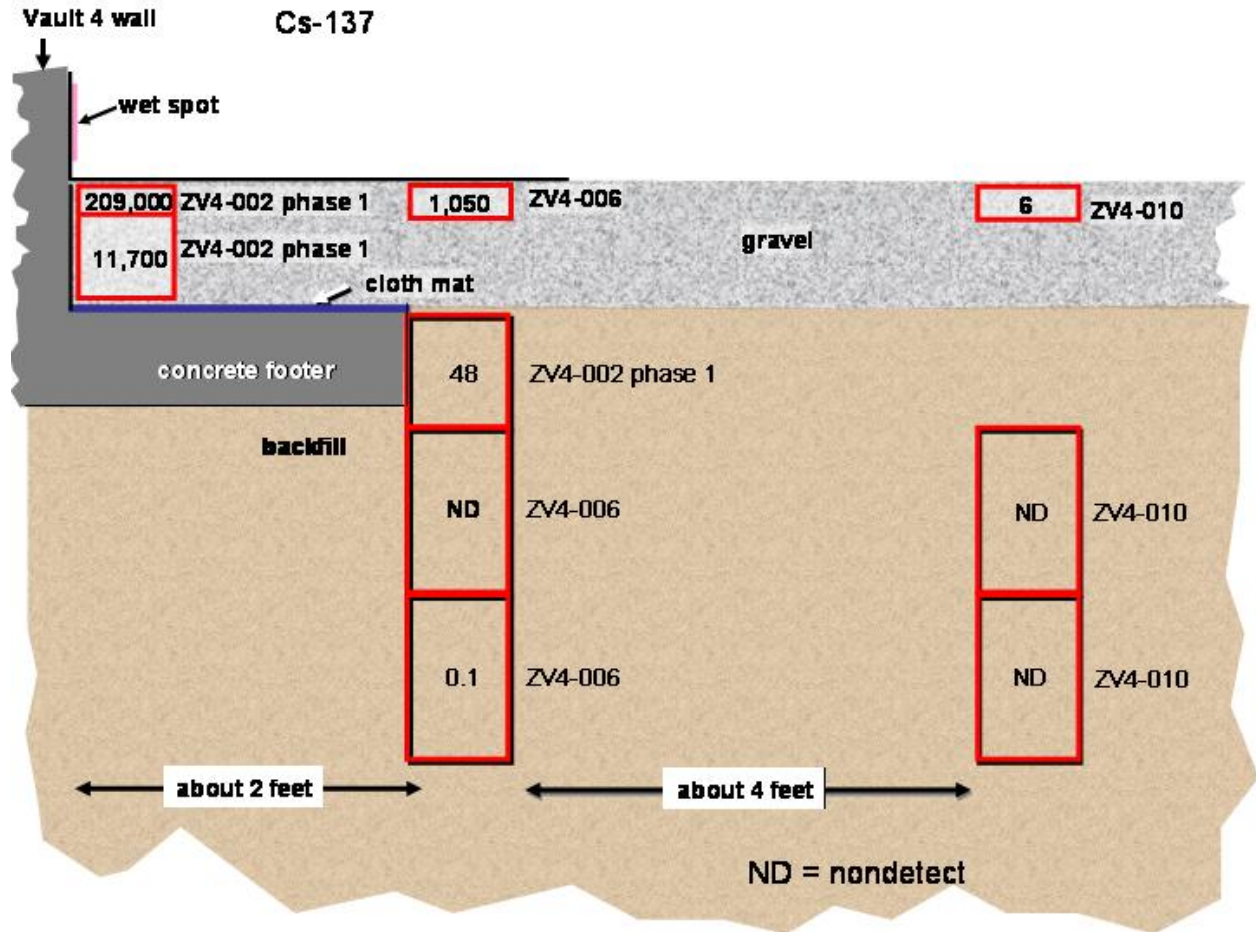


Figure 6. Vertical distribution of Cs-137 in soil (pCi/g) at Vault 4, Cell E

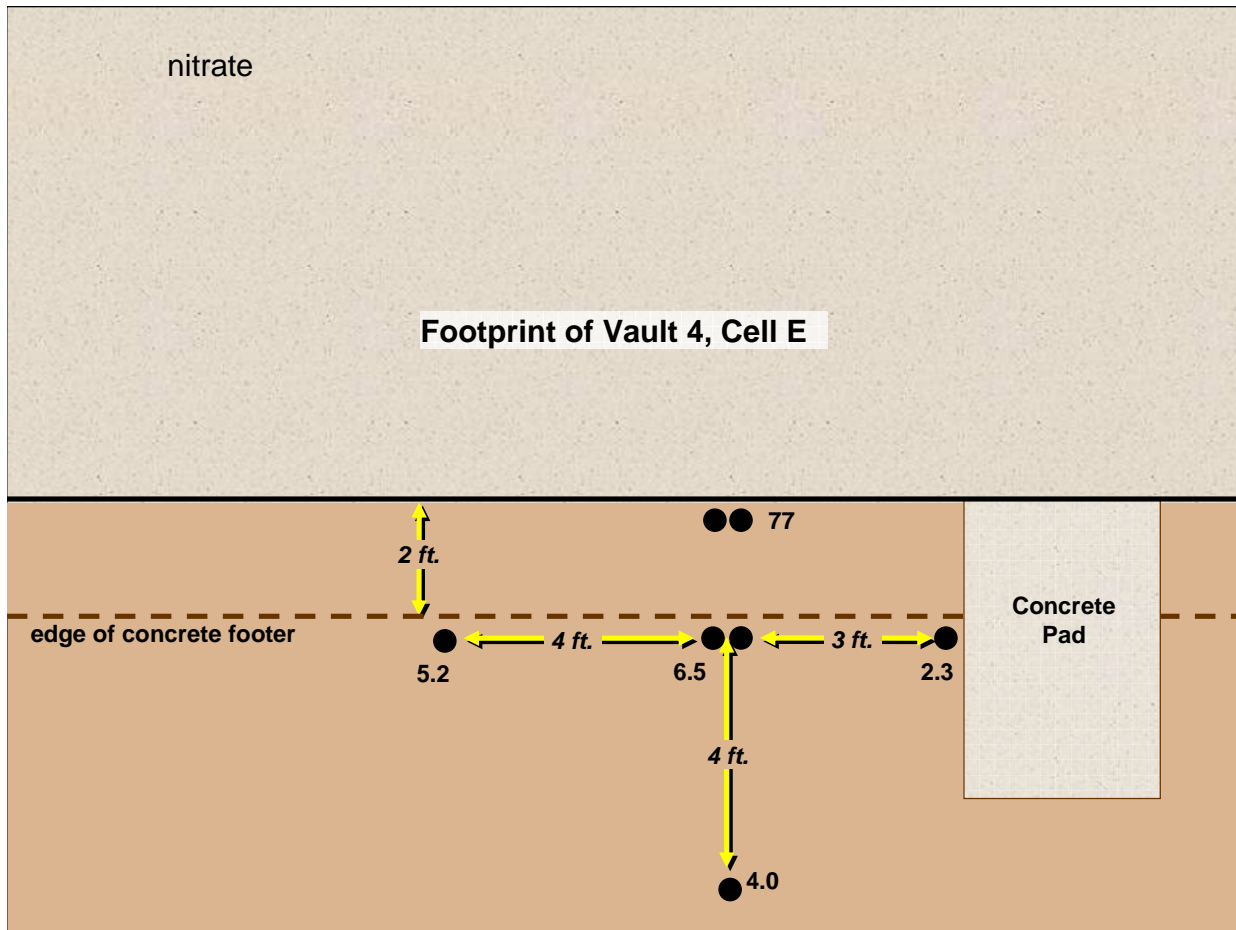


Figure 7. Nitrate concentrations, mg/kg as nitrogen, in surface soil samples (0 to 3 inch depth) at Cell E. Background concentrations are less than 1 mg/kg



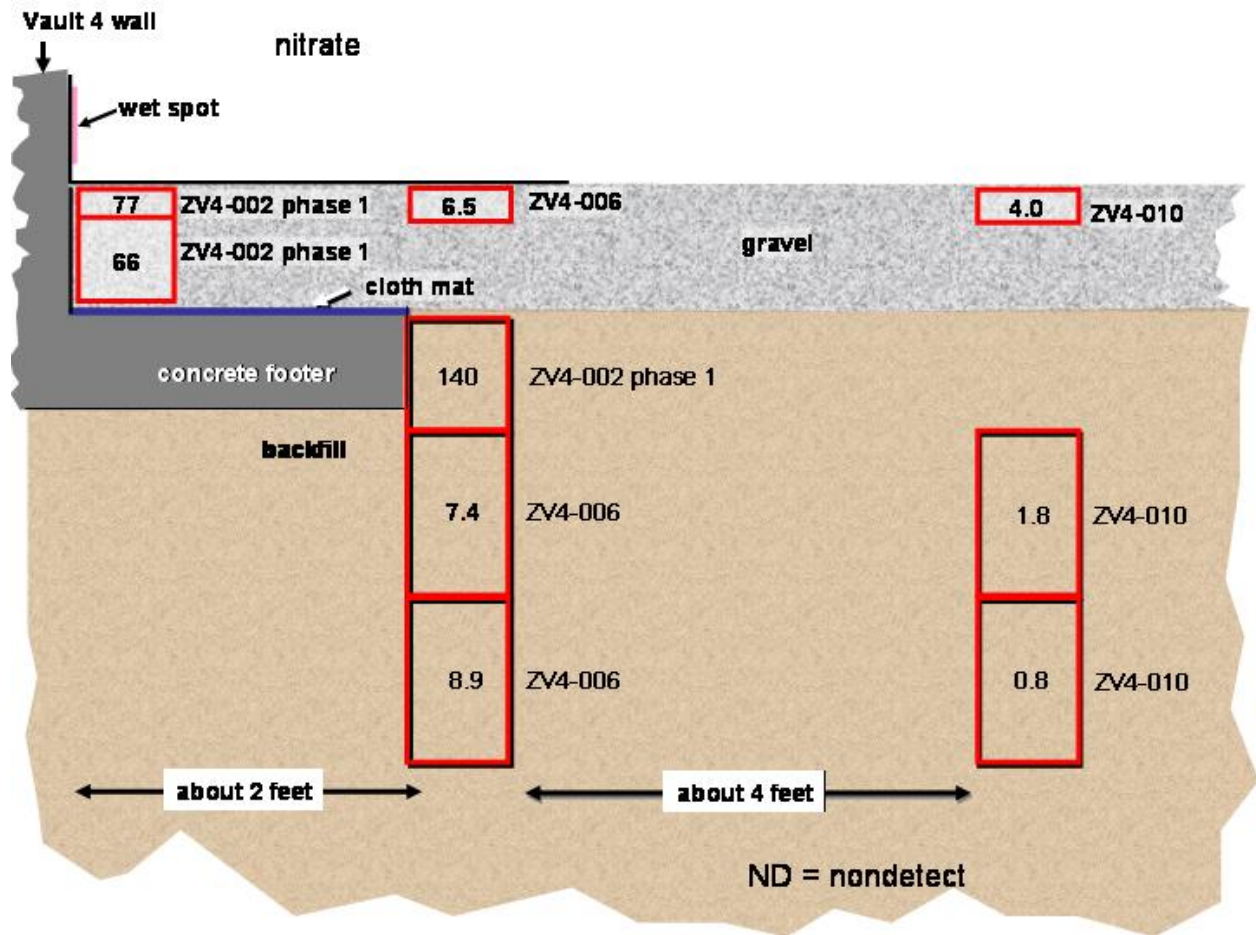


Figure 8. Vertical distribution of nitrate in soil, mg/kg as nitrogen, at Vault 4, Cell E



Table 1. Analytical Results for Saltstone Phase 1 & 2 Sampling

phase	location	station	lab sample ID	depth	G ALPHA	NV BETA	CS-137	SB-125	SR-90	TC-99	C-14	I-129	nitrate
phase 1	background	ZV4-001	ZV4SS-0000002	gravel 0-3	J 19	38	0.2	ND	ND	ND	ND	ND	1.5
phase 1	background	ZV4-001	ZV4SS-0000003	gravel 3-12	38	52	J 0.2	ND	ND	ND	ND	ND	J 0.5
phase 1	background	ZV4-001	ZV4SS-0000001	soil 12-24	J 8	J 9	ND	ND	ND	ND	ND	ND	J 0.9
phase 1	cell E	ZV4-002	ZV4SS-0000005	gravel 0-3	1930	183000	209000	190	34	J 66	ND	R 0.0	77
phase 1	cell E	ZV4-002	ZV4SS-0000006	gravel 3-12	J 81	9680	11700	51	J 6	ND	ND	R 117	66
phase 1	cell E	ZV4-002	ZV4SS-0000004	soil 12-24	12	42	48	4	ND	ND	ND	R 1.7	140
phase 1	cell F	ZV4-003	ZV4SS-0000009	gravel 0-3	1860	187000	171000	511	27	J 79	ND	R 0.4	ND
phase 1	cell F	ZV4-003	ZV4SS-0000010	gravel 3-12	ND	123000	117000	231	ND	ND	ND	J 2.7	ND
phase 1	cell F	ZV4-003	ZV4SS-0000008	soil 12-24	J 16	613	850	86	ND	ND	ND	R 11	324
phase 1	cell J	ZV4-004	ZV4SS-0000012	gravel 0-3	10	J 210	J 401	J 67	ND	ND	ND	R 9.4	1.9
phase 1	cell J	ZV4-004	ZV4SS-0000013	gravel 3-12	14	181	153	10	ND	ND	ND	R 4.3	2.4
phase 1	cell J	ZV4-004	ZV4SS-0000011	soil 12-24	J 7	J 7	J 0.1	ND	ND	ND	ND	ND	ND
phase 1	cell L	ZV4-005	ZV4SS-0000016	gravel 0-3	13	100	50	3	ND	ND	ND	R 3.5	J 0.3
phase 1	cell L	ZV4-005	ZV4SS-0000017	gravel 3-12	16	52	23	J 1	ND	ND	ND	ND	ND
phase 1	cell L	ZV4-005	ZV4SS-0000015	soil 12-24	13	J 7	ND	ND	ND	ND	ND	ND	ND
phase 2	cell E	ZV4-006	ZV4SS-0000025	gravel 0-3	30	917	1050	4	J 4	ND	ND	R 15	6.5
phase 2	cell E	ZV4-006	ZV4SS-0000023	soil 24-48	17	J 10	J 0.1	ND	ND	ND	ND	ND	7.4
phase 2	cell E	ZV4-006	ZV4SS-0000024	soil 48-72	J 9	J 5	J 0.1	ND	ND	ND	ND	ND	8.9
phase 2	cell E	ZV4-008	ZV4SS-0000029	gravel 0-3	26	265	284	2 R	J 0.8	ND	ND	R 2.5	5.2
phase 2	cell E	ZV4-008	ZV4SS-0000027	soil 24-48	22	J 7	3	0.4 R	ND	ND	ND	ND	26
phase 2	cell E	ZV4-008	ZV4SS-0000028	soil 48-72	16	J 13	0.8	ND	ND	ND	ND	ND	0.9
phase 2	cell E	ZV4-009	ZV4SS-0000033	gravel 0-3	23	36	8	0.3 R	ND	ND	ND	ND	2.3
phase 2	cell E	ZV4-009	ZV4SS-0000031	soil 24-48	17	J 15	J 10	0.2 R	ND	ND	ND	ND	J 16
phase 2	cell E	ZV4-009	ZV4SS-0000032	soil 48-72	J 9	J 20	23	ND	ND	ND	ND	ND	1.0
phase 2	cell E	ZV4-010	ZV4SS-0000036	gravel 0-3	30	40	6	0.3 R	ND	ND	ND	ND	4.0
phase 2	cell E	ZV4-010	ZV4SS-0000034	soil 24-48	15	J 18	ND	ND	ND	ND	ND	ND	1.8
phase 2	cell E	ZV4-010	ZV4SS-0000035	soil 48-72	J 11	J 8	ND	ND	ND	ND	ND	ND	0.8
phase 2	cell E	ZV4-002	ZV4SS-0000038	gravel 3-12								J 69	
phase 2	cell E	ZV4-002	ZV4SS-0000037	soil 12-24								ND	

Radiological results in pCi/g; nitrate results in mg/kg as nitrogen.

ND = not detected; J = analyte detected but concentration is uncertain; R = result rejected, analyte may or may not be present

All Phase 2 I-129 results represent the original analysis; no reruns are tabulated.