

US EPA ARCHIVE DOCUMENT

**U.S.ENVIRONMENTAL PROTECTION AGENCY
NATIONAL ANALYTICAL RADIATION ENVIRONMENTAL LABORATORY
540 S. MORRIS AVE., MONTGOMERY, AL 36115
TH ANALYSES**

REPORT OF SAMPLE DELIVERY GROUP #1400013

Project: Petcoke Dust Investigation, Southeast Chicago, IL
Analysis method: Actinides (Thorium) by Extraction Chromatography
Report ID: 1400013-TH
Report type: Original
Date reported: 04/17/2014
Total pages in report: 21

SAMPLES

| NAREL Sample # | Client Sample ID | Location | Matrix | Date Collected | Date Received |
|---------------------------|-------------------------|-----------------|---------------|---------------------------|--------------------------|
| B4.02512P | S-1 | IL:CHICAGO | SOIL | 03/03/2014 | 03/06/2014 |
| B4.02513Q | S-2 | IL:CHICAGO | SOIL | 03/03/2014 | 03/06/2014 |
| B4.02514R | S-3 | IL:CHICAGO | SOIL | 03/03/2014 | 03/06/2014 |
| B4.02515T | S-4 | IL:CHICAGO | SOIL | 03/03/2014 | 03/06/2014 |
| B4.02516U | S-5 | IL:CHICAGO | SOIL | 03/03/2014 | 03/06/2014 |
| B4.02517V | S-6 | IL:CHICAGO | SOIL | 03/03/2014 | 03/06/2014 |
| B4.02518W | N-1 | IL:CHICAGO | SOIL | 03/04/2014 | 03/06/2014 |
| B4.02519X | N-2 | IL:CHICAGO | SOIL | 03/04/2014 | 03/06/2014 |
| B4.02520P | N-3 | IL:CHICAGO | SOIL | 03/04/2014 | 03/06/2014 |
| B4.02521Q | N-4 | IL:CHICAGO | SOIL | 03/04/2014 | 03/06/2014 |
| B4.02522R | N-5 | IL:CHICAGO | SOIL | 03/04/2014 | 03/06/2014 |
| B4.02523T | N-6 | IL:CHICAGO | SOIL | 03/04/2014 | 03/06/2014 |
| B4.02524U | N-2 DUP | IL:CHICAGO | SOIL | 03/04/2014 | 03/06/2014 |

EXCEPTIONS

1. **Packaging and shipping** – Included in the shipment was an empty jar labeled “Blank Rad.” This jar was not logged as a sample, and the client was informed.
2. **Documentation** – No problems were observed.
3. **Sample preparation** – No problems were encountered.
4. **Analysis** – No problems were encountered.
5. **Holding times** – No holding times were specified.

QUALITY CONTROL

1. **QC samples** – All QC analysis results met NAREL acceptance criteria.
2. **Yields** – All chemical yields were within acceptance limits.
3. **Instruments** – Response and background checks for all instruments used in these analyses met NAREL acceptance criteria.

ACCREDITATION



All analyses included in this data package are accredited by the Oregon Environmental Laboratory Accreditation Program (ORELAP) to the TNI standard.

CERTIFICATION

I certify that this data report complies with the terms and conditions of the Quality Assurance Project Plan, except as noted above. Release of the data contained in this report has been authorized by the Director of the Center for Environmental Radioanalytical Laboratory Science and the NAREL Quality Assurance Manager, or their designees, as verified by the following signatures.

Mary F. Wisdom 4-21-14
Mary F. Wisdom Date
Quality Assurance Manager, NAREL

Cynthia White 4-22-14
Cynthia White Date
Director, Center for Environmental Radioanalytical
Laboratory Science

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GENERAL INFORMATION

SAMPLE TYPES

| | |
|-----|---------------|
| BLD | Blind sample |
| FBK | Field blank |
| SAM | Normal sample |

ANALYSIS QC TYPES

| | |
|-----|--|
| ANA | Normal analysis |
| DUP | Laboratory duplicate |
| LCS | Laboratory control sample, or blank spike |
| MS | Matrix spike |
| MSD | Matrix spike duplicate (not currently analyzed) |
| RBK | Method blank |
| STD | External standard (used for ^{228}Ra yield determination) |

QUALITY INDICATORS

| | |
|-----|---|
| RPD | Relative Percent Difference |
| %R | Percent Recovery |
| Z | Number of standard deviations by which a QC measurement differs from the expected value |

RADIOCHEMICAL DATA

Radiochemical analyses usually require the subtraction of an instrument background measurement result from a gross sample measurement result. Both values are positive, but when the sample activity is low, random variations in the two measurements can cause the gross value to be less than the background, resulting in a measured activity less than zero. Although negative activities have no physical significance, they do have statistical importance, as for example in the evaluation of trends or the comparison of two groups of samples.

To the extent practical, it is the policy of NAREL to report results as generated, whether positive, negative, or zero, together with the “2-sigma” measurement uncertainty and a sample-specific estimate of the minimum detectable concentration (MDC). The measurement result, uncertainty, and MDC are always expressed in the same unit of measurement.

EVALUATION OF QC ANALYSES

A method blank result is considered unacceptable if it is more than 3 standard deviations below zero or more than 3 standard deviations above a predetermined upper control limit. For some analyses NAREL has set the upper control limit at zero. For others the control limit is a small positive number.

NAREL evaluates the results of duplicate and spike analyses using “Z scores.” A Z score is the number of standard deviations by which the QC result differs from its ideal value. Generally the score is considered acceptable if its absolute value is not greater than 3.

The Z score for a spiked sample is computed by dividing the difference between the measured value and the target value by the combined standard uncertainty of the difference. The Z score for a duplicate analysis is computed by dividing the difference between the two measured values by the combined standard uncertainty of the difference.

NAREL reports the “relative percent difference,” or RPD, between duplicate results and the “percent recovery,” or %R, for spiked analyses, but does not use these values for evaluation of most analyses. An exception is the use of %R in the evaluation of gross alpha matrix spike results. A gross alpha matrix spike result is considered acceptable if either $|Z| \leq 3$ or $60 \leq \%R \leq 110$.

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NATIONAL ANALYTICAL RADIATION ENVIRONMENTAL LABORATORY**

SDG #1400013

ANALYSIS SUMMARY

Analysis method: NAREL TH-EICHROM
Title: Actinides (Thorium) by Extraction Chromatography

| NAREL Sample # | Client Sample ID | QC Type | Date Completed | Preparation Batch # | Assay Batch # |
|-----------------|------------------|---------|----------------|---------------------|---------------|
| B4.02512P | S-1 | DUP | 04/11/2014 | 0010880P | 0018037E |
| B4.02513Q | S-2 | | 04/11/2014 | 0010880P | 0018037E |
| B4.02514R | S-3 | | 04/11/2014 | 0010880P | 0018037E |
| B4.02515T | S-4 | | 04/11/2014 | 0010880P | 0018037E |
| B4.02515T | S-4 | | 04/11/2014 | 0010880P | 0018037E |
| B4.02516U | S-5 | | 04/11/2014 | 0010880P | 0018037E |
| B4.02517V | S-6 | | 04/11/2014 | 0010880P | 0018037E |
| B4.02518W | N-1 | | 04/11/2014 | 0010880P | 0018037E |
| B4.02519X | N-2 | | 04/11/2014 | 0010880P | 0018037E |
| B4.02520P | N-3 | | 04/11/2014 | 0010880P | 0018037E |
| B4.02521Q | N-4 | | 04/11/2014 | 0010880P | 0018037E |
| B4.02522R | N-5 | | 04/11/2014 | 0010880P | 0018037E |
| B4.02523T | N-6 | | 04/11/2014 | 0010880P | 0018037E |
| B4.02524U | N-2 DUP | | 04/11/2014 | 0010880P | 0018037E |
| LCS-00687695H * | | LCS | 04/11/2014 | 0010880P | 0018037E |
| RBK-00687694G * | | RBK | 04/11/2014 | 0010880P | 0018037E |

* Samples marked with an asterisk are not in this sample delivery group but were analyzed with it for QC purposes.

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SDG #1400013

SAMPLE ANALYSIS REPORT

| | | | |
|---------------------|----------------------|----------------------|------------------|
| Lab sample #: | B4.02512P | Amount analyzed: | 1.055e+00 GDRY |
| Client sample ID: | S-1 | Preparation batch #: | 0010880P |
| Matrix: | SOIL | Assay batch #: | 0018037E |
| Collected: | 2014-03-03 08:30 CST | Prep procedure: | N/A |
| Sample type: | SAM | Analysis method: | NAREL TH-EICHROM |
| Dry/wet weight: | 90.95 % | Analyst: | AS |
| Ash/dry weight: | 0.55 % | QC type: | ANA |
| Sample description: | N/A | | |
| Comment: | N/A | | |

COUNTING INFORMATION

| Date and time | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 04/10/2014 17:05 | 1000.0 | AS100 | CEB |

ANALYTICAL RESULTS

| Analyte | Activity | $\pm 2 \sigma$ Uncertainty | MDC | Unit | Reference Date |
|---------|----------|-------------------------------|---------|----------|----------------------|
| Th227 | 9.11e-03 | 2.0e-02 | 3.4e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th228 | 2.93e-02 | 2.2e-02 | 2.5e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th230 | 3.30e-03 | 3.2e-02 | 6.1e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th232 | 3.43e-03 | 1.3e-02 | 2.7e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |

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SDG #1400013

SAMPLE ANALYSIS REPORT

| | | | |
|---------------------|----------------------|----------------------|------------------|
| Lab sample #: | B4.02513Q | Amount analyzed: | 1.054e+00 GDRY |
| Client sample ID: | S-2 | Preparation batch #: | 0010880P |
| Matrix: | SOIL | Assay batch #: | 0018037E |
| Collected: | 2014-03-03 09:50 CST | Prep procedure: | N/A |
| Sample type: | SAM | Analysis method: | NAREL TH-EICHROM |
| Dry/wet weight: | 95.20 % | Analyst: | AS |
| Ash/dry weight: | 0.49 % | QC type: | ANA |
| Sample description: | N/A | | |
| Comment: | N/A | | |

COUNTING INFORMATION

| Date and time | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 04/10/2014 17:05 | 1000.0 | AS101 | CEB |

ANALYTICAL RESULTS

| Analyte | Activity | $\pm 2 \sigma$ Uncertainty | MDC | Unit | Reference Date |
|---------|-----------|-------------------------------|---------|----------|----------------------|
| Th227 | 9.24e-03 | 1.6e-02 | 2.3e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th228 | 2.45e-02 | 2.0e-02 | 2.5e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th230 | -3.78e-03 | 3.0e-02 | 5.8e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th232 | -2.42e-03 | 6.0e-03 | 1.9e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |

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SDG #1400013

SAMPLE ANALYSIS REPORT

| | | | |
|---------------------|----------------------|----------------------|------------------|
| Lab sample #: | B4.02514R | Amount analyzed: | 1.031e+00 GDRY |
| Client sample ID: | S-3 | Preparation batch #: | 0010880P |
| Matrix: | SOIL | Assay batch #: | 0018037E |
| Collected: | 2014-03-03 10:40 CST | Prep procedure: | N/A |
| Sample type: | SAM | Analysis method: | NAREL TH-EICHROM |
| Dry/wet weight: | 92.65 % | Analyst: | AS |
| Ash/dry weight: | 0.81 % | QC type: | ANA |
| Sample description: | N/A | | |
| Comment: | N/A | | |

COUNTING INFORMATION

| Date and time | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 04/10/2014 17:05 | 1000.0 | AS102 | CEB |

ANALYTICAL RESULTS

| Analyte | Activity | $\pm 2 \sigma$ Uncertainty | MDC | Unit | Reference Date |
|---------|----------|-------------------------------|---------|----------|----------------------|
| Th227 | 1.73e-03 | 1.6e-02 | 3.6e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th228 J | 4.82e-02 | 2.6e-02 | 2.4e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th230 | 1.79e-02 | 3.4e-02 | 6.0e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th232 | 1.25e-03 | 8.7e-03 | 1.9e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |

Note: A "J" qualifier indicates a result that may be significantly under or overestimated.

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SDG #1400013

SAMPLE ANALYSIS REPORT

| | | | |
|---------------------|----------------------|----------------------|------------------|
| Lab sample #: | B4.02515T | Amount analyzed: | 1.053e+00 GDRY |
| Client sample ID: | S-4 | Preparation batch #: | 0010880P |
| Matrix: | SOIL | Assay batch #: | 0018037E |
| Collected: | 2014-03-03 11:15 CST | Prep procedure: | N/A |
| Sample type: | SAM | Analysis method: | NAREL TH-EICHROM |
| Dry/wet weight: | 92.88 % | Analyst: | AS |
| Ash/dry weight: | 2.71 % | QC type: | ANA |
| Sample description: | N/A | | |
| Comment: | N/A | | |

COUNTING INFORMATION

| Date and time | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 04/10/2014 17:05 | 1000.0 | AS103 | CEB |

ANALYTICAL RESULTS

| Analyte | Activity | $\pm 2 \sigma$ Uncertainty | MDC | Unit | Reference Date |
|---------|----------|-------------------------------|---------|----------|----------------------|
| Th227 | 0.00e+00 | 1.1e-02 | 2.6e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th228 | 5.63e-02 | 2.8e-02 | 2.1e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th230 | 3.63e-02 | 3.7e-02 | 5.9e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th232 | 2.87e-02 | 2.1e-02 | 2.3e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |

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SDG #1400013

SAMPLE ANALYSIS REPORT

| | | | |
|---------------------|----------------------|----------------------|------------------|
| Lab sample #: | B4.02515T | Amount analyzed: | 1.053e+00 GDRY |
| Client sample ID: | S-4 | Preparation batch #: | 0010880P |
| Matrix: | SOIL | Assay batch #: | 0018037E |
| Collected: | 2014-03-03 11:15 CST | Prep procedure: | N/A |
| Sample type: | SAM | Analysis method: | NAREL TH-EICHROM |
| Dry/wet weight: | 92.88 % | Analyst: | AS |
| Ash/dry weight: | 2.71 % | QC type: | DUP |
| Sample description: | N/A | | |
| Comment: | N/A | | |

COUNTING INFORMATION

| Date and time | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 04/10/2014 17:05 | 1000.0 | AS104 | CEB |

ANALYTICAL RESULTS

| Analyte | Activity | $\pm 2 \sigma$ Uncertainty | MDC | Unit | Reference Date |
|---------|----------|-------------------------------|---------|----------|----------------------|
| Th227 | 3.38e-03 | 1.5e-02 | 3.1e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th228 J | 7.38e-02 | 3.3e-02 | 2.9e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th230 | 4.71e-02 | 3.9e-02 | 6.0e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th232 | 2.89e-02 | 2.0e-02 | 2.1e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |

Note: A "J" qualifier indicates a result that may be significantly under or overestimated.

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SDG #1400013

SAMPLE ANALYSIS REPORT

| | | | |
|---------------------|----------------------|----------------------|------------------|
| Lab sample #: | B4.02516U | Amount analyzed: | 1.030e+00 GDRY |
| Client sample ID: | S-5 | Preparation batch #: | 0010880P |
| Matrix: | SOIL | Assay batch #: | 0018037E |
| Collected: | 2014-03-03 13:10 CST | Prep procedure: | N/A |
| Sample type: | SAM | Analysis method: | NAREL TH-EICHROM |
| Dry/wet weight: | 91.89 % | Analyst: | AS |
| Ash/dry weight: | 0.37 % | QC type: | ANA |
| Sample description: | N/A | | |
| Comment: | N/A | | |

COUNTING INFORMATION

| Date and time | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 04/10/2014 17:05 | 1000.0 | AS106 | CEB |

ANALYTICAL RESULTS

| Analyte | Activity | $\pm 2 \sigma$ Uncertainty | MDC | Unit | Reference Date |
|---------|-----------|-------------------------------|---------|----------|----------------------|
| Th227 | 2.13e-02 | 2.7e-02 | 3.6e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th228 | 3.77e-02 | 2.8e-02 | 3.8e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th230 | -6.47e-03 | 3.1e-02 | 6.4e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th232 | 6.94e-03 | 1.4e-02 | 2.4e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |

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SDG #1400013

SAMPLE ANALYSIS REPORT

| | | | |
|---------------------|----------------------|----------------------|------------------|
| Lab sample #: | B4.02517V | Amount analyzed: | 1.038e+00 GDRY |
| Client sample ID: | S-6 | Preparation batch #: | 0010880P |
| Matrix: | SOIL | Assay batch #: | 0018037E |
| Collected: | 2014-03-03 13:35 CST | Prep procedure: | N/A |
| Sample type: | SAM | Analysis method: | NAREL TH-EICHROM |
| Dry/wet weight: | 90.96 % | Analyst: | AS |
| Ash/dry weight: | 1.56 % | QC type: | ANA |
| Sample description: | N/A | | |
| Comment: | N/A | | |

COUNTING INFORMATION

| Date and time | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 04/10/2014 17:05 | 1000.0 | AS107 | CEB |

ANALYTICAL RESULTS

| Analyte | Activity | $\pm 2 \sigma$ Uncertainty | MDC | Unit | Reference Date |
|---------|----------|-------------------------------|---------|----------|----------------------|
| Th227 | 5.26e-03 | 1.5e-02 | 2.6e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th228 | 2.71e-02 | 2.2e-02 | 3.0e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th230 | 1.97e-02 | 3.5e-02 | 6.1e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th232 | 1.02e-02 | 1.4e-02 | 2.0e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |

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SDG #1400013

SAMPLE ANALYSIS REPORT

| | | | |
|---------------------|----------------------|----------------------|------------------|
| Lab sample #: | B4.02518W | Amount analyzed: | 1.069e+00 GDRY |
| Client sample ID: | N-1 | Preparation batch #: | 0010880P |
| Matrix: | SOIL | Assay batch #: | 0018037E |
| Collected: | 2014-03-04 08:38 CST | Prep procedure: | N/A |
| Sample type: | SAM | Analysis method: | NAREL TH-EICHROM |
| Dry/wet weight: | 94.98 % | Analyst: | AS |
| Ash/dry weight: | 0.84 % | QC type: | ANA |
| Sample description: | N/A | | |
| Comment: | N/A | | |

COUNTING INFORMATION

| Date and time | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 04/10/2014 17:05 | 1000.0 | AS108 | CEB |

ANALYTICAL RESULTS

| Analyte | Activity | $\pm 2 \sigma$ Uncertainty | MDC | Unit | Reference Date |
|---------|----------|-------------------------------|---------|----------|----------------------|
| Th227 | 9.20e-03 | 1.6e-02 | 2.3e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th228 J | 2.87e-02 | 2.0e-02 | 2.3e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th230 | 2.51e-02 | 3.5e-02 | 5.8e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th232 | 2.01e-02 | 1.7e-02 | 2.1e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |

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SDG #1400013

SAMPLE ANALYSIS REPORT

| | | | |
|---------------------|----------------------|----------------------|------------------|
| Lab sample #: | B4.02519X | Amount analyzed: | 1.055e+00 GDRY |
| Client sample ID: | N-2 | Preparation batch #: | 0010880P |
| Matrix: | SOIL | Assay batch #: | 0018037E |
| Collected: | 2014-03-04 09:10 CST | Prep procedure: | N/A |
| Sample type: | SAM | Analysis method: | NAREL TH-EICHROM |
| Dry/wet weight: | 94.84 % | Analyst: | AS |
| Ash/dry weight: | 0.92 % | QC type: | ANA |
| Sample description: | N/A | | |
| Comment: | N/A | | |

COUNTING INFORMATION

| Date and time | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 04/10/2014 17:05 | 1000.0 | AS109 | CEB |

ANALYTICAL RESULTS

| Analyte | Activity | $\pm 2 \sigma$ Uncertainty | MDC | Unit | Reference Date |
|---------|----------|-------------------------------|---------|----------|----------------------|
| Th227 | 9.84e-03 | 1.7e-02 | 2.5e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th228 | 2.43e-02 | 1.9e-02 | 2.2e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th230 | 1.36e-03 | 3.1e-02 | 5.9e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th232 | 1.17e-03 | 8.3e-03 | 1.8e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |

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SDG #1400013

SAMPLE ANALYSIS REPORT

| | | | |
|---------------------|----------------------|----------------------|------------------|
| Lab sample #: | B4.02520P | Amount analyzed: | 1.067e+00 GDRY |
| Client sample ID: | N-3 | Preparation batch #: | 0010880P |
| Matrix: | SOIL | Assay batch #: | 0018037E |
| Collected: | 2014-03-04 10:30 CST | Prep procedure: | N/A |
| Sample type: | SAM | Analysis method: | NAREL TH-EICHROM |
| Dry/wet weight: | 91.44 % | Analyst: | AS |
| Ash/dry weight: | 0.61 % | QC type: | ANA |
| Sample description: | N/A | | |
| Comment: | N/A | | |

COUNTING INFORMATION

| Date and time | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 04/10/2014 17:05 | 1000.0 | AS111 | CEB |

ANALYTICAL RESULTS

| Analyte | Activity | $\pm 2 \sigma$ Uncertainty | MDC | Unit | Reference Date |
|---------|-----------|-------------------------------|---------|----------|----------------------|
| Th227 | 0.00e+00 | 1.7e-02 | 4.1e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th228 J | 4.94e-02 | 2.8e-02 | 3.0e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th230 | -4.80e-03 | 3.0e-02 | 6.0e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th232 | 3.44e-04 | 9.3e-03 | 2.2e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |

Note: A "J" qualifier indicates a result that may be significantly under or overestimated.

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SDG #1400013

SAMPLE ANALYSIS REPORT

| | | | |
|---------------------|----------------------|----------------------|------------------|
| Lab sample #: | B4.02521Q | Amount analyzed: | 1.047e+00 GDRY |
| Client sample ID: | N-4 | Preparation batch #: | 0010880P |
| Matrix: | SOIL | Assay batch #: | 0018037E |
| Collected: | 2014-03-04 09:50 CST | Prep procedure: | N/A |
| Sample type: | SAM | Analysis method: | NAREL TH-EICHROM |
| Dry/wet weight: | 87.42 % | Analyst: | AS |
| Ash/dry weight: | 0.32 % | QC type: | ANA |
| Sample description: | N/A | | |
| Comment: | N/A | | |

COUNTING INFORMATION

| Date and time | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 04/10/2014 17:05 | 1000.0 | AS112 | CEB |

ANALYTICAL RESULTS

| Analyte | Activity | $\pm 2 \sigma$ Uncertainty | MDC | Unit | Reference Date |
|---------|-----------|-------------------------------|---------|----------|----------------------|
| Th227 | 8.73e-03 | 1.9e-02 | 3.2e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th228 | 2.40e-02 | 2.1e-02 | 2.9e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th230 | -2.05e-03 | 3.0e-02 | 6.0e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th232 | 5.22e-03 | 1.0e-02 | 1.7e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |

**U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL ANALYTICAL RADIATION ENVIRONMENTAL LABORATORY**

SDG #1400013

SAMPLE ANALYSIS REPORT

| | | | |
|---------------------|----------------------|----------------------|------------------|
| Lab sample #: | B4.02522R | Amount analyzed: | 1.058e+00 GDRY |
| Client sample ID: | N-5 | Preparation batch #: | 0010880P |
| Matrix: | SOIL | Assay batch #: | 0018037E |
| Collected: | 2014-03-04 12:50 CST | Prep procedure: | N/A |
| Sample type: | SAM | Analysis method: | NAREL TH-EICHROM |
| Dry/wet weight: | 94.56 % | Analyst: | AS |
| Ash/dry weight: | 1.39 % | QC type: | ANA |
| Sample description: | N/A | | |
| Comment: | N/A | | |

COUNTING INFORMATION

| Date and time | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 04/10/2014 17:05 | 1000.0 | AS119 | CEB |

ANALYTICAL RESULTS

| Analyte | Activity | $\pm 2 \sigma$ Uncertainty | MDC | Unit | Reference Date |
|---------|----------|-------------------------------|---------|----------|----------------------|
| Th227 | 0.00e+00 | 1.3e-02 | 3.1e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th228 | 4.32e-02 | 2.4e-02 | 2.8e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th230 | 2.32e-02 | 3.3e-02 | 5.5e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th232 | 6.26e-03 | 9.4e-03 | 1.4e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |

**U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL ANALYTICAL RADIATION ENVIRONMENTAL LABORATORY**

SDG #1400013

SAMPLE ANALYSIS REPORT

| | | | |
|---------------------|----------------------|----------------------|------------------|
| Lab sample #: | B4.02523T | Amount analyzed: | 1.059e+00 GDRY |
| Client sample ID: | N-6 | Preparation batch #: | 0010880P |
| Matrix: | SOIL | Assay batch #: | 0018037E |
| Collected: | 2014-03-04 13:20 CST | Prep procedure: | N/A |
| Sample type: | SAM | Analysis method: | NAREL TH-EICHROM |
| Dry/wet weight: | 91.09 % | Analyst: | AS |
| Ash/dry weight: | 0.95 % | QC type: | ANA |
| Sample description: | N/A | | |
| Comment: | N/A | | |

COUNTING INFORMATION

| Date and time | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 04/10/2014 17:05 | 1000.0 | AS114 | CEB |

ANALYTICAL RESULTS

| Analyte | Activity | $\pm 2 \sigma$ Uncertainty | MDC | Unit | Reference Date |
|---------|----------|-------------------------------|---------|----------|----------------------|
| Th227 | 2.83e-03 | 1.3e-02 | 2.6e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th228 | 2.80e-02 | 2.1e-02 | 2.7e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th230 | 4.18e-02 | 3.6e-02 | 5.7e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th232 | 8.11e-03 | 1.1e-02 | 1.6e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |

**U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL ANALYTICAL RADIATION ENVIRONMENTAL LABORATORY**

SDG #1400013

SAMPLE ANALYSIS REPORT

| | | | |
|---------------------|----------------------|----------------------|------------------|
| Lab sample #: | B4.02524U | Amount analyzed: | 1.053e+00 GDRY |
| Client sample ID: | N-2 DUP | Preparation batch #: | 0010880P |
| Matrix: | SOIL | Assay batch #: | 0018037E |
| Collected: | 2014-03-04 09:10 CST | Prep procedure: | N/A |
| Sample type: | SAM | Analysis method: | NAREL TH-EICHROM |
| Dry/wet weight: | 95.06 % | Analyst: | AS |
| Ash/dry weight: | 0.85 % | QC type: | ANA |
| Sample description: | N/A | | |
| Comment: | N/A | | |

COUNTING INFORMATION

| Date and time | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 04/10/2014 17:05 | 1000.0 | AS115 | CEB |

ANALYTICAL RESULTS

| Analyte | Activity | $\pm 2 \sigma$ Uncertainty | MDC | Unit | Reference Date |
|---------|-----------|-------------------------------|---------|----------|----------------------|
| Th227 | -1.50e-03 | 1.0e-02 | 2.8e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th228 | 1.20e-02 | 1.5e-02 | 2.3e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th230 | 2.54e-02 | 3.4e-02 | 5.7e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |
| Th232 | 6.09e-03 | 1.2e-02 | 2.1e-02 | PCI/GDRY | 04/10/2014 17:05 CDT |

**U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL ANALYTICAL RADIATION ENVIRONMENTAL LABORATORY**

SDG #1400013

SAMPLE ANALYSIS REPORT

| | | | |
|---------------------|---------------|----------------------|------------------|
| Lab sample #: | LCS-00687695H | Amount analyzed: | 1.000e+00 SAMP |
| Client sample ID: | N/A | Preparation batch #: | 0010880P |
| Matrix: | N/A | Assay batch #: | 0018037E |
| Collected: | N/A | Prep procedure: | N/A |
| Sample type: | N/A | Analysis method: | NAREL TH-EICHROM |
| Dry/wet weight: | N/A | Analyst: | AS |
| Ash/dry weight: | N/A | QC type: | LCS |
| Sample description: | N/A | | |
| Comment: | N/A | | |

COUNTING INFORMATION

| Date and time | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 04/10/2014 17:05 | 1000.0 | AS116 | CEB |

ANALYTICAL RESULTS

| Analyte | Activity | $\pm 2 \sigma$ Uncertainty | MDC | Unit | Reference Date |
|---------|-----------|-------------------------------|---------|------|----------------------|
| Th227 | 4.26e-03 | 1.6e-02 | 3.2e-02 | PCI | 04/10/2014 17:05 CDT |
| Th228 | -6.50e-03 | 8.5e-03 | 2.6e-02 | PCI | 04/10/2014 17:05 CDT |
| Th230 | 2.02e+00 | 2.1e-01 | 5.9e-02 | PCI | 04/10/2014 17:05 CDT |
| Th232 | 2.49e-03 | 8.8e-03 | 1.8e-02 | PCI | 04/10/2014 17:05 CDT |

**U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL ANALYTICAL RADIATION ENVIRONMENTAL LABORATORY**

SDG #1400013

SAMPLE ANALYSIS REPORT

| | | | |
|---------------------|---------------|----------------------|------------------|
| Lab sample #: | RBK-00687694G | Amount analyzed: | 1.000e+00 SAMP |
| Client sample ID: | N/A | Preparation batch #: | 0010880P |
| Matrix: | N/A | Assay batch #: | 0018037E |
| Collected: | N/A | Prep procedure: | N/A |
| Sample type: | N/A | Analysis method: | NAREL TH-EICHROM |
| Dry/wet weight: | N/A | Analyst: | AS |
| Ash/dry weight: | N/A | QC type: | RBK |
| Sample description: | N/A | | |
| Comment: | N/A | | |

COUNTING INFORMATION

| Date and time | Duration (min) | Detector ID | Operator |
|------------------|----------------|-------------|----------|
| 04/10/2014 17:05 | 1000.0 | AS117 | CEB |

ANALYTICAL RESULTS

| Analyte | Activity | $\pm 2 \sigma$ Uncertainty | MDC | Unit | Reference Date |
|---------|-----------|-------------------------------|---------|------|----------------------|
| Th227 | 6.04e-03 | 1.7e-02 | 3.1e-02 | PCI | 04/10/2014 17:05 CDT |
| Th228 | 8.69e-04 | 9.5e-03 | 2.1e-02 | PCI | 04/10/2014 17:05 CDT |
| Th230 | -7.28e-03 | 3.0e-02 | 5.9e-02 | PCI | 04/10/2014 17:05 CDT |
| Th232 | 3.54e-03 | 1.1e-02 | 2.2e-02 | PCI | 04/10/2014 17:05 CDT |

**U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL ANALYTICAL RADIATION ENVIRONMENTAL LABORATORY**

SDG 1400013

PREPARATION BATCH SUMMARY

Preparation batch #: 0010880P
Analysis method: NAREL TH-EICHROM
Preparation procedure: N/A

| NAREL Sample # | Client Sample ID | Analysis # | QC Type | Yield | ± 2 σ Uncertainty | Analyst |
|-----------------|------------------|------------|---------|----------|-------------------|---------|
| B4.02512P | S-1 | 00686323B | DUP | 87.99 % | 8.20 % | AS |
| B4.02513Q | S-2 | 00686329H | | 104.29 % | 9.08 % | AS |
| B4.02514R | S-3 | 00686335F | | 96.42 % | 8.73 % | AS |
| B4.02515T | S-4 | 00686341D | | 92.07 % | 8.41 % | AS |
| B4.02515T | S-4 | 00687693F | | 93.51 % | 8.45 % | AS |
| B4.02516U | S-5 | 00686347K | | 84.31 % | 7.83 % | AS |
| B4.02517V | S-6 | 00686353H | | 87.05 % | 7.77 % | AS |
| B4.02518W | N-1 | 00686359P | | 98.13 % | 8.38 % | AS |
| B4.02519X | N-2 | 00686365M | | 95.24 % | 8.32 % | AS |
| B4.02520P | N-3 | 00686371K | | 87.79 % | 8.20 % | AS |
| B4.02521Q | N-4 | 00686377R | | 91.86 % | 8.39 % | AS |
| B4.02522R | N-5 | 00686383P | | 92.71 % | 7.52 % | AS |
| B4.02523T | N-6 | 00686389W | | 90.85 % | 7.48 % | AS |
| B4.02524U | N-2 DUP | 00686395U | | 84.79 % | 7.14 % | AS |
| LCS-00687695H * | | 00687695H | LCS | 93.16 % | 7.47 % | AS |
| RBK-00687694G * | | 00687694G | RBK | 93.04 % | 7.69 % | AS |

* Samples marked with an asterisk are not in this sample delivery group but were analyzed with it for QC purposes.

QC RESULTS FOR BATCH 0010880P

| NAREL Sample # | Analysis # | QC Type | Analyte | %R | RPD | Z | Evaluation |
|----------------|------------|---------|---------|-------|-------|------|------------|
| B4.02515T | 00687693F | DUP | TH227 | 100.7 | 200.0 | 0.36 | PASS |
| B4.02515T | 00687693F | DUP | TH228 | | 26.9 | 0.82 | PASS-J |
| B4.02515T | 00687693F | DUP | TH230 | | 25.8 | 0.40 | PASS |
| B4.02515T | 00687693F | DUP | TH232 | | 0.6 | 0.01 | PASS |
| LCS-00687695H | 00687695H | LCS | TH230 | | | 0.13 | PASS |
| RBK-00687694G | 00687694G | RBK | TH227 | | | | PASS |
| RBK-00687694G | 00687694G | RBK | TH228 | | | | PASS |
| RBK-00687694G | 00687694G | RBK | TH230 | | | | PASS |
| RBK-00687694G | 00687694G | RBK | TH232 | | | | PASS |

Note: Results qualified with -J may be significantly under or over-estimated and are not evaluated for QC purposes.