

State of Wisconsin

2010

Zion

Environmental Radioactivity Survey

**Wisconsin Department of Health Services
Division of Public Health
Bureau of Environmental and Occupational Health
Radiation Protection Section
P.O. Box 2659
Madison, Wisconsin 53701**

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Introduction

Wisconsin Public Health Statutes 254.41 mandates the Department of Health Services to conduct environmental radiation monitoring around the nuclear power facilities that impact Wisconsin. This environmental monitoring report is for the Zion nuclear generating plant for the calendar year January - December 2010 and provides a description and results of this environmental monitoring program.

WI DHS Zion Environmental Monitoring Sampling Program

The WI DHS environmental monitoring program consists of the collection of various types of samples from the air, water and terrestrial exposure pathways. The sampling program included samples of air, ambient gamma radiation (TLD), surface water, soil and vegetation that are collected from selected locations at planned sampling intervals.

Table 1 is a listing of presently used sampling sites that have been renumbered after eliminating sample sites that have been discontinued. Sampling sites that have been discontinued were last listed as sampling sites in WI DHS's environmental monitoring report for the Zion nuclear plant for the calendar year of January - December, 2000. Table 2 provides a listing of types of samples collected, collection frequency, sites where samples are collected, the number of samples collected, number of samples that were missed or had sample or analysis deviations and a listing of the required analyses. Table 3 provides an explanation of missing samples or non-routine sample analyses. Figure 1 is a map showing the location of each environmental sampling site.

Program Modifications

In January 1998 ComEd announced that it was permanently closing the Zion nuclear power station and initiated the process of decommissioning the Zion station. In response to this and due to other funding restrictions, the Zion environmental monitoring program was reviewed and modified in 1998 and 2000.

Due to funding restrictions, the following program modifications were implemented beginning in the 3rd quarter of 2010.

Air particulate sites: The WI DHS control site (ZI-2) was discontinued.

Surface water: The sampling frequency was reduced from quarterly to twice per year with samples to be collected in the 2nd and 4th quarters of the year.

Vegetation and soil: The sampling frequency was reduced from twice per year to an annual sample.

Laboratory Services and Quality Assurance

The analysis of the samples is performed under contract with the Wisconsin State Laboratory of Hygiene (WSLH). WSLH maintains a quality assurance program. Analytical procedures provide for routine replicate analyses to verify methods and instrument operation. Traceable sources are used to

regularly calibrate the counters and daily performance checks are made between calibrations. In addition, quality control charts are maintained on the counters. WSLH participates in the Environmental Resource Associates' Proficiency Testing program and has performed satisfactorily over the report period. Proficiency testing results are available from the Wisconsin State Laboratory of Hygiene.

Detection Limits

Detection limits, required by WI DHS, will be expressed as a lower limit of detection (LLD). The required WI DHS LLD as indicated in Table 4 under the heading "LLD" is an "a priori" estimate of the capability for detecting an activity concentration by a given measurement system, procedure, and type of sample. Counting statistics of the appropriate instrument background are used to compute the LLD for each specific analysis. Using 4.66 times the standard deviation (s_b) of the instrument background, the LLD for each specific analysis is defined at the 95% Confidence Level.

The LLD for each radioisotope listed in Table 4 has been calculated from the following equation:

$$LLD = \frac{4.66 s_b}{E * V * 2.22 * Y * S * \exp(-dt)}$$

Where:

- LLD is the "a priori" lower limit of detection as defined above, as picocuries per unit mass or volume,
- s_b is the standard deviation of the background counting rate or of the counting rate of blank sample as appropriate, as counts per minute,
- E is the counting efficiency, as counts per disintegration,
- V is the sample size in units of mass or volume,
- 2.22 is the number of disintegrations per minute per picocurie,
- Y is the fractional radiochemical yield, when applicable,
- S is the self-absorption correction factor,
- d is the radioactive decay constant for the particular radionuclide, and
- t for environmental samples is the elapsed time between sample collection, or end of the sample collection period, and time of counting.

Typical values for E, V, Y and dt have been used to calculate the LLD.

Reporting of Sample Analysis Results

Results for specific analyses will be reported as either a "less than" (<) value or an actual activity value. The reporting of results in Table 4 under the heading "Range" and in Tables 5-9 is "a posteriori" calculation based on the actual analysis performed using the actual sample values for E, V, Y and dt. Typically the reported "less than" (<) results are lower than the required WI DHS LLD indicating that the required WI DHS LLD has been met.

An actual activity value will be accompanied by an uncertainty term for that analysis. The uncertainty term is a plus or minus counting uncertainty term at the 2 sigma (95%) confidence interval and is printed as (+- or ±). Examples and explanations of data reporting are:

<u>Example</u>	<u>Nuclide</u>	<u>Activity reported</u>
1	¹³⁷ Cs	< 10 pCi/liter
2	¹³⁷ Cs	15 ± 3 pCi/liter

In example 1 we can be 95% confident that the sample activity, if any, is less than the LLD of 10 pCi/liter. In example 2 we can be 95% confident that the actual sample activity is greater than the LLD for that analysis and is between 12 and 18 pCi/liter.

Table 1. WI DHS Zion environmental monitoring sampling sites.

Sample site	Distance and direction (miles)	Location description
ZI-1	3.8 N	Chiwaukee Prairie.
ZI-2	8.5 NW	Pleasant Prairie, Roger Prange Municipal Center
ZI-3	10.0 N	Water intake - 4700 feet from shore.
ZI-4	5.9 NW	Junction of Highway 31 and County ML.
ZI-T41	4.7 NW	Junction of 122th Street and 39th Avenue
ZI-T42	3.8 N	Chiwaukee Prairie.
ZI-T43	10.1 N	Kenosha Water Utility

Table 2. Sample collection summary and required analyses.

Sample Type	Collection and Frequency	Site locations	Number of Samples Collected	Number of Samples Deviations	Required Analyses
air particulate	C/BW	1, 2 *a	39	1	GA, GB, GI
TLD	C/Q	T41 - T43	12	0	direct exposure
surface water	G/SA	3	3	0	GA, GB, GI, Sr, H
vegetation	G/SA	1, 4	4	0	GA, GB, GI
soil	G/SA	1, 4	4	0	GA, GB, GI

*a – see Program Modification section.

Collection type: C/ = continuous; G/ = grab

Frequency: /W = weekly; /M = monthly; /Q = quarterly; /A = annually; /BW = bi-weekly; /SA = semi-annually

Required analyses: GA = gross alpha; GB = gross beta; GI = gamma isotopic; Sr = strontium; H = tritium

Table 3. Missing sample report and listing of non-routine analyses.

Sample type	Date	Site	Explanation
air particulate	01/13/10	ZI-2	The air site was not operating for approximately 3 days and 3 hours during the indicated time period.

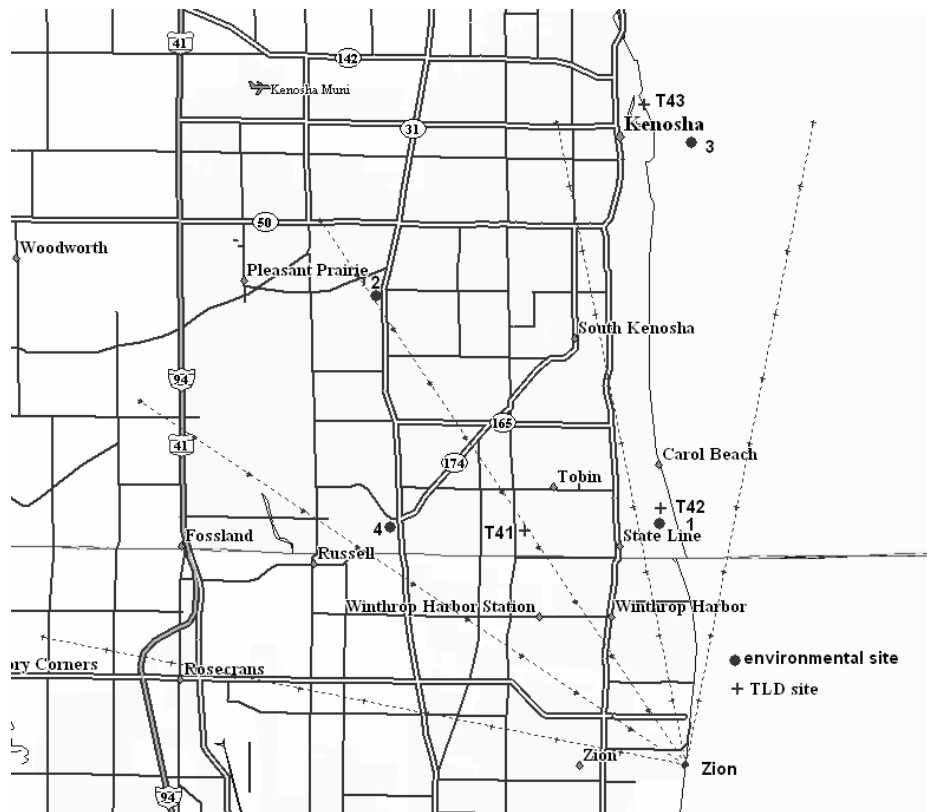


Figure 1. WI DHS environmental monitoring sites for the Zion environmental monitoring program.

Results and Discussion

Air Particulate

A summary of reported activities by WI DHS for air particulate samples is included in Table 4. Results from the individual sample analyses are listed in Tables 5 and 6.

From the bi-weekly and quarterly gross beta activities listed in Table 5 it may be noted that there are no significant differences due to distance from the Zion nuclear facility. With no significant differences due to distance from the Zion nuclear facility an increase in gross beta activity attributable to the Zion plant operation is not evident.

The gamma isotopic analysis of the quarterly air particulate filter composites detected only small amounts of the radioisotopes listed in Table 6. Beryllium-7 (^7Be), detected in all composites, is constantly produced through nuclear reactions between cosmic rays and nuclei in the atmosphere and is detected in air composites from other areas of the state.

Influence by the Zion nuclear facility on air quality is not evident from air particulate analysis.

Ambient Gamma Radiation (TLDs)

A summary of reported activities by WI DHS for ambient gamma radiation is included in Table 4. Results from the individual sample analyses are listed in Table 7.

Ambient gamma radiation (TLD) data for 2010 from the WI DHS network was comparable for all sites. Significant differences in exposure were not noticed at different distances from the Zion nuclear facility. The average quarterly exposure from the three sites located within Wisconsin was 12.8 ± 2.1 milliroentgens. The average yearly exposure is at background levels and is comparable to other areas within Wisconsin.

Surface Water

A summary of reported activities by WI DHS for surface water samples is included in Table 4. Results from the individual sample analyses are listed in Table 8.

The surface water samples showed no unusual activities and are at background levels comparable to previous years. From the gamma isotopic analysis, all radioisotopes were below their respective minimum detectable concentration. All reported activities for gross beta, gross alpha and tritium (^3H) are at background levels. The surface water samples uniformly show activities well below state or federal standards.

Vegetation

A summary of reported activities by WI DHS for vegetation samples is included in Table 4. Results from the individual sample analyses are listed in Table 9.

Analysis of the vegetation samples showed no unusual activities. The gamma isotopic analysis detected only small amounts of the naturally occurring radioisotopes beryllium-7 (^7Be) and potassium-40 (^{40}K) listed in Table 4. All other radioisotopes were below their respective minimum detectable concentration.

Soil

A summary of reported activities by WI DHS for soil samples is included in Table 4. Results from the individual sample analyses are listed in Table 9.

Analysis of the soil samples showed no unusual activities. The gamma isotopic analysis detected only small amounts of the radionuclides listed in Table 4. Potassium-40 (^{40}K) is a naturally occurring radioisotope. The reported activities for cesium-137 (^{137}Cs) were also detected in previous years and are attributable to fallout from previous atmospheric nuclear tests. Naturally occurring radioisotopes such as radium-226 (^{226}Ra), bismuth-214 (^{214}Bi), lead-214 (^{214}Pb), actinium-228 (^{228}Ac), bismuth-212 (^{212}Bi) and lead-212 (^{212}Pb) from the naturally occurring uranium-238 (^{238}U) and thorium-232 (^{232}Th) decay series are commonly detected but have not been quantified or reported.

Dose to an Average Individual

Federal regulations 10 CFR 20, 10 CFR 50 Appendix I and 40 CFR 190 restrict the annual exposure of the population from all parts of the nuclear fuel cycle, including nuclear power plants. Doses resulting from gaseous and liquid effluent releases from the Zion nuclear generating facilities are less than the limits as stated in these Federal regulations.

The WI DHS limits for permissible levels of radiation exposure from external sources in unrestricted areas are defined in the Wis. Adm. Code section HFS 157.23. Doses resulting from gaseous and liquid effluent releases from the Zion nuclear generating facilities are less than the limits as stated in Wis. Adm. Code section HFS 157.23.

References

State of Wisconsin, Wisconsin Administrative Code, HFS 157.23

U.S. Environmental Protection Agency, Environmental Radiation Requirements for Normal Operations of Activities in the Uranium Fuel Cycle, EPA 520/4-76-016, 40 CFR Part 190, November 1976.

U.S. Nuclear Regulatory Commission, Title 10, Part 20.

U.S. Nuclear Regulatory Commission, Title 10, Part 50, Appendix I.

Table 4. Sample activity summary for the WI DHS Zion environmental monitoring program for 2010.

Sample type (units)	LLD	Number of samples ^a	Analysis	Range
air particulate (pCi/m ³)	0.005	39 / 39	gross beta	0.007 - 0.043
			gamma isotopic	
	0.020	6 / 6	Be-7	0.064 - 0.130
	0.002	6 / 0	Mn-54	< 0.0006
	0.002	6 / 0	Co-58	< 0.0006
	0.005	6 / 0	Fe-59	< 0.0011
	0.002	6 / 0	Co-60	< 0.0006
	0.005	6 / 0	Zn-65	< 0.0015
	0.002	6 / 0	Nb-95	< 0.0008
	0.005	6 / 0	Zr-95	< 0.0011
	0.002	6 / 0	Ru-103	< 0.0005
	0.015	6 / 0	Ru-106	< 0.0044
	0.020	6 / 0	I-131	< 0.0020
	0.002	6 / 0	Cs-134	< 0.0005
	0.002	6 / 0	Cs-137	< 0.0005
	0.030	6 / 0	Ba-140	< 0.0041
	0.020	6 / 0	La-140	< 0.0017
	0.002	6 / 0	Ce-141	< 0.0009
0.005	6 / 0	Ce-144	< 0.0025	
ambient gamma (mR/Std Qtr)	1.0 ^b	12 / 12	ambient gamma	9.8 -17.1
vegetation (pCi/kg wet)	5000	4 / 0	gross alpha	< 4600
	4000	4 / 4	gross beta	5800 - 8000
			gamma isotopic	
	600	4 / 4	Be-7	730 - 2070
	2000	4 / 4	K-40	3350 - 3800
	90	4 / 0	Mn-54	< 31
	100	4 / 0	Co-58	< 27
	200	4 / 0	Fe-59	< 64
	100	4 / 0	Co-60	< 38
	250	4 / 0	Zn-65	< 62
	100	4 / 0	Nb-95	< 33
	200	4 / 0	Zr-95	< 47
	80	2 / 0	I-131	< 36
	80	4 / 0	Cs-134	< 33
	90	4 / 0	Cs-137	< 33
	350	4 / 0	Ba-140	< 125
100	4 / 0	La-140	< 32	

Table 4. Sample activity summary for the WI DHS Zion environmental monitoring program for 2010.

Sample type (units)	LLD	Number of samples ^a	Analysis	Range
surface water (pCi/liter)	3.0	3 / 2	gross beta (sol)	< 2.0 – 2.4
	3.0	3 / 0	gross beta (insol)	< 2.4
	3.0	3 / 0	gross alpha (sol)	< 2.2
	3.0	3 / 0	gross alpha (insol)	< 1.2
	300	3 / 0	H-3	< 210
	2.0	3 / 0	Sr-89	< 1.0
	1.0	3 / 0	Sr-90	< 0.3
			gamma isotopic	
	15	3 / 0	Mn-54	< 9
	15	3 / 0	Co-58	< 10
	30	3 / 0	Fe-59	< 16
	15	3 / 0	Co-60	< 10
	30	3 / 0	Zn-65	< 18
	15	3 / 0	Nb-95	< 9
	30	3 / 0	Zr-95	< 16
	15	3 / 0	I-131	< 12
	15	3 / 0	Cs-134	< 11
	15	3 / 0	Cs-137	< 11
	60	3 / 0	Ba-140	< 39
	15	3 / 0	La-140	< 12
soil (pCi/kg dry)	6000	4 / 4	gross beta	11000 - 32700
	10000	4 / 2	gross alpha	< 11200 - 22000
			gamma isotopic	
	800	4 / 4	K-40	8300 - 18900
	60	4 / 0	Mn-54	< 32
	90	4 / 0	Co-58	< 22
	600	4 / 0	Fe-59	< 60
	90	4 / 0	Co-60	< 33
	300	4 / 0	Zn-65	< 72
	100	4 / 0	Nb-95	< 32
	250	4 / 0	Zr-95	< 48
	80	4 / 0	Cs-134	< 26
	80	4 / 4	Cs-137	90 - 150

a - Number of analyses / number of analyses detected above the WI DHS LLD.
b - 1.0 mR/TLD.

Table 5. WI DHS air particulate gross beta analysis results from the Zion environmental monitoring program.

Measurements in units of pCi/m ³					
Site: ZI-1; Chiwaukee Prairie			Site: ZI-2; Pleasant Prairie, Roger Prange Municipal Center		
collection date	volume m ³	air particulate	collection date	volume m ³	air particulate
01/13/10	707	0.032 +- 0.002	01/13/10 *a	754	0.023 +- 0.002
01/25/10	557	0.043 +- 0.003	01/25/10	778	0.035 +- 0.002
02/08/10	761	0.027 +- 0.002	02/08/10	975	0.026 +- 0.002
02/22/10	753	0.017 +- 0.002	02/22/10	974	0.015 +- 0.001
03/08/10	718	0.024 +- 0.002	03/08/10	959	0.021 +- 0.002
03/22/10	747	0.019 +- 0.002	03/22/10	936	0.017 +- 0.002
1st Qtr			1st Qtr		
mean +- s.d.		0.027 +- 0.010	mean +- s.d.		0.023 +- 0.007
04/05/10	737	0.020 +- 0.002	04/05/10	902	0.018 +- 0.002
04/19/10	737	0.015 +- 0.002	04/19/10	939	0.014 +- 0.001
05/03/10	1713	0.011 +- 0.001	05/03/10	938	0.013 +- 0.001
05/17/10	1796	0.007 +- 0.001	05/17/10	921	0.008 +- 0.001
06/08/10	2737	0.010 +- 0.001	06/08/10	1442	0.016 +- 0.001
06/17/10	719	0.011 +- 0.002	06/17/10	592	0.010 +- 0.002
06/29/10	951	0.014 +- 0.001	06/29/10	798	0.012 +- 0.002
2nd Qtr			2nd Qtr		
mean +- s.d.		0.013 +- 0.004	mean +- s.d.		0.013 +- 0.003
07/13/10	1114	0.016 +- 0.001			
07/26/10	1031	0.020 +- 0.002			
08/12/10	1363	0.021 +- 0.001			
08/26/10	1097	0.022 +- 0.002			
09/10/10	1198	0.016 +- 0.001			
09/20/10	806	0.016 +- 0.002			
10/04/10	1127	0.018 +- 0.001			
3rd Qtr			3rd Qtr		
mean +- s.d.		0.018 +- 0.003	mean +- s.d.		
10/20/10	1282	0.026 +- 0.002			
11/01/10	990	0.019 +- 0.002			
11/16/10	1261	0.025 +- 0.002			
11/29/10	1095	0.028 +- 0.002			
12/15/10	1379	0.024 +- 0.001			
12/30/10	1280	0.021 +- 0.001			
4th Qtr			4th Qtr		
mean +- s.d.		0.024 +- 0.003	mean +- s.d.		

* a - The air site was not operating for approximately 3 days and 3 hours during the indicated time period.

Table 6. WI DHS gamma isotopic analysis results from the quarterly composites of air particulate filters collected from the Zion environmental monitoring program.

Measurements in units of pCi/m³

Site: ZI-1	1st quarter	2nd quarter	3 rd quarter	4th quarter
Be-7	0.110 +- 0.006	0.085 +- 0.010	0.082 +- 0.008	0.064 +- 0.007
Mn-54	< 0.0006	< 0.0004	< 0.0002	< 0.0004
Co-58	< 0.0006	< 0.0005	< 0.0004	< 0.0003
Fe-59	< 0.0010	< 0.0008	< 0.0007	< 0.0006
Co-60	< 0.0006	< 0.0005	< 0.0004	< 0.0003
Zn-65	< 0.0015	< 0.0006	< 0.0009	< 0.0007
Nb-95	< 0.0008	< 0.0004	< 0.0004	< 0.0004
Zr-95	< 0.0011	< 0.0004	< 0.0005	< 0.0007
Ru-103	< 0.0005	< 0.0004	< 0.0004	< 0.0004
Ru-106	< 0.0044	< 0.0029	< 0.0022	< 0.0030
I-131	< 0.0018	< 0.0017	< 0.0020	< 0.0009
Cs-134	< 0.0005	< 0.0003	< 0.0003	< 0.0004
Cs-137	< 0.0005	< 0.0003	< 0.0003	< 0.0004
Ba-140	< 0.0041	< 0.0030	< 0.0031	< 0.0026
La-140	< 0.0012	< 0.0010	< 0.0017	< 0.0008
Ce-141	< 0.0009	< 0.0007	< 0.0006	< 0.0007
Ce-144	< 0.0025	< 0.0017	< 0.0014	< 0.0025

Site: ZI-2

Be-7	0.130 +- 0.006	0.100 +- 0.011
Mn-54	< 0.0005	< 0.0003
Co-58	< 0.0005	< 0.0004
Fe-59	< 0.0010	< 0.0011
Co-60	< 0.0006	< 0.0004
Zn-65	< 0.0010	< 0.0008
Nb-95	< 0.0005	< 0.0004
Zr-95	< 0.0010	< 0.0005
Ru-103	< 0.0005	< 0.0004
Ru-106	< 0.0040	< 0.0027
I-131	< 0.0016	< 0.0020
Cs-134	< 0.0005	< 0.0004
Cs-137	< 0.0005	< 0.0003
Ba-140	< 0.0034	< 0.0028
La-140	< 0.0017	< 0.0017
Ce-141	< 0.0006	< 0.0007
Ce-144	< 0.0018	< 0.0016

Radioisotopes other than those reported were not detected.

Table 7. WI DHS TLD network for the Zion environmental monitoring program.

	1st quarter	2nd quarter	3rd quarter	4th quarter
Date Placed:	01/05/10	04/07/10	07/06/10	10/04/10
Date Removed:	04/07/10	07/06/10	10/04/10	01/04/11
Days in the Field:	92	90	90	92

Individual quarterly date is reported as : mR / Standard Quarter + 2 sigma counting error.

T-41	13.9 +- 0.6	11.5 +- 0.7	17.1 +- 1.1	14.3 +- 0.5
T-42	12.3 +- 0.5	10.2 +- 0.7	14.4 +- 0.7	12.3 +- 0.6
T-43	11.6 +- 0.6	9.8 +- 0.7	14.2 +- 0.7	11.9 +- 0.6

Table 8. WI DHS analysis results for surface water samples collected for the Zion environmental monitoring program.

Measurements in units of pCi/liter

ZI-3

Collection date:	01/11/10	04/13/10	10/20/10
gross alpha-sol	< 1.9	< 2.2	< 1.9
gross beta-sol	2.3 +- 1.2	2.4 +- 1.3	< 2.0
gross alpha-insol	< 0.9	< 1.2	< 1.2
gross beta-insol	< 1.8	< 2.3	< 2.4
H-3	< 185	< 210	< 180
Sr-89	< 0.3	< 1.0	< 0.4
Sr-90	< 0.3	< 0.3	< 0.2
gamma isotopic			
Mn-54	< 8	< 9	< 3
Co-58	< 10	< 7	< 3
Fe-59	< 16	< 14	< 5
Co-60	< 10	< 9	< 3
Zn-65	< 18	< 16	< 5
Nb-95	< 9	< 8	< 3
Zr-95	< 16	< 16	< 5
I-131	< 12	< 10	< 4
Cs-134	< 11	< 10	< 3
Cs-137	< 11	< 10	< 3
Ba-140	< 39	< 35	< 11
La-140	< 12	< 11	< 4

Radioisotopes other than those reported were not detected.

Table 9. WI DHS analysis results for vegetation and soil samples collected for the Zion environmental monitoring program.

Vegetation				
Measurements in units of pCi/kilogram (wet)				
Site:	ZI-1	ZI-4	ZI-1	ZI-4
Collection date:	06/16/10	06/16/10	09/21/10	09/21/10
gross alpha	< 3100	< 2800	< 4600	< 2600
gross beta	6800 +- 1000	5800 +- 900	8000 +- 1400	5900 +- 800
gamma isotopic				
Be-7	730 +- 260	800 +- 260	2070 +- 290	1040 +- 240
K-40	3800 +- 770	3750 +- 820	3480 +- 720	3350 +- 700
Mn-54	< 20	< 31	< 23	< 19
Co-58	< 17	< 27	< 22	< 22
Fe-59	< 29	< 64	< 30	< 46
Co-60	< 23	< 38	< 21	< 28
Zn-65	< 47	< 62	< 47	< 56
Nb-95	< 19	< 33	< 21	< 20
Zr-95	< 31	< 47	< 31	< 32
I-131	< 25	< 36	< 17	< 27
Cs-134	< 21	< 33	< 21	< 25
Cs-137	< 22	< 33	< 21	< 25
Ba-140	< 87	< 125	< 60	< 75
La-140	< 29	< 32	< 30	< 23
Soil				
Measurements in units of pCi/kilogram (dry)				
Site:	ZI-1	ZI-4	ZI-1	ZI-4
Collection date:	06/16/10	06/16/10	09/21/10	09/21/10
gross alpha	< 11000	18800 +- 9300	< 11200	22000 +- 9800
gross beta	11000 +- 3000	32200 +- 3800	13600 +- 3200	32700 +- 3800
gamma isotopic				
K-40	8700 +- 1700	18300 +- 3600	8300 +- 1600	18900 +- 2900
Mn-54	< 16	< 32	< 8	< 19
Co-58	< 20	< 22	< 7	< 16
Fe-59	< 47	< 60	< 18	< 32
Co-60	< 22	< 33	< 9	< 17
Zn-65	< 51	< 72	< 17	< 42
Nb-95	< 31	< 32	< 6	< 17
Zr-95	< 35	< 48	< 11	< 29
Cs-134	< 18	< 26	< 6	< 15
Cs-137	130 +- 20	150 +- 40	124 +- 15	90 +- 20
Naturally occurring radioisotopes such as radium-226 (²²⁶ Ra), bismuth-214 (²¹⁴ Bi), lead-214 (²¹⁴ Pb), actinium-228 (²²⁸ Ac), bismuth-212 (²¹² Bi), lead-212 (²¹² Pb) from the naturally occurring uranium-238 (²³⁸ U) and thorium-232 (²³² Th) decay series are commonly detected but have not been quantified or reported.				
Radioisotopes other than those reported were not detected.				