State of Wisconsin

2013

Zion

Environmental Radioactivity Survey

Wisconsin Department of Health Services
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State of Wisconsin, Department of Health Services

2013

Zion Environmental Monitoring Survey

Executive Summary

Section 254.41 of the Wisconsin Statutes mandates the State of Wisconsin, Department of Health Services to conduct environmental radiation monitoring around the nuclear power facilities that affect Wisconsin. This environmental monitoring report is for the Zion nuclear generating plant, located in Zion, Illinois, for the calendar year January - December 2013. It provides a description and results of this environmental monitoring program.

The Wisconsin Department of Health Services' environmental monitoring program consists of the collection of various types of samples from the air, water and terrestrial exposure pathways, sample analysis and interpretation of the data. The sampling program included samples of air, ambient gamma radiation, surface water, soil and vegetation that are collected from selected locations at planned sampling intervals.

Program Summary

For 2013, all sample results from the Zion environmental monitoring area were less than state and federal standards or guidelines.

The Wisconsin Department of Health Services' environmental monitoring programs provide an ongoing baseline of radioactivity measurements to assess any Wisconsin health concerns from the operation of nuclear power generating facilities in or near Wisconsin or other radiological incidents that may occur within Wisconsin or worldwide. These monitoring programs show the following:

- Environmental radioactivity levels have been trending downward in the time period since the 1950's-1960's atmospheric nuclear testing and such radiological incidents as the Chernobyl nuclear reactor incident.
- There were no incidents during 2013, such as the 2011 Japan Fukushima Daiichi incident, that required additional environmental monitoring.
- There is no radioactive problem in types of food consumed in Wisconsin and no health problem related to radioactivity for Wisconsin citizens.

The Department's ongoing environmental monitoring programs will continue to provide assurances to the citizens of Wisconsin that the environment surrounding the Zion nuclear power facility and other monitoring areas will continue to be evaluated.

Table of Contents

	Page
Introduction	**1**
Wisconsin DHS Zion Environmental Monitoring Sampling Program	**1**
Program Modifications	**1**
Laboratory Services and Quality Assurance	**2**
Detection Limits	**2**
Reporting of Sampling Analysis Results	**2**
Sample Collection Summary	**3**
Zion Environmental Monitoring Sampling Sites	**3**
Results and Discussion for the Zion Environmental Monitoring Program	**5**
References	**6**
Sample Activity Summary	**7**

List of Tables

		Page
Table 1.	Wisconsin DHS Zion environmental monitoring sampling sites.	3
Table 2.	Sample collection summary and required analyses.	3
Table 3.	Missing sample report and listing of non-routine analyses.	4
Table 4.	Sample activity summary for the Wisconsin DHS Zion environmental monitoring program.	7
Table 5.	Wisconsin DHS air particulate gross beta results from the Zion environmental monitoring program.	9
Table 6.	Wisconsin DHS gamma isotopic results from the quarterly composites of air particulate filters for the Zion environmental monitoring program.	9
Table 7.	Wisconsin DHS TLD results from the Zion environmental monitoring program.	10
Table 8.	Wisconsin DHS analysis results for surface water samples collected for the Zion environmental monitoring program.	10
Table 9.	Wisconsin DHS analysis results for vegetation and soil samples collected for the Zion environmental monitoring program.	11

List of Figures

Figure 1.	Wisconsin DHS environmental monitoring sites for the Zion environmental monitoring program.	4

State of Wisconsin DHS

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Introduction

Section 254.41 of the Wisconsin Statutes mandates the Wisconsin Department of Health Services (DHS) to conduct environmental radiation monitoring around the nuclear power facilities that impact Wisconsin. This environmental monitoring report is for the Zion nuclear facility, located in Zion, Illinois, for the calendar year January - December 2013. It provides a description and results of this environmental monitoring program.

Wisconsin DHS Zion Environmental Monitoring Sampling Program

The Wisconsin 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 as measured by thermoluminescent dosimeters (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 Wisconsin DHS's environmental monitoring report for the Zion nuclear plant for the calendar year January - December 2000. Table 2 provides a listing of types of samples collected, collection frequency, sites where samples are collected, 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 Commonwealth Edison 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 and the relocation of the spent fuel to the Zion Independent Spent Fuel Storage Installation (ISFSI), program modifications were implemented beginning in the third quarter of 2013.

Air particulate: Sampling site ZI-1 was discontinued. All air particulate sampling has ended for the Zion environmental monitoring program.

TLD: Sampling site ZI-T43 was discontinued. Quarterly monitoring will be continued at the remaining two (2) sites.

Surface water: Surface water sampling at site ZI-3 was discontinued. Sample site ZI-5 will be sampled on an annual basis.

Soil and vegetation: Soil and vegetation sampling was changed from semi-annual to annual.

Laboratory Services and Quality Assurance

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 Wisconsin DHS, will be expressed as a lower limit of detection (LLD). The required 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 an "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 Wisconsin DHS LLD indicating that the required 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:

Example	Nuclide	Activity reported
1	^{137}Cs	< 10 pCi/liter
2	^{137}Cs	15 $\pm$ 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. Wisconsin 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 (discontinued July 2010)
ZI-3	10.0 N	Water intake - 4700 feet from shore. (discontinued July 2013)
ZI-4	5.9 NW	Junction of Highway 31 and County ML.
ZI-5	3.5 N	Prairie Island Yacht Club
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 (discontinued July 2013)

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	12	0	GA, GB, GI
TLD	C/Q	T41 - T43	10	0	direct exposure
Surface Water	G/A	5	1	0	GA, GB, GI, Sr, H
Vegetation	G/A	1, 4	2	0	GA, GB, GI
Soil	G/A	1, 4	2	0	GA, GB, GI

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
There were no missed samples or non-routine analyses.			

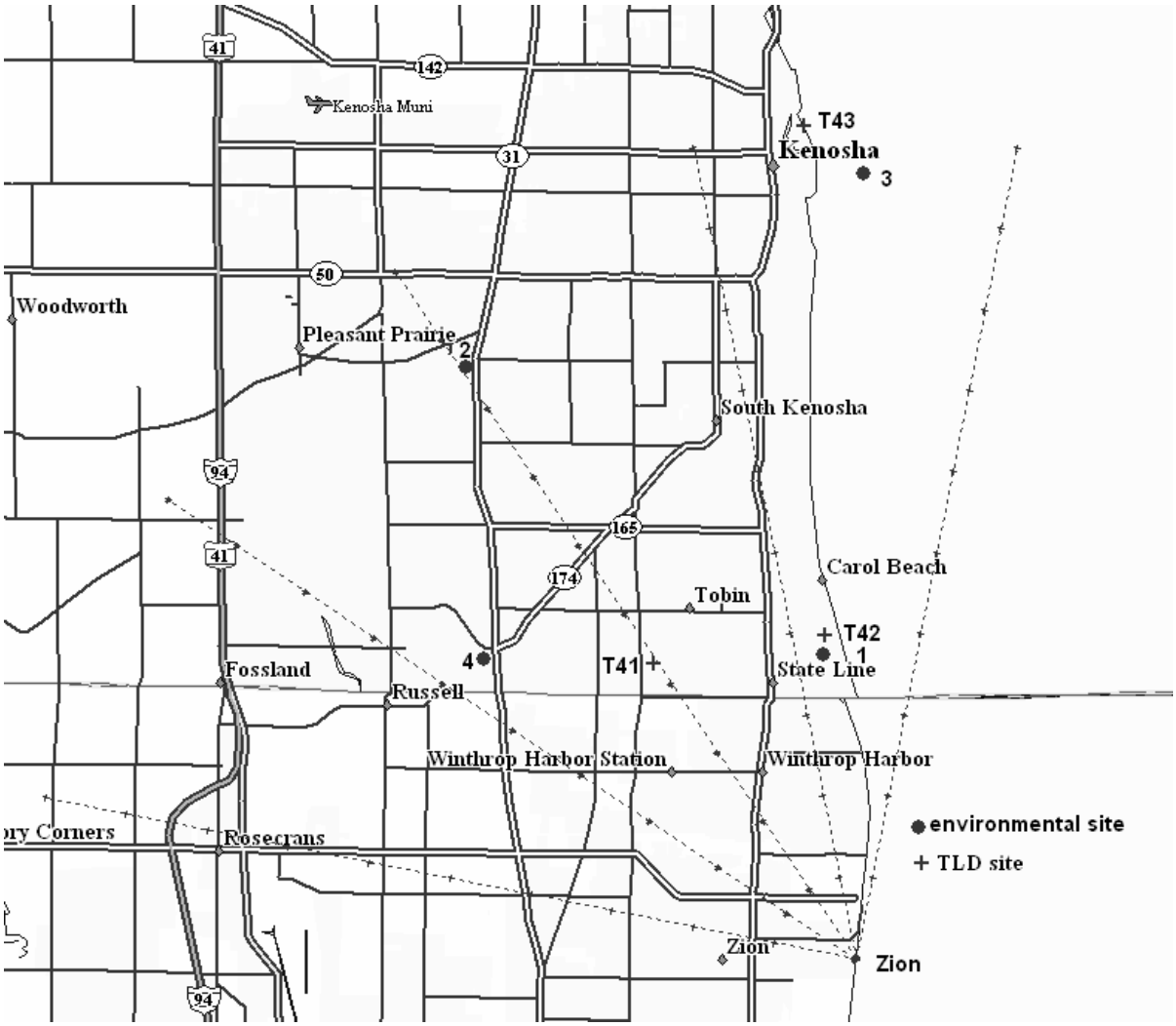

Figure 1. Wisconsin DHS environmental monitoring sites for the Zion environmental monitoring program.

Results and Discussion for the Zion Environmental Monitoring Program

Air Particulate

A summary of reported activities by Wisconsin 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 from gross beta activities in the three other Wisconsin DHS environmental monitoring programs. With no significant differences, an increase in gross beta activity attributable to the Zion facility is not evident.

The gamma isotopic analysis of the quarterly air particulate filter composites detected only small amounts of the radioisotopes listed in Table 4. Beryllium-7 (^{7}Be), detected in all composites, is a naturally occurring radioisotope that is constantly produced through nuclear reactions between cosmic rays and nuclei in the atmosphere and is detected in air composites from other areas of Wisconsin on a routine basis. Influence by the Zion facility on air quality is not evident from air particulate analysis.

Ambient Gamma Radiation – Thermoluminescent Dosimeters (TLDs)

A summary of reported activities by Wisconsin 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 2013 from the Wisconsin DHS network was comparable for all sites. Significant differences in exposure were not noticed at different distances from the Zion facility. The average quarterly exposure from the three sites located within Wisconsin was 14.7 $\pm$ 1.0 milliroentgens. The average yearly exposure is at background levels and is comparable to other areas within Wisconsin. Influence by the Zion facility is not evident from air ambient gamma radiation analysis.

Surface Water

A summary of reported activities by Wisconsin 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. All detected activities are at background levels and are comparable to data from previous years. The surface water samples uniformly show activities below state or federal standards. Influence by the Zion facility is not evident from surface water sample analysis.

Vegetation

A summary of reported activities by Wisconsin 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 (^{7}Be) and potassium-40 (^{40}K) listed in Table 4. Influence by the Zion facility is not evident from vegetation sample analysis.

Soil

A summary of reported activities by Wisconsin 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 from the uranium-238 (^{238}U) and thorium-232 (^{232}Th) decay series are commonly detected but have not been quantified or reported. Influence by the Zion facility is not evident from soil sample analysis.

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 facility are less than the limits as stated in these Federal regulations.

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

References

State of Wisconsin, Wisconsin Administrative Code, ch. DHS 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 Wisconsin DHS Zion environmental monitoring program for 2013.

Sample type (units)	LLD	Number of samples [a]	Analysis	Range
Air particulate	0.005	12 / 12	gross beta	0.012 - 0.047
(pCi/m^3)			gamma isotopic	
	0.020	2 / 2	Be-7	0.065 – 0.071
	0.002	2 / 0	Mn-54	< 0.0004
	0.002	2 / 0	Co-58	< 0.0003
	0.005	2 / 0	Fe-59	< 0.0008
	0.002	2 / 0	Co-60	< 0.0004
	0.005	2 / 0	Zn-65	< 0.0008
	0.002	2 / 0	Nb-95	< 0.0004
	0.005	2 / 0	Zr-95	< 0.0006
	0.002	2 / 0	Ru-103	< 0.0003
	0.015	2 / 0	Ru-106	< 0.0021
	0.020	2 / 0	I-131	< 0.0020
	0.002	2 / 0	Cs-134	< 0.0003
	0.002	2 / 0	Cs-137	< 0.0002
	0.030	2 / 0	Ba-140	< 0.0025
	0.020	2 / 0	La-140	< 0.0010
	0.002	2 / 0	Ce-141	< 0.0005
	0.005	2 / 0	Ce-144	< 0.0015
Ambient gamma (mR/Std Qtr)	1.0 [b]	10 / 10	ambient gamma	13.4 -16.5
Vegetation	5000	2 / 0	gross alpha	< 1280
(pCi/kg wet)	4000	2 / 2	gross beta	3510 – 4570
			gamma isotopic	
	600	2 / 2	Be-7	890 – 970
	2000	2 / 2	K-40	3860 – 4570
	90	2 / 0	Mn-54	< 22
	100	2 / 0	Co-58	< 24
	200	2 / 0	Fe-59	< 47
	100	2 / 0	Co-60	< 38
	250	2 / 0	Zn-65	< 59
	100	2 / 0	Nb-95	< 20
	200	2 / 0	Zr-95	< 47
	80	2 / 0	I-131	< 30
	80	2 / 0	Cs-134	< 28
	90	2 / 0	Cs-137	< 36
	350	2 / 0	Ba-140	< 98
	100	2 / 0	La-140	< 29

Table 4. Sample activity summary for the Wisconsin DHS Zion environmental monitoring program for 2013, continued.

Sample type (units)	LLD	Number of samples [a]	Analysis	Range
Surface water	3.0	1 / 1	gross beta (sol)	1.6
(pCi/liter)	3.0	1 / 0	gross beta (insol)	< 0.9
	3.0	1 / 1	gross alpha (sol)	1.1
	3.0	1 / 0	gross alpha (insol)	< 0.5
	300	1 / 0	H-3	< 250
	2.0	1 / 0	Sr-89	< 0.4
	1.0	1 / 1	Sr-90	0.4
			gamma isotopic	
	15	1 / 0	Mn-54	< 7
	15	1 / 0	Co-58	< 7
	30	1 / 0	Fe-59	< 10
	15	1 / 0	Co-60	< 7
	30	1 / 0	Zn-65	< 16
	15	1 / 0	Nb-95	< 8
	30	1 / 0	Zr-95	< 10
	15	1 / 0	I-131	< 7
	15	1 / 0	Cs-134	< 7
	15	1 / 0	Cs-137	< 7
	60	1 / 0	Ba-140	< 29
	15	1 / 0	La-140	< 10
Soil	6000	2 / 2	gross beta	8700 – 20000
(pCi/kg dry)	10000	2 / 1	gross alpha	< 4000 – 9590
			gamma isotopic	
	800	2 / 2	K-40	8520 – 17300
	60	2 / 0	Mn-54	< 23
	90	2 / 0	Co-58	< 19
	600	2 / 0	Fe-59	< 49
	90	2 / 0	Co-60	< 26
	300	2 / 0	Zn-65	< 49
	100	2 / 0	Nb-95	< 20
	250	2 / 0	Zr-95	< 32
	80	2 / 0	Cs-134	< 18
	80	2 / 1	Cs-137	72 - 190

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

Table 5. Wisconsin 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

Collection Date	Volume m^3	Air Particulate	Collection Date	Volume m^3	Air Particulate
01/11/13	1131	0.047 +- 0.002	04/19/13	2308	0.012 +- 0.001
01/24/13	1030	0.024 +- 0.002	05/01/13	918	0.023 +- 0.002
02/06/13	1052	0.033 +- 0.002	05/15/13	1073	0.015 +- 0.001
02/20/13	1100	0.019 +- 0.001	05/29/13	1077	0.013 +- 0.001
03/04/13	949	0.012 +- 0.001	06/13/13	1120	0.014 +- 0.001
03/20/13	1247	0.017 +- 0.001	06/26/13	972	0.013 +- 0.001
1st Qtr			2rd Qtr		
mean +- s.d.		0.025 +- 0.013	mean +- s.d.		0.015 +- 0.004

Table 6. Wisconsin 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/m^3

Site: ZI-1	1st quarter	2nd quarter	3rd quarter	4th quarter
Be-7	0.065 +- 0.005	0.071 +- 0.008		
Mn-54	< 0.0002	< 0.0004		
Co-58	< 0.0002	< 0.0003		
Fe-59	< 0.0004	< 0.0008		
Co-60	< 0.0003	< 0.0004		
Zn-65	< 0.0003	< 0.0008		
Nb-95	< 0.0003	< 0.0004		
Zr-95	< 0.0004	< 0.0006		
Ru-103	< 0.0002	< 0.0003		
Ru-106	< 0.0015	< 0.0021		
I-131	< 0.0020	< 0.0010		
Cs-134	< 0.0002	< 0.0003		
Cs-137	< 0.0002	< 0.0002		
Ba-140	< 0.0025	< 0.0023		
La-140	< 0.0010	< 0.0010		
Ce-141	< 0.0005	< 0.0005		
Ce-144	< 0.0012	< 0.0015		

Radioisotopes other than those reported were not detected.

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

	1st quarter	2nd quarter	3rd quarter	4th quarter
Date Placed:	01/03/13	04/01/13	07/01/13	09/30/13
Date Removed:	04/01/13	07/01/13	09/30/13	01/08/14
Days in the Field:	88	91	91	100
	Individual quarterly date is reported as: mR / Standard Quarter + 2 sigma counting error.			
T-41	15.0 +- 0.8	15.3 +- 0.9	15.3 +- 0.8	16.5 +- 1.0
T-42	13.4 +- 0.6	14.1 +- 0.6	14.1 +- 0.9	13.4 +- 0.7
T-43	14.4 +- 0.6	15.3 +- 0.7	discontinued	discontinued

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

Measurements in units of pCi/liter

ZI-3	
Collection date:	04/09/13
gross alpha-sol	1.1 +- 0.9
gross beta-sol	1.6 +- 0.8
gross alpha-insol	< 0.5
gross beta-insol	< 0.9
H-3	< 250
Sr-89	< 0.4
Sr-90	0.4 +- 0.2
gamma isotopic	
Mn-54	< 7
Co-58	< 7
Fe-59	< 10
Co-60	< 7
Zn-65	< 16
Nb-95	< 8
Zr-95	< 10
I-131	< 7
Cs-134	< 7
Cs-137	< 7
Ba-140	< 29
La-140	< 10

Radioisotopes other than those reported were not detected.

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

	Vegetation pCi/kilogram (wet)		**Soil** pCi/kilogram (dry)	
Site:	ZI-1	ZI-4	ZI-1	ZI-4
Collection date:	07/23/13	07/23/13	07/23/13	07/23/13
gross alpha	< 1280	< 844	< 4000	9590 +- 3660
gross beta	3510 +- 417	4530 +- 327	8700 +- 1200	20000 +- 1520
gamma isotopic				
Be-7	890 +- 90	970 +- 70		
K-40	3860 +- 390	4570 +- 420	8520 +- 730	17300 +- 1520
Mn-54	< 22	< 11	< 16	< 23
Co-58	< 24	< 14	< 15	< 19
Fe-59	< 47	< 22	< 38	< 49
Co-60	< 38	< 16	< 20	< 26
Zn-65	< 59	< 28	< 37	< 49
Nb-95	< 26	< 11	< 16	< 20
Zr-95	< 47	< 17	< 29	< 32
I-131	< 30	< 12		
Cs-134	< 28	< 12	< 14	< 18
Cs-137	< 36	< 12	190 +- 20	72 +- 8
Ba-140	< 98	< 33		
La-140	< 29	< 16		

Soil: 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