State of Wisconsin

2015

Zion

Environmental Radioactivity Survey

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

2015

Zion Environmental Monitoring Survey

Executive Summary

Wisconsin Stat. § 254.41 mandates the Wisconsin Department of Health Services (DHS) 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 2015. It provides descriptions and results of this environmental monitoring program.

The DHS 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 includes samples of ambient gamma radiation, surface water, soil, and vegetation that are collected from selected locations at planned sampling intervals.

Program Summary

For 2015, all sample results from the Zion environmental monitoring area were less than state and federal standards or guidelines.

DHS 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 1950s-1960s atmospheric nuclear testing and such radiological incidents as the Chernobyl nuclear reactor incident of 1986.
- There were no incidents during 2015 that required additional environmental monitoring.
- There are no radioactive problems in types of food consumed in Wisconsin and no health problems related to radioactivity for Wisconsin citizens.

DHS'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.

Zion is currently undergoing decommissioning; DHS will continue monitoring Zion throughout the entire decommissioning process. Decommissioning is expected to be completed in 2020.

Table of Contents

List of Tables

Page Number

List of Figures

Page Number

List of Appendices

Page Number

State of Wisconsin DHS

2015

Zion Environmental Radioactivity Survey

Introduction

Wisconsin Stat. § 254.41 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 2015. It provides descriptions and results of this environmental monitoring program.

Wisconsin DHS Zion Environmental Monitoring Sampling Program

DHS environmental monitoring program consists of the collection of various types of samples from the air, water, and terrestrial exposure pathways. The sampling program includes samples of 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 DHS's environmental monitoring report for the Zion nuclear plant for the calendar year January - December 2013. 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

There were no program modifications for 2015.

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 daily to regularly calibrate instrumentation and conduct performance checks. Instrumentation quality control charts are maintained and available upon written request.

WSLH participates in the Environmental Resource Associates' Proficiency Testing program and has performed satisfactorily over the report period. In addition, WSLH participates in the Multi Analytical Performance Evaluation Program (MAPER) for environmental matrix analysis. Proficiency testing results are available from WSLH.

In late 2014, WSLH experienced some personnel issues resulting in the inability to analyze strontium and iodine. The personnel issues resulted in the 2015 reporting period surface water samples being sent to ATI Environmental Inc. Midwest Laboratory.

ATI Environmental Inc. Midwest Laboratory participated in the National Environmental Laboratory Accreditation Conference Standards (2003) for a variety of radiological analyses during the reporting period.

Detection Limits

Detection limits, required by DHS, are 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.
t	is the elapsed time, for environmental samples, 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 are 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 DHS LLD, indicating that the required DHS LLD has been met.

An actual activity value is 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 $\pm$). 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-4	5.9 NW	Junction of Highway 31 and County ML.
ZI-5	3.5 N	Prairie Harbor Yacht Club
ZI-T41	4.7 NW	Junction of 122th Street and 39th Avenue
ZI-T42	3.8 N	Chiwaukee Prairie

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
TLD	C/Q	T41 - T42	8	0	direct exposure
Surface Water	G/A	5	1	0	GA, GB, GI, Sr, H
Vegetation	G/A	1, 4	2	1	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
Vegetation	7/10/2015	ZI-1	Sample was more than six months old, too old to run Gross alpha/beta
Vegetation	7/10/2015	ZI-4	Sample was more than six months old, too old to run Gross alpha/beta

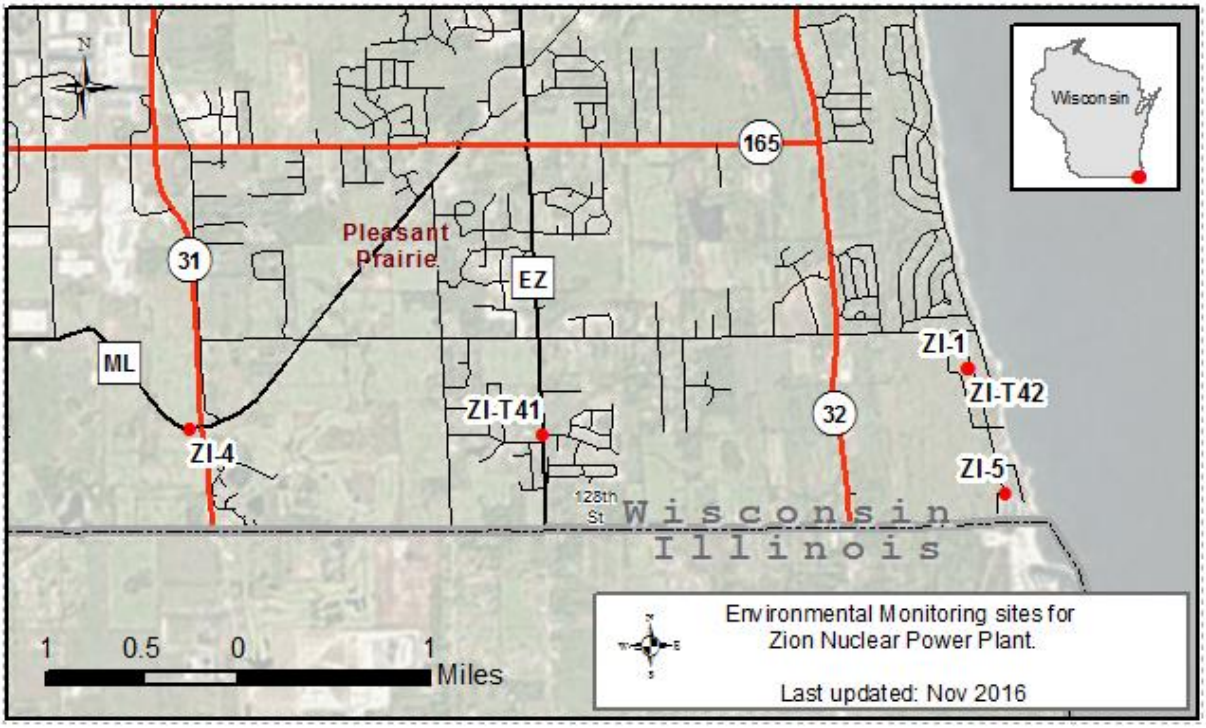

Figure 1. Wisconsin DHS environmental monitoring sites for the Zion environmental monitoring program.

Results and Discussion for the Zion Environmental Monitoring Program

Ambient Gamma Radiation – Thermoluminescent Dosimeters (TLDs)

Table 4 provides a summary of reported activities by DHS for ambient gamma radiation. Table 5 provides results from the individual sample analyses.

Ambient gamma radiation (TLD) data for 2015 from the 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 two sites located within Wisconsin was 13.7 $\pm$ 2.1 milliroentgens. The average yearly exposure was at background levels and was comparable to other areas within Wisconsin. Influence by the Zion decommissioning is not evident from air ambient gamma radiation analysis.

Surface Water

Table 4 provides a summary of reported activities by DHS for surface water samples. Table 7 provides results from the individual sample analyses. During this reporting period, samples were sent to ATI Environmental Inc. Midwest Laboratory as a result of Wisconsin State Lab of Hygiene's inability to analyze strontium.

The gamma isotopic analysis detected strontium-89 (89Sr) concentration slightly above the LLD; all other gamma emitting isotopes measured below detection levels. All other detected activities were at background levels and were 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

Table 4 provides a summary of reported activities by DHS for vegetation samples. Table 6 provides results from individual sample analyses.

The gross alpha and beta analysis was not conducted because the sample was more than six months old. The gamma isotopic analysis detected beryilium-7 (^{7}Be) and naturally occurring potassium-40 (^{40}K) concentration at sites ZI-1 and ZI-4 were above the LLD. Influence by the Zion facility is not evident from vegetation sample analysis. All samples with values above the LLD were below state or federal standards. All other gamma emitting isotopes measured below detection levels.

Soil

Table 4 provides a summary of reported activities by DHS for soil samples. A table 6 provides results from individual sample analyses.

Gross alpha concentrations were above the LLD at site ZI-4, and the gross beta concentrations were above the LLD at sites ZI-1 and ZI-4. The gamma isotopic analysis detected naturally occurring radioisotope potassium-40 (^{40}K) was above the LLD. 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.

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

References

Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors, NUREG-1301, Generic Letter 89-01, Supplement No. 1, April 1991.

Wisconsin Admin. Code § DHS 157.23

U.S. Environmental Protection Agency (EPA), Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion, Federal Guidance Report No. 11, EPA-520/1-88-020, (Office of Radiation Programs Washington, DC), September 1988.

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.

Sample Activity Summary

Table 4. Sample activity summary for the Wisconsin DHS Zion environmental monitoring program for 2015.

Sample type (units)	LLD	Number of samples [a]	Analysis	Range
Ambient gamma (mR/Std Qtr)	1.0 [b]	8 / 8	ambient gamma	11.9 -17.8
Vegetation (pCi/kg wet)	5000	2 / 0	gross alpha	*c
	4000	2 / 0	gross beta	*c
			gamma isotopic	
	600	2 / 2	Be-7	773 – 898
	2000	2 / 2	K-40	4960 – 6290
	90	2 / 0	Mn-54	< 24
	100	2 / 0	Co-58	< 24
	200	2 / 0	Fe-59	< 55
	100	2 / 0	Co-60	< 35
	250	2 / 0	Zn-65	< 40
	100	2 / 0	Nb-95	< 28
	200	2 / 0	Zr-95	< 40
	80	2 / 0	I-131	< 46
	80	2 / 0	Cs-134	< 23
	90	2 / 0	Cs-137	< 33
	350	2 / 0	Ba-140	< 119
	100	2 / 0	La-140	< 31
Surface water (pCi/liter)	3.0	1 / 0	gross alpha (sol)	0.5
	3.0	1 / 0	gross beta (sol)	1.3
	3.0	1 / 0	gross alpha (insol)	< 0.7
	3.0	1 / 0	gross beta (insol)	< 1.0
	300	1 / 0	H-3	< 204
	2.0	1 / 1	Sr-89	< 3.3
	1.0	1 / 0	Sr-90	0.6
			gamma isotopic	
	15	1 / 0	Mn-54	< 7
	15	1 / 0	Co-58	< 7
	30	1 / 0	Fe-59	< 14
	15	1 / 0	Co-60	< 11
	30	1 / 0	Zn-65	< 15
	15	1 / 0	Nb-95	< 8
	30	1 / 0	Zr-95	< 12
	15	1 / 0	I-131	< 13
	15	1 / 0	Cs-134	< 9
	15	1 / 0	Cs-137	< 11
	60	1 / 0	Ba-140	< 38
	15	1 / 0	La-140	< 14

Table 4 (continued). Sample activity summary for the Wisconsin DHS Zion environmental monitoring program for 2014.

Sample type (units)	LLD	Number of samples [a]	Analysis	Range
Soil	10000	2 / 1	gross alpha	2560 – 16800
(pCi/kg dry)	6000	2 / 2	gross beta	9420 – 25400
			gamma isotopic	
	800	2 / 2	K-40	10100 – 20500
	60	2 / 0	Mn-54	< 26
	90	2 / 0	Co-58	< 43
	600	2 / 0	Fe-59	< 171
	90	2 / 0	Co-60	< 26
	300	2 / 0	Zn-65	< 70
	100	2 / 0	Nb-95	< 98
	250	2 / 0	Zr-95	< 78
	80	2 / 0	Cs-134	< 20
	80	2 / 2	Cs-137	136 - 202

a - Number of analyses / number of analyses detected above the WI DHS LLD.
b - 1.0 mR/TLD
c - Sample was more than six months old, too old to run Gross alpha/beta

Table 5. Wisconsin DHS TLD network for the Zion environmental monitoring program.

	1st quarter	2nd quarter	3rd quarter	4th quarter
Date Placed:	01/05/15	04/10/15	07/14/15	10/14/15
Date Removed:	04/08/15	07/14/15	10/14/15	01/13/16
Days in the Field:	93	95	92	91

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

T-41	12.4 +- 0.7	15.3 +- 1.0	13.3 +- 0.7	17.8 +- 0.8
T-42	11.9 +- 0.6	12.8 +- 0.6	11.3 +- 0.6	14.4 +- 0.8

Table 6. Wisconsin DHS analysis results for vegetation and soil samples collected for the Zion environmental monitoring program.

	Vegetation		Soil	
	pCi/kilogram (wet)		pCi/kilogram (dry)	
Site:	ZI-1	ZI-4	ZI-1	ZI-4
Collection date:	07/10/15	07/10/15	07/10/15	07/10/15
gross alpha	*a	*a	2560 +- 2960	16800 +- 4000
gross beta	*a	*a	9420 +- 1170	25400 +- 1670
gamma isotopic				
Be-7	898 +- 162	773 +- 134		
K-40	4960 +- 912	6290 +- 1120	10100 +- 1660	20500 +- 3200
Mn-54	< 24	< 24	< 20	< 26
Co-58	< 24	< 22	< 30	< 43
Fe-59	< 55	< 52	< 127	< 171
Co-60	< 35	< 22	< 18	< 26
Zn-65	< 61	< 44	< 43	< 70
Nb-95	< 28	< 23	< 84	< 98
Zr-95	< 40	< 36	< 66	< 78
I-131	< 46	< 32	*b	*b
Cs-134	< 23	< 21	< 17	< 20
Cs-137	< 33	< 23	202 +- 22	136 +- 16
Ba-140	< 119	< 103		
La-140	< 23	< 31		

*a = Sample was more than six months old, too old to run Gross alpha/beta
*b = Analytics is not tested as part of the regularly tested isotopes

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

Table 7. Wisconsin DHS analysis results for surface water samples collected for the Zion environmental monitoring program.

Measurements in units of pCi/liter

Site ZI-5

Collection date:	07/13/15
gross alpha-sol	0.5 +- 0.5
gross beta-sol	1.3 +- 0.7
gross alpha-insol	< 0.7
gross beta-insol	< 1.0
H-3	< 204
Sr-89	< 3.3
Sr-90	< 0.6
gamma isotopic	
Mn-54	< 7
Co-58	< 7
Fe-59	< 14
Co-60	< 11
Zn-65	< 15
Nb-95	< 8
Zr-95	< 12
I-131	< 13
Cs-134	< 9
Cs-137	< 11
Ba-140	< 38
La-140	< 14

Radioisotopes other than those reported were not detected.

Appendices

Appendix A – Radionuclide Concentration Levels needing review by state radiological coordinator (SRC)

Should radioactivity concentrations exceed SRC review levels for a given radionuclide, the SRC will be consulted for review and assessment.

Medium	Radionuclide	SRC Review Level [a]
Water (pCi/l)	Gross Alpha	10
	Gross Beta	30
	H-3	10,000
	Mn-54	100
	Fe-59	40
	Co-58	100
	Co-60	30
	Zr-Nb-95	40
	Cs-134	10
	Cs-137	20
	Ba-La-140	100
	Sr-89	8
	Sr-90	8
	Zn-65	30
Vegetation (pCi/kg wet)	Gross Beta	30,000
	I-131	100
	Cs-134	200
	Cs-137	200
	Sr-89	1,000
	Sr-90	1,000
Soil, Bottom Sediment (pCi/kg)	Gross Beta	5,000
	Cs-134	5,000
	Cs-137	5,000
	Sr-89	5,000
	Sr-90	5,000

Radionuclides will be monitored by the Wisconsin Department of Health Services, Radiation Protection Sections, Environmental Monitoring program and concentrations above the listed levels will be reported to the Wisconsin state radiological coordinator (SRC) for further review and assessment.

Appendix B – Sample Point Locations

The sample point locations.

Sample Point	Location Description
ZI-1	Chiwaukee Prairie.
ZI-4	Junction of Highway 31 and County ML.
ZI-5	Prairie Harbor Yacht Club
ZI-T41	Junction of 122th Street and 39th Avenue
ZI-T42	Chiwaukee Prairie.