State of Wisconsin

2015

La Crosse Boiling Water Reactor

Environmental Radioactivity Survey

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

2015

La Crosse Boiling Water Reactor 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 La Crosse Boiling Water Reactor (LACBWR) nuclear generating plant 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, fish, soil, and vegetation that are collected from selected locations at planned sampling intervals.

Program Summary

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

The 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, 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 DHS ongoing environmental monitoring programs will continue to provide assurances to the citizens of Wisconsin that the environment surrounding the LACBWR nuclear power facility and other monitoring areas will continue to be evaluated.

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Introduction

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 La Crosse Boiling Water Reactor (LACBWR) for the calendar year January - December 2015. It provides descriptions and results of this environmental monitoring program.

Wisconsin DHS LACBWR Environmental Monitoring Sampling Program

The 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, fish, soil, and vegetation that are collected from selected locations at planned sampling intervals.

Table 1 is a listing of sampling sites and includes a description, direction, and distance from the monitored power plant. Table 2 provides a listing of the types of samples collected, sites where samples are collected, number of samples collected, number of samples that were missed or had noted problems, 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

On April 30, 1987, Dairyland Power Cooperative permanently shut down the LACBWR facility. Their USNRC (United States Nuclear Regulatory Commission) license was amended to a possess-but-not-operate status on August 4, 1987, and they are now in the process of decommissioning the LACBWR facility. Since any severe accident involving the stored spent fuel will have little off-site consequences, the DHS environmental radioactivity monitoring program was modified in June 1988. These modifications included the elimination of precipitation, shoreline sediment, and well water samples as well as a reduction in vegetation, soil, and some surface water sampling.

In response to decommissioning and funding restrictions, the LACBWR environmental monitoring program was reviewed and modified in 1998, 1999, 2000, 2013, and 2014. The 2014 program modifications were made due to the inability to find a reliable source of fish from the immediate area. Table 1 shows current sample sites and discontinued sites in the third quarter of 2013.

Fish: Fish sampling was discontinued in 2014.

Bottom Sediment: Bottom sediments were stopped for 2014, but restarted in 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 the 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 participates 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	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 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 5-8 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 LACBWR environmental monitoring sampling sites.

Sample site	Distance and direction (miles)	Location description
LAC-2	0.6 N	Lock & Dam #8 (discontinued 1st quarter 2014)
LAC-3	0.1 WSW	Discharge channel
LAC-4	0.7 SSW	Boat launch area
LAC-5	0.6 NNE	Hwy 35 parking lot
LAC-6	0.7 S	Boat launch access road
LAC-10	0.6 N	South of Lock & Dam #8
LAC-19	0.6 SSW	Island across from the boat launch
LAC-T1	0.6 N	Lock & Dam #8
LAC-T2	0.5 SSE	Edgewood Trailer Court, Hwy 35
LAC-T3	0.2 S	ISFSI outer fence (outside on fence)
LAC-T4	0.2 W	ISFSI outer fence (outside on fence)

Table 2. Sample collection summary and required analyses.

Sample Type	Collection and Frequency	LAC Site locations	Number of Samples Collected	Number of Sample Deviations	Required Analyses
TLD	G/Q	LAC T1-T4	16	0	direct exposure
surface water	G/A	LAC 4	1	0	GA, GB, GI, Sr, H
bottom sediment	G/A	LAC 3,10,19	3	0	GA,GB,GI
fish	G/A	discontinued			
vegetation	G/A	LAC 5, 6	2	0	GA, GB, GI
soil	G/A	LAC 5, 6	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. Wisconsin DHS missing sample or non-routine analysis report for 2015.

Sample type	**Date**	**Site**	**Explanation**
bottom sediment	4/29/2015	LAC-3	The cesium 137 activity is significantly higher than the LLD, but below SRC review levels.

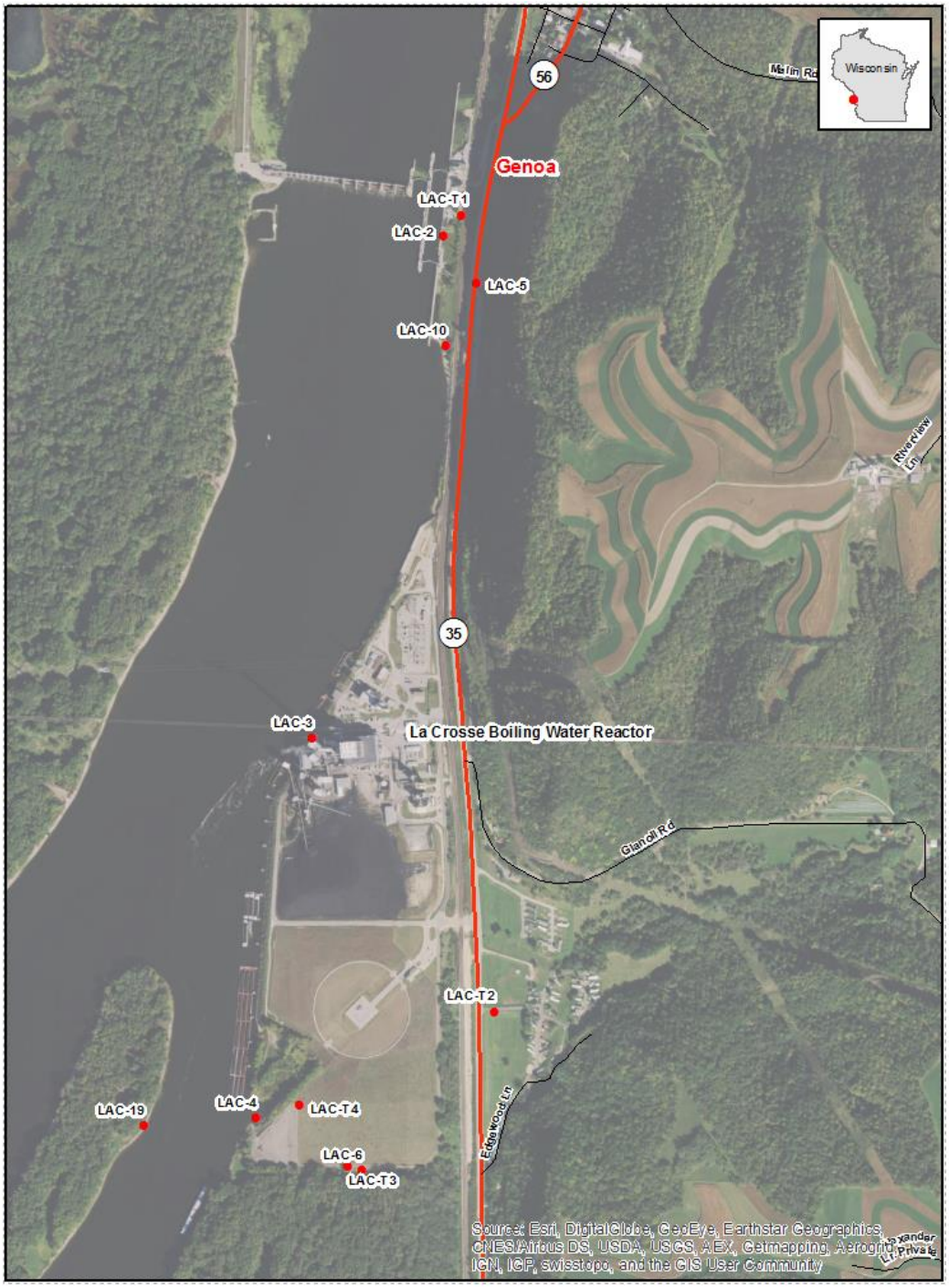

Figure 1. Wisconsin DHS environmental monitoring sampling sites for the LACBWR monitoring program.

Results and Discussion for the LACBWR 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 LACBWR facility. The average quarterly exposure from the four sites located within Wisconsin was 18.3 $\pm$ 1.1 milliroentgens. The average quarterly exposure for 2015 was at background levels and was comparable to other areas within Wisconsin. Influence by the LACBWR facility is not evident from air ambient gamma radiation analysis.

Fish

Sampling was discontinued on March 2015 due to the unavailability of fish from the immediate area.

Surface Water

Table 4 provides a summary of reported activities by DHS for surface water samples. Table 8 provides results from the individual sample analysis.

The gamma isotopic analysis detected strontium-89 (^{89}Sr) concentrations 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 showed activities below state or federal standards. Influence by the LACBWR facility is not evident from surface water sample analysis.

Vegetation

Table 4 provides a summary of reported activities by DHS for vegetation samples. Table 7 provides results from the individual sample.

The gross beta concentration at LAC-5 was slightly above the LLD. The gamma isotopic analysis detected a beryilium-7 (^{7}Be) concentration at LAC-5, which was above the LLD. Also, naturally occurring potassium-40 (^{40}K) was above the LLD at both sites. Influence by the LACBWR 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. Table 7 provides results from the individual sample analyses.

Analysis of the soil samples showed no unusual activities. The gamma isotopic analysis detected only small amounts of gross alpha, gross beta, cesium-137 (^{137}Cs), listed in Table 4 above the LLD. The naturally occurring radioisotope potassium-40 (^{40}K) was detected above the LLD in all samples. The reported activities for cesium-137 (^{137}Cs) were also detected in previous years and can be attributed to residual fallout from previous atmospheric nuclear weapons 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 LACBWR facility is not evident from soil sample analysis.

Bottom Sediments

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

The naturally occurring radioisotope potassium-40 (^{40}K) was detected in all samples. Gross beta counts were above the LLD in all samples, but at levels similar to previous years. The gamma isotopic analysis of the bottom sediment samples taken at sites LAC-3 and LAC-19 detected small activities for cesium-137 (^{137}Cs). The reported activities for cesium-137 (^{137}Cs) can be attributed to past effluent discharges from the LACBWR facility and have also been detected in previous years. 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 LACBWR facility is not evident from bottom sediment 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 LACBWR 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 LACBWR facility are less than the limits as stated in Wis. Admin. Code § DHS 157.23.

References

Off-Site 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 LACBWR environmental monitoring program.

Sample type (units)	LLD	Number of samples [a]	Analysis	Range
Direct Exposure (TLD) (mR/Std Qtr)	1.0 [b]	16 / 16	direct exposure	12.2 – 24
Surface Water (pCi/liter)	3.0	1 / 0	gross alpha (sol)	1.2
	3.0	1 / 0	gross beta (sol)	2.7
	3.0	1 / 0	gross alpha (insol)	0.5
	3.0	1 / 0	gross beta (insol)	1.1
	300	1 / 0	H-3	< 207
	2.0	1 / 1	Sr-89	< 5.2
	1.0	1 / 0	Sr-90	< 0.5
			gamma isotopic	
	10	1 / 0	Mn-54	< 6
	15	1 / 0	Co-58	< 7
	30	1 / 0	Fe-59	< 11
	15	1 / 0	Co-60	< 7
	30	1 / 0	Zn-65	< 16
	15	1 / 0	Nb-95	< 8
	30	1 / 0	Zr-95	< 12
	15	1 / 0	I-131	< 9
	15	1 / 0	Cs-134	< 8
	15	1 / 0	Cs-137	< 7
	60	1 / 0	Ba-140	< 32
	15	1 / 0	La-140	< 11
Soil (pCi/kg dry)	13000	2 / 2	gross alpha	14500 – 21500
	6000	2 / 2	gross beta	21500 – 25300
			gamma isotopic	
	800	2 / 2	K-40	10400 – 23700
	60	2 / 0	Mn-54	< 14
	90	2 / 0	Co-58	< 28
	600	2 / 0	Fe-59	< 146
	90	2 / 0	Co-60	< 12
	300	2 / 0	Zn-65	< 35
	100	2 / 0	Nb-95	< 98
	250	2 / 0	Zr-95	< 61
	80	2 / 0	Cs-134	< 10
	80	2 / 1	Cs-137	< 10 - 163

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

Sample type (units)	LLD	Number of samples [a]	Analysis	Range
Vegetation	5000	2 / 0	gross alpha	< 1160
(pCi/kg wet)	4000	2 / 1	gross beta	3150 – 4290
			gamma isotopic	
	600	2 / 1	Be-7	511 – 769
	2000	2 / 2	K-40	3630 – 5740
	90	2 / 0	Mn-54	< 17
	100	2 / 0	Co-58	< 17
	200	2 / 0	Fe-59	< 52
	100	2 / 0	Co-60	< 22
	250	2 / 0	Zn-65	< 44
	100	2 / 0	Nb-95	< 19
	200	2 / 0	Zr-95	< 32
	80	2 / 0	I-131	< 38
	80	2 / 0	Cs-134	< 18
	90	2 / 0	Cs-137	< 21
	350	2 / 0	Ba-140	< 92
	100	2 / 0	La-140	< 28
Bottom Sediment	13000	3 / 0	gross alpha	< 4040 – 10800
(pCi/kg dry)	6000	3 / 3	gross beta	6020 – 20800
			gamma isotopic	
	800	3 / 3	K-40	6030 – 16700
	60	3 / 0	Mn-54	< 11
	90	3 / 0	Co-58	< 23
	600	3 / 0	Fe-59	< 133
	90	3 / 0	Co-60	< 8
	300	3 / 0	Zn-65	< 43
	100	3 / 0	Nb-95	< 99
	250	3 / 0	Zr-95	< 50
	80	3 / 0	Cs-134	< 6
	80	3 / 2	Cs-137	< 7 - 1780

a - Number of analysis / number of analyses detected above the Wisconsin DHS LLD.

b – 1.0 mR / TLD.

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

	1st quarter	2nd quarter	3rd quarter	4th quarter
Date Placed:	01/13/15	04/02/15	07/07/15	10/06/15
Date Removed:	04/02/15	07/07/15	10/06/15	01/05/16
Days in the Field:	79	96	96	91
Individual quarterly date is reported as: mR / Standard Quarter + 2 sigma counting error.				
LAC-T1	20.4 +- 2.3	15.0 +- 0.7	16.7 +- 2.0	15.9 +- 0.6
LAC-T2	12.3 +- 1.2	19.4 +- 1.5	19.0 +- 1.0	22.1 +- 1.1
LAC-T3	15.3 +- 1.1	22.0 +- 1.0	19.2 +- 0.6	24.3 +- 0.6
LAC-T4	12.2 +- 1.3	19.0 +- 0.9	18.4 +- 1.3	20.9 +- 0.9

ND = No Data, TLD lost in the field

Table 6. Wisconsin DHS analysis results for bottom sediment samples collected for the LACBWR environmental monitoring program.

Measurements in units of pCi/kilogram (dry)

Collection date:	4/29/2015	4/29/2015	4/29/2015
Site:	LAC-10 upstream	LAC-3 discharge	LAC-19 downstream
gross alpha	4990 +- 3330	< 4040	10800 +- 4040
gross beta	10200 +- 1270	6020 +- 1260	20800 +- 1470
K-40	8230 +- 1310	6030 +- 964	16700 +- 2550
Mn-54	< 11	< 6	< 9
Co-58	< 20	< 18	< 23
Fe-59	< 119	< 95	< 133
Co-60	< 7	< 6	< 8
Zn-65	< 19	< 17	< 43
Nb-95	< 98	< 88	< 99
Zr-95	< 44	< 42	< 50
Cs-134	< 6	< 6	< 6
Cs-137	< 7	1780 +- 100	96 +- 6

Table 7. Wisconsin DHS analysis results for vegetation and soil samples collected for the LACBWR environmental monitoring program.

Vegetation - Measurements in units of pCi/kilogram (wet)

Site:	LAC-5	LAC-6
Collection date:	05/26/2015	5/26/2015
gross alpha	< 553	< 1160
gross beta	4290 +- 226	3150 +- 320
gamma isotopic		
Be-7	769 +- 126	511 +- 92
K-40	5740 +- 1010	3630 +- 646
Mn-54	< 16	< 17
Co-58	< 17	< 16
Fe-59	< 52	< 36
Co-60	< 22	< 21
Zn-65	< 44	< 37
Nb-95	< 19	< 19
Zr-95	< 32	< 31
I-131	< 35	< 38
Cs-134	< 17	< 18
Cs-137	< 16	< 21
Ba-140	< 79	< 92
La-140	< 28	< 28

Soil - Measurements in units of pCi/kilogram (dry)

Site:	LAC-5	LAC-6
Collection date:	05/26/2015	5/26/2015
gross alpha	14500 +- 3940	21500 +- 4700
gross beta	25300 +- 1590	21500 +- 1600
gamma isotopic		
K-40	23700 +- 3760	10400 +- 1610
Mn-54	< 14	< 13
Co-58	< 27	< 28
Fe-59	< 146	< 121
Co-60	< 12	< 11
Zn-65	< 35	< 29
Nb-95	< 98	< 98
Zr-95	< 61	< 58
Cs-134	< 10	< 10
Cs-137	163 +- 13	< 10

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

Measurements in units of pCi/liter

Site:	LAC-4
Collection date:	5/26/2015
gross alpha-sol	1.2 +- 1.0
gross beta-sol	2.7 +- 0.8
gross alpha-insol	< 0.5
gross beta-insol	1.1 +- 0.7
H-3	< 207
Sr-89	< 5.2
Sr-90	< 0.5
gamma isotopic	
Mn-54	< 6
Co-58	< 7
Fe-59	< 11
Co-60	< 7
Zn-65	< 16
Nb-95	< 8
Zr-95	< 12
I-131	< 9
Cs-134	< 8
Cs-137	< 7
Ba-140	< 32
La-140	< 11

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
LAC-2	Lock & Dam #8
LAC-3	Discharge sample location (bottom sediment)
LAC-4	Boat launch area
LAC-5	Hwy 35 parking lot
LAC-6	Boat launch access road
LAC-T1	Lock & Dam #8
LAC-T2	Trailer court, Hwy 35
LAC-T3	ISFSI outer fence (outside on fence)
LAC-T4	ISFSI outer fence (outside on fence)
LAC-10	Upstream sample location (bottom sediment)
LAC-19	Downstream sample location (bottom sediment)