

Kansas Department of Health and Environment
Report of Radiological Environmental Monitoring of the Environs Surrounding
Wolf Creek Generating Station



July 2010-June 2011
Division of Health, Bureau of Environmental Health
Radiation and Asbestos Control Section
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Kansas Department of Health and Environment
 Environmental Radiation Surveillance Report
 Wolf Creek Generating Station
 State Fiscal Year 2011

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Introduction

Wolf Creek Generating Station (WCGS) is a pressurized water nuclear reactor capable of producing over 1,200 megawatts of electrical power. Located near Burlington Kansas, the plant is operated by Wolf Creek Nuclear Operating Corporation (WCNOC). The facility releases radioactive material to the environment in the form of liquid and gaseous effluents. This report details the results of surveillance of the environs surrounding WCGS conducted by the Kansas Department of Health and Environment (KDHE) from July 1, 2010 through June 30, 2011.

KDHE's Wolf Creek Environmental Radiation Surveillance (ERS) program began in 1979 in accordance with Kansas Administrative Regulation (K.A.R.) 28-19-81 with the initial selection of surface water sampling locations. The ERS program parallels (and partially overlaps) the WCNOC Radiological Environmental Monitoring Program (REMP).

The purpose of the ERS program is to detect, identify, and measure radioactive material and direct radiation released to the environment from the operation of WCGS. Data indicating the release of elevated levels of radioactive material will be used to determine the need for corrective and/or protective actions to protect the health and safety of the public.

The ERS program includes the following monitoring methods:

- Measurement of ambient external radiation levels using optically stimulated luminescence dosimetry
- Monitoring of radionuclides present in ambient air through weekly collection and laboratory analysis of continuous air samples
- Monitoring of radionuclides present in water, terrestrial vegetation, aquatic vegetation, fish, sediments, and soil through scheduled and random sample collection and laboratory analysis.

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Discussion of Impact of Japan Earthquake and Radiological Release

On March 11, 2011, the Japanese island of Honshu experienced a magnitude 9.0 earthquake which resulted in a tsunami which produced waves up to 133 feet. Some of the waves traveled inland up to six miles, resulting in massive damage and loss of critical infrastructure.

The earthquake and subsequent tsunami resulted in damage to six nuclear power plants on the island. Radioactive material released from at least four of the plants was carried across the Pacific Ocean to the United States. Samples obtained in conjunction with the ERS Program detected low levels of radioiodine and cesium in various samples:

- Radioiodine was detected in air sampler particulate and iodine cartridge samples on March 25, March 31, April 7, and April 14, 2011 (per Table 1 note)
- Radioiodine was detected in a soil sample collected April 5, 2011
- Radioiodine was detected in milk samples collected March 24 and April 18, 2011.
- Radioiodine and cesium were detected in a vegetation sample collected on April 5, 2011

No radionuclides were detected in subsequent samples obtained after the releases in Japan were significantly reduced.

These data are reported in the applicable tables in the Sample Results section of this report.

These radionuclides were not the result of Wolf Creek Generating Station operation, and are so indicated in the results tables.

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Results Summary

The most significant radionuclide present in surface water samples collected in the Coffey County Lake is tritium (^3H), a beta emitter. The highest ^3H concentration measured in the Coffey County Lake during SFY 2011 was 16,890 pCi/l in March, 2011. This maximum Coffey County Lake ^3H concentration is 84% of the National Primary Drinking Regulation maximum contaminant level (MCL) of 20,000 pCi/l. *The water from the Coffey County Lake is not used as a drinking water source.* The average CCL surface water ^3H concentration for SFY 2011 was 12,457 pCi/l, or 62% of MCL. Coffey County Lake is not approved for any aquatic recreation other than fishing. All other non-CCL surface water and ground water samples collected in the environs of WCGS during SFY 2011 indicated no radionuclides present attributable to the operation of WCGS.

Aquatic vegetation samples are the best indicators for monitoring the seasonal fluctuations of fission and activation product levels in the Coffey County Lake. No aquatic vegetation sample showed any nuclides attributable to WCGS operation. Five trending samples and six random samples were analyzed.

Sediment samples have been excellent indicators for the long-term buildup of fission and activation product activity levels in the Coffey County Lake. The highest fission product activity in sediments during SFY 2011 was 326.3 pCi/kg-dry ^{137}Cs found at the Environmental Education Area (WCBS-AR-1).

Airborne sample analysis indicated that no radionuclides attributable to the operation of WCGS were present above the lower limits of detection during SFY 2011.

Sample analysis of terrestrial vegetation, soil, milk, grain, and vegetable samples collected in the environs of WCGS during SFY 2011 indicated no radionuclides present attributable to the operation of WCGS.

Samples of nine species of fish were taken from the Coffey County Lake during SFY 2011. Sample analysis of edible fish portions collected in the environs of WCGS during SFY 2011 indicated that no gamma emitters attributable to WCGS operation were present. The highest ^3H concentration in tissue was 7,224 pCi/kg-wet found in a channel catfish sample taken from the CCL. Using an ICRP 30 dose conversion factor for ingestion ($h_{E,50}$) of 6.40×10^{-8} mrem per pCi ^3H ingested, a standard man consuming 21 kg/y of fish containing 7,224 pCi/kg ^3H would receive a committed effective dose equivalent of 0.01 mrem. The projected dose equivalent is far below the 100 mrem/yr regulatory limit for a member of the public.

Data from direct radiation monitoring sites revealed no significant changes from preoperational data. The lowest direct radiation levels are found closest to the WCGS. The direct radiation levels on the Coffey County Lake baffle dikes at the 1,200 m exclusion area boundary are the lowest of any monitored site. The limestone used to construct the baffle dikes has a lower natural background radioactivity than the original soil present before the construction of the Coffey County Lake. This effect of construction on the terrestrial component of natural background radiation was noted on radiation surveys conducted around the WCGS site before bringing the initial fuel load on the site. The water from the Coffey County Lake also acts as an effective shield from terrestrial radiation that was present before Coffey County Lake filling.

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The ratio of KDHE results to WCNOG results ranged from 0.5-1.6. A summary of comparison data may be found in the Results Comparison Table.

Results Summary Table

Type of Sample	Number of Sampling Stations	Total Samples Collected
Air (particulate and iodine)	5	520
Soil	5	5
Random Soil	10	10
Direct Radiation	31	248
Surface Water	5	41
Offsite Ground Water	6	24
Onsite Ground Water	3	12
Sediments	9	10
Random Sediments	16	17
Aquatic Vegetation	5	5
Random Aquatic Vegetation	6	6
Milk	2	10
Fish	2	15
Game Animals/Domestic Meat	1	1
Terrestrial Vegetation	7	9
Random Terrestrial Vegetation	10	10
Total	123	939

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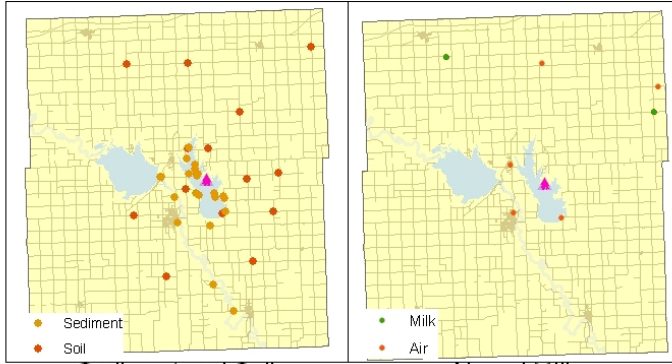
Results Comparison Table

Description	Average	Standard Deviation	Minimum	Maximum	N
OSLD direct radiation, mR per 90 day quarter	17.7	3.6	6.7	24.7	124
Airborne particulate and radioiodine cartridge gamma isotopic analysis	No activity detected above the Lower Limit of Detection				
Coffey County Lake Surface water tritium (³ H), pCi/l	12457	2079	9343	16890	24
John Redmond Reservoir, control (N-1/MUSH) (³ H), pCi/l	<350	N/A	N/A	N/A	12
Coffey County Lake (J1A/DC) (³ H), pCi/l	12421	2079	9711	15369	12
Coffey County Lake MUDS (³ H), pCi/l	12497	2464	9343	16890	12
Neosho River Near LeRoy (³ H), pCi/l	<350	N/A	N/A	N/A	4
New Strawn City Lake (³ H), pCi/l	<350	N/A	N/A	N/A	1
Offsite ground water tritium (³ H), pCi/l (All Stations)	No activity detected above the Lower Limit of Detection				
Onsite ground water tritium (³ H), pCi/l (Stations where activity was detected)	1427	848	640	3079	7
Well Water Gamma Isotopic Analysis	No activity detected above the Lower Limit of Detection				
Gamma isotopic analysis of soil, pasturage, garden vegetables, and grain.	No activity detected above the Lower Limit of Detection				
Maximum activity attributable to Wolf Creek Generating Station operation, pCi/kg					
Coffey County Lake shoreline sediment, dry	326.3 pCi/kg ¹³⁷ Cs, EEA, 4/12/2011				
Coffey County Lake fish, wet	7224 pCi/kg ³ H, 10/19/2010				
Analysis	Average Ratio of KDHE results to WCNOG results		Comments		
OSLD Direct Radiation	0.98, N=48		12 Collocated sites		
Surface Water ³ H	0.9, N=12		Coffey County Lake spillway		
Sediment gamma isotopic	1.25, N=9		Comparison of ¹⁴⁰ K results		
Fish tritium (³ H)	0.96, N=1				

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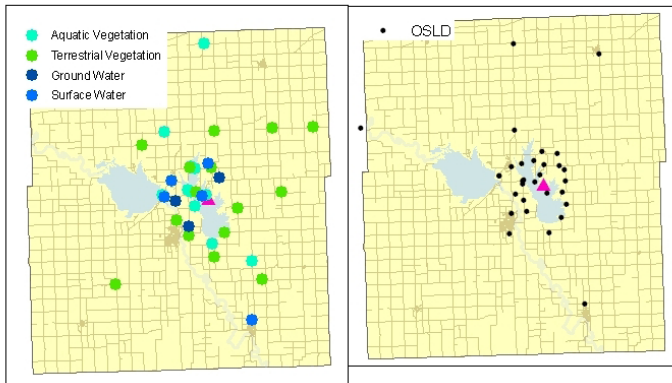
Sample Location Maps

2011 Wolf Creek ERS Program



Sediment and Soil

Air and Milk



Vegetation and Water

Direct Radiation (OSLD)

0 5 10 Miles

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Sample Results

Inhalation Pathway

Air Particulate and Iodine

Air samples were collected weekly. Five air-sampling sites, four of which are collocated with WCNOG, have continuously operating low-volume air samplers contained in a fiberglass housing mounted on utility poles approximately one meter from the ground. Air samplers are located at Sharpe, KS (A-1), east of the Coffey County Lake dam (H-1), Burlington, KS (L-1), New Strawn, KS (P-1), and near Westphalia, KS (D-2). The collocated sites include the highest calculated annual average ground level relative concentration (X/Q) area at Sharpe, the highest calculated annual average ground level relative deposition (D/Q) area at New Strawn, and a control location near Westphalia. An average flow rate of 30 liters per minute is used with 47 mm diameter glass fiber particulate filters and 5 percent triethylenediamine (TEDA) impregnated carbon cartridges for radioiodine activity (the major isotope of concern is ¹³¹I). TEDA binds the iodine chemically and reduces losses from desorption.

Field assay of each particulate filter was performed at the time of collection. The particulate filter was counted using a thin window GM 'pancake' detector (Ludlum Model 44-40 or equivalent) and a count rate instrument. A sample net count rate of greater than two times the net count rate of the current control (Westphalia D-2) air sample indicates a potential anomaly and the filter is then flagged for individual gamma isotopic analysis.

Gamma isotopic analysis was performed on two composite samples, one composed of the five particulate filters and the other of the five charcoal cartridges. Indication of ¹³¹I or any other fission or activation product requires gamma isotopic analysis of each individual particulate filter and associated charcoal cartridge.

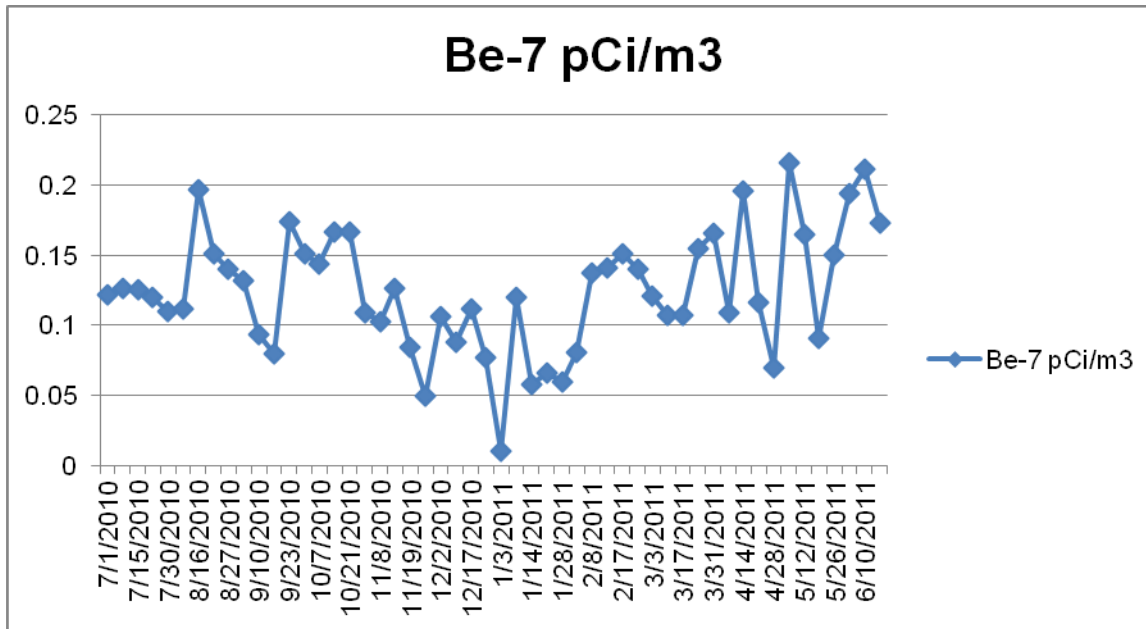
Table 1. Weekly air particulate/iodine monitoring (pCi/m³)

Number of Samples	Average ⁷ Be Concentration	Average Iodine Concentration
520	0.14 ± 0.05	<0.033 ¹

¹ Average does not include radioiodine (¹³¹I) from Japan earthquake and nuclear incident aftermath. Radioiodine was detected in air filters collected March 25, March 31, April 7 and April 14, 2011. Levels detected were 0.047, 0.137, 0.043 and 0.004 pCi/m³ respectively. Air filters collected before and after these dates had no detectable radioiodine.

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Graph 1. Weekly Particulate ⁷Be Concentration



Airborne Pathway

Soil

Four indicator, one control, and ten random annual soil samples were collected. Indicator soil samples were collected near Stringtown Cemetery, east of the CCL dam, at the CCL MUDS area, and at the public environmental education area. One control soil sample was collected east of WCGS at the Scott Valley Church. Random soil samples were collected at ten locations within the 50 mile zone around WCGS, nine of which were within the ten mile zone around WCGS. Soil samples collected from the Coffey County Lake public use areas are split with WCNOG.

A gamma isotopic analysis is performed on all soil samples collected.

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Table 2. Annual Samples for Radionuclide Deposition on Soil, pCi/kg KDHE (WCNOC)

Nuclide	A-1 Near Stringtown Cemetery	E-1 Scott Valley Church (control)	H-1 East of CCL Dam
		4/20/2011	8/18/2010
²²⁸ Ac	1173 ± 14	1576.5 ± 15.7	1226 ± 15
¹³⁷ Cs	388 ± 12	319.7 ± 7.7	228 ± 7
⁴⁰ K	11958 ± 366	15616.2 ± 187.5	11453 ± 341
	P-1 (MUDS)	R-1 (EEA)	
	6/2/2011	8/10/2010	
²²⁸ Ac	1096 ± 12	1020.6 ± 14.6	
¹³⁷ Cs	111 ± 4 (<60.8)	275 ± 6.8 (336.1 ± 37.8)	
⁴⁰ K	11124 ± 341 (8,791.4 ± 1,143.0)	8855.7 ± 130.4 (9,437.1 ± 612.2)	

Table 3. Random Samples for Radionuclide Deposition on Soil

Location	Date	¹³⁷ Cs	Nuclide ⁴⁰ K
Hwy K-31 and Xeric Rd.	7/8/2010	15.8 ± 2.5	17564.3 ± 207.8
24th and Native Rd.	9/27/2010	192.2 ± 7	17706.5 ± 283.5
12th Rd. and Underwood Rd.	12/7/2010	150.7 ± 6	13177.1 ± 423.3
14th Rd. and Native Rd.	12/7/2010	10.6 ± 1.2	10781.1 ± 329.4
1/4 Mi. North of 15th Rd. on Shetland	1/6/2011	34 ± 2.2	11577 ± 362
Between Juneberry Rd. and Iris Rd. on 12th Rd	2/16/2011	209.4 ± 6.6	9570.8 ± 297.2
Near 8th Rd. and Shetland Rd.	2/16/2011	88 ± 3.2	12928.9 ± 389.6
Near 22nd Rd. and Iris Rd. ¹	4/5/2011	254 ± 8	13291 ± 397
Near 7th Rd. and Lynx Rd.	4/27/2011	317 ± 10	8570 ± 265
Near 20th Rd. and Reaper Rd.	6/7/2011	15.8 ± 2.5	17564.3 ± 207.8

¹Sample contained 57.0 ± 3 pCi/kg ¹³¹I, not result of WCGS operation.

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Direct Radiation Pathway

Direct Radiation Monitoring

Direct radiation monitoring was accomplished using Landauer Luxel optically stimulated luminescence dosimeters (OSLDs). OSLDs are read by Landauer. OSLD readings are corrected for transit and handling exposure.

Thirty-one locations around the WCGS were monitored by KDHE, including three control locations greater than ten miles from WCGS. Two OSLDs were used per site to generate an average quarterly reading. The dosimeters are contained in specially constructed holders suspended approximately one meter above the ground. Staff members exchange OSLDs quarterly. KDHE has collocated OSLDs with WCNOG at twelve sites.

Table 4. Quarterly Direct Radiation Monitoring

Location	Quarter 1	Quarter 2	Quarter 3	Quarter 4
1. A-1 (1), North of WCGS	16.5	13.2	20.4	22.7
2. A-2, Sharpe	16.0	13.7	18.4	23.7
3. A-3, Forward Staging Area	12.5	12.2	17.4	21.7
4. B-1, East Sharpe	14.5	12.2	18.4	24.7
5. B-2, Waverly Control	17.5	16.2	20.4	23.2
6. C-1, near residence	17.5	15.2	18.9	24.2
7. D-1 (9), near residence	15.5	13.2	17.9	22.7
8. E-1, near residence	18.5	15.7	19.9	22.2
9. F-1, near residence	18.0	15.2	18.4	23.2
10. G-1 (14), WCNOG gate	20.5	19.7	18.4	23.2
11. H-0 (42), CCL baffle dike A	10.5	9.2	17.4	16.2
12. H-1, east of CCL dam	16.5	14.2	18.4	21.7
13. H-2, LeRoy control	16.5	14.7	18.4	22.2
14. J-1, near residence	14.5	12.2	16.4	21.7
15. K-1 (29), near residence	14.5	12.2	15.9	18.7
16. L-1 (27), near residence	16.5	13.7	18.9	21.7
17. L-2, Burlington	17.5	15.2	17.9	24.7
18. L-3, Coffey County Shop	16.0	14.2	15.4	20.7
19. M-1 (26), near residence	15.0	13.7	17.9	22.2
20. N-1, near pasture	18.0	16.7	18.9	22.7
21. P-0 (43), CCL baffle dike B	9.0	6.7	14.9	16.7
22. P-1, New Strawn	15.5	15.2	17.9	21.2
23. P-2, Hartford Control	14.0	12.7	16.9	18.2
24. P-3, CCL entrance	19.0	16.7	19.4	23.7
25. P-4 (46), CCL near MUDS	16.0	15.2	18.9	23.7
26. P-5, JRR public use area	17.0	14.7	17.4	22.2
27. Q-1, near residence	16.5	15.2	18.4	22.7
28. R-0 (41), Stringtown cemetery	16.5	16.7	19.4	21.7
29. R-1 (37), near residence	18.5	17.2	16.9	22.2
30. R-2 (44), CCL EEA	17.5	15.7	19.4	23.7
31. R-3, near Coffey County Airport	17.0	14.7	18.9	24.7

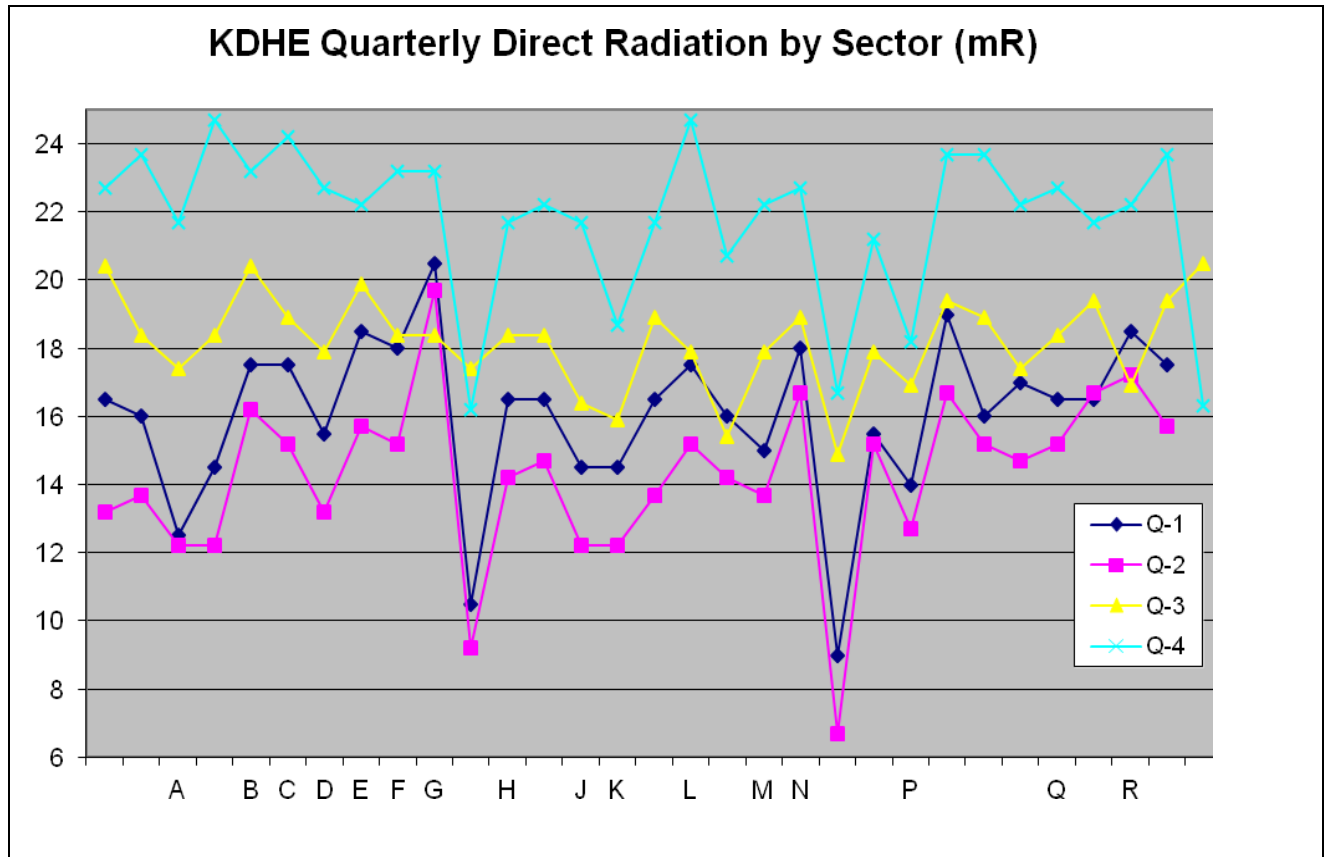
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Table 5. Quarterly Collocated Direct Radiation Monitoring

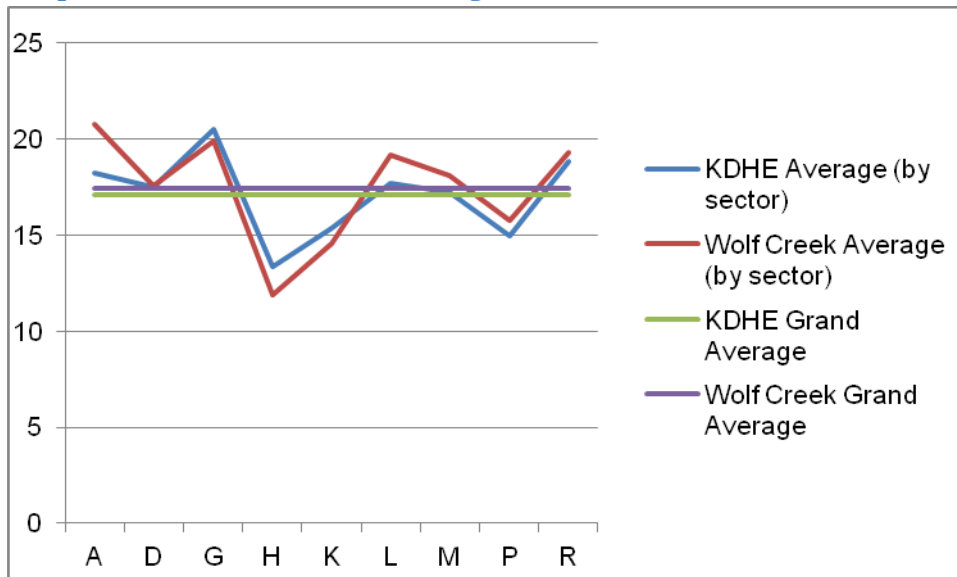
Location KDHE(WCNOC)	KDHE Monitoring Period	KDHE	WCNOC
1. A-1 (1)	7/8/2010-10/13/2010	16.5	20.8
	10/13/2010-1/7/2011	13.2	21.0
	1/7/2011-4/13/2011	20.4	21.1
	4/13/2011-7/8/2011	22.7	20.2
2. D-1 (9)	7/8/2010-10/13/2010	15.5	16.4
	10/13/2010-1/7/2011	13.2	17.4
	1/7/2011-4/13/2011	17.9	18.3
	4/13/2011-7/8/2011	22.7	18.2
3. G-1 (14)	7/8/2010-10/13/2010	20.5	22.5
	10/13/2010-1/7/2011	19.7	20.5
	1/7/2011-4/13/2011	18.4	18.3
	4/13/2011-7/8/2011	23.2	19.1
4. H-0 (42)	7/8/2010-10/13/2010	10.5	11.0
	10/13/2010-1/7/2011	9.2	12.4
	1/7/2011-4/13/2011	17.4	13.1
	4/13/2011-7/8/2011	16.2	11.1
5. K-1 (29)	7/8/2010-10/13/2010	14.5	13.8
	10/13/2010-1/7/2011	12.2	14.6
	1/7/2011-4/13/2011	15.9	15.9
	4/13/2011-7/8/2011	18.7	13.8
6. L-1 (27)	7/8/2010-10/13/2010	16.5	17.1
	10/13/2010-1/7/2011	13.7	20.4
	1/7/2011-4/13/2011	18.9	19.1
	4/13/2011-7/8/2011	21.7	19.9
7. M-1 (26)	7/8/2010-10/13/2010	15.0	18.2
	10/13/2010-1/7/2011	13.7	18.6
	1/7/2011-4/13/2011	17.9	17.7
	4/13/2011-7/8/2011	22.2	17.7
8. P-0 (43)	7/8/2010-10/13/2010	9.0	11.6
	10/13/2010-1/7/2011	6.7	12.4
	1/7/2011-4/13/2011	14.9	11.2
	4/13/2011-7/8/2011	16.7	10.7
9. P-4 (46)	7/8/2010-10/13/2010	16.0	21.4
	10/13/2010-1/7/2011	15.2	20.9
	1/7/2011-4/13/2011	18.9	19.6
	4/13/2011-7/8/2011	23.7	18.2
10. R-0 (41)	7/8/2010-10/13/2010	16.5	19.1
	10/13/2010-1/7/2011	16.7	18.3
	1/7/2011-4/13/2011	19.4	19.3
	4/13/2011-7/8/2011	21.7	19.6
11. R-1 (37)	7/8/2010-10/13/2010	18.5	20.1
	10/13/2010-1/7/2011	17.2	18.9
	1/7/2011-4/13/2011	16.9	19.3
	4/13/2011-7/8/2011	22.2	17.5
12. R-2 (44)	7/8/2010-10/13/2010	17.5	20.4
	10/13/2010-1/7/2011	15.7	20.4
	1/7/2011-4/13/2011	19.4	19.6
	4/13/2011-7/8/2011	23.7	18.7

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Graph 2. Quarterly direct radiation results for KDHE OSLD sites

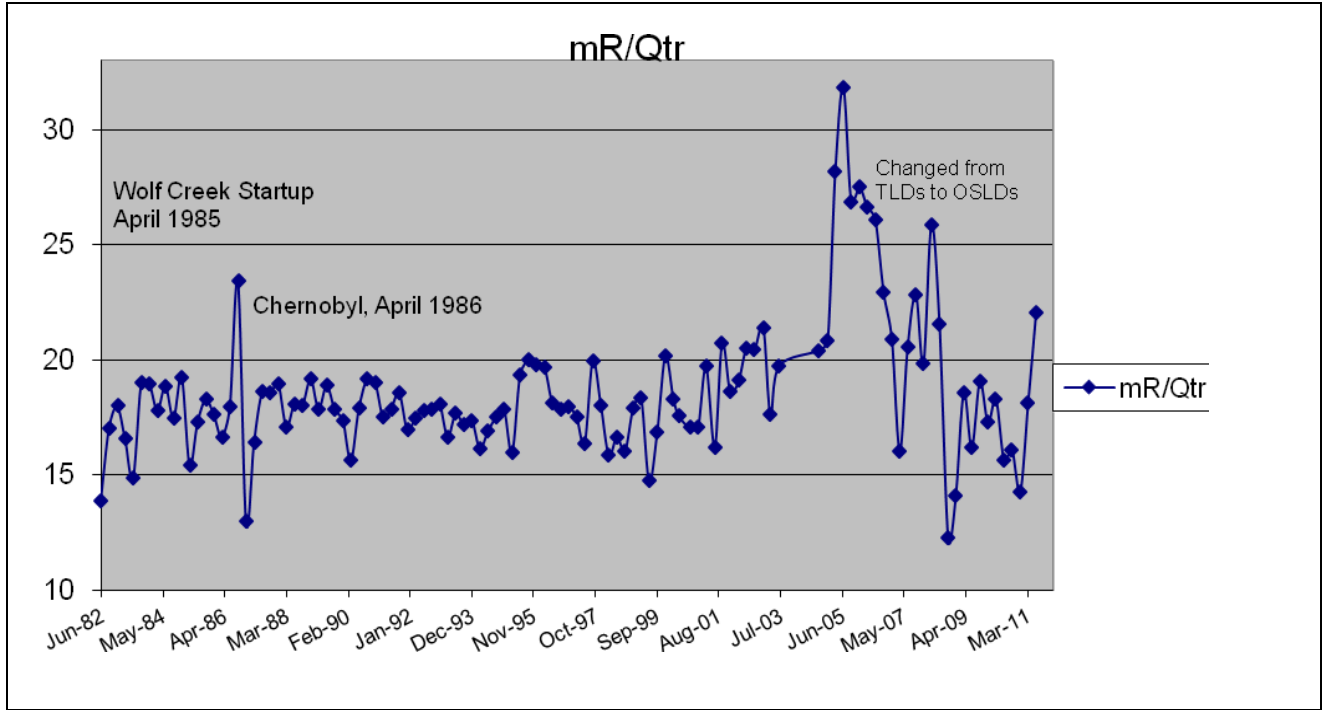


Graph 3. Direct radiation monitoring results for co-located OSLD sites (mR)



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Graph 4. Historical KDHE direct radiation monitoring results



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Waterborne Pathway

Surface Water

Surface water sampling was accomplished through the collection of one-gallon grab samples at the indicated locations. A control sample was collected monthly from John Redmond Reservoir. One sample was collected monthly from the Coffey County Lake (CCL) at the spillway. One sample was collected monthly at the public fishing area on CCL, near the Makeup Discharge Structure (MUDS). Samples were collected monthly from the Neosho River near Leroy only when Coffey County Lake was overflowing to Wolf Creek at the spillway. A sample was also collected annually from the New Strawn City Lake.

A gamma isotopic and tritium (^3H) analysis was done on each CCL water sample and ^3H analysis was done quarterly on a composite sample from JRR. Samples from John Redmond Reservoir and the Coffey County Lake Spillway were split with WCNOG.

Table 6. Monthly samples for waterborne radionuclides in surface water (^3H , pCi/L)

J-1A (Spillway)			N-1 (JRR/MUSH) Control			P-1 MUDS	
Date	KDHE	WCNOG	Date	KDHE	WCNOG	Date	KDHE
7/19/2010	9711 ± 310	9645 ± 281	7/19/2010	<350	<179	7/15/2010	9739 ± 311
8/23/2010	10425 ± 312	10097 ± 294	8/23/2010	<350	<181	8/12/2010	11057 ± 178
9/27/2010	10269 ± 312	10914 ± 322	9/27/2010	<350	<160	9/23/2010	10827 ± 322
10/18/2010	9902 ± 314	10689 ± 316	10/18/2010	<350	<159	10/12/2011	9343 ± 316
11/15/2011	12593 ± 338	13436 ± 355	11/15/2011	<350	<163	11/9/2010	12356 ± 337
12/20/2010	12480 ± 343	12093 ± 320	12/20/2010	<350	<161	12/7/2010	13992 ± 320
1/31/2011	13188 ± 346	13458 ± 330	1/31/2011	<350	<143	1/24/2011	13467 ± 351
2/21/2011	13700 ± 353	13787 ± 349	2/21/2011	<350	<147	2/17/2011	13700 ± 353
3/28/2011	15369 ± 369	15523 ± 359	3/28/2011	<350	<146	3/24/2011	16890 ± 381
4/20/2011	14883 ± 365	14785 ± 354	4/20/2011	<350	<141	4/14/2011	15671 ± 376
5/19/2011	15111 ± 521	14066 ± 340	5/19/2011	<350	<141	5/26/2011	15435 ± 371
6/20/2011	11421 ± 333	14374 ± 353	6/20/2011	<350	<148	6/22/2011	10425 ± 314

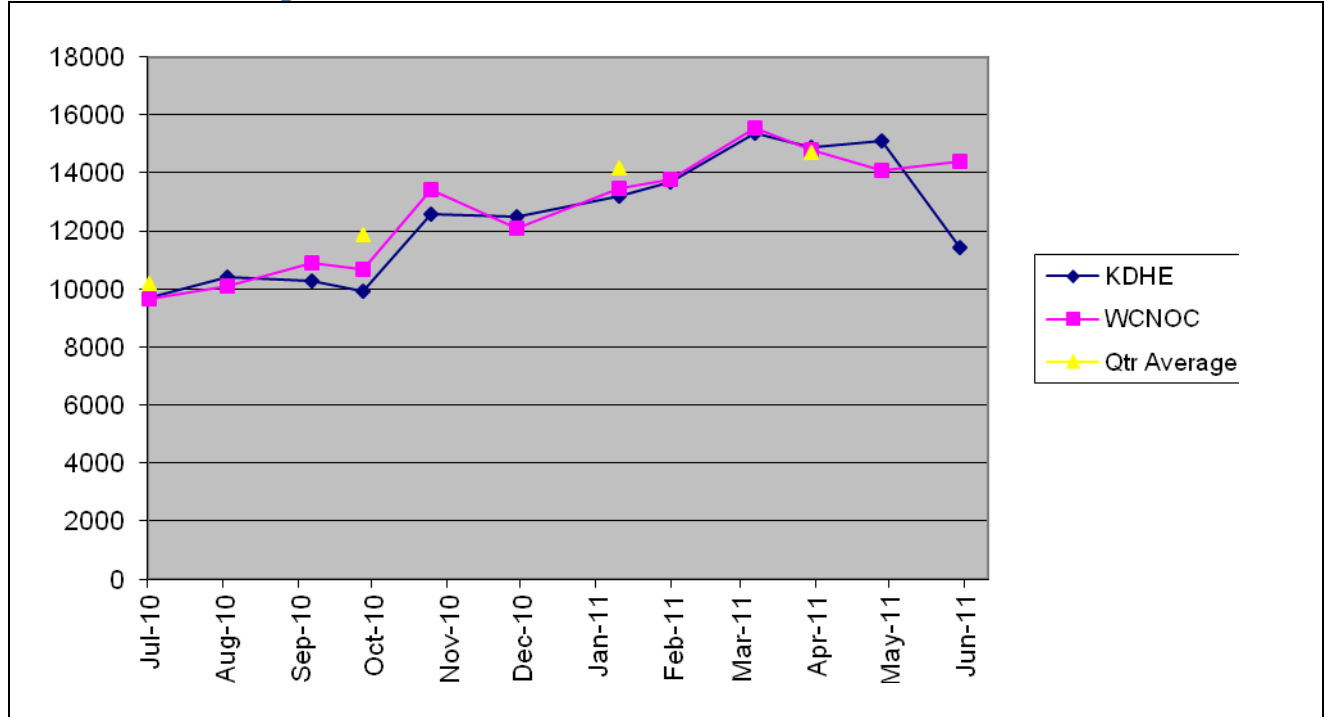
Date	H-1 Neosho River Near Leroy, KDHE
7/15/2010	<350
3/23/2011	<350
4/27/2011	<350
6/17/2011	<350

Table 7. Annual samples for deposition of airborne radionuclides in surface water (pCi/L)

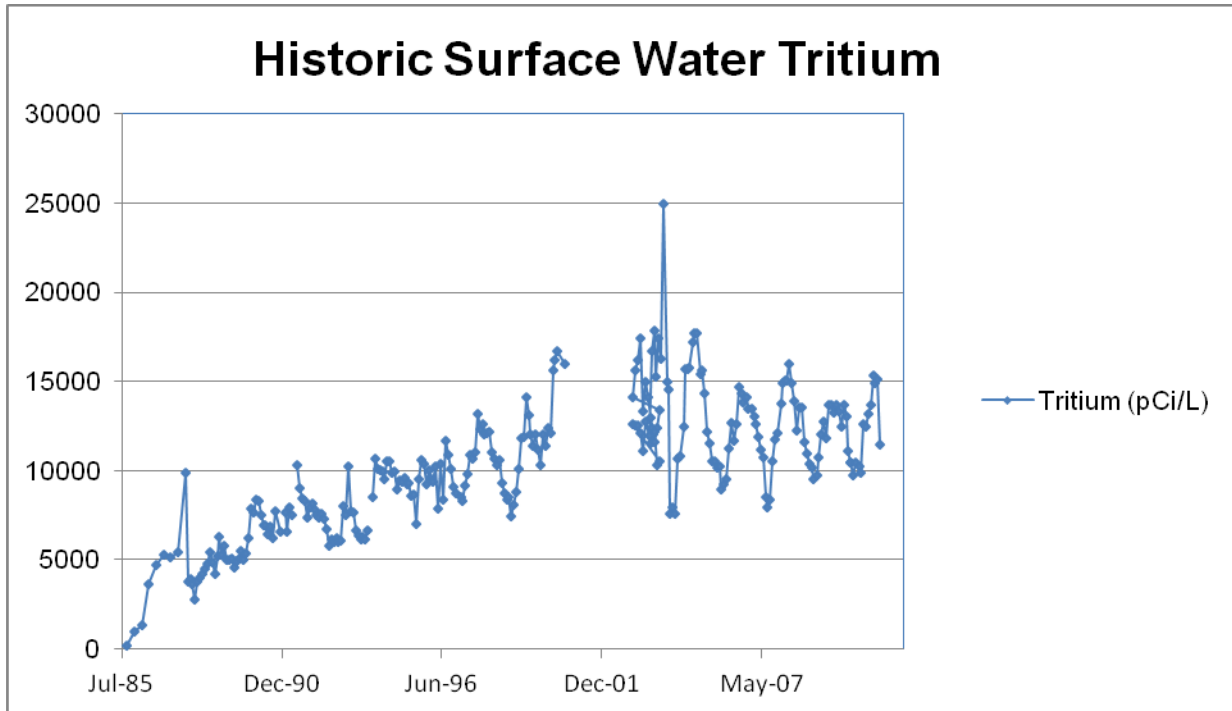
Location	Date	Tritium (^3H)
P-1, New Strawn City Lake	4/27/2011	<350

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Graph 6. Comparison of CCL Spillway monthly surface water tritium results (pCi/L)



Graph 7. Historical KDHE surface water tritium results (CCL Spillway)



Ground Water

Ground water was collected quarterly offsite at wells in sectors B (control), C, F, G, and J. The control sample location was hydrologically up gradient from the facility and the other five are hydrologically down gradient. Samples were split with WCNOG. Samples were collected within the Wolf Creek owner controlled area along the Essential Service Water-buried pipe (two locations) and in the Wolf Creek protected area near the Auxiliary Building.

Gross alpha, beta, tritium and gamma isotopic analysis are done on each sample.

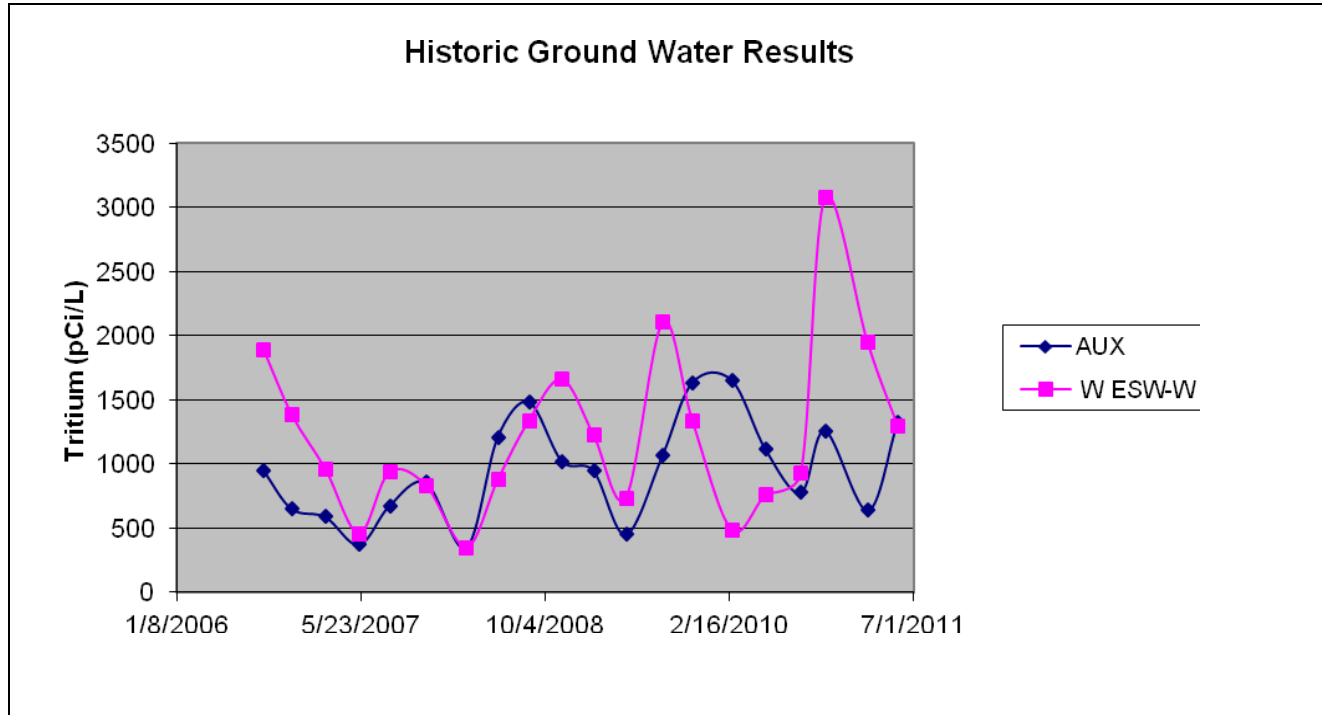
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Table 8. Quarterly samples for waterborne radionuclides in ground water (pCi/L)

Offsite Ground Water					
B-1 (B-12)			G-1 (G-2)		
Date	H-3 KDHE	WCNOC	DATE	H-3 KDHE	WCNOC
8/23/2010	<350	<181	8/23/2010	<350	<181
11/22/2010	<350	<144	11/22/2010	<350	<144
2/28/2011	<350	<152	2/28/2011	<350	<152
5/23/2011	<350	<141	5/23/2011	<350	<141
F-1 (F-1)			C-2 (C-49)		
8/23/2010	< 350	<181	8/23/2010	<350	<181
11/22/2010	<350	<144	11/22/2010	<350	<144
2/28/2011	<350	<152	2/28/2011	<350	<152
5/23/2011	< 350	<141	5/23/2011	<350	<141
J-1 (J-2)			C-1 (C-10)		
8/23/2010	<350	<181	8/23/2010	<350	<181
11/22/2010	<350	<144	11/22/2010	<350	<144
2/28/2011	<350	<152	2/28/2011	<350	<152
5/23/2011	<350	<141	5/23/2011	<350	<141
Onsite Ground Water					
Date	H-3 KDHE	WCNOC	DATE	H-3 KDHE	WCNOC
Auxiliary Building			West ESW-W		
8/31/2010	777 ± 153	982 ± 121	8/30/2010	926 ± 179	1167 ± 128
11/4/2010	1259 ± 268	1270 ± 136	11/4/2010	3079 ± 220	3061 ± 185
2/28/2011	640 ± 178	679 ± 106	2/28/2011	1946 ± 202	2097 ± 154
5/21/2011	1331 ± 271	1337 ± 124	5/21/2011	1292 ± 272	1298 ± 123
East ESW-W					
8/30/2010	<350	<160			
11/4/2010	<350	<163			
2/28/2011	<350	<152			
5/21/2011	<350	<141			

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Graph 8. Historic Owner Controlled Area (Onsite) Groundwater Tritium



Shoreline and Bottom Sediments

Shoreline sediment and bottom sediment were collected in the environment surrounding WCGS. Indicator bottom sediment samples were collected in the Coffey County Lake discharge cove, public environmental education area, and the CCL MUDS public access fishing area. A control sample of bottom sediment was obtained from John Redmond Reservoir. Indicator shoreline sediment was collected at the CCL discharge cove, the CCL MUDS public access fishing area, Wolf Creek below the CCL dam, and Stringtown Cemetery. A control sample of shoreline sediment was collected at JRR. Eleven random bottom sediments were collected on CCL. Six random shoreline sediments were collected on CCL and the Neosho River. The CCL and JRR samples are split with WCNOG.

A gamma isotopic analysis is done on all sediment samples collected.

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**Table 9. Annual samples for waterborne radionuclides in sediments
(pCi/kg dry)**

Location	Type	Date	¹³⁷ Cs	⁶⁰ Co	⁴⁰ K
			KDHE (WCNOC)	KDHE (WCNOC)	KDHE (WCNOC)
J-1 Wolf Creek	Shoreline	6/28/2011	17 ± 3	<11.0	12196 ± 337
Q-1 CCL Discharge Cove	Shoreline	11/8/2010	22.7 ± 2.5 (<20.3)	<11.0 (<19.8)	13732.3 ± 444.4 (11,494.0 ± 703.2)
	Shoreline	6/28/2011	8.9 ± 2.3 (144.5 ± 37.7)	<11.0 (<24.9)	13163 ± 507 (10,597.0 ± 653.9)
	Bottom	11/8/2010	93.7 ± 8.1 (110.9 ± 55.7)	<11.0 (<59.3)	15879.5 ± 516.8 (10003.0 ± 1264.0)
	Bottom	06/28/2011	104 ± 10 (99.0 ± 48.2)	<11.0 (<52.6)	15586 ± 483 (10099.0 ± 1028.0)
	Bottom	11/8/2010	81.6 ± 11 (111.7 ± 58.1)	<11.0 (<39.8)	17701.5 ± 634.3 (13040.0 ± 1501.0)
N-1 John Redmond Reservoir (Control)	Shoreline	11/8/2010	22.7 ± 2.5 (<21.0)	<11.0 (<11.0)	17033.8 ± 524.9 (12370 ± 729.9)
	Bottom	06/30/2011	79.0 ± 6 (<62.5)	<11.0 (<29.3)	16105.0 ± 588 (11650.0 ± 1074.0)
	Shoreline	06/30/2011	<10.0 (<30.6)	<11.0 (<24.1)	12200 ± 396 (9377.3 ± 973.6)
	Shoreline	4/12/2011	326.3 ± 10.8 (250.5 ± 33.7)	<11.0 (<18.4)	14801.8 ± 476.6 (10655.0 ± 663.3)
R-1 Wolf Creek Environmental Education Area	Bottom	4/12/2011	45 ± 2 (66.4 ± 33.1)	<11.0 (<12.7)	12020 ± 367 (11062.0 ± 622.5)
	Bottom	6/22/2011	38 ± 3 (<27.0)	<11.0 (<19.1)	12042 ± 334 (9,567.9 ± 580.1)
P-1 Wolf Creek Public Fishing Area (MUDS)	Bottom	6/22/2011	38 ± 3 (<27.0)	<11.0 (<19.1)	12042 ± 334 (9,567.9 ± 580.1)
R-2 Stringtown Cemetery	Bottom	6/28/2011	224 ± 7	<11.0	12288 ± 368

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Table 10. Random samples for waterborne radionuclides in sediments

Type	Location	Date	Isotope	
			¹³⁷ Cs	⁶⁰ Co
Shoreline Sediment	Neosho River	3/23/2011	<8.0	<11.0
	Neosho River	3/23/2011	33 ± 2	<11.0
	Neosho River	3/23/2011	<8.0	<11.0
	Black Bear Bosin Recreation Area	4/12/2011	<8.0	<11.0
	East of Dam	4/12/2011	69 ± 3	<11.0
	Neosho River	6/22/2011	<8.0	<11.0
	North End of CCL	9/7/2010	27.1 ± 1.4	<11.0
	North End of CCL	9/7/2010	25.4 ± 1.6	<11.0
	North End of CCL	9/7/2010	15.9 ± 1.9	<11.0
	North End of CCL	9/7/2010	11.5 ± 1.3	<11.0
Bottom Sediment	South End of CCL	9/7/2010	12.3 ± 1.7	<11.0
	W End of CCL	5/16/2011	20 ± 1	<11.0
	SE End of CCL	5/16/2011	18 ± 3	<11.0
	SE End of CCL	5/16/2011	25 ± 3	<11.0
	SE End of CCL	5/16/2011	<8.0	<11.0
	SE End of CCL	5/16/2011	14 ± 1.9	<11.0
	East of Dam	5/21/2011	<8.0	<11.0

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Aquatic Vegetation and Algae

Annual aquatic vegetation (algae and/or rooted) indicator samples were collected from the Coffey County Lake and Wolf Creek below the Coffey County Lake dam. Control samples of aquatic vegetation were obtained at John Redmond Reservoir. The Coffey County Lake samples are split with WCNOG.

Gamma isotopic analysis is performed on all aquatic vegetation samples.

Table 11. Annual samples for waterborne radionuclides in aquatic vegetation KDHE (WCNOG)

Sample ID	Location	Sample type	Date	K-40 pCi/kg	Be7 pCi/kg
J-1	Wolf Creek	Water Willow	6/28/2011	37392 ± 1473	1422 ± 114
N-1	JRR above dam	Smartweed	10/1/2010	18435 ± 725	4882 ± 240
P-1	CCL MUDS	Algae	6/22/11	4469 ± 154 (2611.7 ± 328.9)	9262 ± 398 (3207.8 ± 241.2)
Q-1	CCL DC	American Lotus	8/25/2010	1838 ± 143 (2448.8 ± 291.3)	<360 (691.1 ± 196.3)
R-1	CCL EEA	Water Primrose	8/10/2010	1703 ± 119 (2,666.6 ± 381.9)	2723.3 ± 119 (430.6 ± 165.1)

Table 12. Random samples for waterborne radionuclides in aquatic vegetation KDHE

Location	Sample Type	Date	K-40 pCi/kg	Be-7 pCi/kg
CCL	Lotus	8/6/2010	37263 ± 1125	<360
CCL	Arrowhead	8/6/2010	25045 ± 781	<360
Creek Near 20th and Lynx	Buttonbush	8/23/2010	15512 ± 754	5814 ± 330
N end of CCL	Naiad	9/7/2010	19017 ± 624	933 ± 101
N end of CCL	Pondweed	9/7/2011	10780 ± 367	<360
0.25 Mi E of Oxen Lane on 27th Rd	Horsetails	10/1/2010	23422 ± 1224	2316 ± 315

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Ingestion Pathway

Milk

Milk was sampled quarterly in Coffey County at two locations. Indicator samples were obtained from the Sunrise Dairy near Westphalia, KS. Control samples were obtained from Linsey Dairy near Lebo, KS. Each milk sample is analyzed for low levels of radioiodine and other gamma emitting nuclides. Radioiodine was detected in milk samples from Sunrise Dairy on April 14 and March 20. This was determined to be the result of the Japan earthquake and tsunami and resulting incident at the Fukushima nuclear power plants, not from operation of WCGS. Sunrise dairy cows are fed on pasture grass, while Linsey dairy cows are fed on stored feed, which accounts for no radioiodine being detected in Linsey milk samples.

Table 13. Quarterly samples for radionuclides in milk (pCi/L)

Linsey Dairy			Sunrise Dairy		
Date	I-131	K-40	Date	I-131	K-40
8/10/2010	<1.0	1684 ± 62	9/30/2010	<1.0	1386 ± 115
11/18/2010	<1.0	1234 ± 60	12/17/2010	<1.0	1445 ± 75
3/14/2011	<1.0	1153 ± 42	3/24/2011	3.0 ± 1.0 ¹	1447 ± 60
4/20/2011	<1.0	1518 ± 55	4/18/2011	1518 ± 55 ¹	1507 ± 54
6/29/2011	<1.0	1411 ± 59	6/22/2011	<1.0	1231 ± 63

¹ **Not result of WCGS operation.** Radioiodine released from Japan nuclear reactors after March 11 earthquake/tsunami. Sunrise Dairy feeds cattle on pasture grass, Linsey Dairy on stored feed.

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Fish/Game Animals/Domestic Meat

Fish samples were collected from the Coffey County Lake and below John Redmond Reservoir on the Neosho River. Sample portions from fish collected in the Coffey County Lake and below John Redmond Reservoir on the Neosho River were split with WCNOG. Fish collected at John Redmond Reservoir on the Neosho River are used for control samples. Fifteen fish for a total of eight species were sampled.

Game animal sampling is usually limited to the collection of edible meat portions from road-killed deer. Sample portions of road-killed deer are usually collected as available by WCNOG and split with KDHE for laboratory analysis. One deer sample was obtained during SFY 2011.

A gamma isotopic analysis is done on all samples collected. Sample portions were edible. Tritium in tissue analysis (fat and water) is done on at least one species of fish from each location sampled.

Table 14. Annual samples for radionuclides in fish (pCi/kg, wet)

Location	Date	Type	Tritium	Gamma Activity	
10/19/2010	Coffey County Lake	Channel Catfish	7224 ± 273 (8051 ± 250)	No gamma emitting nuclides were detected in any fish sample above method detection limits.	
		Walleye	Not Performed		
		Common Carp	Not Performed		
		Smallmouth Buffalo	Not Performed		
		Wiper	Not Performed		
		Flathead Catfish	Not Performed		
		Blue Catfish	Not Performed		
		White Bass	Not Performed		
White Crappie	Not Performed				
11/8/2010	John Redmond Reservoir	Smallmouth Buffalo	<1200 (<100)	No gamma emitting nuclides were detected in any fish sample above method detection limits.	
		Common Carp	Not Performed		
		Channel Catfish	Not Performed		
6/30/2011	John Redmond Reservoir	White Crappie	Not Performed		No gamma emitting nuclides were detected in any fish sample above method detection limits.
		Common Carp	<1200 (<116)		
		Smallmouth Buffalo	<1200 (<114)		

Table 15. Random samples for radionuclides in game

Sample Location	Date	Sample Type	KDHE(WCNOG)	
			K-40 pCi/kg	Be-7 pCi/kg
2.5 Mi NW of WCGS	12/10/2010	White Tail Deer	3652 ± 127 (626 ± 92)	<78 (Not Reported)
.36 Mi NE of WCGS	06/29/2011	White Tail Deer	4388.0 ± 169 (3,124.4 ± 360.6)	<78 (Not Reported)

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Terrestrial Vegetation and Food Products

Terrestrial vegetation samples were taken at various locations around WCGS. This includes samples of crops grown throughout Coffey County, broadleaf vegetation taken from gardens near the WCGS boundary, and pasturage near WCGS. Samples collected on WCNOG property and samples of crops were split with WCNOG. A control sample was collected at Scott Valley Church approximately 6 miles from WCGS. Ten random samples were collected from locations around WCGS within the 50 mile zone.

A gamma isotopic analysis was done on each vegetation sample and edible portions of food products collected.

Table 16. Annual Samples for Terrestrial Vegetation and Food Products

Sample ID	Location	Sample Type	Date	K-40 pCi/kg KDHE (WCNOG)	Be-7 pCi/kg KDHE (WCNOG)
WCFV-1-E-087-5.8	Scott Valley Church (Control)	Red Milo	8/18/2010	1791 ± 69	<360.0
NR-U1	Sector K, 4 mi. SSW of Wolf Creek	Non-Irrigated Corn	10/13/2010	3235 ± 115 (2832.7 ± 248.1)	<360.0 (<61.4)
NR-D2	Sector K, 11.5 mi. S of Wolf Creek	Irrigated Corn	9/23/2010	167 ± 120 (2871.0 ± 238.5)	<360 (<41.7)
NR-D1	Sector J, 8.9 mi. S of Wolf Creek	Irrigated Corn	9/29/2010	3029 ± 122 (2670.5 ± 225.4)	<360 (34.3)
NR-U1	Sector K, 4 mi. SSW of Wolf Creek	Irrigated Soybeans	10/13/2010	13908 ± 500 (14278.0 ± 568.5)	<360.0 (<78.7)
WCFV-1-A-005-2.5	Sharpe	Pasturage	4/5/2011	13485 ± 574	18708 ± 700 ¹
WCFV-1-A-005-2.5	Sharpe	Pasturage	6/20/2011	22866 ± 820	11645 ± 445 ²
WCFV-1-R-330-2.9	EEA	Prairie Grass	6/28/2011	28832 ± 1092	7296 ± 349
WCFV-3-P-289-1.6	MUDS	Pasturage	6/22/2011	<152 (4160.7 ± 478.1)	7173 ± 351 (4971.5 ± 426.5)

¹Sample contained 2072.0 ± 72 pCi/kg ¹³¹I and 503.0 ± 29 ¹³⁷Cs. This was not a result of WCGS operation, but is attributed to the Fukushima nuclear incident in Japan.

²No iodine or cesium detected in resample.

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Table 17. Random Samples for Terrestrial Vegetation and Food Products

Location	Sample Type	Date	K-40 pCi/kg	Be-7 pCi/kg
20th Rd. 1/5th mi. west of Xeric Rd.	Wheat	7/1/2010	4232 ± 165	<360
18th and Juneberry	Pears	8/23/2010	9287 ± 409	<360
Near 10th and Planter Road	Corn on Cob	9/14/2010	3679 ± 141	<360
Near 10th Rd. and Planter Rd.	Red Milo	9/14/2010	3679 ± 141	<360
Near 8th Rd. and Homestead Rd.	Corn on Cob	9/20/2010	2585 ± 128	557 ± 40
13th Rd. and US-75	White Milo	9/20/2010	3377 ± 114	<360
Near 10th and Native	Soybeans	10/1/2010	17855 ± 531	<360
Near 14th and Reaper	Apples	10/1/2010	7313 ± 300	921 ± 220
Between Trefoil and Underwood on 20th	Soybeans	10/21/2010	15001 ± 473	<360
Near Trefoil Lane and 8th Rd.	Wheat	6/17/2011	2800 ± 120	<360

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KDHE Radiochemistry Laboratory

Quality Assurance

The KDHE Radiation Laboratory has an established internal Quality Assurance program. Quality Control elements include routine calibrations and performance checks on counting equipment and participation in an environmental radioactivity laboratory intercomparison studies program. This program is currently accomplished with blind samples purchased from Environmental Resource Associates. Results for SFY 2011 are presented in Table 18.

Equipment

The following is a description of the equipment used by the KHEL Radiochemistry laboratory.

Multichannel gamma-spectrometer

Gamma radiation is measured spectra determined with a Canberra Genie-2000 Multichannel Analyzer (MCA) system. Detectors available are three high purity germanium detectors (efficiencies – 20 % - 40%) and one germanium-lithium (GeLi) Detector (efficiency 20%).

Low background alpha/beta system

Low background alpha/beta gas-flow internal proportional counters – one Tennelec LB5100, one Oxford Series 5XLB, one Tennelec LB4000 multi-detector and one Canberra 2201.

Internal proportional counter (IPC)

Gross alpha and radium analyses are performed with windowless gas-flow internal proportional counters – four Protean MPC 2000 and two NMC PC5.

Liquid scintillation

Analysis for tritium in water is performed using a one Wallac 1409 and one PE Tri-Carb 3100 TR.

Miscellaneous equipment

The Radiochemistry Section has various devices used for special purposes. A Ludlum Model 2200 single channel analyzer is used with a radon flask scintillation counter for radon and radium analyses. Another Ludlum Model 2200 single channel analyzer is used with a halogen quenched GM pancake probe for routine monitoring of personnel and incoming samples.

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Table 18. KDHE Radiochemistry Laboratory ERA Intercomparison Studies

Analyte	Date	Average Reported Value (pCi/L)	Assigned Value (pCi/L)	Acceptance Limits (pCi/L)	Performance Evaluation
⁸⁹ Sr	8/31/2010	56.1	55.3	44.1 - 62.9	Acceptable
	3/8/2011	50.6	55.3	44.1 - 62.9	Acceptable
⁹⁰ Sr	8/31/2010	31.5	32.8	24.0 - 38.0	Acceptable
	3/8/2011	32.2	33.1	24.2 - 38.3	Acceptable
¹³³ Ba	8/31/2010	84.0	89.1	75.0 - 98.0	Acceptable
	12/1/2010	67.5	68.9	57.5 - 75.8	Acceptable
	3/8/2011	47.4	52.3	43.1 - 57.9	Acceptable
¹³⁴ Cs	8/31/2010	83.0	88.3	72.4 - 97.1	Acceptable
	12/1/2010	42.0	43.2	34.5 - 47.5	Acceptable
	3/8/2011	51.7	56.2	45.4 - 61.8	Acceptable
¹³⁷ Cs	8/31/2010	207.3	210	189 - 232	Acceptable
	12/1/2010	129.3	123	111 - 138	Acceptable
	3/8/2011	97.4	100	90.0 - 112	Acceptable
⁶⁰ Co	8/31/2010	76.4	72.8	65.5 - 82.5	Acceptable
	12/1/2010	59.7	53.4	48.1 - 61.3	Acceptable
	3/8/2011	71.5	68.9	62.0 - 78.2	Acceptable
⁶⁵ Zn	8/31/2010	115.7	110	99.0 - 131	Acceptable
	12/1/2010	113.4	102	91.8 - 122	Acceptable
	3/8/2011	157	153	138 - 180	Acceptable
Gross Alpha	8/31/2010	55.1	61.1	32.0 - 75.9	Acceptable
	3/8/2011	70	62.5	32.7 - 77.5	Acceptable
Gross Beta	8/31/2010	46.5	56.4	38.6 - 63.3	Acceptable
	3/8/2011	48	51.9	35.3 - 58.9	Acceptable
¹³¹ I	8/31/2010	28.9	28.4	23.6 - 33.3	Acceptable
	3/8/2011	29.9	26.8	22.3 - 31.5	Acceptable
³ H	8/31/2010	20102	19800	17300 - 21700	Acceptable
	12/1/2010	13266	12900	11200 - 14200	Acceptable
	3/8/2011	5312	3460	2930 - 3820	Not Acceptable*
	9/8/2011	7688	7620	6600-8370	Acceptable

*Lab results considered valid as long as no two consecutive PE samples are adjudged as "Not Acceptable".

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Table 19 Method Detection Limits

GeLi [HPGe] detection system^a						
Environmental Sampling						
	Water and Milk	Filter	Wipe	Soil and Sediment	Biota	Vegetation and Food Products
Minimum sample size	2000 ml	1500 m ³	Total	0.45 kg	0.3 kg	1 kg
Minimum Counting Time	8 hr.	3 hr	3 hr.	15 hr.	15 hr.	15 hr.
Method Detection Limit	pCi/L	pCi/m ³	pCi/wipe	pCi/kg-dry	pCi/kg-wet	pCi/kg-dry
⁷ Be	64 [22]	0.03 [0.02]	N/A	346 [186]	231 [144]	35 [19]
⁴⁰ K	88 [39]	0.03 [0.02]	N/A	828 [654]	459 [262]	152 [72]
⁵¹ Cr	52 [32]	0.01 [0.009]	5 [3]	35 [22]	41 [32]	55 [46]
⁵⁴ Mn	4 [2]	0.004 [0.003]	1 [0.7]	44 [11]	30 [15]	72 [24]
⁵⁸ Co	4 [2]	0.008 [0.002]	2 [1]	45 [23]	37 [20]	92 [36]
⁵⁹ Fe	8 [3]	0.01 [0.01]	3 [2]	51 [16]	41 [15]	97 [52]
⁶⁰ Co	11 [7]	0.01 [0.0053]	2.5 [1.7]	56 [35]	43 [26]	79 [50]
⁶⁵ Zn	8 [4]	0.01 [0.007]	N/A	48 [30]	38 [22]	93 [63]
⁹⁵ Nb	7 [3]	0.009 [0.007]	2.5 [1.4]	68 [30]	44 [26]	9 [4]
⁹⁵ Zr	6 [3]	0.01 [0.002]	0.5 [0.3]	35 [27]	27 [19]	84 [54]
⁹⁹ Mo	5 [3]	0.002 [0.0014]	1 [0.6]	73 [43]	33 [21]	****
¹⁰³ Ru	10 [7]	0.004 [0.003]	N/A	29 [20]	29 [21]	69 [47]
¹⁰⁶ Ru	55 [43]	0.07 [0.05]	1.5 [1]	269 [192]	43 [29]	96 [65]
^{110m} Ag	4 [3]	0.006 [0.0002]	N/A	47 [33]	47 [34]	86 [55]
¹²⁵ Sb	35 [12]	0.02 [0.01]	N/A	97 [44]	96 [51]	15 [6]
¹³¹ I	5 [3] (1) ^b	0.00027 [0.00027] ^c	1.5 [1]	33 [20]	37 [23]	45 [13]
¹³⁴ Cs	5 [3]	0.007 [0.004]	1.4 [1]	44 [29]	37 [24]	57 [39]
¹³⁷ Cs	7 [4]	0.006 [0.004]	1 [0.3]	49 [29]	32 [21]	80 [56]

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¹⁴⁰ Ba	10 [6]	0.004 [0.003]	N/A	26 [17]	24 [15]	60 [39]
¹⁴⁰ La	9 [5]	0.01 [0.02]	N/A	28 [9]	34 [21]	13 [6]
¹⁴¹ Ce	8 [3]	0.002 [0.001]	N/A	46 [23]	22 [13]	6 [3]
¹⁴⁴ Ce	35 [14]	0.013 [0.0096]	N/A	216 [103]	110 [70]	28 [14]
²²⁶ Ra	116 [69]	0.05 [0.03]	N/A	828 [654]	323 [195]	90 [51]
²²⁸ Ac	30 [18] 15 h	0.0127 [0.0099]	N/A	68 [33]	146 [87]	27 [12]
²²⁸ Th	387 [142]	0.09 [0.06]	N/A	859 [317]	944 [356]	454 [167]
²³⁴ Th	618 [87] 15 h	0.159 [.0423]	N/A	1009 [378]	1300 [556]	570 [94]
²³⁵ U	N/A	N/A	45 [30] 15 h	N/A	N/A	N/A
²³⁹ Np	41 [33]	0.01 [0.009]	5 [3]	64 [44]	40 [30]	97 [71]

^a GeLi = Germanium lithium; HPGe = High purity germanium.

^b Two methods of analysis are done: **1)** 8 hour direct gamma isotopic analysis of a 2000 mR milk or water sample that has a method detection limit (MDL) of 3 pCi/R, and **2)** 3 hour gamma isotopic analysis of ion exchange resin after a 1500 mR milk sample is filtered through an ion exchange column that has an MDL of 1 pCi/R.

^c The MDL for ¹³¹I when analyzing a charcoal cartridge is 0.03 [0.02] pCi/m³ based upon a 250 m³ sample volume. If the sample volume is increased to 1500 m³, the MDL is 0.002 [0.001] pCi/m³.

Method detection limits of present analytical methods for selected radionuclides monitored by the KHEL Radiochemistry Laboratory. These limits are intended as guides to order of magnitude sensitivities and are calculated with a 95% level of confidence (activity will be detected 95% of the time if it is present).

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Low Background Alpha and Beta Counting System					
	Water	Milk	Wipe	Soil & Sediment	Vegetation & Food products
Minimum Sample Size	1000 ml	1000 ml	Total	0.01 kg	0.1 kg
Minimum Counting Time	200 min.	200 min.	200 min.	200 min.	200 min.
Method Detection Limit	pCi/L	pCi/L	pCi/wipe	pCi/kg-dry	pCi/kg-dry
⁸⁹ Sr	1	2	3	200	500
⁹⁰ Sr	1	2	4	200	500
¹³¹ I	1	N/A	N/A	N/A	N/A
²²⁸ Ra	1.2	N/A	0.3	60	N/A
Gross Beta					
	Water	Filter	Wipe	Soil and Sediment	
Minimum Sample Size	200 ml	250 m ³	Total	0.001 kg	
Minimum Counting Time	200 min.	100 min.	100 min.	100 min.	
Method Detection Limit	4 pCi/l	0.004 pCi/m ³	2 pCi/Wipe	160 pCi/kg-dry	
Gross Alpha					
	Water	Filter	Wipe		
Minimum Sample Size	200 ml	250 m ³	Total		
Minimum Counting Time	200 min.	100 min.	100 min.		
Method Detection Limit	1 pCi/l	0.0006 pCi/ m ³	0.5 pCi/Wipe		
Random Scintillation Counting System					
²²⁶ Ra (radium) in water					
Minimum Sample Size		1000 ml			
Minimum Counting Time		200 min.			
Method Detection Limit		0.04 pCi/l			
Liquid Scintillation Counting System					
	Tritium (³ H)		²²² Rn (Radon)		
	In water	In Tissue	In Water		
Minimum Sample Size	10 ml	3 g	10 ml		
Minimum Counting Time	100 min.	120 min.	60 min.		
Method Detection Limit	350 pCi/l	1200 pCi/kg-wet	25 pCi/l		