

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



July 2007-June 2008
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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, 2007 through June 30, 2008.

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 was ready for operational use in 1984, which allowed for one year of baseline data collection prior to the commercial operation of WCGS, which commenced in September 1985. 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 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.

A tabular summary of the WCGS environmental radiation surveillance program samples collected by KDHE during SFY 2008 is presented as Table I (Page 11).

PROGRAM DESCRIPTION AND ELEMENTS

State program samples were delivered to Kansas Health and Environment Laboratories (KHEL) Radiochemistry Laboratory at Forbes Field for analysis. State optically stimulated luminescence dosimeters (OSLDs) were processed by Landauer, Inc. under contract.

Wolf Creek Environmental Management personnel collected samples for the WCNOG REMP. WCNOG has a contract with Environmental Inc., Midwest Laboratory, of Northbrook, IL for laboratory analysis of REMP samples. Enrico Fermi Unit 2 dosimetry department processed and evaluated WCNOG thermoluminescent dosimeters (TLDs) for the first two quarters, WCNOG OSLDs for the third and fourth quarters were processed by Landauer, Inc.

The KDHE Environmental Radiation Surveillance program utilizes the WCNOG emergency planning sector logic for identification of the sample geographic sector relative to WCGS plant center. Sixteen 22.5-degree sectors are established and designated by letter. The first sector, sector A, is 11.25 degrees east of true north to 11.25 degrees west of true north, i.e. from 348.75 degrees true to 11.25 degrees true. The remaining sectors continue in a clockwise direction, from B to R (the letters I and O are not used). The main thrust of the program is within the 10-mile emergency-planning zone (EPZ).

Air (See Table 1.0, page 15)

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 Harris, KS (D-1). 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 East of Coffey County Lake, and a control location at Harris. An average flow rate of 30 liters per minute is used with 47 mm diameter glass fiber particulate filters and 5 percent triethylene diamine (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 22-40 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 (Harris D-1) 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.

Direct Radiation Monitoring (See Table 2.0, page 15; Table 2.1, page 16)

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.

Surface water (See Table 3.0, page 17; Table 4.0, page 17)

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. No discharges to the river occurred during this reporting period. 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.

Ground water (See Table 5.0, page 18)

Ground water was collected quarterly offsite at wells in sectors B(control), L, F, G, and J. The control sample location was hydrologically up gradient from the facility and the others are hydrologically down gradient. Samples were split with WCNOG. Samples were collected within the Wolf Creek owner controlled area at the Essential Service Water Piping (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.

Soil (See Table 6.0, page 19; Table 6.1, page 19)

Four indicator, one control, and ten random annual soil samples were collected. Indicator soil samples were collected close to Sharpe, 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 public use areas are split with WCNOG.

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

Milk (See Table 7.0, page 20)

Milk samples were collected 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. Seven out of eight scheduled samples were obtained as the result of scheduling problems.

Sediment (See Table 8.0, page 20; Table 8.1, page 21; Table 9.0, page 21; Table 9.1, page 22)

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. Six random bottom sediments were collected on CCL. Twelve 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.

Fish, game animals, and domestic meat (See Table 10.0, page 22; Table 10.1, page 23).

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. Eleven fish for a total of nine species were sampled. *The laboratory results for tritium in fish samples exceeded the maximum probable tissue concentrations and were rejected.*

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 2008.

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.

Aquatic vegetation (See Table 11.0, page 23; Table 11.1, page 23)

Annual aquatic vegetation (algae and/or rooted aquatics) 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 WCNOOC.

Gamma isotopic analysis is performed on all aquatic vegetation samples.

Terrestrial vegetation (See Table 12.0, page 24; Table 12.1, page 25)

Terrestrial vegetation samples were taken at various locations around WCGS. This includes samples of crops grown throughout Coffey County, broad leaf vegetation taken from gardens near the WCGS boundary, pasturage near WCGS, and crops irrigated with water from the Neosho River. Pasturage samples were usually collected concurrently with soil samples. Samples collected on WCNOOC property, garden vegetables collected from gardens near WCGS, and samples of crops irrigated with water from the Neosho River were split with WCNOOC. A control sample was collected at Scott Valley Church approximately 6 miles from WCGS. Eleven random samples were collected from locations around WCGS within the 50 mile zone but concentrated in the 10 mile zone in the primary downwind sectors of P-R and A-K.

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

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.

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 (see Table 13.0, page 26). This program is currently accomplished with blind samples purchased from Environmental Resource Associates.

Units

The unit of radioactivity used is the picoCurie (pCi). One pCi is equal to 2.22 disintegrations per minute or 0.037 Becquerels (Bq). Radioactivity concentrations in liquids such as water and milk are expressed in picoCuries per liter (pCi/l), radioactivity concentrations in air are expressed in picoCuries per cubic meter (pCi/m³), and radioactivity in solids such as soil or vegetation is expressed in picoCuries per kilogram (pCi/kg). OSLD exposure results are expressed as milliRoentgen (mR) per a 90-day quarter. One mR is equivalent to ten micro-Grays (10 µGy or 10⁻⁵ Gy).

Uncertainty statistics

Radioactive decay of unstable atomic nuclei is a random event. The greater the number of total counts obtained (a function of sample count time and sample volume/mass); the closer the measurements will be to the actual value. Due to the large number of samples analyzed and the limited resources available for counting individual samples, each sample is counted only once and for the minimum time necessary to reduce the statistical error to an acceptable level. Unless otherwise specified, results for all samples are reported at the 95 percent confidence level. Because systematic (non-random) uncertainties involved in sample collection and sample preparation are highly subjective and generally difficult or impossible to quantify with substantial accuracy, the KHEL Radiochemistry Laboratory reports only the uncertainty resulting from random processes (propagation of statistical counting error).

A "less than" value reported indicates that the radioactivity in the sample is below the lower limit of detection for the procedures, equipment, and counting time used. The KHEL Radiochemistry Laboratory method detection limits (MDLs) for various analyses are summarized in Table 14.0, pages 27-28, of this report. MDLs will vary based on sample matrix, sample size, counting time, detector efficiencies, and type of measurement required. WCNO's lower limits of detection values are found in Table 15.0, page 29.

RESULTS

Results are reported in the following data tables for the samples taken around WCGS during SFY 2008. Radionuclides detected in the environment surrounding WCGS during SFY 2008 include ^{228}Ac , ^7Be , ^{60}Co , ^{137}Cs , ^3H , ^{40}K , ^{226}Ra , ^{125}Sb and ^{228}Th . The isotopes ^{228}Ac , ^7Be , ^{40}K , ^{226}Ra , and ^{228}Th are naturally occurring radionuclides common in the environment. The isotopes ^{137}Cs and ^3H are fission products from WCGS nuclear reactor operation. The isotopes ^{60}Co and ^{125}Sb are activation products, also the result of WCGS nuclear reactor operation. A small background component of the ^3H (half-life = 12.3 y) and ^{137}Cs (half-life = 30.1 y) activity is attributable to previous nuclear weapons tests. Small amounts of ^3H are also produced naturally from cosmic ray interactions with water vapor in the upper atmosphere. Background levels of ^{137}Cs and ^3H are accounted for in control samples and in preoperational data. The fission and activation product activity levels found to date in the environment surrounding WCGS are not above expected regulated levels and are very small when compared with activity levels due to naturally occurring radionuclides.

The radionuclide of interest 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 2008 was 16,346 pCi/l in April, 2008. This maximum Coffey County Lake ^3H concentration is 82% 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 2008 was 12,118 pCi/l, or 61% 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 2008 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 2008 was 158 pCi/kg-dry ^{137}Cs found at the Coffey County Lake Discharge Cove (WCBS-AQ-1). Nine trending samples and 18 random samples were analyzed.

Airborne sample analysis indicated that no radionuclides attributable to the operation of WCGS were present above the lower limits of detection during SFY 2008.

Sample analysis of terrestrial vegetation, soil, milk, grain, and vegetable samples collected in the environs of WCGS during SFY 2008 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 2008. Sample analysis of edible fish portions collected in the environs of WCGS during SFY 2008

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indicated that no gamma emitters attributable to WCGS operation were present. The laboratory results for tritium in fish samples exceeded the maximum probable tissue concentrations and were rejected. An improved method for tritium analysis in fish samples using a vacuum distillation technique has been implemented for SFY2009.

Data from direct radiation monitoring sites revealed no significant changes from preoperational conditions. 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.

The ratio of KDHE results to WCNOG results ranged from 0.5 to 1.6. The KDHE Grand Average of all sites was 97.2 mR/yr. A summary of comparison data may be found in Table III, page 13. Data tables and maps are also attached.

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TABLE I. ERS Program summary report for SFY 2008

Type of Sample	Number of Sampling Stations	Total Samples Collected
Air (particulate and iodine)	5	520
Direct Radiation	31	248
Surface Water	5	37 ^a
Offsite Ground Water	6	24
Onsite Ground Water	3	12
Sediments	9	9
Random Sediments	16	18
Milk	2	7
Aquatic Vegetation	5	5
Random Aquatic Vegetation	6	6
Fish	2	19
Game Animals/Domestic Meat	1	1
Soil	5	5
Random Soil	10	10
Terrestrial Vegetation	9	10
Random Terrestrial Vegetation	10	12
Total	125	942

^aNeosho River surface water samples not required, CCL did not discharge to river

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TABLE II. ERS Program, Results Summary Statistics SFY 2008

Description	Average	Standard deviation	Standard error of the mean	Min	Max	N
OSLD direct radiation, mR per 90 day quarter	24.3	5.0	0.45	12.8	28.2	124
Airborne particulate and radioiodine cartridge gamma isotopic analysis	Gamma isotopic analysis indicated that no gamma emitters attributable to Wolf Creek Generating Station operation were present above the lower limits of detection in any air particulate filter or radioiodine cartridge evaluated.					
Surface water tritium (³ H), pCi/l						
John Redmond Reservoir, control (N-1/MUSH)	<350	--	--	--	--	12
Coffey County Lake (J1A/SP)	11857.5	3027.5	874.6	7903	15948	12
Coffey County Lake (MUDS)	12346.8	3006.0	867.6	8431	16346	12
Neosho River Near Leroy	--	--	--	--	--	0
Ponds surrounding WCGS	<350	--	--	--	--	1
Offsite ground water tritium (³ H), pCi/l (All Stations)	<350	--	--	--	--	24
Onsite ground water tritium (³ H), pCi/l (All Stations)	810.0	314.7	90.8	<350	1471	12
Water sample gamma isotopic analysis	Gamma isotopic analysis indicated that no gamma emitters attributable to Wolf Creek Generating Station operation were present above the lower limits of detection in any surface water, drinking water, or ground water sample evaluated.					
Gamma isotopic analysis of soil, pasturage, garden vegetables, and grain.	Gamma isotopic analysis indicated that no gamma emitters attributable to Wolf Creek Generating Station operation were present above the lower limits of detection in any soil, milk, pasturage, garden vegetable and grain sample evaluated.					
Maximum activity attributable to Wolf Creek Generating Station operation, pCi/kg						
Coffey County Lake bottom sediment, dry	¹³⁷ Cs 158.1 ± 11.7 Discharge Cove					

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TABLE III. ERS program data comparison ^a with WCNOC summary statistics SFY 2008

Description	Average	Standard Deviation	Standard error of the mean	Min	Max	N
OSLD direct radiation, mR ^b	22.2 (13.5)	3.8 (4.7)	0.6 (0.7)	12.8 (4.8)	27.5 (21.4)	48
Airborne particulate filter and charcoal cartridge gamma isotopic analysis	Gamma isotopic analysis by both KDHE and WCNOC (Environmental, Inc.) demonstrated that no gamma emitters attributable to Wolf Creek Generating Station operation were present above the lower limits of detection in any particulate filter or charcoal cartridge evaluated.					
Surface water tritium (³ H), pCi/l						
CCL ^c spillway, J-1A (SP)	11858 (12379)	3028 (3208)	874 (927)	7903 (8262)	15948 (16607)	12
JRR ^d below dam (control), N-1 (MUSH)	<350 (<164)	--	--	<350 (<193)	<350 (<127)	12
Offsite ground water ³ H, pCi/l	< 350 (<165)	--	--	< 350 (<178)	<350 (<140)	24
Onsite ground water ³ H, pCi/l	810 (772)	315 (287)	90.8 (82.7)	< 350 (< 127)	1471 (1137)	12
Surface and ground water gamma isotopic analysis	Gamma isotopic analysis by both KDHE and WCNOC (Environmental, Inc.) indicated that no gamma emitters attributable to Wolf Creek Generating Station operation were present above the lower limits of detection in any surface, ground, or drinking water sample evaluated.					

Maximum activity by isotope attributable to WCGS operation, pCi/kg

Bottom sediment	Gamma emitter: ¹³⁷ Cs, 158.1 ± 11.7 (216.5 ± 51.9)
CCL fish	All results for fish indicated that no gamma emitters attributable to Wolf Creek Generating Station operation were present <i>above</i> the lower limits of detection.
Shoreline Sediment	All results for shoreline sediments indicated that no gamma emitters attributable to Wolf Creek Generating Station operation were present <i>above</i> the lower limits of detection at co-located sites.
Soil, terrestrial vegetation	Gamma isotopic analysis by both KDHE and WCNOC (Environmental, Inc.) indicated that no comparable gamma emitters attributable to Wolf Creek Generating Station operation were present above the lower limits of detection in any soil, shoreline sediments or terrestrial vegetation sample evaluated.

^a KDHE (WCNOC).

^b mR per 90-day quarter.

^c Coffey County Lake.

^d John Redmond Reservoir.

^e Average of MDA values.

TABLE IV. Data comparison summary by selected analysis SFY 2008

Analysis	Average Ratio of KDHE results to WCNOC results ^a	Comments
OSLD Direct Radiation	1.6 N=48	12 collocated sites. Wolf Creek results significantly lower upon changing from TLDs to OSLDs.
Surface Water ³ H	0.96 N=12	Coffey County lake spillway
Bottom sediment gamma isotopic	0.92 N=4	Comparison of ¹³⁷ Cs results
Fish tritium (³ H) in tissue	N/A	KDHE ³ H results rejected.

^a KDHE/WCNOC

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TABLE 1.0 - ERS Weekly Air Particulate/Iodine Monitoring

Number of Samples	Average ⁷ Be Concentration	Average Iodine Concentration
52	0.13 ± 0.017	<0.03

Gamma emitting radionuclides routinely analyzed for include ⁷Be, ⁴⁰K, ⁵¹Cr, ⁵⁴Mn, ^{58/60}Co, ⁵⁹Fe, ⁶⁵Zn, ⁶⁷Ga, ⁹⁵Nb, ⁹⁵Zr, ⁹⁹Mo, ^{99m}Tc, ¹⁰³Ru, ¹⁰⁶Ru, ^{110m}Ag, ¹¹¹In, ¹²³I, ¹²⁵Sb, ¹³¹I, ^{134/137}Cs, ¹⁴⁰Ba, ¹⁴⁰La, ^{141/144}Ce, ¹⁶⁹Yb, ²²⁶Ra, ²²⁸Ac, ^{234/228}Th, and ²³⁹Np. **No radionuclides attributable to WCGS operation were detected.** See Map #1.0, pg 39, for sample locations.

TABLE 2.0 - ERS Quarterly Direct Radiation Monitoring SFY 2008

Direct radiation monitoring results in mR. Exposures are normalized to a 90-day quarter. Results are expressed as the average of two OSLD readings per location. WCNOG sample location designations are denoted by parentheses. Sample locations are shown on Map #2.0, page 40.

Location	QTR 1	QTR 2	QTR 3	QTR 4
1. A-1 (1), North of WCGS	24.9	22.3	27.2	23.7
2. A-2, Sharpe	23.4	20.3	25.2	22.2
3. A-3, Forward Staging Area	21.4	17.3	24.7	21.7
4. B-1, East Sharpe	26.4	21.3	26.7	19.7
5. B-2, Waverly Control	24.4	21.8	25.7	22.7
6. C-1, near residence	24.4	21.8	26.2	21.2
7. D-1 (9), near residence	21.9	19.8	26.7	20.7
8. E-1, near residence	25.9	21.3	24.7	20.2
9. F-1, near residence	24.4	20.3	27.2	21.2
10. G-1 (14), WCNOG gate	24.4	22.3	27.2	25.2
11. H-0 (42), CCL baffle dike A	17.4	12.8	22.7	17.2
12. H-1, east of CCL dam	22.4	20.8	26.7	22.7
13. H-2, LeRoy control	22.9	20.3	24.2	20.7
14. J-1, near residence	23.9	18.8	27.2	21.2
15. K-1 (29), near residence	18.4	16.8	26.2	15.2
16. L-1 (27), near residence	23.4	19.8	27.2	22.7
17. L-2, Burlington	23.4	17.8	25.2	22.7
18. L-3, Coffey County Shop	20.4	18.3	27.2	20.7
19. M-1 (26), near residence	21.9	18.3	26.2	20.7
20. N-1, near pasture	23.9	20.3	24.2	22.2
21. P-0 (43), CCL baffle dike B	16.9	14.3	23.7	14.7
22. P-1, New Strawn	23.4	20.8	25.7	24.2
23. P-2, Hartford Control	21.9	18.8	23.7	20.2
24. P-3, CCL entrance	22.4	22.3	27.2	23.7
25. P-4 (46), CCL near MUDS	21.9	20.3	25.7	21.7
26. P-5, JRR public use area	22.9	20.8	24.2	21.2
27. Q-1, near residence	24.9	19.8	25.2	23.2
28. R-0 (41), Stringtown cemetery	26.4	23.3	26.7	24.2
29. R-1 (37), near residence	24.4	20.3	26.2	22.7
30. R-2 (44), CCL EEA	23.9	21.3	27.7	24.2
31. R-3, near Coffey County Airport	19.9	20.8	28.2	24.2

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TABLE 2.1 - ERS Collocated Quarterly Direct Radiation Monitoring SFY 2008

Direct radiation monitoring results in mR. WCNOC results are expressed as normalized 90-day quarter average \pm two standard deviations of two dosimeters at each location (two TLD chips per badge were used for data evaluation) for SFY Q1 and Q2, OSLD results for Q3 and Q4. KDHE results are expressed as a normalized 90-day quarter average of two OSLDs at each location. Note: WCNOC started subtracting transit dose from OSLD readings in 2008.

Location KDHE (WCNOC)	KDHE Monitoring period	KDHE	WCNOC
1. A-1 (1)	7/8/2007-10/9/2007	24.9	21.4 \pm 5.1
	10/9/2007-1/9/2008	22.3	19.8 \pm 1.5
	1/9/2008-4/8/2008	27.2	12.4 ^a
	4/8/2008-7/8/2008	23.7	12.8
2. D-1 (9)	7/8/2007-10/9/2007	21.9	17.8 \pm 2.0
	10/9/2007-1/9/2008	19.8	16.8 \pm 0.6
	1/9/2008-4/8/2008	26.7	9.5
	4/8/2008-7/8/2008	20.7	10.7
3. G-1 (14)	7/8/2007-10/9/2007	24.4	20.8 \pm 1.8
	10/9/2007-1/9/2008	22.3	18.4 \pm 1.7
	1/9/2008-4/8/2008	27.5	14.2
	4/8/2008-7/8/2008	25.3	11.6
4. H-0 (42)	7/8/2007-10/9/2007	17.4	13.0 \pm 1.3
	10/9/2007-1/9/2008	12.8	13.5 \pm 1.1
	1/9/2008-4/8/2008	22.7	0.8
	4/8/2008-7/8/2008	17.2	6.2
5. K-1 (29)	7/8/2007-10/9/2007	18.4	16.4 \pm 3.2
	10/9/2007-1/9/2008	16.8	15.3 \pm 1.3
	1/9/2008-4/8/2008	26.2	4.8
	4/8/2008-7/8/2008	15.2	7.6
6. L-1 (27)	7/8/2007-10/9/2007	23.4	19.7 \pm 1.6
	10/9/2007-1/9/2008	19.8	18.5 \pm 1.1
	1/9/2008-4/8/2008	27.2	12.6
	4/8/2008-7/8/2008	22.7	10.0
7. M-1 (26)	7/8/2007-10/9/2007	21.9	19.1 \pm 4.5
	10/9/2007-1/9/2008	18.3	16.8 \pm 0.9
	1/9/2008-4/8/2008	26.2	8.9
	4/8/2008-7/8/2008	20.7	9.0
8. P-0 (43)	7/8/2007-10/9/2007	16.9	12.5 \pm 0.4
	10/9/2007-1/9/2008	14.3	12.7 \pm 1.0
	1/9/2008-4/8/2008	23.7	7.7
	4/8/2008-7/8/2008	14.7	5.2
9. P-4 (46)	7/8/2007-10/9/2007	21.9	19.4 \pm 1.6
	10/9/2007-1/9/2008	20.3	17.6 \pm 0.7
	1/9/2008-4/8/2008	25.7	9.0
	4/8/2008-7/8/2008	21.7	10.4
10. R-0 (41)	7/8/2007-10/9/2007	26.4	20.1 \pm 4.0
	10/9/2007-1/9/2008	23.3	19.3 \pm 1.8
	1/9/2008-4/8/2008	26.7	8.3
	4/8/2008-7/8/2008	24.2	11.4
11. R-1 (37)	7/8/2007-10/9/2007	24.2	18.0 \pm 0.8
	10/9/2007-1/9/2008	20.3	17.6 \pm 2.1
	1/9/2008-4/8/2008	26.2	9.5
	4/8/2008-7/8/2008	22.7	7.3
12. R-2 (44)	7/8/2007-10/9/2007	23.9	18.0 \pm 1.2
	10/9/2007-1/9/2008	21.3	17.9 \pm 0.4
	1/9/2008-4/8/2008	27.7	10.6
	4/8/2008-7/8/2008	24.2	9.2

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TABLE 3.0 - ERS monthly samples for waterborne radionuclides in surface water SFY 2008

Gamma isotopic analyses by both KDHE and WCNOC of surface water samples indicated that no gamma emitters attributable to WCGS operation were present above the lower limits of detection. Sample results in pCi/l tritium (³H).

Date	J-1A (Spillway)		N-1 (JRR/MUSH) Control		Date	P-1	H-1
	KDHE	WCNOC	KDHE	WCNOC		MUDS	Neosho R.
7/18/07	8545 ± 278	8262 ± 263	<350	<148	7/31/07	8431 ± 278	N/A ¹
8/9/07	7903 ± 265	8875 ± 201	<350	<156	8/24/07	8566 ± 281	
9/13/07	8386 ± 275	8265 ± 263	<350	<193	9/19/07	9023 ± 289	
10/11/07	10520 ± 300	10063 ± 284	<350	<148	10/10/08	9781 ± 292	
11/8/07	11718 ± 313	10423 ± 286	<350	<176	11/13/07	10251 ± 309	
12/13/07	12068 ± 317	11474 ± 316	<350	<173	12/27/07	11728 ± 317	
1/24/08	13766 ± 331	13150 ± 322	<350	<183	1/15/08	14882 ± 342	
2/14/08	14891 ± 343	15848 ± 367	<350	<175	2/28/08	15507 ± 352	
3/13/08	15011 ± 345	16130 ± 360	<350	<150	3/25/08	14937 ± 346	
4/10/08	15063 ± 346	16607 ± 365	<350	<150	4/22/08	16346 ± 382	
5/8/08	15948 ± 374	15579 ± 351	<350	<143	5/28/08	14656 ± 364	
6/12/08	14937 ± 373	13872 ± 343	<350	<168	6/25/08	14045 ± 366	

¹Neosho River samples not required, Coffey County Lake level remained below overflow levels for SFY 2008.

TABLE 4.0 - ERS annual samples for deposition of airborne radionuclides on surface water (ponds) SFY 2008

Sample results in pCi/l. Results reported at the 95% confidence level. Gamma isotopic analysis showed that no gamma emitters attributable to Wolf Creek operation were present above the lower limits of detection. Gamma emitting radionuclides routinely analyzed for include ⁷Be, ⁴⁰K, ⁵¹Cr, ⁵⁴Mn, ⁵⁸Co, ⁵⁹Fe, ⁶⁰Co, ⁶⁵Zn, ⁶⁷Ga, ⁹⁵Nb, ⁹⁵Zr, ⁹⁹Mo, ^{99m}Tc, ¹⁰³Ru, ¹⁰⁶Ru, ^{110m}Ag, ¹¹¹In, ¹²³I, ¹²⁵Sb, ¹³¹I, ¹³⁴Cs, ¹³⁷Cs, ¹⁴⁰Ba, ¹⁴⁰La, ¹⁴¹Ce, ¹⁴⁴Ce, ¹⁶⁹Yb, ²²⁶Ra, ²²⁸Ac, ²²⁸Th, ²³⁴Th, and ²³⁹Np. See Map #1.0 for sample locations. WCNOC sample location designations are denoted by parenthesis. No radionuclides attributable to WCNOC operations were found above method detection limits.

Location	Date	Tritium (³ H)
P-1, New Strawn City Lake	4/22/2008	<350

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TABLE 5.0 - ERS Quarterly Samples for Waterborne Radionuclides in Ground Water SFY 2008

Sample results in pCi/l. Results reported at the 95% confidence level. Gamma isotopic analysis showed that no gamma emitters attributable to Wolf Creek operation were present above the lower limits of detection. Gamma emitting radionuclides routinely analyzed for include ⁷Be, ⁴⁰K, ⁵¹Cr, ⁵⁴Mn, ⁵⁸Co, ⁵⁹Fe, ⁶⁰Co, ⁶⁵Zn, ⁶⁷Ga, ⁹⁵Nb, ⁹⁵Zr, ⁹⁹Mo, ^{99m}Tc, ¹⁰³Ru, ¹⁰⁶Ru, ^{110m}Ag, ¹¹¹In, ¹²³I, ¹²⁵Sb, ¹³¹I, ¹³⁴Cs, ¹³⁷Cs, ¹⁴⁰Ba, ¹⁴⁰La, ¹⁴¹Ce, ¹⁴⁴Ce, ¹⁶⁹Yb, ²²⁶Ra, ²²⁸Ac, ²²⁸Th, ²³⁴Th, and ²³⁹Np. WCNOC sample location designations are denoted by parenthesis. *No radionuclides attributable to WCNOC operations were found above method detection limits.* See Map #1.0, pg 39, for sample locations. (WCNOC results for tritium only).

B-1 (B-12)

G-1 (G-2)

Date	Alpha KDHE	Beta KDHE	H-3 KDHE (WCNOC)	Date	Alpha KDHE	Beta KDHE	H-3 KDHE (WCNOC)
8/9/2007	<1	10 ± 3	<350 (<156)	8/9/2007	<1	5 ± 3	<350 (<156)
11/16/2007	6 ± 5	8 ± 4	<350 (<178)	11/16/2007	<1	<4	<350 (<178)
2/14/2008	4 ± 2	4 ± 4	<350 (<175)	2/14/2008	2 ± 2	<4	<350 (<151)
5/30/2008	<1	4	<350 (<166)	5/30/2008	2 ± 1	<4	<350 (<166)

F-1 (F-1)

C-2 (C-49)

Date	Alpha KDHE	Beta KDHE	H-3 KDHE (WCNOC)	Date	Alpha KDHE	Beta KDHE	H-3 KDHE (WCNOC)
8/9/2007	<1	6 ± 3	<350 (<156)	8/9/2007	4 ± 4	10 ± 3	<350 (<156)
11/16/2007	4 ± 5	4 ± 4	<350 (<178)	11/16/2007	10 ± 8	7 ± 5	<350 (<178)
2/14/2008	<1	<4	<350 (<175)	2/14/2008	7 ± 4	<4	<350 (<151)
5/30/2008	<1	<4	<350 (<166)	5/30/2008	<1	4 ± 1	<350 (<164)

J-1 (J-2)

C-1 (C10)

Date	Alpha KDHE	Beta KDHE	H-3 KDHE (WCNOC)	Date	Alpha KDHE	Beta KDHE	H-3 KDHE (WCNOC)
8/9/2007	6 ± 2	7 ± 3	<350 (<156)	8/9/2007	7 ± 2	<4	<350 (<156)
11/16/2007	4 ± 2	8 ± 4	<350 (<178)	11/16/2007	<1	6 ± 4	<350 (<178)
2/14/2008	<1	<4	<350 (<151)	2/14/2008	1 ± 4	<4	<350 (<175)
5/30/2008	<1	<4	<350 (<166)	5/30/2008	<1	<4	<350 (<166)

Auxiliary Building

ESW WNE

Date	Alpha KDHE	Beta KDHE	H-3 KDHE (WCNOC)	Date	Alpha KDHE	Beta KDHE	H-3 KDHE (WCNOC)
8/9/2007	2 ± 1	11 ± 3	677 ± 161 (703 ± 108)	8/9/2007	12 ± 4	<4	937 ± 187 (894 ± 115)
11/16/2007	2 ± 1	9 ± 5	856 ± 165 (885 ± 122)	11/16/2007	25 ± 8	15 ± 5	832 ± 164 (816 ± 120)
3/4/2008	4 ± 2	<4	<350 (344 ± 102)	3/4/2008	11 ± 4	7 ± 4	<350 (<177)
5/29/2008	5 ± 2	6 ± 1	1210 ± 183 (1184 ± 131)	5/29/2008	7 ± 1	6 ± 1	876 ± 179 (1137 ± 130)

ESW WNW

Date	Alpha KDHE	Beta KDHE	H-3 KDHE (WCNOC)
8/9/2007	7 ± 3	13 ± 3	1471 ± 189 (644 ± 106)
11/16/2007	7 ± 6	8 ± 5	753 ± 164 (872 ± 121)
3/4/2008	11 ± 5	<4	672 ± 160 (793 ± 119)
5/29/2008	12 ± 2	7 ± 1	735 ± 163 (810 ± 120)

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TABLE 6.0 - ERS annual samples for airborne radionuclide deposition on soil SFY 2008

Sample results in pCi/kg-dry. Results reported at the 95% confidence level. The presence of ¹³⁷Cs is not attributable to Wolf Creek operation unless accompanied by other reactor nuclides. Gamma emitting radionuclides routinely analyzed for include ⁷Be, ⁴⁰K, ⁵¹Cr, ⁵⁴Mn, ⁵⁸Co, ⁵⁹Fe, ⁶⁰Co, ⁶⁵Zn, ⁶⁷Ga, ⁹⁵Nb, ⁹⁵Zr, ⁹⁹Mo, ^{99m}Tc, ¹⁰³Ru, ¹⁰⁶Ru, ^{110m}Ag, ¹¹¹In, ¹²³I, ¹²⁵Sb, ¹³¹I, ¹³⁴Cs, ¹³⁷Cs, ¹⁴⁰Ba, ¹⁴⁰La, ¹⁴¹Ce, ¹⁴⁴Ce, ¹⁶⁹Yb, ²²⁶Ra, ²²⁸Ac, ²²⁸Th, ²³⁴Th, and ²³⁹Np. The symbol * indicates naturally occurring radionuclides. See Map #1.0, page 39, for sample location. **No radionuclides attributable to WCNOC operations were observed above method detection limits.**

Isotope	A-1 Sector A Sharpe KDHE 11/20/07 0.5m ²	E-1 Scott Valley Church (Control) 10/23/07 0.5m ²	H-1 East of CCL Dam Near HCA H-1 10/23/07 0.5m ²
²²⁸ Ac*	1645 ± 40	1293.7 ± 29.1	1367.9 26.8
¹³⁷ Cs	<8.0	284.4 ± 18.4	334.9 17.7
⁴⁰ K*	14696 ± 21.6	12217.6 ± 595.2	12608.5 ± 600.4
	P-1 (MUDS) 6/10/08	R-1 EEA 5/13/08	
²²⁸ Ac*	543.3 ± 15.4	955.2 ± 22.9	
¹³⁷ Cs	114.8 ± 8.1	231.3 ± 15.5	
⁴⁰ K*	6799.5 ± 447.4	8071.2 ± 539.1	

TABLE 6.1 - ERS random samples for airborne radionuclide deposition in soil SFY 2008

Sample results in pCi/kg-dry. Results reported at the 95% confidence level. Gamma emitting radionuclides routinely analyzed for include ⁷Be, ⁴⁰K, ⁵¹Cr, ⁵⁴Mn, ⁵⁸Co, ⁵⁹Fe, ⁶⁰Co, ⁶⁵Zn, ⁶⁷Ga, ⁹⁵Nb, ⁹⁵Zr, ⁹⁹Mo, ^{99m}Tc, ¹⁰³Ru, ¹⁰⁶Ru, ^{110m}Ag, ¹¹¹In, ¹²³I, ¹²⁵Sb, ¹³¹I, ¹³⁴Cs, ¹³⁷Cs, ¹⁴⁰Ba, ¹⁴⁰La, ¹⁴¹Ce, ¹⁴⁴Ce, ¹⁶⁹Yb, ²²⁶Ra, ²²⁸Ac, ²²⁸Th, ²³⁴Th, and ²³⁹Np. The isotopes ⁸⁹Sr and ⁹⁰Sr are beta emitters. This table reports only ¹³⁷Cs and ⁴⁰K activity. *No isotopes attributable to WCNOC operations were found above method detection limits.* See Map #3.0, page 41, for locations.

Sample ID	Location	Date	Isotope	
			¹³⁷ Cs	⁴⁰ K
WCRS-1-L-214-7.0	Near 9th Rd. and Lynx	8/7/2007	<8.0	10534.8 ± 790.1
WCRS-1-C-039-9.1	22nd & Underwood	8/28/2007	57.2 ± 4.4	11917.3 ± 555.9
WCRS-1-J-178-8.9	Near Planter and 5th Rd.	9/10/2007	<8.0	16363.1 ± 747.6
WCRS-1-M-250-8.4	12th Between Garner and Homestead	10/9/2007	299.5 ± 20.2	11527.7 ± 769.4
WCRS-1-Q-311-7.9	Iris and 20th Rd.	11/13/2007	241.6 ± 13.3	11786.1 ± 564.8
WCRS-A-1-004-7.5	0.5 Mi. S. of 23rd on Oxen	4/1/2008	12.9 ± 2.8	12276.8 ± 781.7
WCRS-1-E-099-5.6	14th and Underwood	5/2/2008	303.7 ± 19	9506.7 ± 610.6
WCRS-1-H-157-9.7	6th Lane between Shetland and Trefoil	5/2/2008	<8.0	9334.6 ± 608.8
WCRS-1-B-041-1.9	16th Rd. East of Planter Rd.	5/28/2008	<8.0	9720.8 ± 631.5
WCRS-1-M-242-10.0	10th and Garner Rd.	6/11/2008	10.5 ± 2.5	13824.2 ± 886.8

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TABLE 7.0 - ERS ingestion pathway samples for radionuclide bioaccumulation in milk (from airborne radionuclide deposition on pasturage with subsequent ingestion by milk producing cattle) SFY 2008

Sample results in pCi/L. Results reported at the 95% confidence level. Gamma isotopic analysis showed that no gamma emitters attributable to Wolf Creek operation were present above the lower limits of detection. Gamma emitting radionuclides routinely analyzed for include ^7Be , ^{40}K , ^{51}Cr , ^{54}Mn , ^{58}Co , ^{59}Fe , ^{60}Co , ^{65}Zn , ^{67}Ga , ^{95}Nb , ^{95}Zr , ^{99}Mo , $^{99\text{m}}\text{Tc}$, ^{103}Ru , ^{106}Ru , $^{110\text{m}}\text{Ag}$, ^{111}In , ^{123}I , ^{125}Sb , ^{131}I , ^{134}Cs , ^{137}Cs , ^{140}Ba , ^{140}La , ^{141}Ce , ^{144}Ce , ^{169}Yb , ^{226}Ra , ^{228}Ac , ^{228}Th , ^{234}Th , and ^{239}Np . See Map #1.0, page 39, for sample location. *No isotopes attributable to WCNOG operations were found above method detection limits.*

Date	^{40}K Natural	Date	^{40}K Natural
Lebo, R-1 (control)		Sunrise Dairy, D-1	
8/31/2007	1329 ± 118	1/4/2008	1409 ± 87
12/06/07	1655 ± 101	3/25/2008	1390 ± 90
03/25/08	1380 ± 90	6/25/2008	1390 ± 99
05/29/08	1372 ± 98.4		

TABLE 8.0 - ERS samples for waterborne radioisotope concentration in bottom sediments SFY 2008

Results in pCi/kg-dry. Results reported at the 95% confidence level. Gamma emitting radionuclides routinely analyzed for include ^7Be , ^{40}K , ^{51}Cr , ^{54}Mn , ^{58}Co , ^{59}Fe , ^{60}Co , ^{65}Zn , ^{67}Ga , ^{95}Nb , ^{95}Zr , ^{99}Mo , $^{99\text{m}}\text{Tc}$, ^{103}Ru , ^{106}Ru , $^{110\text{m}}\text{Ag}$, ^{111}In , ^{123}I , ^{125}Sb , ^{131}I , ^{134}Cs , ^{137}Cs , ^{140}Ba , ^{140}La , ^{141}Ce , ^{144}Ce , ^{169}Yb , ^{226}Ra , ^{228}Ac , ^{228}Th , ^{234}Th , and ^{239}Np . The isotopes ^{89}Sr and ^{90}Sr are beta emitters. Strontium analysis is done on selected samples. The symbol * indicates naturally occurring radioisotopes. See Map #1.0, page 40, for sample location. WCNOG sample location designations are denoted by parentheses.

Isotope	WCBS-AQ-1 (DC) CCL discharge cove 5/8/08 KDHE (WCNOG)	WCBS-AN-1 (JRR) John Redmond Reservoir Control 8/10/07 KDHE (WCNOG)
$^{228}\text{Ac}^*$	1579.9 ± 36.5 (Not reported)	1664.9 ± 37.9 (Not reported)
^{137}Cs	158.1 ± 11.7 (216.5 ± 51.9)	128.6 ± 10.7 (121.5 ± 37.5)
$^{40}\text{K}^*$	15818.3 ± 819.4 (16124.0 ± 963.8)	20315.4 ± 1009 (14889 ± 1091)

Isotope	WCBS-AR-1 EEA 4/22/08 KDHE (WCNOG)	WCBS-AP-1 MUDS 4/22/08 KDHE (WCNOG)
$^{228}\text{Ac}^*$	1038.2 ± 22.5 (Not reported)	1378.8 ± 26.9 (Not reported)
^{137}Cs	60.6 ± 5.2 (<59.6 ± 33.5)	<8.0 (<17.8)
$^{40}\text{K}^*$	12086.8 ± 769 (10267 ± 878.1)	7740.7 ± 505.1 (7650.1 ± 549.5)

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TABLE 8.1 - ERS random samples for waterborne radioisotope concentration in bottom sediment SFY 2008

Sample results in pCi/kg-dry. Results reported at the 95% confidence level. Gamma emitting radionuclides routinely Analyzed for include ⁷Be, ⁴⁰K, ⁵¹Cr, ⁵⁴Mn, ⁵⁸Co, ⁵⁹Fe, ⁶⁰Co, ⁶⁵Zn, ⁶⁷Ga, ⁹⁵Nb, ⁹⁵Zr, ⁹⁹Mo, ^{99m}Tc, ¹⁰³Ru, ¹⁰⁶Ru, ^{110m}Ag, ¹¹¹In, ¹²³I, ¹²⁵Sb, ¹³¹I, ¹³⁴Cs, ¹³⁷Cs, ¹⁴⁰Ba, ¹⁴⁰La, ¹⁴¹Ce, ¹⁴⁴Ce, ¹⁶⁹Yb, ²²⁶Ra, ²²⁸Ac, ²²⁸Th, ²³⁴Th, and ²³⁹Np. The isotopes ⁸⁹Sr and ⁹⁰Sr are beta emitters. This table reports only ¹³⁷Cs and ⁶⁰Co activity. See Map #3.0, page 41, for locations.

Location	Date	Isotope		
		¹³⁷ Cs	⁶⁰ Co	
WCRBS-1-P-289-1.5	Boat Ramps	10/30/2007	10.1 ± 3.1	<11.0
WCRBS-1-Q-291-0.8	Discharge Cove	6/26/2008	136.6 ± 10.8	37.7 ± 5.9
WCRBS-2-Q-291-0.8	Discharge Cove	6/26/2008	130.3 ± 10.6	22.5 ± 3.4
WCRBS-3-Q-291-0.8	Discharge Cove	6/26/2008	83.9 ± 8.1	15.7 ± 2.8
WCRBS-4-Q-291-0.8	Discharge Cove	6/26/2008	120.8 ± 9.5	20.6 ± 3.0
WCRBS-5-Q-291-0.8	Discharge Cove	6/26/2008	44.4 ± 5.8	<11.0

TABLE 9.0 - ERS annual samples for waterborne radioisotope concentration in shoreline sediment SFY 2008

Sample results in pCi/kg-dry. Results reported at the 95% confidence level. Gamma emitting radionuclides routinely Analyzed for include ⁷Be, ⁴⁰K, ⁵¹Cr, ⁵⁴Mn, ⁵⁸Co, ⁵⁹Fe, ⁶⁰Co, ⁶⁵Zn, ⁶⁷Ga, ⁹⁵Nb, ⁹⁵Zr, ⁹⁹Mo, ^{99m}Tc, ¹⁰³Ru, ¹⁰⁶Ru, ^{110m}Ag, ¹¹¹In, ¹²³I, ¹²⁵Sb, ¹³¹I, ¹³⁴Cs, ¹³⁷Cs, ¹⁴⁰Ba, ¹⁴⁰La, ¹⁴¹Ce, ¹⁴⁴Ce, ¹⁶⁹Yb, ²²⁶Ra, ²²⁸Ac, ²²⁸Th, ²³⁴Th, and ²³⁹Np. The isotopes ⁸⁹Sr and ⁹⁰Sr are beta emitters. Strontium analysis is done on selected samples. The symbol *indicates naturally occurring radioisotopes. See Map #1.0, page 39, for sample location. WCNOC sample location designations are denoted by parentheses.

Isotope	N-1 (JRR) John Redmond Reservoir Control 11/9/07 KDHE (WCNOC)	J-1 Wolf Creek 6/18/08 KDHE	Q-1 (DC) CCL Discharge Cove 10/26/07 KDHE (WCNOC)
¹³⁷ Cs	<8.0 (<19.3)	28.5 ± 3.3	11.6 ± 5.4 (<23.4)
⁶⁰ Co	<11.0 (<19.9)	<11.0	<11.0 (<9.6)
⁴⁰ K*	11221 ± 682.1 (11685 ± 632.8)	10225 ± 656.3	13078.2 ± 698.8 (11518 ± 666.6)

Isotope	Q-2 (DC) CCL Discharge Cove 5/8/08 KDHE (WCNOC)	R-2 Stringtown Cemetery 6/25/08 KDHE
¹³⁷ Cs	<8.0 (<22.8)	<8.0
⁶⁰ Co	62.9 ± 6.9 (<16.0)	<11.0
⁴⁰ K*	9003.9 ± 585.1 (11045 ± 556.3)	15454.3 ± 991.9

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TABLE 9.1 - ERS random samples for waterborne radioisotope concentration in shoreline sediments SFY 2008

Sample results in pCi/kg-dry. Results reported at the 95% confidence level. Gamma emitting radionuclides routinely analyzed for include ⁷Be, ⁴⁰K, ⁵¹Cr, ⁵⁴Mn, ⁵⁸Co, ⁵⁹Fe, ⁶⁰Co, ⁶⁵Zn, ⁶⁷Ga, ⁹⁵Nb, ⁹⁵Zr, ⁹⁹Mo, ^{99m}Tc, ¹⁰³Ru, ¹⁰⁶Ru, ^{110m}Ag, ¹¹¹In, ¹²³I, ¹²⁵Sb, ¹³¹I, ¹³⁴Cs, ¹³⁷Cs, ¹⁴⁰Ba, ¹⁴⁰La, ¹⁴¹Ce, ¹⁴⁴Ce, ¹⁶⁹Yb, ²²⁶Ra, ²²⁸Ac, ²²⁸Th, ²³⁴Th, and ²³⁹Np. The isotopes ⁸⁹Sr and ⁹⁰Sr are beta emitters. This table reports only ¹³⁷Cs and ⁶⁰Co activity. Strontium analysis is performed on selected samples. See Map #3.0, page 41, for locations.

Location	Date	¹³⁷ Cs	Isotope ⁶⁰ Co
WCRSS-1-H-161-10.3	Neosho River	7/9/2007	<8.0
WCRSS-1-H-180-3.0	East of Dam	10/30/2007	19.2 ± 6.6
WCRSS-1-Q-316-2.4	Black Bear Bosin Recreation Area	10/30/2007	<8.0
WCRSS-1-M-239-3.1	Neosho River	11/2/2007	<8.0
WCRSS-1-H-157-3.0	CCL	12/4/2007	<8.0
WCRSS-1-K-210-4.4	Neosho River	12/4/2007	11.2 ± 2.2
WCRSS-1-A-357-1.0	CCL Stringtown	12/6/2007	<8.0
WCRSS-1-H-157-3.0	CCL E of Dam	12/6/2007	<8.0
WCRSS-1-K-210-4.4	Neosho River	12/6/2007	11.2 ± 2.2
WCRSS-1-L-221-4.0	Neosho River	4/15/2008	71.6 ± 5.5
WCRSS-1-R-338-3.1	CCL	4/15/2008	127.7 ± 9.4
WCRSS-Q-1-311-2.3	EEA	5/13/2008	49.7 ± 4.7

TABLE 10.0 - ERS fish ingestion pathway duplicate samples for waterborne radioisotope bioaccumulation in fish SFY 2008

Sample results in pCi/kg-wet. Results reported at the 95% confidence level. Gamma emitting radionuclides routinely analyzed for include ⁷Be, ⁴⁰K, ⁵¹Cr, ⁵⁴Mn, ⁵⁸Co, ⁵⁹Fe, ⁶⁰Co, ⁶⁵Zn, ⁶⁷Ga, ⁹⁵Nb, ⁹⁵Zr, ⁹⁹Mo, ^{99m}Tc, ¹⁰³Ru, ¹⁰⁶Ru, ^{110m}Ag, ¹¹¹In, ¹²³I, ¹²⁵Sb, ¹³¹I, ¹³⁴Cs, ¹³⁷Cs, ¹⁴⁰Ba, ¹⁴⁰La, ¹⁴¹Ce, ¹⁴⁴Ce, ¹⁶⁹Yb, ²²⁶Ra, ²²⁸Ac, ²²⁸Th, ²³⁴Th, and ²³⁹Np. A Tritium (³H) in tissue analysis is done on all edible fish portions collected. ³H is a beta emitter. See Map #1.0, page 39, for sample locations. WCNOG sample location designations are denoted by parentheses.

Location	Date	Description	³ H KDHE (WCNOG)
Q-1 (DC) CCL Discharge Cove	10/24/07	Flathead Catfish	Invalid Results(5788 ± 199)
	5/9/08	Common Carp Smallmouth Buffalo Wiper White Bass Smallmouth Bass	Invalid Results(10603 ± 250) Invalid Results(9721 ± 227) Invalid Results(9767 ± 233) Invalid Results(11021 ± 262) Invalid Results (11140±262)
N-1 (JRR) John Redmond Reservoir Below dam on Neosho River (Control)	11/9/07	Common Carp Channel Catfish Small mouth Buffalo	Invalid Results (<153)
	5/30/08	White Crappie Bigmouth Buffalo Common Carp Channel Catfish	Invalid Results (<131) Invalid Results (<120) Invalid Results (<136) Invalid Results (<141)

NOTE: KDHE Fish tritium results rejected based on suspected laboratory analysis error. Fish tritium results were not used in statistical calculations.

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TABLE 10.1 - ERS random samples for ingestion pathway in game SFY 2008

Sample results in pCi/kg. Results reported at the 95% confidence level. *No isotopes attributable to WCNOC operations were found above method detection limits.* Gamma emitting radionuclides routinely analyzed for include ^7Be , ^{40}K , ^{51}Cr , ^{54}Mn , ^{58}Co , ^{59}Fe , ^{60}Co , ^{65}Zn , ^{67}Ga , ^{95}Nb , ^{95}Zr , ^{99}Mo , $^{99\text{m}}\text{Tc}$, ^{103}Ru , ^{106}Ru , $^{110\text{m}}\text{Ag}$, ^{111}In , ^{123}I , ^{125}Sb , ^{131}I , ^{134}Cs , ^{137}Cs , ^{140}Ba , ^{140}La , ^{141}Ce , ^{144}Ce , ^{169}Yb , ^{226}Ra , ^{228}Ac , ^{228}Th , ^{234}Th , and ^{239}Np .

Location	Date	Description	Nuclide	pCi/kg
.5 mile north of WC main gate	5/13/2008	Deer	^{40}K	2834 ± 253

TABLE 11.0 - ERS samples for waterborne radioisotope bioaccumulation in aquatic vegetation SFY 2008.

Sample results in pCi/kg-dry (KDHE) and pCi/kg-wet (WCNOC). Results reported at the 95% confidence level. *No isotopes attributable to WCNOC operations were found above method detection limits.* Gamma emitting radionuclides routinely analyzed for include ^7Be , ^{40}K , ^{51}Cr , ^{54}Mn , ^{58}Co , ^{59}Fe , ^{60}Co , ^{65}Zn , ^{67}Ga , ^{95}Nb , ^{95}Zr , ^{99}Mo , $^{99\text{m}}\text{Tc}$, ^{103}Ru , ^{106}Ru , $^{110\text{m}}\text{Ag}$, ^{111}In , ^{123}I , ^{125}Sb , ^{131}I , ^{134}Cs , ^{137}Cs , ^{140}Ba , ^{140}La , ^{141}Ce , ^{144}Ce , ^{169}Yb , ^{226}Ra , ^{228}Ac , ^{228}Th , ^{234}Th , and ^{239}Np . The isotopes ^{89}Sr and ^{90}Sr are beta emitters. See Map #1.0, page 39, for sample location.

Location	Type	Date	Isotope		
			^7Be	^{40}K	
WCAV-N-1	JRR Below the Dam	Spikerush	6/18/2008	2516 ± 282	35917 ± 2745
WCAV-J-1	Wolf Creek 11 th St. Bridge	Arrowhead	6/6/2008	1826 ± 258	13657 ± 13385
WCAL-P-1	MUDS	Pondweed	6/10/2008	1087 ± 166	11515 ± 1193
WCAV-Q-1	Coffey County Lake DC	Pondweed	6/10/2008	5216 ± 501	13291 ± 1318
WCAV R-1	EEA	Water Plantain	6/11/2008	2221 ± 287	19798 ± 1879

TABLE 11.1 - ERS random samples for waterborne radioisotope bioaccumulation in aquatic vegetation SFY 2008.

Sample results in pCi/kg-dry (KDHE) and pCi/kg-wet (WCNOC). Results reported at the 95% confidence level. *No isotopes attributable to WCNOC operations were found above method detection limits.* Gamma emitting radionuclides routinely analyzed for include ^7Be , ^{40}K , ^{51}Cr , ^{54}Mn , ^{58}Co , ^{59}Fe , ^{60}Co , ^{65}Zn , ^{67}Ga , ^{95}Nb , ^{95}Zr , ^{99}Mo , $^{99\text{m}}\text{Tc}$, ^{103}Ru , ^{106}Ru , $^{110\text{m}}\text{Ag}$, ^{111}In , ^{123}I , ^{125}Sb , ^{131}I , ^{134}Cs , ^{137}Cs , ^{140}Ba , ^{140}La , ^{141}Ce , ^{144}Ce , ^{169}Yb , ^{226}Ra , ^{228}Ac , ^{228}Th , ^{234}Th , and ^{239}Np . The isotopes ^{89}Sr and ^{90}Sr are beta emitters. See Map #3.0, page 41, for sample location.

Location	Date	Description	Isotope	
			^7Be	^{40}K
Near Ottumwa	8/1/2007	Pondweed	4508± 423	13153± 1006
N end of CCL off 17th Bridge	8/1/2007	Root Aquatic	955± 176	11990± 1305
Hwy 75 between 7th and 8th Rd.	8/1/2007	Pondweed	1043± 191	12440± 1331
N Side of CCL off 17th RD Bridge	8/7/2007	Algae	5847± 490	15377± 1244
Hwy 75 and 13th Rd	8/28/2007	Root Aquatic	4530± 433	8895± 979
12th and Wayside	6/6/2008	Root Aquatic	2012± 249	19808± 537

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**TABLE 12.0 - ERS samples for airborne radionuclide deposition on terrestrial vegetation
SFY 2008.**

Includes ingestion pathway sampling of garden vegetables and sampling for waterborne radionuclide bioaccumulation in irrigated crops. Sample results in pCi/kg-dry (KDHE) and pCi/kg-wet (WCNOC). Results reported at the 95% confidence level. *No isotopes attributable to WCNOC operation were found above method detection limits.* Gamma emitting radionuclides routinely analyzed for include ^7Be , ^{40}K , ^{51}Cr , ^{54}Mn , ^{58}Co , ^{59}Fe , ^{60}Co , ^{65}Zn , ^{67}Ga , ^{95}Nb , ^{95}Zr , ^{99}Mo , $^{99\text{m}}\text{Tc}$, ^{103}Ru , ^{106}Ru , $^{110\text{m}}\text{Ag}$, ^{111}In , ^{123}I , ^{125}Sb , ^{131}I , ^{134}Cs , ^{137}Cs , ^{140}Ba , ^{140}La , ^{141}Ce , ^{144}Ce , ^{169}Yb , ^{226}Ra , ^{228}Ac , ^{228}Th , ^{234}Th , and ^{239}Np . The isotopes ^{89}Sr and ^{90}Sr are beta emitters. Strontium analysis is done on selected samples. See Map #1.0, page 39, for sample location. WCNOC sample location designations are denoted by parentheses.

Location	Date	Description	Isotope	
			^7Be natural KDHE (WCNOC)	^{40}K natural KDHE (WCNOC)
WCFV-J-1 (NR-D2) Near Leroy, crops that may be irrigated with water from the Neosho River below the confluence with Wolf Creek	11/13/07	Irrigated soybeans	<360 (<115.8)	13226.0 ± 874.0 (14596.0 ± 599.4)
WCFV-J-2 (NR-D1) Near Leroy, crops that may be irrigated with water from the Neosho River below the confluence with Wolf Creek	10/12/07	Irrigated corn	<360 (<48.8)	2533.0 ± 222.0 (3390.3 ± 229.9)
WCFV-J-3 (NR-D2) Near Leroy, crops that may be irrigated with water from the Neosho River below the confluence with Wolf Creek	9/24/07	Irrigated corn	<360 (<63.6)	2245.0 ± 174.0 (1378.5 ± 305.0)
K-1 (NR-U1) 4.5 Miles SSW of Wolf Creek	9/17/07	Non-irrigated corn	<360 (<136.7)	2259 ± 226 (2854.6 ± 440.9)
K-1 (NR-U1) 4.5 Miles SSW of Wolf Creek	10/11/07	Non-irrigated soybeans	<360 (<102.4)	2175 ± 234 (15944 ± 601)
E-1 Scott Valley Church (Control)	10/23/07	Pasturage	<360	4756.0 ± 611.0
A-1 Sector A, Sharpe/Pasture near Sharpe	5/28/08	Pasturage	<360	15658.0 ± 1536.0
H-1 East of CCL dam, near WCA H-1	9/24/07	Pasturage	<360	5963.0 ± 623.0
P-1 CCL public access area, north side of parking lot, 10 m from shore	6/10/08	Pasturage	<360	15235 ± 1502.0
R-1 (EEA) CCL environmental education area	5/13/08	Pasturage	<360 (688.1 ± 154.6)	51900.0 ± 3442.0 (4588.5 ± 409.6)

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TABLE 12.1 - ERS random samples for airborne radionuclide deposition on terrestrial vegetation SFY 2008

Includes ingestion pathway sampling of garden vegetables. Sample results in pCi/kg-dry. Results reported at the 95% confidence level. *No isotopes attributable to WCNOG operation were found above method detection limits.* Gamma emitting radionuclides routinely analyzed for include ^7Be , ^{40}K , ^{51}Cr , ^{54}Mn , ^{58}Co , ^{59}Fe , ^{60}Co , ^{65}Zn , ^{67}Ga , ^{95}Nb , ^{95}Zr , ^{99}Mo , $^{99\text{m}}\text{Tc}$, ^{103}Ru , ^{106}Ru , $^{110\text{m}}\text{Ag}$, ^{111}In , ^{123}I , ^{125}Sb , ^{131}I , ^{134}Cs , ^{137}Cs , ^{140}Ba , ^{140}La , ^{141}Ce , ^{144}Ce , ^{169}Yb , ^{226}Ra , ^{228}Ac , ^{228}Th , ^{234}Th , and ^{239}Np . The isotopes ^{89}Sr and ^{90}Sr are beta emitters. Strontium analysis is done on selected samples. See Map #3.0, page 41, for sample location. WCNOG sample location designations are denoted by parentheses.

Location	Date	Description	Nuclide	
			^7Be	^{40}K
Between Reaper and Shetland on 15th	7/9/2007	Wheat	<360	2326 ± 330
Milo Lane near 7th Road	7/18/2007	Chicory	1153.0 ± 171.0	14164 ± 2105.3
Near Quail and 11th	8/7/2007	Brome Hay	4281.0 ± 389.0	6412 ± 913
18th and Reaper	8/7/2007	Whole Corn on Cob	<360	4146 ± 312
22nd & Shetland	8/15/2007	Milo	951.0 ± 223.0	16117 ± 2335
21st on Native	8/15/2007	Wild Sunflower	<360	7198 ± 601
0.5 Mi. South of 18th Rd. on Underwood	8/28/2007	Corn on Cob	<360	2303 ± 149
16th and Wayside	9/6/2007	Corn Kernels	<360	2799 ± 179
HWY 31 and Underwood	9/25/2007	Red Milo	406.0 ± 59.0	3164 ± 350
Near Oxen Rd and Oxen Lane	10/9/2007	Soybeans	514.0 ± 97.0	12644 ± 1045
Near 11th and Shetland	11/13/2007	Soybeans	<360	12650 ± 822

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TABLE 13.0 - KDHE RADIOCHEMISTRY LABORATORY ERA INTERCOMPARISON STUDIES

Analysis	Date	Average Reported Value (pCi/L)	Assigned Value (pCi/L)	Acceptance Limits (pCi/L)	Performance Evaluation
⁸⁹ Sr	1/7/08	67.8	65.3	53.0-73.4	Acceptable
	5/29/08	57.3	60.4	48.6-68.2	Acceptable
	9/5/08	34.4	28.7	20.4-35.3	Acceptable
⁹⁰ Sr	1/7/08	42.9	41.4	30.5-47.6	Acceptable
	5/29/08	38.9	39.2	28.8-45.1	Acceptable
	9/5/08	41.4	40.0	29.4-46.0	Acceptable
¹³³ Ba	10//5/07	12.9	12.6	8.64-15.5	Acceptable
	1/7/08	22.5	25.7	20.0-29.5	Acceptable
	9/5/08	49.4	46.6	38.1-51.8	Acceptable
¹³⁴ Cs	10//5/07	72.5	71.1	58.0-78.2	Acceptable
	1/7/08	74.4	92.6	76.0-102	Not Acceptable ¹
	9/5/08	94.5	93.2	76.6-102	Acceptable
¹³⁷ Cs	10//5/07	177	180	162-200	Acceptable
	1/7/08	130	158	142-176	Not Acceptable ¹
	9/5/08	57.7	54.6	49.1-62.9	Acceptable
⁶⁰ Co	10//5/07	23.7	23.2	19.9-28.3	Acceptable
	1/7/08	12.8	14.4	11.4-18.7	Acceptable
	9/5/08	26.2	25.7	22.3-31.0	Acceptable
⁶⁵ Zn	10//5/07	264	251	226-294	Acceptable
	1/7/08	175	204	184-240	Not Acceptable ¹
	9/5/08	104	98.8	88.9-118	Acceptable
Gross Alpha	1/7/08	15.9	14.8	7.15-21.2	Acceptable
	5/29/08	46.4	50.8	26.5-53.7	Acceptable
	9/5/08	28.6	30.7	15.7-40.0	Acceptable
Gross Beta	1/7/08	22.4	22.5	13.7-30.6	Acceptable
	5/29/08	45.3	51.4	30.5-58.4	Acceptable
	9/5/08	26.5	25.8	16.1-33.7	Acceptable
¹³¹ I	1/7/08	17.8	23.6	19.6-28.0	Not Acceptable ¹
	5/29/08	27.2	28.7	23.9-33.6	Acceptable
	9/5/08	19.8	21.3	17.6-25.5	Acceptable
³ H	10//5/07	9133	9400	8430-10700	Acceptable
	1/7/08	3479	3540	3000-3910	Acceptable
	9/5/08	3863	3720	3160-4000	Acceptable

¹Results deemed "Not Acceptable" were determined to be caused by inaccurate pipette calibration. Corrective actions were taken to correct the low bias results.

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TABLE 14.0 - KHEL Radiochemistry Laboratory method detection limits SFY 2008

Listed below are method detection limits of present analytical methods for some of the radionuclides monitored by the 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).

GeLi [HPGe] detection system^a						
Environmental Sampling						
	Water and Milk	Filter	Wipe	Soil and Sediment	Biota	Vegetation and food products
Minimum sample size Minimum Counting Time Method Detection Limit	2000 ml 8 hr. pCi/l	1500 m ³ 3 hr. pCi/m ³	Total 3Hr. pCi/wipe	.45 kg 15 hr. pCi/kg-dry	0.3 kg 15 hr. pCi/kg-wet	1 kg 15 hr pCi/kg-dry
⁷ Be	64 [22]	0.03 [0.02]	****	346 [186]	231 [144]	35 [19]
⁴⁰ K	88 [39]	0.03 [0.02]	****	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]	****	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]	****	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]	****	47 [33]	47 [34]	86 [55]
¹²⁵ Sb	35 [12]	0.02 [0.01]	****	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]
¹⁴⁰ Ba	10 [6]	0.004 [0.003]	****	26 [17]	24 [15]	60 [39]
¹⁴⁰ La	9 [5]	0.01 [0.02]	****	28 [9]	34 [21]	13 [6]
¹⁴¹ Ce	8 [3]	0.002 [0.001]	****	46 [23]	22 [13]	6 [3]
¹⁴⁴ Ce	35 [14]	0.013 [0.0096]	****	216 [103]	110 [70]	28 [14]
²²⁶ Ra	116 [69]	0.05 [0.03]	****	828 [654]	323 [195]	90 [51]
²²⁸ Ac	30 [18] 15 h	0.0127 [0.0099]	****	68 [33]	146 [87]	27 [12]
²²⁸ Th	387 [142]	0.09 [0.06]	****	859 [317]	944 [356]	454 [167]
²³⁴ Th	618 [87] 15 h	0.159 [0.0423]	****	1009 [378]	1300 [556]	570 [94]
²³⁵ U	****	****	45 [30] 15 h	****	****	****
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 mP milk or water sample that has a method detection limit (MDL) of 3 pCi/P, and **2)** 3 hour gamma isotopic analysis of ion exchange resin after a 1500 mP milk sample is filtered through an ion exchange column that has an MDL of 1 pCi/P.

^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.

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Table 14.0, continued - KHEL Radiochemistry Laboratory method detection limits SFY 2008.

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).

Low Background Alpha and Beta Counting System					
	Water	Milk	Wipe Total	Soil and Sedimen 0.01kg	Vegetation and Food products 0.1 kg
Minimum Sample Size	1000 ml	1000 ml	200 min.	200 min.	200 min.
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	****	****	****	****
²²⁸ Ra	1.2	****	0.3	60	****
Gross Beta					
	Water			Filter	Wipe
Minimum Sample Size	200 ml			250m ³	Total
Minimum Counting Time	200 min.			100 min.	100 min.
Method Detection Limit	4 pCi/l			0.004 pCi/m ³	2pCi/Wipe
Gross Alpha					
	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	1 pCi/l	0.0006 pCi/m	0.5 pi/Wipe	160 pCi/kg-dry	
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		

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Table 15.0 - Lower limit of detection (LLD) values for selected radionuclides for Wolf Creek environmental sample analysis^a.

Analysis	Water (pCi/l)	Airborne (pCi/m ³)	Fish (pCi/kg-wet)	Milk (pCi/l)	Food Products ^b (pCi/kg-wet)	Sediment (pCi/kg-dry)	Aquatic Vegetation (pCi/kg-wet)
Gross Beta	4 (2)	0.01 (0.003)	*	*	*	*	*
³ H	2000 ^c (1000)	*	(300)	*	*	*	*
⁵⁴ Mn	15	*	130	*	(40)	(30)	(40)
⁵⁹ Fe	30	*	260	*	*	*	*
⁵⁸ Co and ⁶⁰ Co	15 (5)	*	130	*	(10)	(30)	(40)
⁶⁵ Zn	30	*	260	*	*	*	(10)
⁹⁵ Zr and ⁹⁵ Nb	15	*	*	*	(10)	*	(40)
¹³¹ I	1 ^d (0.5)	0.07 (0.007)	*	1 (0.3)	60	*	*
¹³⁴ Cs	15	0.05	130	15	60	150 (60)	(20)
¹³⁷ Cs	18	0.06	150	18	80 (10)	180 (60)	(10)
¹⁴⁰ Ba and ¹⁴⁰ La	15	*	*	15	*	*	*
⁵¹ Cr	*	*	*	*	*	*	(500)
¹²⁵ Sb	*	*	*	*	*	*	(50)
²²⁶ Ra	*	*	*	*	(200)	(500)	(200)
²²⁸ Th	*	*	*	*	(20)	(40)	(20)
⁷ Be	*	(0.001)	*	*	(100)	(300)	(100)
⁴⁰ K	*	(0.002)	(500)	(100)	(500)	(500)	(500)

^a This table is adapted from Table 5-3 of WCNO's Offsite Dose Calculation Manual (ODCM). Values in parenthesis reflect typical LLDs achievable by offsite laboratories. This list does not mean that only these nuclides are to be considered. Other peaks that are identifiable, together with those of the above nuclides, shall also be analyzed and reported. The LLD is defined as the smallest concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with

$$LLD = 2.10x \left[\frac{S_b}{E V Y \exp(-\lambda \Delta t)} \right]$$

95 percent probability with only 5 percent probability of falsely concluding that a blank observation represents a "real" signal. For a particular measurement system, which may include radio-chemical separation.

Where LLD is the *a priori* lower limit of detection (picoCuries per Unit mass or Volume), S_b is the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (counts per minute), E is the counting efficiency (counts per disintegration), V is the sample size (units of mass or volume), 2.10 is a conversion factor with units picoCurie per disintegration per minute (4.66/2.22 dpm/pCi), Y is the fractional radiochemical yield (when applicable), λ is the radioactive decay constant for the particular radionuclide (s^{-1}), and Δt is the elapsed time between sample collection (or end of the sample collection period), and time of counting (s).

It should be recognized that the LLD is defined as an *a priori* (before the fact) limit representing the capability of a measurement system and not used as an *a posteriori* (after the fact) limit for a particular measurement. Analyses shall be performed in such a manner that the stated LLDs will be achieved under routine conditions. Occasionally background fluctuations, unavoidable small sample sizes, the presence of interfering nuclides, or other uncontrollable circumstances may render these LLDs unachievable. In such cases, the contributing factors shall be identified and described.

^b Includes terrestrial vegetation.

^c LLD for drinking water and ground water samples. For surface water samples, a value of 3000 pCi/P may be used.

^d LLD for drinking water and ground water samples. For surface water samples, a value of 15 pCi/l may be used.

Note: If the above equation is used with an actual background count of a sample and a recently determined counting efficiency (using *a posteriori* values instead of assumed *a priori* values), the minimum detectable activity (MDA) may be calculated. Ideally, the MDA will be very close to the LLD. The LLD is a device to predict the detection capability of the counting system, while the MDA reflects the actual detection capability of a counting system. An MDA should be determined for each sample analyzed. The method detection limit (MDL) and MDA are equivalent.

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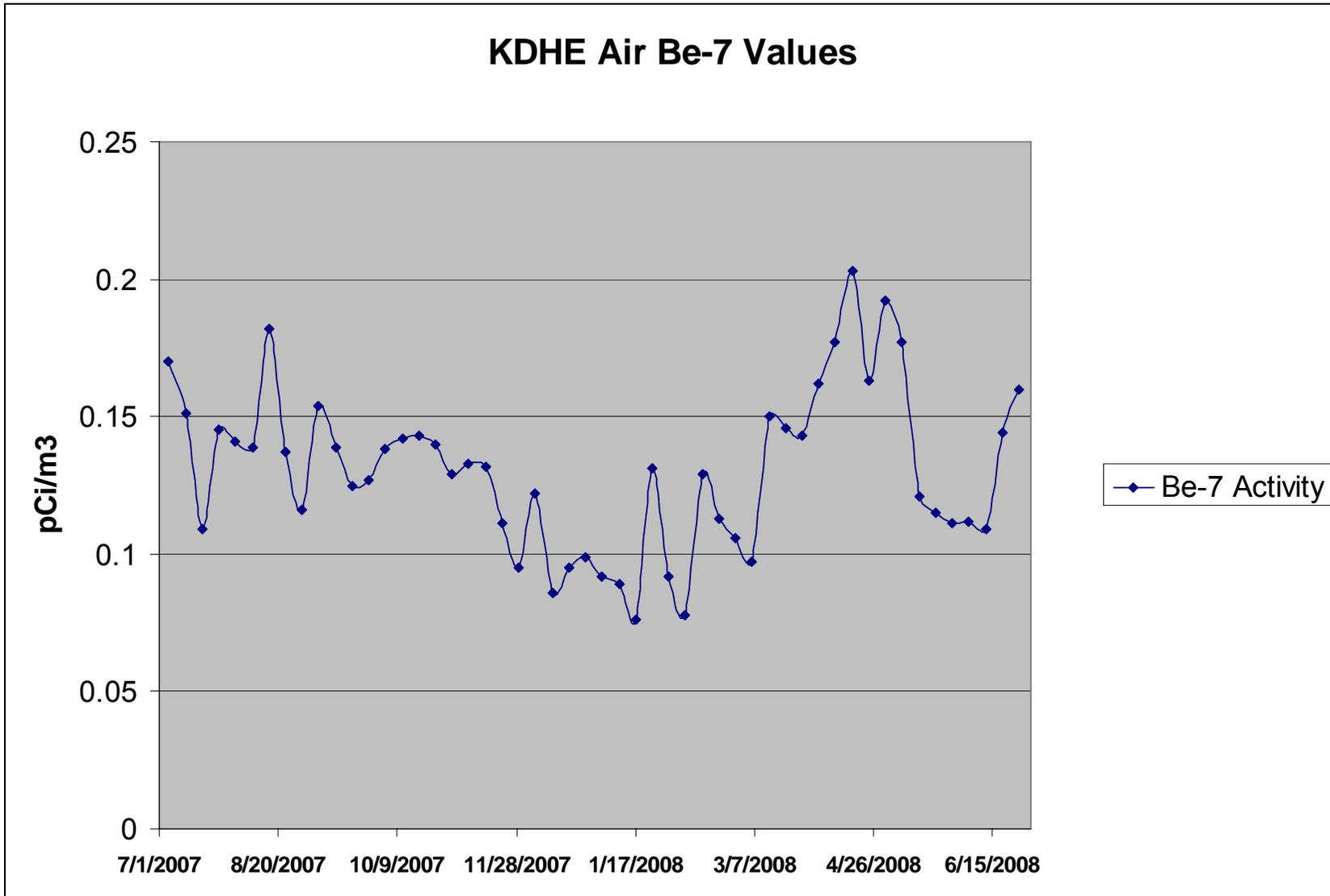
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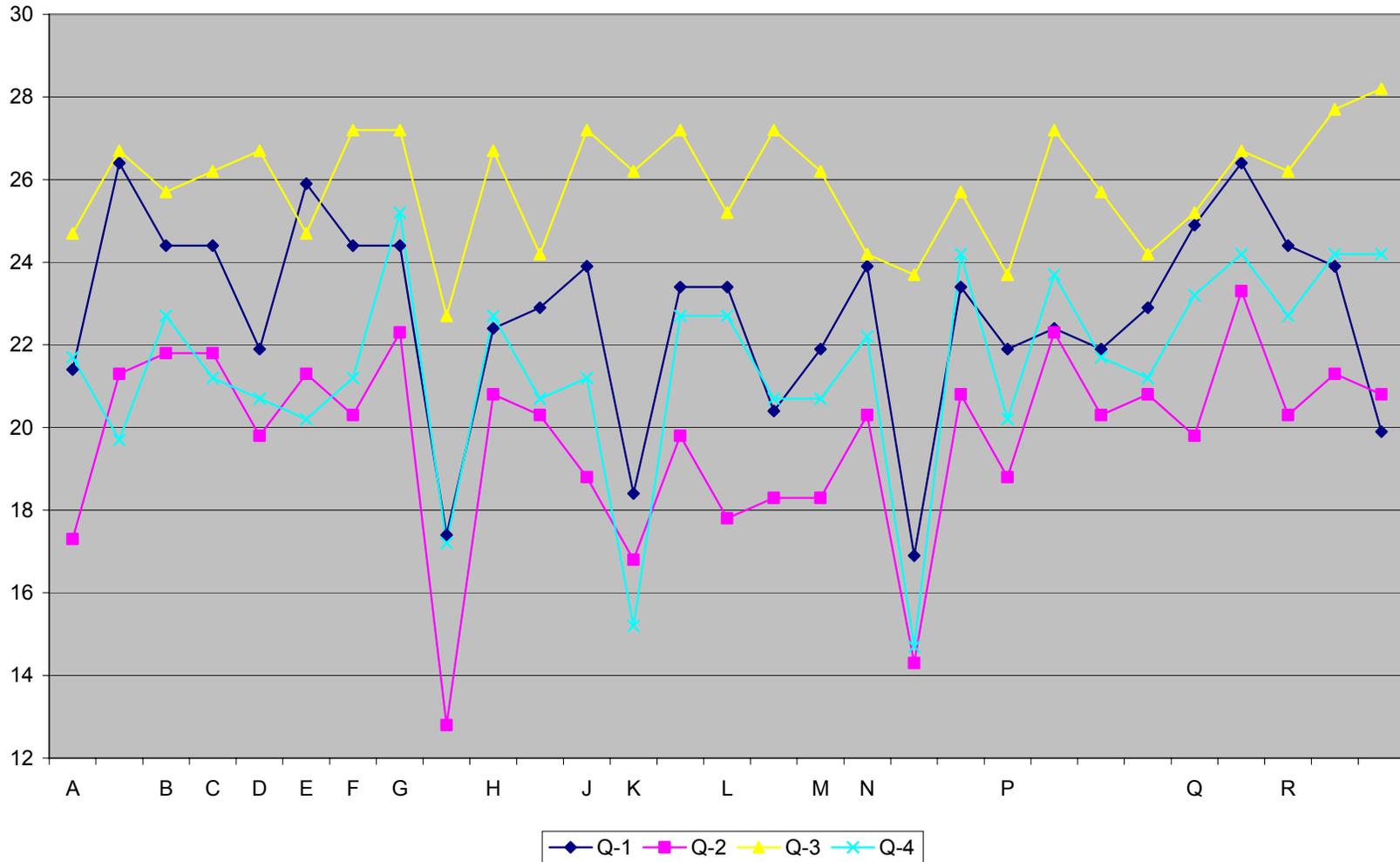
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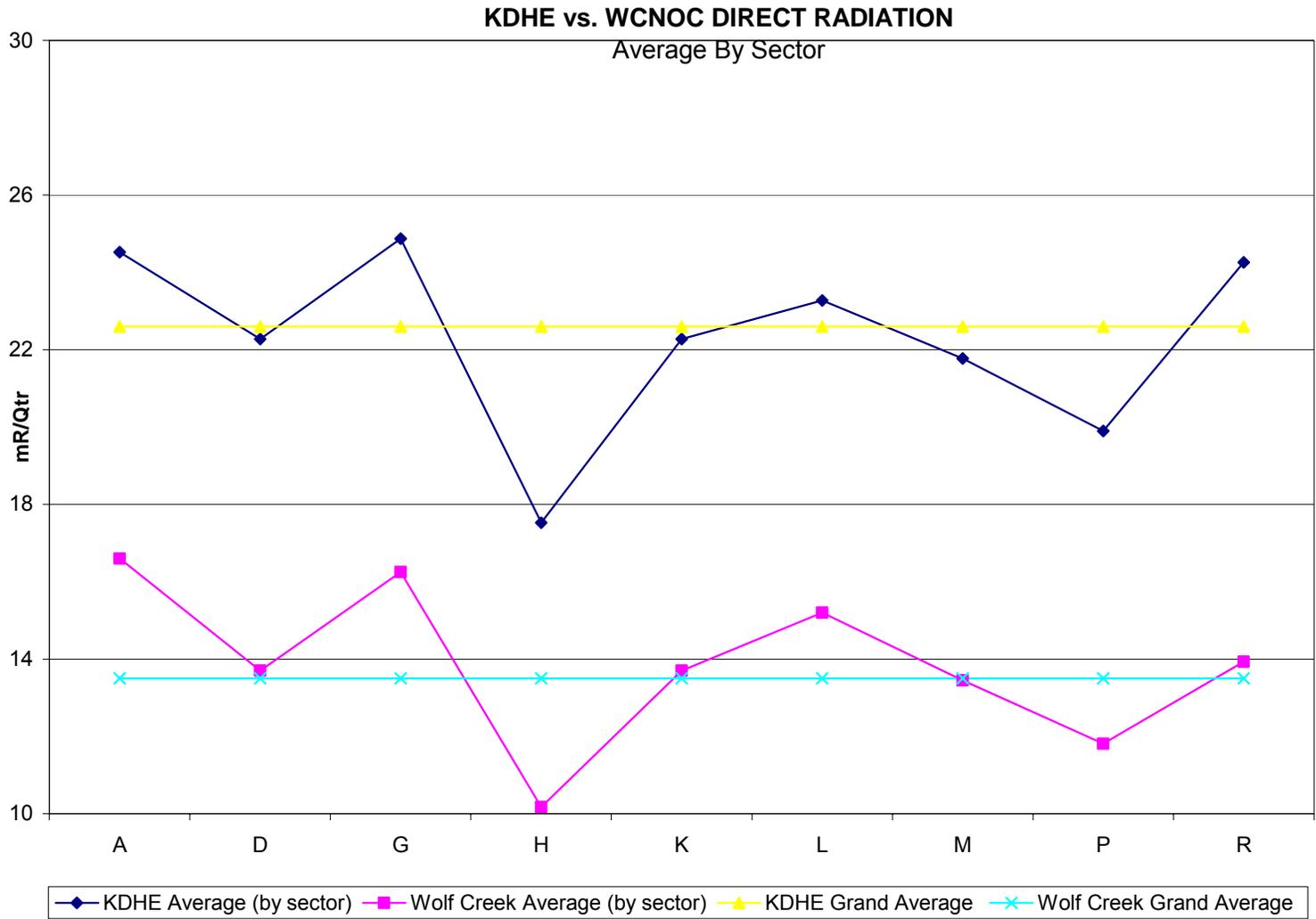
Graph 1.0 - Weekly Air Particulate Sample Comparison

KDHE Quarterly Direct Radiation by Sector



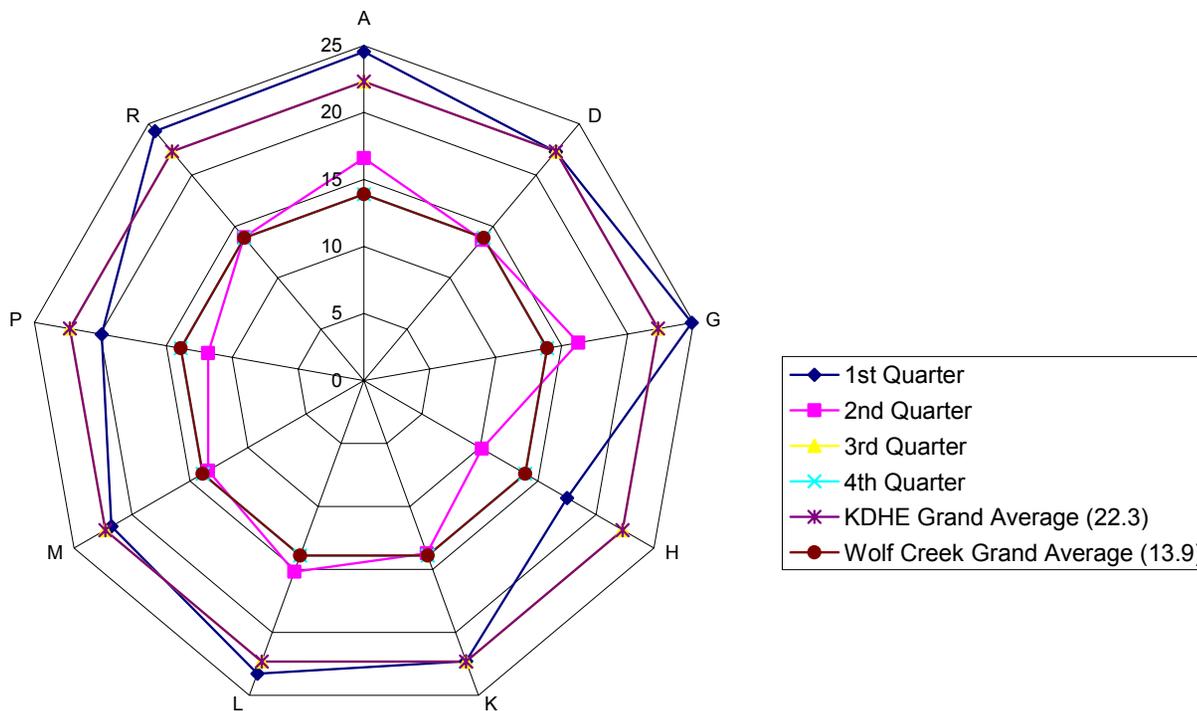
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Graph 2.1 - Quarterly Direct Radiation Monitoring Results for Collocated Sites

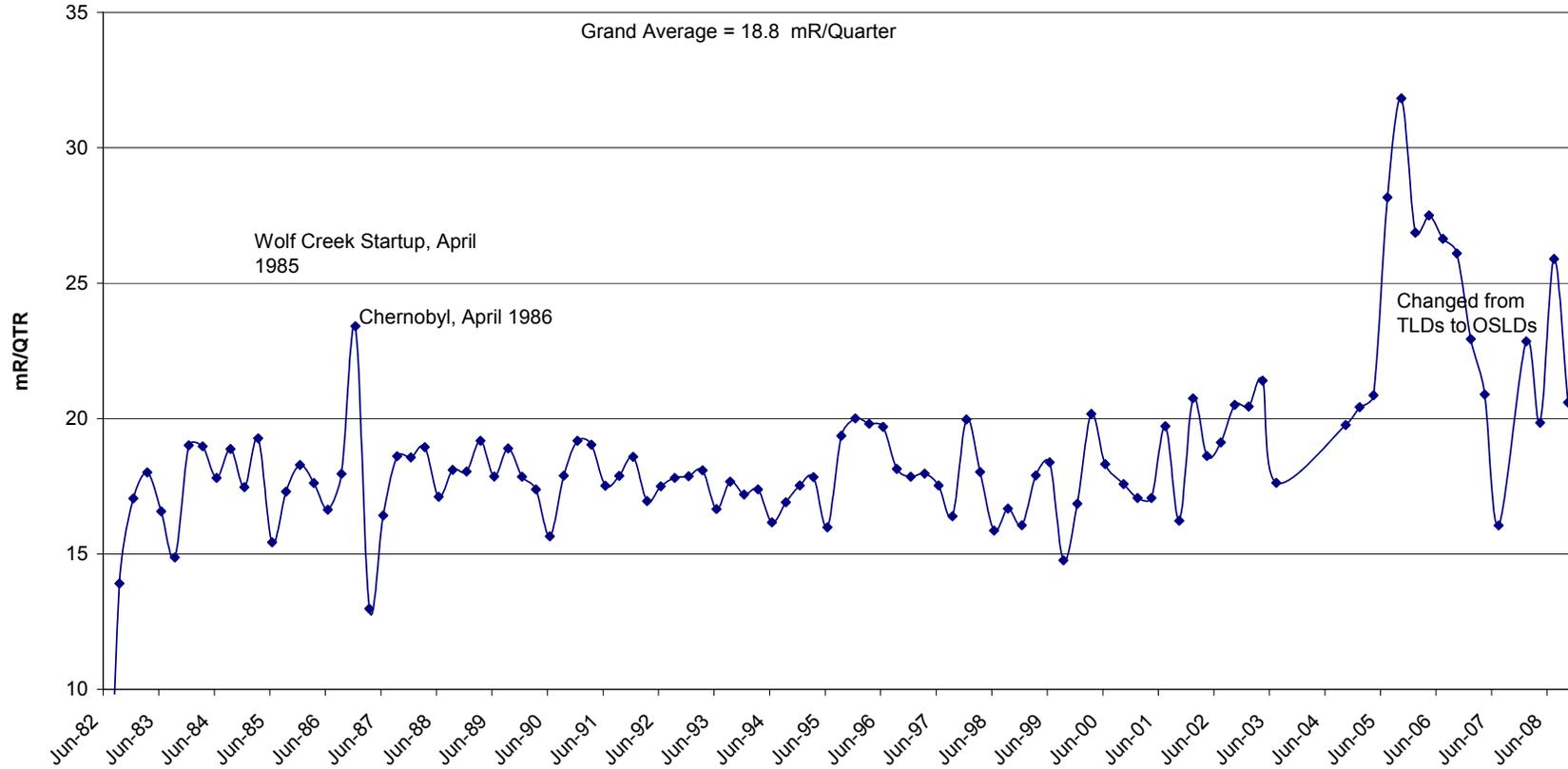
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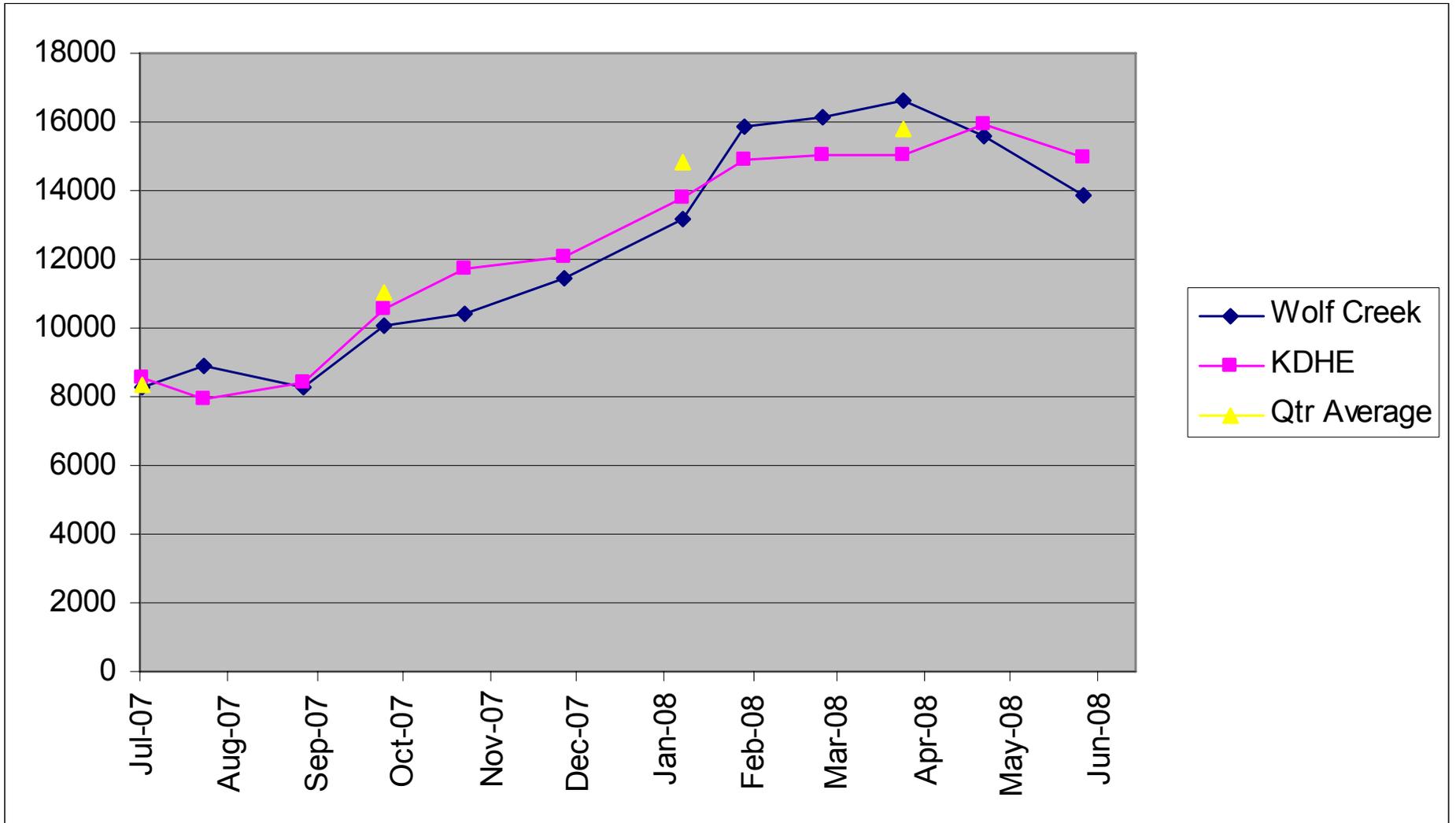
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Historical TLD Results

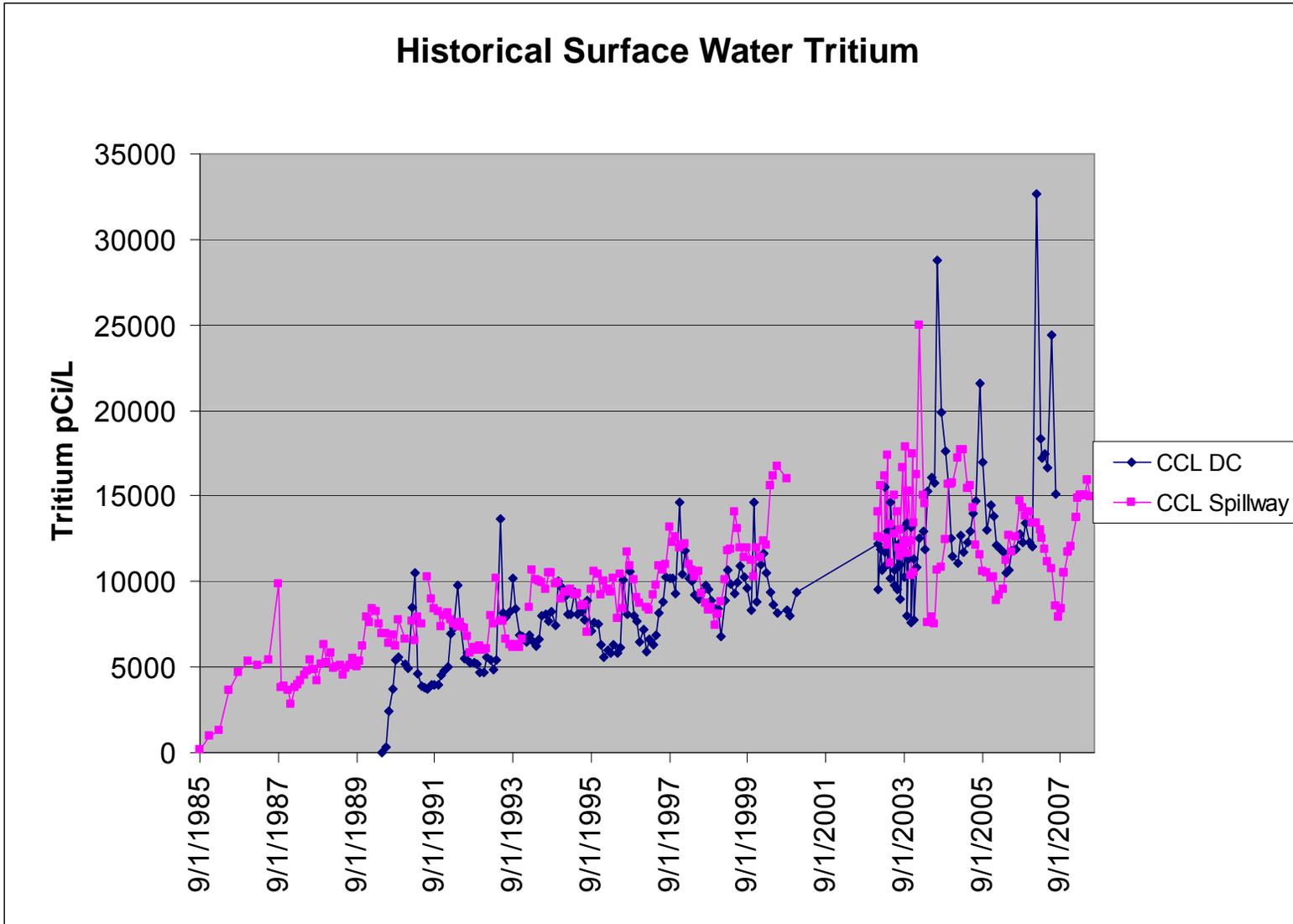


Graph 2.3 - Historical KDHE Direct Radiation Monitoring (TLD) Results

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Graph 3.0 - Comparison of Monthly Surface Water Tritium Results



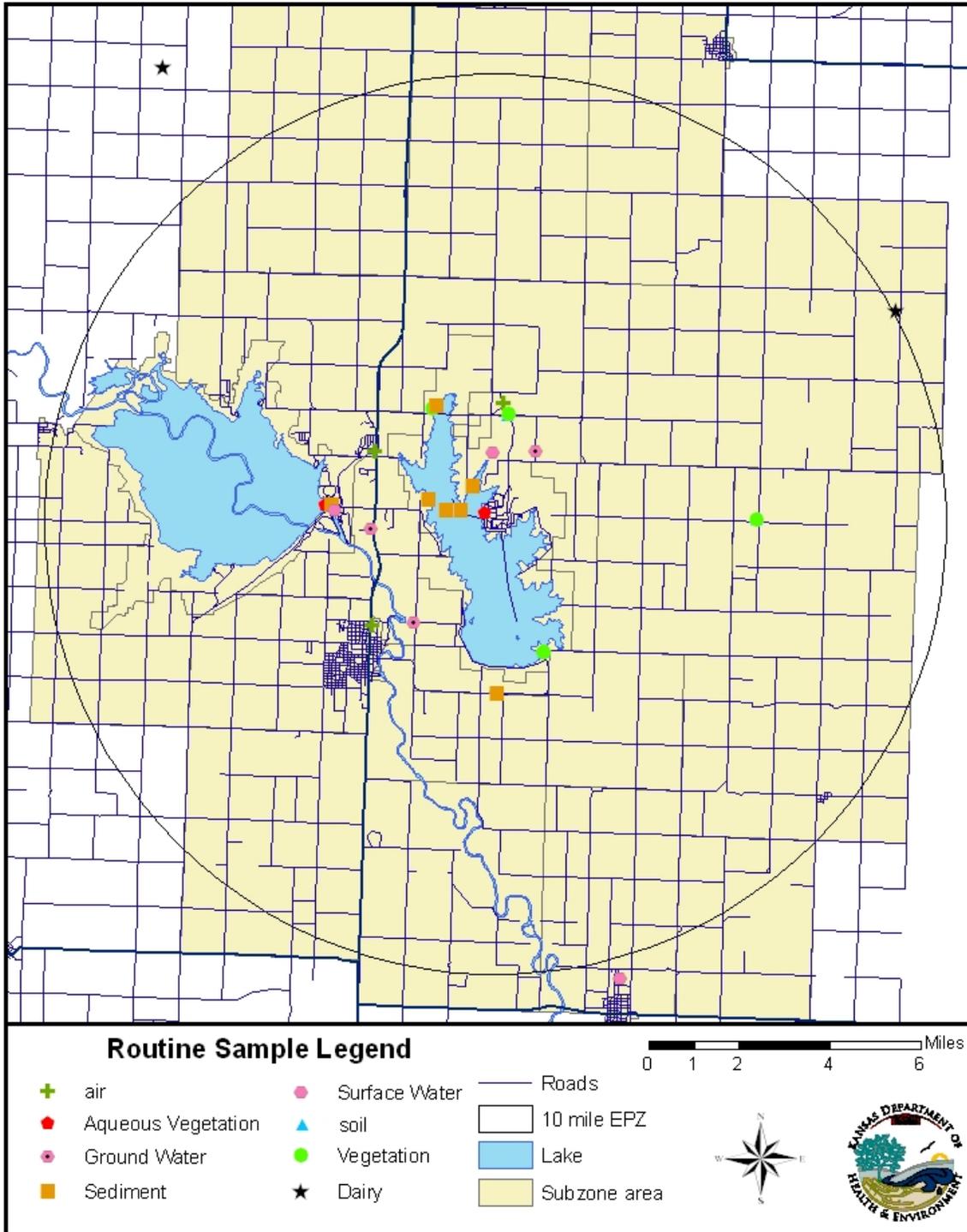
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Maps

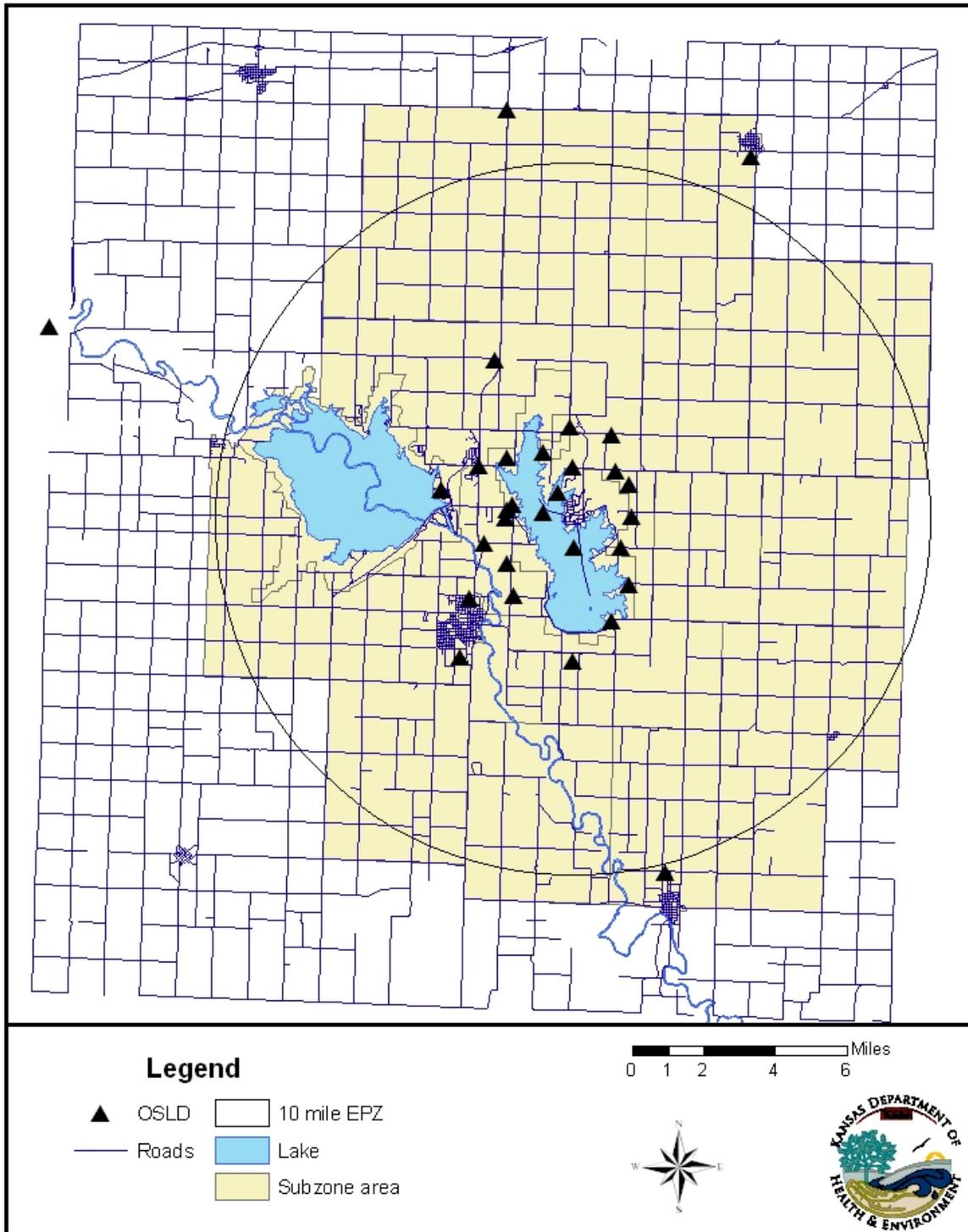
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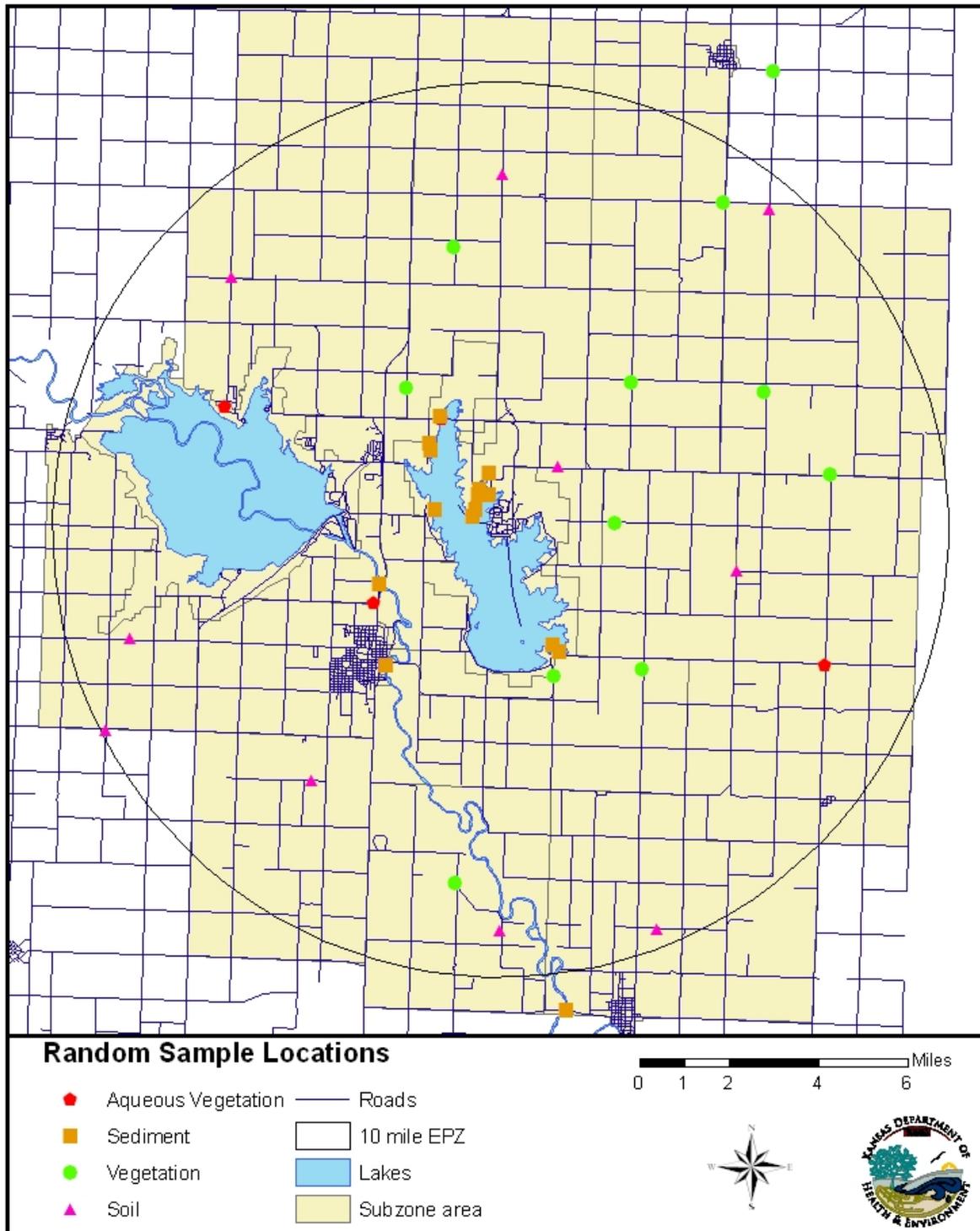
Map 1.0 Routine Sample Locations

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Map 2.0 KDHE OSLD Locations

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Map 3.0 Random Sample Locations