

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



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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, 2006 through June 30, 2007.

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 luminescent 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 conducted during SFY 2007 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 luminescent dosimeters (OSLDs) were processed by Landauer, Inc. under contract.

Wolf Creek Environmental Management personnel collect 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 processes and evaluates WCNOG thermoluminescent dosimeters (TLDs).

The ERS 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 west 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 are collected weekly. Five air-sampling sites, three of which are co-located 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 co-located 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 at Harris. 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 ^{131}I). TEDA binds the iodine chemically and reduces losses from desorption.

Field assay of each particulate filter is performed at the time of collection. The particulate filter is 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 flagged for individual gamma isotopic analysis.

Gamma isotopic analysis is performed on two composite samples, one composed of the five particulate filters and the other of the five charcoal cartridges. Indication of ^{131}I 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 is accomplished using Landauer Luxel OSLDs. OSLDs are read by Landauer. OSLD readings are corrected for transit and handling exposure.

Thirty-one locations around the WCGS are monitored by KDHE, including three control locations greater than ten miles from WCGS. Two OSLDs are 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 TLDs and OSLDs quarterly. KDHE has co-located OSLDs with WCNOG TLDs at twelve sites.

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

Surface water sampling is done by the collection of one-gallon grab samples at the indicated locations. A control sample is collected from John Redmond Reservoir. One sample is collected monthly from the Coffey County Lake at the spillway. One sample is collected monthly at the public fishing area on CCL, near the Makeup Discharge Structure (MUDS). Samples are collected from the Neosho River near Leroy only when Coffey County Lake is overflowing to Wolf Creek at the spillway. A sample is also collected annually from the New Strawn City Lake. Due to administrative error, only four of the 12 planned surface water samples at the public fishing area on CCL, near the Makeup Discharge Structure (MUDS) were collected. No samples were collected from the Neosho River near Leroy during the reporting period because the Lake did not ever overflow at the spillway during that time.

A gamma isotopic and tritium (^3H) analysis is done on each CCL water sample and ^3H analysis is done quarterly on a composite sample from JRR. Samples are split with WCNOG.

Ground water (See Table 5.0, page 18)

Ground water is collected semi-annually at wells in sectors B (control), F, G, L, and N. Three additional samples are collected quarterly at three locations within the Wolf Creek owner-controlled area, one of which is inside the Protected Area Boundary. The control sample location is hydrologically up gradient from the facility and the other two are hydrologically down gradient. Samples are split with WCNOG. Gross alpha, beta, tritium and gamma isotopic analysis are done on each sample.

Soil (See Table 6.0, page 18; 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. Gamma isotopic analysis is performed on all soil samples collected.

Milk (See Table 7.0, page 19)

Milk samples were collected in Coffey County. Control samples were obtained from Linsey Dairy near Lebo, KS. Planned indicator samples from the Sunrise Dairy near Westphalia, KS were not collected due to administrative error. Each milk sample is analyzed for low levels of radioiodine and other gamma emitting nuclides. Only three out of eight planned samples were obtained as the result of scheduling problems.

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

Shoreline and bottom sediment was collected in the environment surrounding WCGS. Indicator bottom sediment was collected at the CCL discharge cove, the public environmental education area, the CCL MUDS public access fishing area, and Stringtown Cemetary. Indicator shoreline sediment was collected at the CCL discharge cove, the public environmental education area, and Wolf Creek below the CCL dam. A control sample of bottom sediment was collected at JRR. Two control samples of shoreline sediment were collected at JRR. Six random bottom sediment samples were collected on CCL. Six random shoreline sediment samples were collected on CCL. Two random shoreline sediment samples were collected downstream of CCL on the Neosho River. 22 of the 26 planned sediment samples were collected with the shortage due to administrative errors.

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 22)

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. Sixteen fish for a total of ten 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 road-killed deer sample was obtained in SFY 2007. 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 Discharge Cove, Coffey County Lake MUDS public access fishing area, Wolf Creek below the Coffey County Lake dam, and the Environmental Education Area. A sample of aquatic vegetation was collected at John Redmond Reservoir as a control. The Coffey County Lake samples are split with WCNOG. Six random aquatic vegetation samples were collected either on the Coffey County Lake, or in areas within the ten mile zone, downstream of the Coffey County discharge on Wolf Creek, Neosho River, or their tributaries. Gamma isotopic analysis was 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 ten indicator 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 WCNOG property, garden vegetables collected from gardens near WCGS, and samples of crops irrigated with water from the Neosho River 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, 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.

RADIOCHEMISTRY LABORATORY

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 14.0). This program is currently accomplished with blind samples purchased from Environmental Resource Associates (ERA).

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 15.0 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 16.0.

RESULTS

Results are reported in the following data tables for the samples taken around WCGS during SFY 2007. Radionuclides detected in the environment surrounding WCGS during SFY 2007 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 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 2007 was 12,704 pCi/l in May 2007. This maximum Coffey County Lake ^3H concentration is 64% 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 2007 was 10,700 pCi/l, or 54% 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 2007 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 2007 was 196 pCi/kg-dry ^{137}Cs found at the Coffey County Lake Discharge Cove (WCBS-AQ-1). Ten trending samples and 13 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 2007.

Sample analysis of terrestrial vegetation, soil, milk, grain, and vegetable samples collected in the environs of WCGS during SFY 2007 indicated no radionuclides present attributable to the operation of WCGS.

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
SFY 2007

Samples of six species of fish were taken from the Coffey County Lake during SFY 2007. Sample analysis of edible fish portions collected in the environs of WCGS during SFY 2007 indicated that no gamma emitters attributable to WCGS operation were present. The highest ^3H concentration in tissue was 12,864 pCi/kg-wet found in a white bass sample taken at the CCL Discharge Cove. 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 12,864 pCi/kg ^3H would receive a committed effective dose equivalent of 0.017 mrem. The projected dose equivalent is far below the 100 mrem/y 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.

The ratio of KDHE results to WCNOG results ranged from 0.5 to 2. The KDHE Grand Average of all sites was 107.1 mR/yr. A summary of comparison data may be found in Table III. Data tables and maps are also attached.

Kansas Department of Health and Environment
 Environmental Radiation Surveillance Report
 Wolf Creek Generating Station
 SFY 2007

Table I. ERS Program summary report for SFY 2007

Type of Sample	Number of Sampling Stations	Total Samples Collected
Air (particulate and iodine)	5	520
Direct Radiation	31	248
Surface Water	5	29
Ground Water	8	36
Sediments	6	10
Random Sediments	13	13
Milk	2	3
Aquatic Vegetation	5	5
Random Aquatic Vegetation	6	6
Fish	2	16
Game Animals/Domestic Meat	0	1
Soil	5	5
Random Soil	10	10
Terrestrial Vegetation	9	11
Random Terrestrial Vegetation	10	10
Total	117	923

**Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
SFY 2007**

Table II ERS Summary Statistics SFY 2007

Description	Average	Standard deviation	Standard error of the mean	Min	Max	N
TLD direct radiation, mR per 90 day quarter	20.1	3.3	0.3	11.1	26.9	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)	12989.1	1239.7	357.9	10748	14689	12
Coffey County Lake (J1A/SP)	<350	N/A	N/A	<350	<350	12
Coffey County Lake (MUDS)	10464.5	1358.3	679.2	8449	11411	4
Ponds surrounding WCGS	<350	N/A	N/A	N/A	N/A	1
Onsite ground water tritium (³ H), pCi/l (All Stations)	1080.8	514.5	148.5	374	1895	12
Offsite ground water tritium (³ H), pCi/l (All Stations)	<350	---	---	---	---	24
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, 195 ± 14.1					
Coffey County Lake fish, wet	Fish Data Rejected Based on Exceeding CCL Tritium level					

**Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
SFY 2007**

TABLE III. ERS program data comparison^a summary statistics SFY 2007.

Description	Average	Standard Deviation	Standard error of the mean	Min	Max	N
TLD direct radiation, mR ^b	19.5 (17.1)	3.6 (2.7)	0.5 (0.4)	11.1 (10.6)	25.9 (21.4)	48
Airborne particulate filter and charcoal cartridge gamma isotopic analysis	Gamma isotopic analysis by both KDHE and WCNOG (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)	12989.1 (11051.8)	1239.7 (3509.8)	357.9 (1058.1)	10748 (9572)	14689 (14267)	12
JRR ^d below dam (control), N-1 (MUSH)	<350	--	--	<350 (<186)	<350 (<143)	12
Offsite ground water ³ H, pCi/l	<350 (<158)	--	--	<350 (<186)	<350 (<143)	3
Surface and ground water gamma isotopic analysis	Gamma isotopic analysis by both KDHE and WCNOG (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, 195.6 ± 14.1 (224.1 ± 64.4)					
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. KDHE Tritium Results rejected.					
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 WCNOG (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 (WCNOG).
^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 2007

Analysis	Average Ratio of KDHE results to WCNOG results ^a	Comments
TLD Direct Radiation	1.13 N=24	12 collocated sites.
Surface Water ³ H	1.03 N=12	Coffey County lake spillway
Bottom sediment gamma isotopic	0.96 N=3	Comparison of ¹³⁷ Cs results
Fish tritium (³ H) in tissue	N/A	WCNOG samples are analyzed for tritium content in the water of the tissue while KDHE analyzes for the tritium content in the fat and water of the tissue. Rejected results not compared.

^a KDHE/WCNOG

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
SFY 2007

DATA TABLES

PAGE

1.0	WEEKLY AIR PARTICULATE.....	15
2.0	QUARTERLY DIRECT RADIATION MONITORING.....	15
2.1	COLLOCATED QUARTERLY DIRECT RADIATION MONITORING.....	16
3.0	MONTHLY SURFACE WATER.....	17
4.0	ANNUAL SURFACE WATER (PONDS).....	17
5.0	ANNUAL GROUND WATER.....	18
6.0	SOIL.....	18
6.1	RANDOM SOIL.....	19
7.0	MILK.....	19
8.0	BOTTOM SEDIMENT.....	20
8.1	RANDOM BOTTOM SEDIMENT.....	20
9.0	SHORELINE SEDIMENT.....	21
9.1	RANDOM SHORELINE SEDIMENT.....	21
10.0	FISH.....	22
10.1	GAME.....	22
11.0	AQUATIC VEGETATION.....	23
11.1	RANDOM AQUATIC VEGETATION.....	23
12.0	TERRESTRIAL VEGETATION	24
12.1	RANDOM TERRESTRIAL VEGETATION.	25
13.0	KDHE RADIOCHEMISTRY LABORATORY EPA INTERCOMPARISON STUDIES.....	26
14.0	KDHE RADIOCHEMISTRY LABORATORY METHOD DETECTION LIMIT.....	27
15.0	WCNOC LOWER LIMIT OF DETECTION VALUES	29

Kansas Department of Health and Environment
 Environmental Radiation Surveillance Report
 Wolf Creek Generating Station
 SFY 2007

TABLE 1.0 ERS Weekly Air Particulate/Iodine Monitoring

Number of Samples	Average ⁷ Be Concentration	Average Iodine Concentration
52	0.11 ± 0.01	<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 for sample locations.

TABLE 2.0 ERS quarterly **direct radiation** monitoring SFY 2007

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

Location	QTR 1	QTR 2	QTR 3	QTR 4
1. A-1 (1), North of WCGS	25.4	23.7	17.1	23.4
2. A-2, Sharpe	24.4	21.7	17.1	21.4
3. A-3, Forward Staging Area	20.9	17.7	17.6	17.4
4. B-1, East Sharpe	26.9	22.7	15.6	22.4
5. B-2, Waverly Control	23.9	22.7	17.1	22.4
6. C-1, near residence	23.9	22.7	15.1	22.4
7. D-1 (9), near residence	22.4	20.7	17.6	20.4
8. E-1, near residence	26.4	24.2	17.6	23.9
9. F-1, near residence	23.9	22.7	16.1	22.4
10. G-1 (14), WCNOG gate	24.9	22.2	17.1	21.9
11. H-0 (42), CCL baffle dike A	17.9	14.7	13.1	14.4
12. H-1, east of CCL dam	22.9	21.7	16.1	21.4
13. H-2, LeRoy control	23.4	21.2	16.6	20.9
14. J-1, near residence	23.4	19.7	15.6	19.4
15. K-1 (29), near residence	18.9	17.7	13.6	17.4
16. L-1 (27), near residence	23.9	21.7	17.6	21.4
17. L-2, Burlington	24.4	17.7	15.6	18.9
18. L-3, Coffey County Shop	20.4	19.2	14.6	17.4
19. M-1 (26), near residence	22.4	19.2	14.6	18.9
20. N-1, near pasture	23.9	21.2	18.6	20.9
21. P-0 (43), CCL baffle dike B	17.4	15.2	11.1	14.9
22. P-1, New Strawn	23.9	21.7	17.1	21.4
23. P-2, Hartford Control	21.4	19.7	13.6	19.4
24. P-3, CCL entrance	22.4	23.2	17.6	22.9
25. P-4 (46), CCL near MUDS	22.4	21.2	16.1	20.9
26. P-5, JRR public use area	22.4	21.7	15.1	21.4
27. Q-1, near residence	24.4	20.7	17.1	20.4
28. R-0 (41), Stringtown cemetery	25.9	24.2	18.1	23.9
29. R-1 (37), near residence	23.9	21.2	15.1	20.9
30. R-2 (44), CCL EEA	22.9	22.2	15.6	21.9
31. R-3, near Coffey County Airport	19.4	21.7	17.1	21.4

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
SFY 2007

TABLE 2.1 ERS collocated quarterly **direct radiation** monitoring SFY 2007

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 are used for data evaluation). KDHE results are expressed as a normalized 90-day quarter average of two OSLDs at each location.

Location KDHE (WCNOC)	KDHE Monitoring period	KDHE	WCNOC
1. A-1 (1)	7/11/2006-10/6/2006	25.4	18.1 \pm 1.3
	10/6/2006-1/7/2007	23.7	19.8 \pm 0.9
	1/7/2007-4/8/2007	17.1	16.4 \pm 0.9
	4/8/2007-7/6/2007	23.4	21.3 \pm 1.1
2. D-1 (9)	7/11/2006-10/6/2006	22.4	16.4 \pm 0.6
	10/6/2006-1/7/2007	20.7	17.4 \pm 0.8
	1/7/2007-4/8/2007	17.6	13.9 \pm 0.7
	4/8/2007-7/6/2007	20.4	19.4 \pm 2.8
3. G-1 (14)	7/11/2006-10/6/2006	24.9	18.2 \pm 1
	10/6/2006-1/7/2007	22.2	19.5 \pm 0.9
	1/7/2007-4/8/2007	17.1	16.7 \pm 1.1
	4/8/2007-7/6/2007	21.9	21.4 \pm 1.7
4. H-0 (42)	7/11/2006-10/6/2006	17.9	10.9 \pm 0.4
	10/6/2006-1/7/2007	14.7	14.1 \pm 0.6
	1/7/2007-4/8/2007	13.1	12.0 \pm 3.2
	4/8/2007-7/6/2007	14.4	16.0 \pm 1.3
5. K-1 (29)	7/11/2006-10/6/2006	18.9	13.6 \pm 0.3
	10/6/2006-1/7/2007	17.7	16.9 \pm 1.0
	1/7/2007-4/8/2007	13.6	13.1 \pm 0.9
	4/8/2007-7/6/2007	17.4	18.0 \pm 1.5
6. L-1 (27)	7/11/2006-10/6/2006	23.9	17.5 \pm 0.1
	10/6/2006-1/7/2007	21.7	20.0 \pm 0.9
	1/7/2007-4/8/2007	17.6	17.9 \pm 3.6
	4/8/2007-7/6/2007	21.4	20.4 \pm 0.3
7. M-1 (26)	7/11/2006-10/6/2006	22.4	15.1 \pm 0.8
	10/6/2006-1/7/2007	19.2	18.1 \pm 1.0
	1/7/2007-4/8/2007	14.6	16.0 \pm 3.2
	4/8/2007-7/6/2007	18.9	19.5 \pm 1.0
8. P-0 (43)	7/11/2006-10/6/2006	17.4	10.6 \pm 1.1
	10/6/2006-1/7/2007	15.2	13.7 \pm 1.8
	1/7/2007-4/8/2007	11.1	12.1 \pm 3.5
	4/8/2007-7/6/2007	14.9	14.9 \pm 0.9
9. P-4 (46)	7/11/2006-10/6/2006	22.4	17.8 \pm 3.5
	10/6/2006-1/7/2007	21.2	19.2 \pm 1.1
	1/7/2007-4/8/2007	16.1	15.5 \pm 0.2
	4/8/2007-7/6/2007	20.9	19.7 \pm 1.4
10. R-0 (41)	7/11/2006-10/6/2006	25.9	17.6 \pm 0.9
	10/6/2006-1/7/2007	24.2	20.3 \pm 1.1
	1/7/2007-4/8/2007	18.1	16.7 \pm 0.9
	4/8/2007-7/6/2007	23.9	21.6 \pm 2.0
11. R-1 (37)	7/11/2006-10/6/2006	23.9	15.9 \pm 0.6
	10/6/2006-1/7/2007	21.2	18.6 \pm 1.3
	1/7/2007-4/8/2007	15.1	15.8 \pm 1.4
	4/8/2007-7/6/2007	20.9	20.7 \pm 2.8
12. R-2 (44)	7/11/2006-10/6/2006	22.9	17.1 \pm 1.4
	10/6/2006-1/7/2007	22.2	19.0 \pm 0.8
	1/7/2007-4/8/2007	15.6	16.4 \pm 1.8
	4/8/2007-7/6/2007	21.9	20.6 \pm 1.6

Kansas Department of Health and Environment
 Environmental Radiation Surveillance Report
 Wolf Creek Generating Station
 SFY 2007

TABLE 3.0 ERS monthly duplicate samples for waterborne radionuclides in **surface water** SFY 2007

Gamma isotopic analyses by both KDHE and WCNOG 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		P-1 MUDS	
	KDHE	WCNOG	KDHE	WCNOG		
7/13/2006	12572 ± 318	11571 ± 300	<350	<147	10/12/2006	11052 ± 295
8/24/2006	14689 ± 339	13661 ± 328	<350	<143	11/14/2006	10946 ± 303
9/14/2006	14325 ± 338	12976 ± 325	<350	<186	5/29/2007	11411 ± 309
10/12/2006	13850 ± 331	14267 ± 342	<350	<181	6/12/2007	8449 ± 275
11/16/2006	14092 ± 336	13479 ± 331	<350	<166		
12/14/2006	13446 ± 329	12883 ± 317	<350	<139		
1/18/2007	13453 ± 328	±	<350	<188		
2/23/2007	13043 ± 324	11985 ± 306	<350	<180		
3/8/2007	12569 ± 318	12181 ± 311	<350	<167		
4/12/2007	11915 ± 311	11391 ± 309	<350	<180		
5/10/2007	11167 ± 306	9899 ± 280	<350	<169		
6/14/2007	10748 ± 300	9572 ± 287	<350	<147		

TABLE 4.0 ERS annual samples for deposition of airborne radionuclides on **surface water** SFY 2007

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. WCNOG sample location designations are denoted by parenthesis. *No radionuclides attributable to WCNOG operations were found above method detection limits.*

Location	Date	Tritium (³ H)
P-1, New Strawn City Lake	7/20/2006	<350

**Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
SFY 2007**

TABLE 5.0 ERS Annual samples for waterborne radionuclides in ground water SFY 2007

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 for sample locations.

Offsite Ground Water				
Date	L-1 (L49)	N-1 (C-10)	B-1 (B-12)	J-1 (J-1)
	KDHE (WCNOC)	KDHE (WCNOC)	KDHE (WCNOC)	KDHE (WCNOC)
TRITIUM (³ H)				
08/30/06	<350 (<173)	<350 (<139)	<350 (<139)	<350 (<139)
05/18/07	<350 (<140)	<350 (<140)	<350 (<140)	<350 (<135)
Date	J-2 (J-2)	G-1 (G-2)	J-2 (B-J-2)	F-1 (F-1)
	KDHE (WCNOC)	KDHE (WCNOC)	KDHE (WCNOC)	KDHE (WCNOC)
TRITIUM (³ H)				
08/30/06	<350 (<173)	<350 (<139)	<350 (<139)	<350 (<139)
11/16/06	<350 (<140)	<350 (<140)	<350 (<140)	<350 (<171)
03/06/07	<350	<350	<350	<350
05/18/07	<350 (<140)	<350	<350	<350 (<140)

Onsite Ground Water			
Date	ESW W-NW	ESW W-N	Auxiliary Building
	KDHE (WCNOC)	KDHE (WCNOC)	KDHE (WCNOC)
TRITIUM (³ H)			
09/01/06	1658 ± 179	1895 ± 179	950 ± 160
11/16/06	1387 ± 173	1630 ± 178	653 ± 159
02/16/07	959 ± 163 (958 ± 110)	941 ± 164 (1418 ± 123)	590 ± 155 (682 + 99)
05/18/07	457 ± 156 (897 ± 108)	1476 ± 172 (355 ± 97)	374 ± 152 (373 ± 87)

TABLE 6.0 ERS annual samples for airborne radionuclide deposition on soil SFY 2007

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 for sample location. WCNOC sample location designations are denoted by parenthesis. **No radionuclides attributable to WCNOC operations were observed above method detection limits.**

Isotope	A-1 Sector A Sharpe	E-1 Scott Valley Church	H-1 East of CCL Dam
	KDHE 4/18/06 0.5m ²	(Control) KDHE 6/21/06 0.5m ²	KDHE Near HCA H-1 10/18/05 0.5m ²
²²⁸ Ac*	<28	1408.5 ± 34.2	956.4 ± 23.7
¹³⁷ Cs	<35	546.8 ± 27.8	276.3 ± 14.9
⁴⁰ K*	<33	13856.2 ± 866.4	11123.9 ± 541.4
	P-1 (MUDS) 6/26/06 KDHE (WCNOC)	R-1 EEA 5/21/07 KDHE	
²²⁸ Ac*	1001.5 ± 23.9 (N/A)	1111.6 ± 25 (N/A)	
¹³⁷ Cs	69.4 ± 6.0 (<46.3)	25.2 ± 4.2 (446.2 ± 64.8)	
⁴⁰ K*	10721.8 ± 524.9 (10501.0 ± 939.8)	12370.6 ± 595.4 (9090.3 ± 833.1)	

TABLE 6.1 ERS random samples for airborne radionuclide deposition in soil SFY 2007

**Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
SFY 2007**

Sample 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. This table reports only ^{137}Cs and ^{40}K activity. No isotopes attributable to WCNO operations were found above method detection limits. See Map #7.0 for locations.

Location	Date	Isotope		
		^{137}Cs	^{40}K	
WCRS-1-R-345-5.5	20th and Native Rd.	8/15/2006	35.3 ± 3.5	12032 ± 562.6
WCRS-1-H-157-3.1	East of Dam off 12 th Rd.	9/7/2006	226.8 ± 12.2	12157.5 ± 568.3
WCRS-1-H-166-8.4	1 mile north of LeRoy	10/03/06	22.6 ± 2.2	11228 ± 541.8
WCRS-1-C-055-4.2	17th and Quail	11/14/2006	<8	10184.9 ± 502.2
WCRS-1-M-250-0.8	Homestead between 11 th and 12 th	1/9/2007	131.4 ± 9.5	11710 ± 583.1
WCRS-1-N-266-8.8	14th and Garner	1/9/2007	204.9 ± 14.6	12185.8 ± 903
WCRS-1-F-112-7.4	12th and Wayside	3/13/2007	63.7 ± 5.8	12014 ± 584.1
WCRS-1-E-098-5.5	Near Star Cemetery	5/8/2007	470.2 ± 23.3	15069.1 ± 745
WCRS-Q-1-286-0.6	CCL Discharge Cove	5/30/2007	<8	11853.8 ± 585.7
WCRS-B-1-029-7.3	22nd and Shetland	6/5/2007	31.3 ± 4.4	9992.7 ± 494.8

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 2007

Sample is collected at Lebo, R-1 (Linsey Dairy). Lebo is a control location. 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 for sample location. No isotopes attributable to WCNO operations were found above method detection limits.

Date	^{40}K Natural
Lebo, R-1	
8/22/2006	1760 ± 17.9
12/14/2006	1423 ± 14.7
05/08/07	1641 ± 15.6

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
SFY 2007

TABLE 8.0 ERS annual samples for waterborne radioisotope concentration in **bottom sediments** SFY 2007

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 for sample location. WCNOC sample location designations are denoted by parentheses.

Isotope	Q-1 (DC) CCL discharge cove 11/21/06	N-1 (JRR) John Redmond Reservoir Control 11/27/06	R-2 (DC) CCL DC near Stringtown Cemetery 6/27/07 KDHE
	²²⁸ Ac* ¹³⁷ Cs ⁴⁰ K*	KDHE (WCNOC) 1418.2 ± 37 (not reported) 195.6 ± 14.1 (224.1 ± 64.4) 14092.5 ± 787.2 (14040 ± 1221)	KDHE (WCNOC) 1451.8 ± 49 (not reported) 113.2 ± 13.6 (140.5 ± 45.6) 17859.3 ± 1132.2 (17323 ± 846.3)

Isotope	R-1 EEA 6/22/07 KDHE (WCNOC)	P-1 MUDS 6/15/2007 KDHE
	²²⁸ Ac* ¹³⁷ Cs ⁴⁰ K*	1163.8 ± 12.4 (not reported) 123.6 ± 3.8 (96.9 ± 33.6) 12798.1 ± 300.0(12874.0 ± 715.7)

TABLE 8.1 ERS random samples for waterborne radioisotope concentration in **bottom sediments** SFY 2007.

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 for locations.

Location	Date	Isotope		
		¹³⁷ Cs	⁶⁰ Co	
WCRBS-1-R-330-3.4	CCL	3/6/2007	<11	71 ± 6.6
WCRBS-4	CCL	6/7/2007	41.5 ± 5.5	138.6 ± 11.6
WCRSS-Q-1-286-0.6	CCL DC	5/30/2007	77.9 ± 6.2	162.9 ± 12.4
WCRBS-2	CCL	6/4/2007	14 ± 3	83.8 ± 6.9
WCRBS-3	CCL	6/4/2007	23.7 ± 2.4	109.4 ± 6.8
WCRBS-4	CCL	6/4/2007	<11	10.3 ± 3.9

Kansas Department of Health and Environment
 Environmental Radiation Surveillance Report
 Wolf Creek Generating Station
 SFY 2007

TABLE 9.0 ERS annual samples for waterborne radioisotope concentration in **shoreline sediment** SFY 2007

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 for sample location. WCNOG sample location designations are denoted by parentheses.

Isotope	N-1 (JRR) John Redmond Reservoir (Control) 11/27/06 KDHE (WCNOG)	J-1 Wolf Creek 7/21/06 KDHE	Q-1 (DC) CCL Discharge Cove 10/25/06 KDHE (WCNOG)
¹³⁷ Cs	<14 (140.5 ± 45.6)	33.7 ± 3.5	<14 (<53.5)
⁶⁰ Co	<11 (<20.7)	<11	<11 (<16.7)
⁴⁰ K*	12911.6 ± 740.3 (17323 ± 846.3)	12505.8 ± 584.8	12398.8 ± 874.8 (11521 ± 965.7)

Isotope	N-1 (JRR) John Redmond Reservoir (Control) 6/7/07 KDHE (WCNOG)	R-1 (EEA) Environmental Education Area 6/22/07 KDHE
¹³⁷ Cs	107.2 ± 9.7 (108.2 ± 43.3)	<11.0
⁶⁰ Co	<11 (29.3)	39.6 ± 3.4
⁴⁰ K*	13762 ± 731 (12087 ± 915.4)	9456.1 ± 444.4

TABLE 9.1 ERS random samples for waterborne radioisotope concentration in **shoreline sediments** SFY 2007

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 for locations.

Location	Date	¹³⁷ Cs	Isotope	⁶⁰ Co
WCRSS-1-Q-313-2.3	CCL	5/21/2006	9.2 ± 2.5	<11
WCRSS-1-A-358-0.5	Stringtown Cemetery	10/17/2006	<14	<11
WCRSS-2-H-156-2.9	East of Dam	10/17/2006	16.9 ± 3.9	<11
WCRSS-2-L-222-4.0	Neosho River Northeast Burlington	10/24/2006	<14	<11
WCRSS-1-L-222-3.3	Neosho River South Burlington	11/14/2006	<14	<11
WCRSS-1-N-278-1.7	CCL	3/6/2007	<14	<11
WCRSS-1-H-151-3.1	CCL	3/13/2007	<14	<11
WCRSS-Q-1-286-0.6	Discharge Cove	5/30/2007	15.9 ± 3.8	<11

**Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
SFY 2007**

TABLE 10.0 ERS fish ingestion pathway duplicate samples for waterborne radioisotope bioaccumulation in **fish**
SFY 2007

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 for sample locations. WCNOG sample location designations are denoted by parentheses. Two samples were rejected due to analyzed tritium levels which exceeded the tritium level of Coffey County Lake. ^aKDHE values exceed lake water values and are not considered valid, and are not used in statistical calculations.

Location	Date	Description	³ H KDHE (WCNOG ^a)
Q-1 (DC) CCL Discharge Cove	10/12/06	Channel Catfish Common Carp Wiper White Bass Smallmouth Buffalo	15560 ± 2250 (12694 ± 270) 20220 ± 2500 (9642 ± 241) 20030 ± 2820 (13021 ± 263) 17100 ± 2510 (14745 ± 291) 22770 ± 2614 (12513 ± 247)
	5/11/07	Smallmouth Buffalo White Bass Common Carp Smallmouth Bass	30725 ± 2848 (5505 ± 178) 15070 ± 1282 (5917 ± 206) 16268 ± 1677 (7266 ± 208) 14217 ± 1143 (6022 ± 193)
N-1 (JRR) John Redmond Reservoir Below dam on Neosho River Control	11/27/06	Channel Catfish Smallmouth Buffalo Largemouth Bass	3533 ± 1960 (<122) 3301 ± 1976 (<150) 3870 ± 373 (<141)
	6/1/07	Channel Catfish Large Mouth Bass Common Carp	1885 ± 196 2738 ± 381 3373 ± 345.8

TABLE 10.1 ERS random samples for ingestion pathway in **game** SFY 2007

Sample results in pCi/kg. 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, 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.

Location	Date	Description	Nuclide
			⁴⁰ K
0.8 Miles NNE of Wolf Creek	11/27/2006	Deer	2851 ± 335

Kansas Department of Health and Environment
 Environmental Radiation Surveillance Report
 Wolf Creek Generating Station
 SFY 2007

TABLE 11.0 Wolf Creek samples for waterborne radioisotope bioaccumulation in **aquatic vegetation** SFY 2007

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 for sample location.

Location	Type	Date	Isotope		
			^7Be	^{40}K	
WCAV-N-1	JRR Below the Dam	Algae	7/7/06	<360	12554 ± 662
WCAV-J-1	Wolf Creek 11 th St. Bridge	Arrowhead	7/21/06	1188 ± 128	21710 ± 1372
WCAL-P-1	MUDS	Water Naiad	11/14/06	878 ± 188 (252.8 ± 124.8)	31377 ± 1918(3363.2 ± 335.7)
WCAV-Q-1	Coffey County Lake Discharge Cove	Cattails	6/27/07	625 ± 130 (285.4 ± 149.8)	7135 ± 828 (2504.1 ± 321.5)
WCAV R-1	EEA	Spikerush	6/12/07	3696 ± 344 (1162.7 ± 210.3)	15027 ± 1188(3384.6 ± 358.6)

TABLE 11.1 ERS random samples for waterborne radioisotope bioaccumulation in **aquatic vegetation** SFY 2007

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 #8.0 for sample location.

Location	Date	Description	Isotope	
			^7Be	^{40}K
17th and Native	07/10/06	Bullrush	2929 ± 378	11166± 613
Mathias Lake	07/10/06	American Lotus	<360	14066± 3278
12th and Underwood	08/15/06	Primrose	2804 ± 222	11101± 252
Lynx 1/2 mi S. of 12th	08/22/06	Horsetails	3087 ± 292	20422± 1633
Neosho River	10/24/06	Algae	2732 ± 216	8801.5± 539
CCL Boat Ramps	06/05/07	Pondweed Naiad	961 ± 120	10279± 751

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
SFY 2007

TABLE 12.0 ERS trending samples for airborne radionuclide deposition on **terrestrial vegetation** SFY 2007

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 for sample location. WCNOC sample location designations are denoted by parentheses.

Location	Date	Description	^7Be natural KDHE (WCNOC)	Isotope ^{40}K natural KDHE (WCNOC)
WCFV-J-2 (NR-D2) Near Leroy, crops that may be irrigated with water from the Neosho River below the confluence with Wolf Creek	9/26/2006	Irrigated Corn	<360 (<78.1)	2372 ± 143 (2372.7 ± 250.4)
WCFV-J-2 (NR-D2) Near Leroy, crops that may be irrigated with water from the Neosho River below the confluence with Wolf Creek	10/18/2006	Irrigated Soybeans	<360 (<108.1)	13021 ± 629 (20398.0 ± 841.0)
WCFV-J-1 (NR-D1) Near Leroy, crops that may be irrigated with water from the Neosho River below the confluence with Wolf Creek	11/8/2006	Irrigated Soybeans	<360 (<137.3)	15515 ± 752 (18112.0 ± 756.0)
WC-FV-K-1 (NR-U1) 4.5 miles SSW of Wolf Creek	11/8/2006	Non-irrigated Corn	<360 (<121.4)	2085 ± 148 (2524.1 ± 609.3)
WC-FV-K-1 (NR-U1) 4.5 miles SSW of Wolf Creek	11/8/2006	Non-irrigated Soybeans	<360 (<107.1)	11341 ± 689 (14696.0 ± 609.3)
WC FV-N-1 (WC-N-1) 2.4 miles west of Wolf Creek	6/15/2007	Horseradish Leaves	2808 ± 271 (858.1 ± 229.8)	10448 ± 1105 (2787.3 ± 439.7)
E-1 Scott Valley Church Control	5/8/2007	Pasturage	6807 ± 649	16842 ± 1321
A-1 Sector A, Sharpe/Pasture near Sharpe	5/8/2007	Wildflowers	5400 ± 624	17714 ± 3430
H-1 East of CCL dam, near WCA H-1	5/8/2007	Pasturage	4048 ± 485	21647 ± 2093
P-1 (MUDS) CCL public access area, north side of parking lot, 10 m from shore	6/22/07	Pasturage	749 ± 111 (407.5 ± 192.9)	11618 ± 1005 (4952.7 ± 336.8)
R-1 (EEA) CCL environmental education area	5-21-07	Tallgrass	1542 ± 233 (739.5 ± 283.4)	28646 ± 1941 (7001.4 ± 506.6)

Kansas Department of Health and Environment
 Environmental Radiation Surveillance Report
 Wolf Creek Generating Station
 SFY 2007

TABLE 12.1 ERS random samples for airborne radionuclide deposition on **terrestrial vegetation** SFY 2007

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, 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. See Map #6.0 for sample location. WCNOG sample location designations are denoted by parentheses.

Location	Date	Description	Nuclide	
			⁷ Be	⁴⁰ K
17th and Trefoil	7/18/2006	Wild carrot	4422 ± 359	16842 ± 1321
20th and Reaper	7/18/2006	Pasturage	2848 + 346	13507 ± 549
12th and Shetland	7/27/2006	Corn on cob	<360	2256 ± 133
15th and Underwood	8/31/2006	Milo	822 ± 80	4031 ± 378
19th Rd. Between Native and Oxen	9/7/2006	Corn	<360	2266 ± 159
10th Rd between Native and Oxen	9/7/2006	Corn	<360	9546.8 ± 846.3
Near 20th and Juneberry	9/19/2006	Soybeans	624.7 ± 150.8	21055.1 ± 4118.2
9th between Planter and Quail	9/19/2006	Red milo	2407.1 ± 332	7035.6 ± 679.9
New Strawn Golf Course	9/26/2006	Apples	<360	2117.5 ± 128.5
One Mile North of Wolf Creek	6/28/2007	Wheat	<360	4084 ± 1045

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
SFY 2007

Table 13.0 KDHE Radiochemistry Laboratory ERA Intercomparison Studies

Analyte	Date	Average Reported Value (pCi/L)	Assigned Value (pCi/L)	Acceptance Limits (pCi/L)	Performance Evaluation
Sr-89	1/8/07	62.4	60.8	52.1 - 69.5	Acceptable
	4/9/2007	37.4	35.4	26.7 - 44.1	Acceptable
	7/9/07	59.6	58.2	49.5 - 66.9	Acceptable
Sr-90	1/8/07	28.2	28.1	19.4-36.8	Acceptable
	4/9/2007	39.8	42.1	33.4-50.8	Acceptable
	7/9/07	17.5	19	10.3-27.7	Acceptable
Ba-133	1/8/07	92.2	90.5	74.8-106	Acceptable
	7/9/07	17.8	19.4	10.7-28.1	Acceptable
Cs-134	1/8/07	90.5	88.9	80.2-97.6	Acceptable
	7/9/07	61.6	68.9	60.2-77.6	Acceptable
Cs-137	1/8/07	231	231	211-251	Acceptable
	7/9/07	54.4	61.3	52.6-70.0	Acceptable
Co-60	1/8/07	106	101	92.2-110	Acceptable
	7/9/07	31.9	33.5	24.8-42.2	Acceptable
Zn-65	1/8/07	357	350	289-410	
	7/9/07	53	54.6	45.2-64.0	Acceptable
Gross Alpha	1/8/07	11.1	12.7	4.04-21.4	Acceptable
	4/9/2007	54.2	56.5	32.0-81.0	Acceptable
	7/9/07	25.2	27.1	15.4-38.8	Acceptable
Gross Beta	1/8/07	37.1	36.2	27.5-44.9	Acceptable
	4/9/2007	24.6	25.3	16.6-34.0	Acceptable
	7/9/07	13.9	11.5	2.84-20.2	Acceptable
I-131	1/8/07	15	14.7	11.2-18.2	Acceptable
	4/9/2007	18.6	18.9	13.7-24.1	Acceptable
	7/9/07	26	26.5	21.3-31.7	Acceptable
H-3	1/8/07	11000	11300	9340-13200	Acceptable
	7/9/07	1720	1770	1180-2360	Acceptable

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
SFY 2007

TABLE 14.0 KHEL Radiochemistry Laboratory method detection limits SFY 2007

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 mRmilk 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 mRmilk 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.

Kansas Department of Health and Environment
 Environmental Radiation Surveillance Report
 Wolf Creek Generating Station
 SFY 2007

Table 14.0 continued. KHEL Radiochemistry Laboratory method detection limits SFY 2007

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		

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
SFY 2007

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 WCNOG'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 samples. If no drinking water pathway exists, a value of 3000 pCi/R may be used.

^d LLD for drinking water samples. If no drinking water pathway exists, the LLD of gamma isotopic analysis 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.

GRAPHS

PAGE

1.0 Weekly Air Particulate Sample Comparison	31
2.0 Quarterly Direct Radiation Results for all KDHE Direct Radiation Sites.....	32
2.1 Quarterly Direct Radiation Monitoring Results for Collocated Sites	33
2.2 Comparison of WCNOG and KDHE Average Direct Radiation Readings.....	34
2.3 Historical KDHE Direct Radiation Monitoring (TLD) Results	35
3.0 Comparison of Monthly Surface Water Tritium Results.....	36
3.1 Historical KDHE Surface Water Tritium Results	37

Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
SFY 2007

KDHE Air Particulate Be-7 Activity

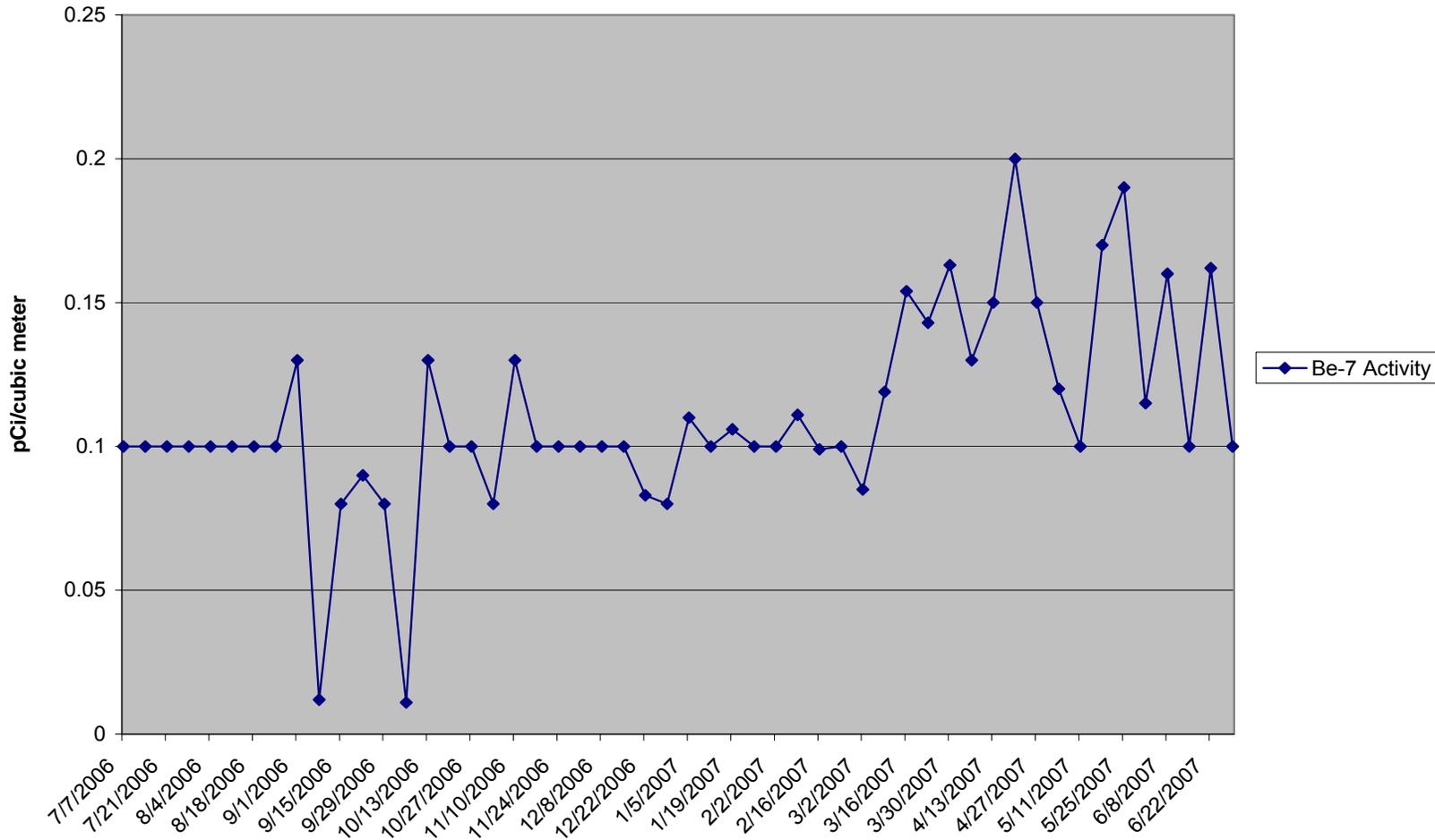


Chart 1.0 KDHE Air Particulate Activity
Weekly results of Be-7 concentration in composite of 5 sample locations.

Kansas Department of Health and Environment
 Environmental Radiation Surveillance Report
 Wolf Creek Generating Station
 SFY 2007

KDHE Quarterly Direct Radiation by Sector

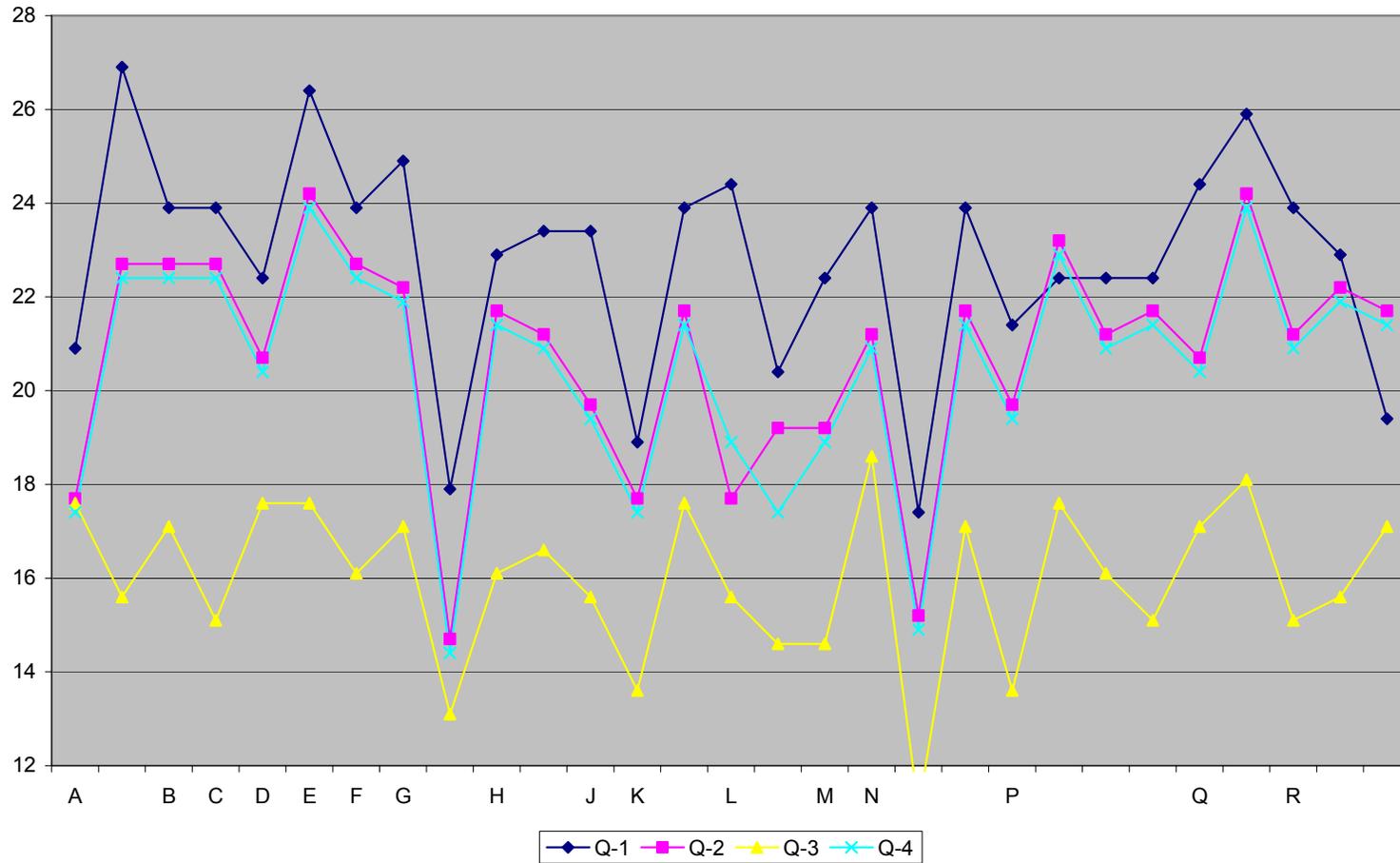


Chart 2.0 Quarterly Direct Radiation Results for all KDHE Direct Radiation Sites.
 Average quarterly direct radiation per sector in mR/Quarter.

Kansas Department of Health and Environment
 Environmental Radiation Surveillance Report
 Wolf Creek Generating Station
 SFY 2007

Quarterly Direct Radiation Dose (mR/Quarter)
 Collocated Sites (By Sector)

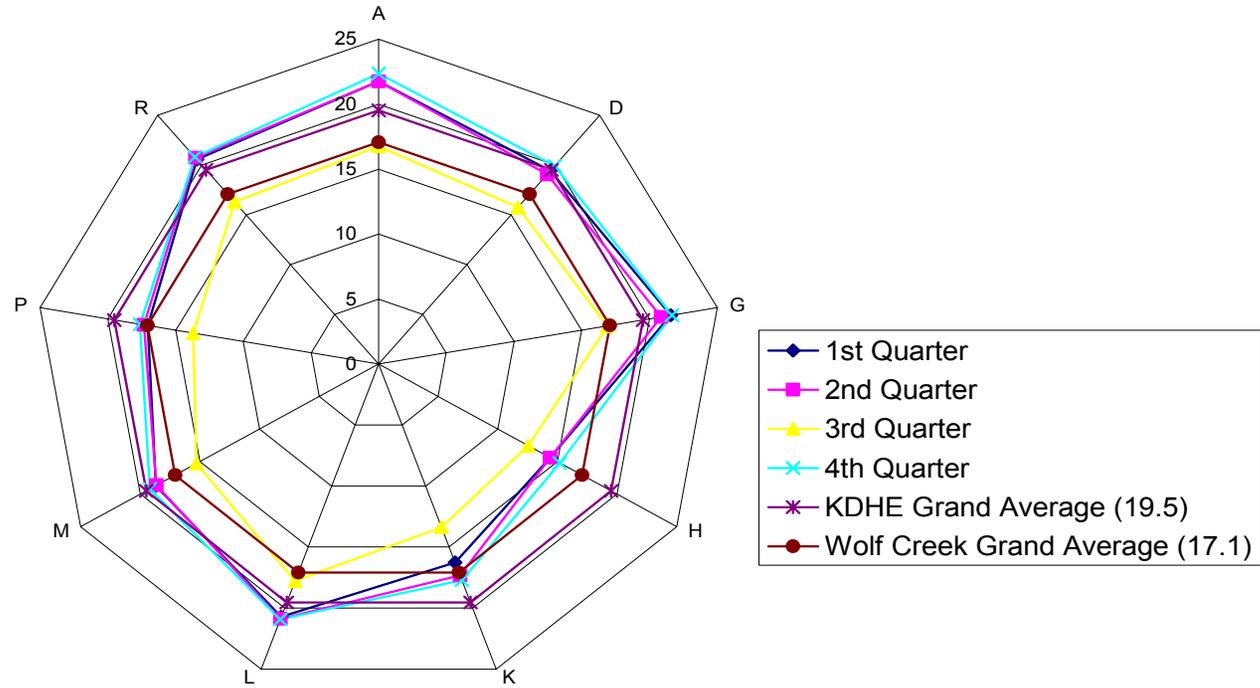


Chart 2.1 Quarterly Radiation Comparison for Collocated Sites
 Average of KDHE/WCNOC results for each sector in mR/Quarter

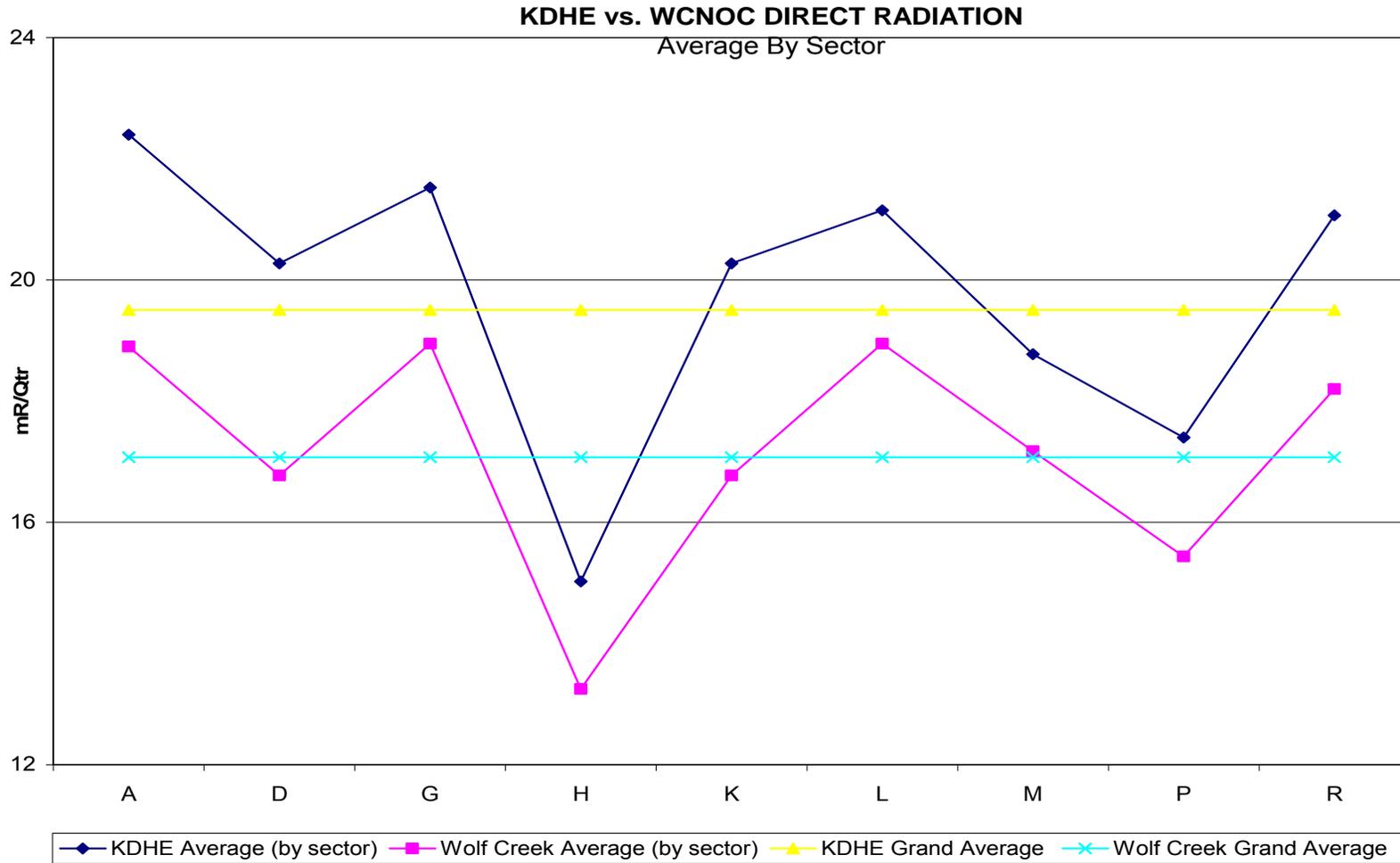


Chart 2.2 Comparison of WCNOC and KDHE Average Direct Radiation Readings
Side-by-side comparison of KDHE and Wolf Creek average direct radiation readings (OSLD/TLD) in mR/Quarter.

C

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 Wolf Creek Generating Station
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Historical TLD Results

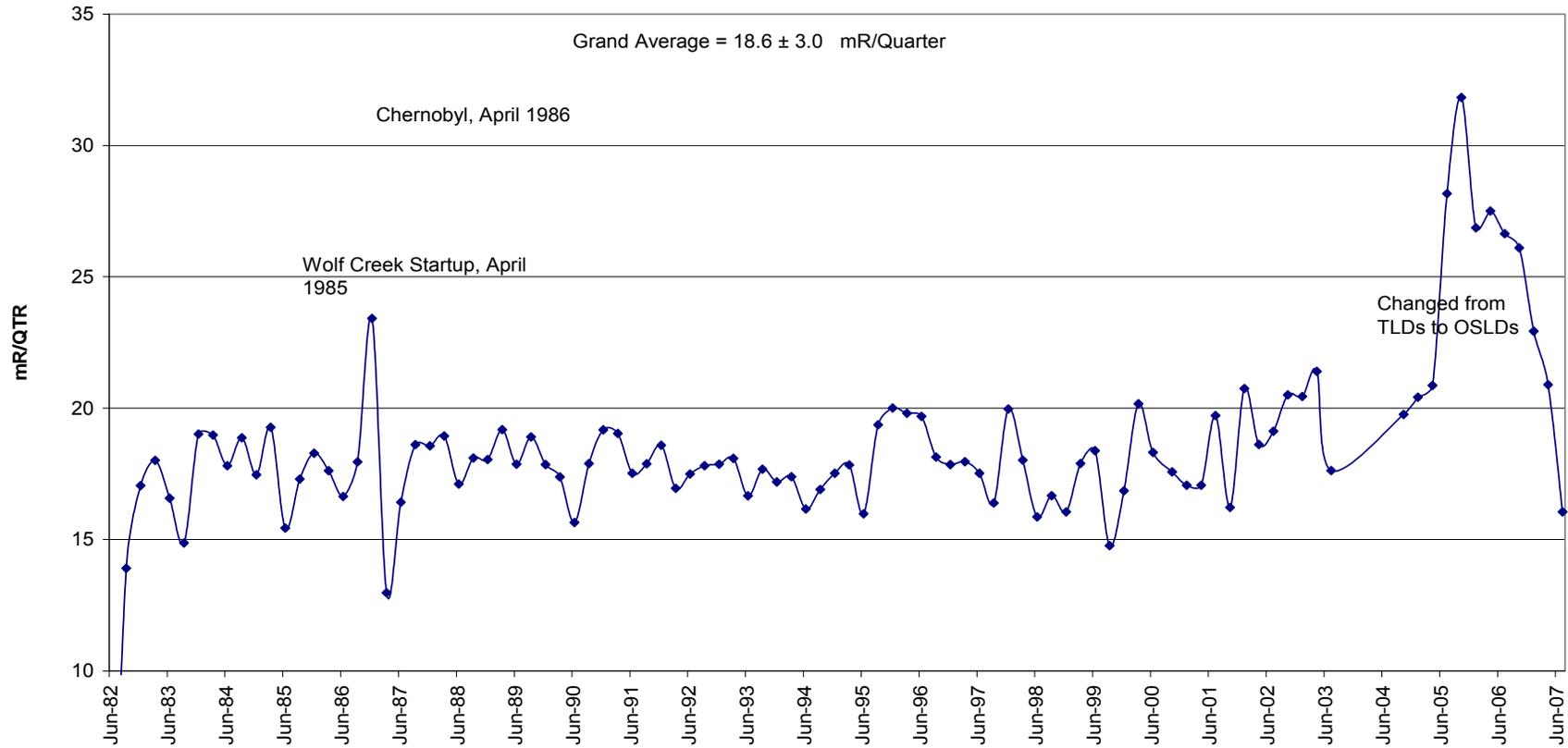


Chart 2.3 KDHE Historical Direct Radiation Monitoring (TLD) Results
Average direct radiation dose per quarter since initiation of ERS Program

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Wolf Creek Generating Station
SFY 2007

KDHE/Wolf Creek Surface Water

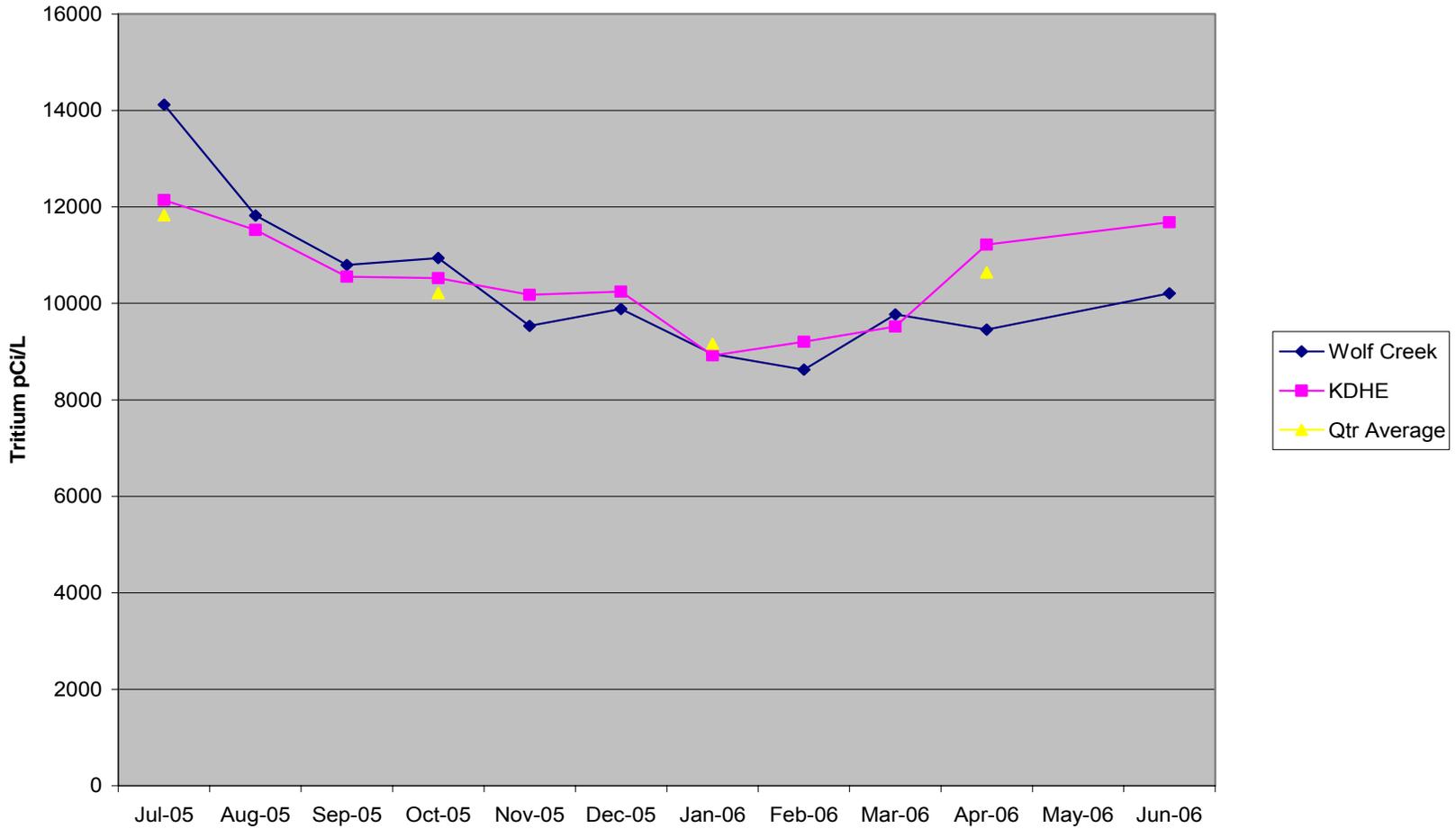


Chart 3.0 Comparison of Monthly Surface Water Tritium Results

Direct comparison of monthly KDHE/WCNOG surface water tritium results, and the quarterly average of KDHE/WCNOG results.

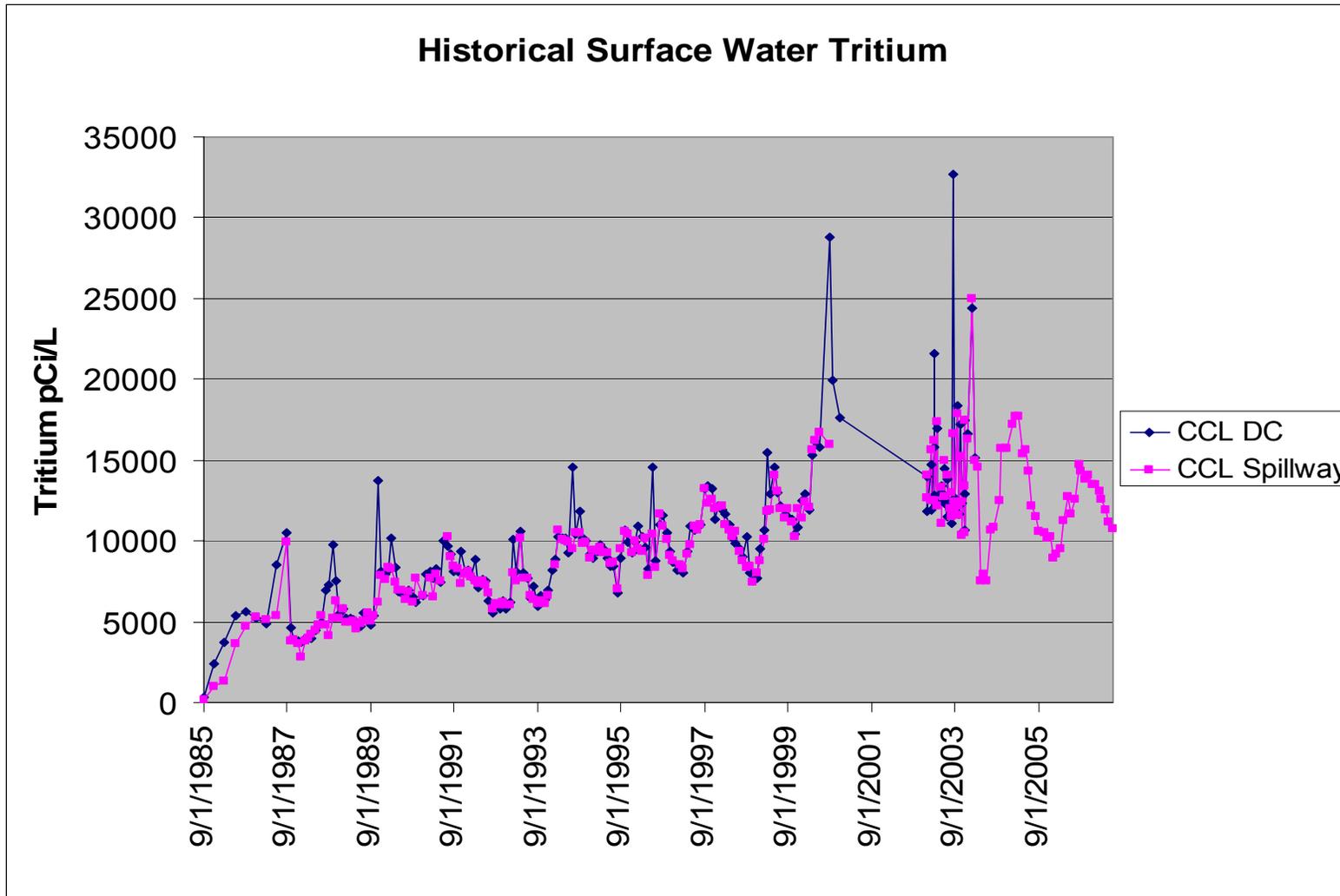


Chart 3.1 Historical KDHE Surface Water Tritium Results

Surface water tritium in pCi/L during ERS program lifetime. Discharge Cove (DC) sample discontinued 2003.

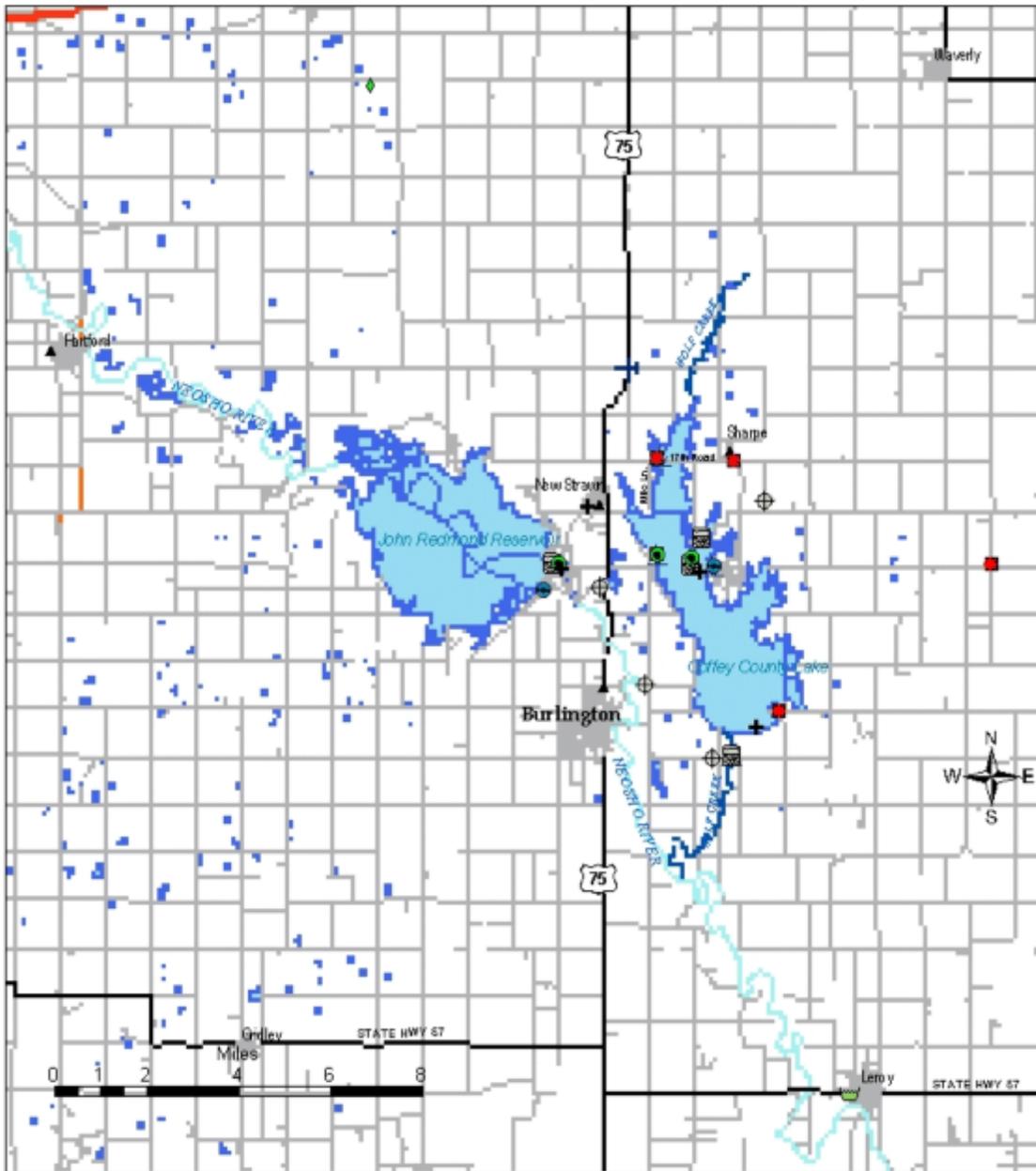
Kansas Department of Health and Environment
Environmental Radiation Surveillance Report
Wolf Creek Generating Station
SFY 2007

Maps

Page

1.0	Routine Sample Locations.....	39
2.0	KDHE OSLD Locations.....	40
3.0	Random Sample Locations.....	41

Kansas Department of Health and Environment
 Environmental Radiation Surveillance Report
 Wolf Creek Generating Station
 SFY 2007

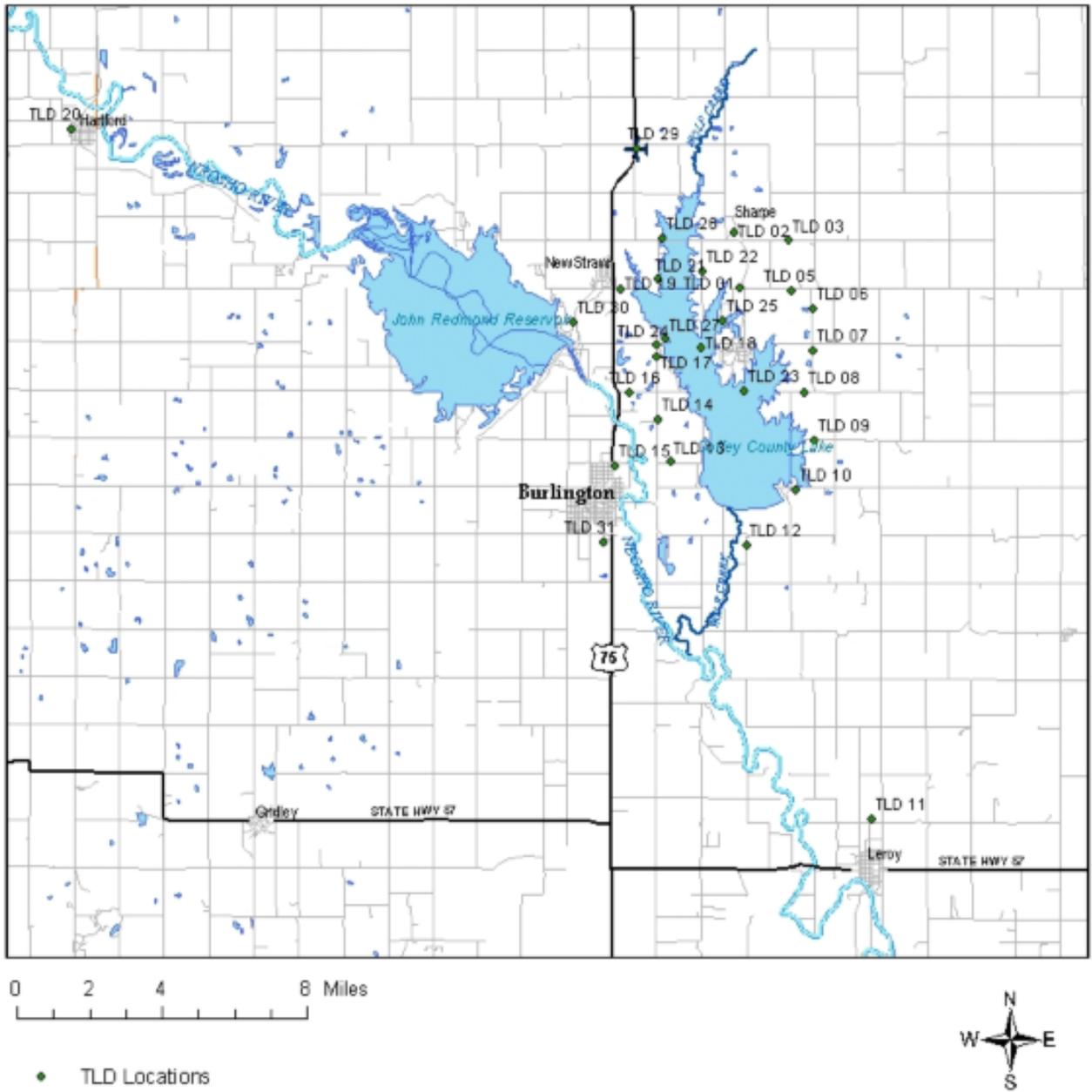


Routine Sample Locations

- | | | |
|--|--|---|
|  Aquatic Vegetation |  Drinking Water |  Ground Water |
|  Air Monitor |  Fish |  Milk |
|  Bottom Sediment |  Vegetation |  Soil |
| |  Shoreline Sediment |  Surface Water |

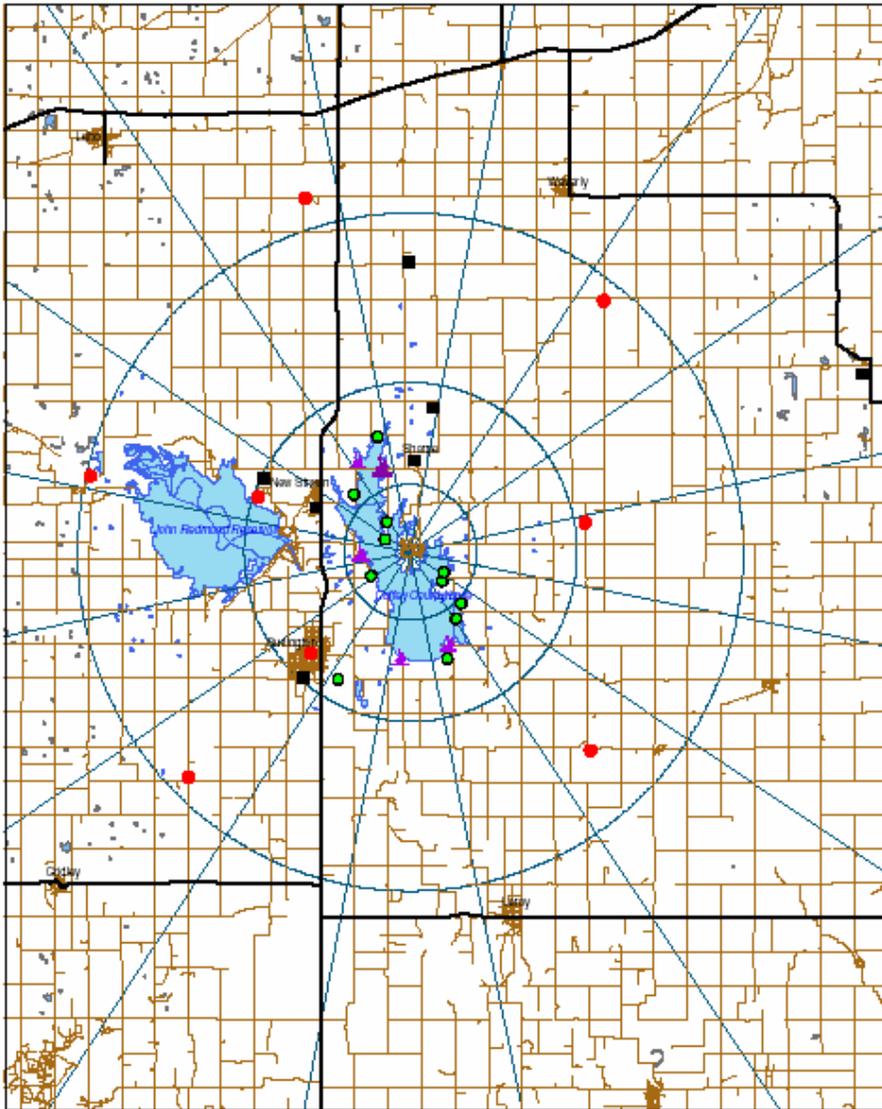
Map 1.0 Routine Sample Locations

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Map 2.0 KDHE OSLD (Shown as TLD) Locations

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Random Sample Locations



0 0.5 1 2 3 4 Miles

- Vegetation
- Soil
- Shoreline Sediment
- ▲ Aquatic Vegetation

Chart 3.0 Random Sample Locations