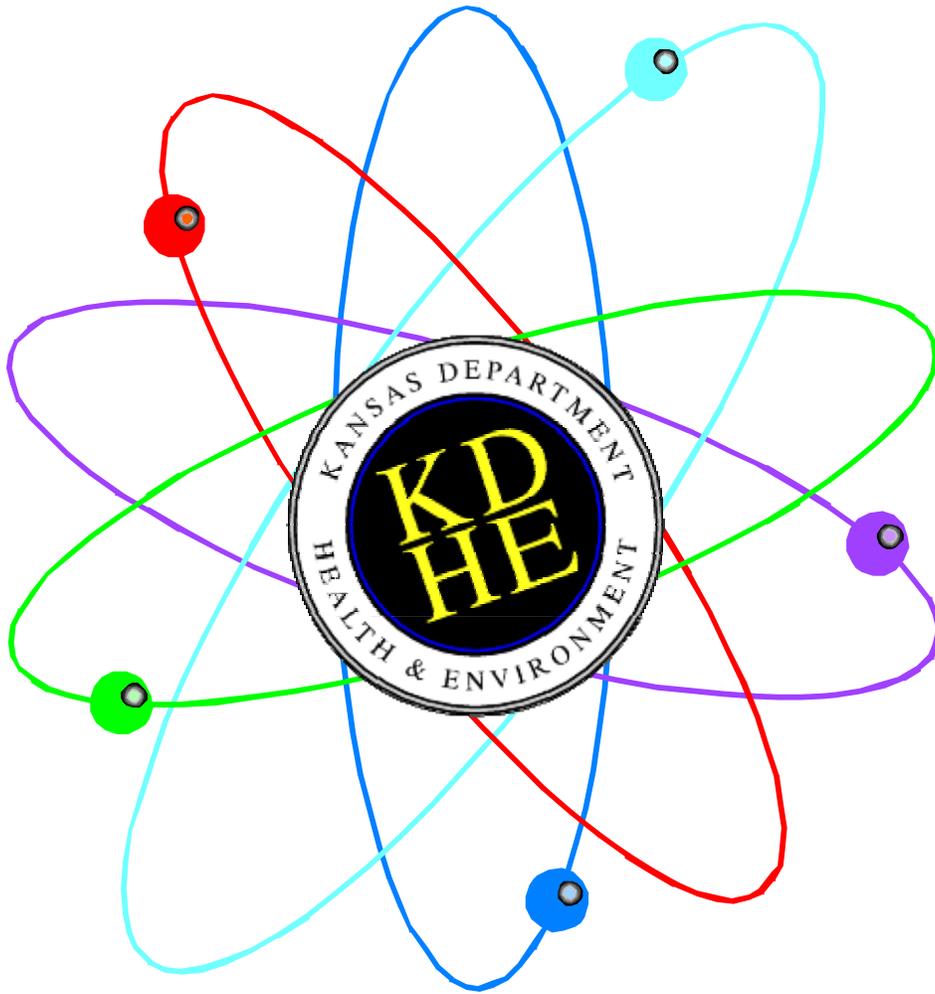


Kansas Department of Health and Environment
Report of Radiological Environmental Monitoring of the Environs Surrounding
Wolf Creek Generating Station



July 2003-June 2004
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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, 2003 through June 30, 2004.

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, instituted in 1985, 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.

Following an internal review in SFY 2003 improvements in the efficiency and the quality of the program were identified. As a result, in July 2003 a revised program was approved and implemented by KDHE. The changes involved replacement of the Victoreen axial bulb thermoluminescent dosimeters for direct radiation monitoring with optically stimulated luminescence dosimetry obtained on contract from Landauer, Inc. For SFY 2004 OSLDs were used alongside TLDs. The primary purpose of the program remains the same, the focus being the detection of radioactive material from effluent releases and evaluation of the long-term effects of Wolf Creek operations on the environment of Coffey County and Kansas.

Although not its primary function, the ERS program is also essential to the State's *Nuclear Facilities Incident Response Plan*. If an unplanned release of radioactive materials from WCGS should occur, data collected from air and radiation-monitoring sites will be used to determine doses to affected populations and to assess potential environmental impacts.

The ERS program includes the following monitoring methods:

- Measurement of ambient external radiation levels using thermoluminescent and 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, milk, 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 2004 is presented as Table I.

Program Description and Elements

State program samples were delivered to Kansas Health and Environment Laboratories (KHEL) Radiochemistry Laboratory at Forbes Field for analysis. State TLDs were processed by the Environmental Radiation and Emergency Preparedness (ER&EP) section of the Radiation and Asbestos Control Program of the Bureau of Air and Radiation.

Wolf Creek 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 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

Air samples are 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 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 TEDA (Triethylene diamine) 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 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 done 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

Direct radiation monitoring is accomplished using Victoreen Model 2600-49 axial bulb manganese-doped calcium fluoride ($\text{CaF}_2: \text{Mn}$) TLDs and Landauer Luxel OSLDs. The TLDs are read on a Victoreen 2800M reader. OSLDs are read by Landauer. TLDs are individually calibrated to ^{137}Cs (cesium) and each reading is corrected for fading, self-irradiation, and dose received in transit. 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. Three bulb dosimeters and 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 collocated TLDs/OSLDs with WCNOG at fourteen sites. WCNOG uses Panasonic Model UD-814-AQ TLDs. Each dosimeter consists of one lithium borate element and three calcium sulfate elements in a plastic case.

OSLDs were utilized to determine their suitability to replace TLDs owing to the age, obsolescence and lack of reliability of the KDHE's TLD reader. A quarterly comparison of OSLD results indicated that the ratios of OSLD readings to TLD readings were 1.1 for quarter 1 (July-September 2003), 1.4 for quarter 4 (October-December 2003), 0.9 for quarter 3 (January-March 2004) and 0.7 for quarter 4 (April-June 2004), with an overall average of 1.1. Accordingly, OSLDs will be utilized in place of TLDs commencing in SFY 2005.

Surface water

Surface water sampling is done by the collection of one-gallon grab samples at the indicated locations. A control sample is collected monthly from John Redmond Reservoir. Two samples are collected from the Coffey County Lake, one monthly at the discharge cove and the other at the spillway. A sample is also collected annually from the New Strawn City Lake. The discharge canal sample was discontinued by WCNOG in February 2004.

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. Gross alpha+beta analysis is done on each CCL discharge cove sample. Samples are split with WCNOG.

Ground water

Ground water is collected annually at wells in sectors B (control), L, and N. The control sample location is hydrologically up gradient from the facility and the other three are hydrologically down gradient. Samples are split with WCNOG. The previously sampled location in sector J was not sampled by WCNOG.

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

Drinking water

Two public water supplies, which use the Neosho River as their source, were sampled for drinking water. Burlington, upstream from WCGS, was sampled as a control location, and LeRoy, the first public water supply downstream of WCGS, was sampled as a monitoring location. Both sites are collocated with WCNO. WCNO operated and maintained water samplers both at Burlington and at LeRoy. WCNO water samplers collect 27 ml every two hours over a 30-day period. WCNO personnel collect the samples monthly. The LeRoy samples are split with KDHE. Sample collection at both locations was terminated when LeRoy stopped using the Neosho River source and started purchasing finished drinking water from Burlington in February 2004.

Samples are analyzed for tritium, and gamma isotopes.

Milk

Milk samples were collected in quarters 2, 3 and 4 in Coffey County at the Linsey Dairy near Lebo, KS. These samples are controls as no indicator locations are available within the 10-mile Emergency Planning Zone of WCGS. The planned sample during quarter 1 was not obtained due to staff scheduling conflicts.

Each milk sample is analyzed for low levels of radioiodine and other gamma emitting nuclides. A strontium analysis is done annually.

Sediment and soil

Shoreline sediment, bottom sediment and soil samples were taken in the environment surrounding WCGS. Sediment samples for trending were collected annually in the Coffey County Lake discharge cove, public environmental education area, and public fishing area. Sediment samples for trending were also collected on Wolf Creek below the Coffey County Lake dam and at John Redmond Reservoir. The sediment samples obtained at John Redmond Reservoir are used as controls. The Coffey County Lake and John Redmond Reservoir trending sediment samples are split with WCNO.

Random sediment samples were collected at 12 locations (bottom or shoreline) on Coffey County Lake and 4 locations on the Neosho River and Wolf Creek.

Annual soil samples for trending were collected close to Sharpe, east of WCGS at the Scott Valley Church (control), east of the Coffey County Lake dam, and at the Coffey County Lake public fishing and environmental education areas. Trending soil samples collected from the

Coffey County public use areas are split with WCNO. Random soil samples were collected at 10 locations within the 50-mile Ingestion Pathway Zone (IPZ) concentrating in downwind sectors within the 10-mile Emergency Planning Zone (EPZ).

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

Fish, game animals, and domestic meat

Fish samples were collected from the Coffey County Lake and below John Redmond Reservoir on the Neosho River. Sample portions from fish collected in the Coffey County Lake and below John Redmond Reservoir on the Neosho River were split with WCNO. Fish collected at John Redmond Reservoir on the Neosho River are used for control samples. A total of nine species of fish 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 WCNO and split with KDHE for laboratory analysis. One road-kill deer specimen was obtained.

Domestic meat samples are obtained on an as available basis. One specimen of free-range domestic hen was obtained from western Coffey County.

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.

Terrestrial and aquatic vegetation

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 WCNO property, garden vegetables collected from gardens near WCGS, and samples of crops irrigated with water from the Neosho River were split with WCNO. There were five annual pasturage, and two grain (feed) samples collected. There were fourteen random samples for pasturage, food and feed collected.

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

As available, semiannual aquatic vegetation (algae and/or rooted aquatics) trending samples are normally collected from the Coffey County Lake, Wolf Creek below the Coffey County Lake dam, and John Redmond Reservoir. The aquatic vegetation samples obtained at John Redmond Reservoir are used as controls. The Coffey County Lake samples are split with WCNO.

Gamma isotopic analysis is done on all aquatic vegetation samples 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 a Harshaw 3-inch x 3-inch NaI (TI) crystal, a 105cc (20 percent efficiency) GeLi crystal, a 40 percent efficient high purity Ge crystal, and a 15 percent efficient high purity Ge crystal.

Low background alpha/beta system

An Oxford Series 5XLB and a Tennelec 5100 alpha/beta low background IPC system is used for strontium (^{89}Sr and ^{90}Sr), radium (^{228}Ra), and gross beta counting.

Internal proportional counter (IPC)

Gross alpha and radium analyses are performed with Nuclear Measurement Corporation (NMC) windowless gas flow IPC systems.

Liquid scintillation

Analysis for tritium in water is performed using a Beckman LS-230 and a Wallace-1409 liquid scintillation system.

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.

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). TLD exposure results are expressed as milliRoentgen (mR) per a 90-day quarter. One mR is equivalent to ten micro-Grays (10 μ Gy 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), 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. WCNOG'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 2004. Radionuclides detected in the environment surrounding WCGS during SFY 2004 include ²²⁸Ac, ⁷Be, ⁶⁰Co, ¹³⁷Cs, ³H, ⁴⁰K, ²²⁶Ra, ¹²⁵Sb and ²²⁸Th. The isotopes ²²⁸Ac, ⁷Be, ⁴⁰K, ²²⁶Ra, and ²²⁸Th are naturally occurring radionuclides common in the environment. The isotopes ¹³⁷Cs and ³H are fission products from WCGS nuclear reactor operation. The isotopes ⁶⁰Co and ¹²⁵Sb are activation products, also the result of WCGS nuclear reactor operation. A small background component of the ³H (half-life = 12.3 y) and ¹³⁷Cs (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 ¹³⁷Cs 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.

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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 2004 was 32,676 pCi/l in February 2004. This maximum Coffey County Lake ^3H concentration is 164% 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 2004 was 16,350 pCi/l, or 82% of MCL. Coffey County Lake is not approved for any aquatic recreation other than fishing. All other non-CCL surface water, ground water, and drinking water samples collected in the environs of WCGS during SFY 2004 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. A total of twelve samples were taken this SFY; seven random samples and five routine trending samples.

Sediment samples have been excellent indicators for the long-term buildup of fission and activation product activity levels in the Coffey County Lake. A total of 24 sediment samples were taken this fiscal year; (seventeen random and seven trending). The highest fission product activity in sediments during SFY 2004 was 259 pCi/kg-dry ^{137}Cs found in CCL (WCRBS-1-P-289-1.1). The highest activation product activity observed during SFY 2004 was 68 pCi/kg-dry ^{60}Co found in Coffey County Lake bottom sediment sample WCRBS-3-Q-318-1.5.

Airborne sample analysis indicated that no radionuclides attributable to the operation of WCGS were present above the lower limits of detection during SFY 2004.

Sample analysis of terrestrial vegetation, soil, milk, grain, and vegetable samples collected in the environs of WCGS during SFY 2004 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 2004. Sample analysis of edible fish portions collected in the environs of WCGS during SFY 2004 indicated that no gamma emitters attributable to WCGS operation were present. Fish samples collected during SFY 2004 were analyzed for ^3H in tissue (fat and water). The highest ^3H concentration in tissue was 15,470 pCi/kg-wet found in a Walleye 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 15,470 pCi/kg ^3H would receive a committed effective dose equivalent of 0.021 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 grand yearly average of all sites was 73 mR/y, corresponding to 8 $\mu\text{R/h}$. 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

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monitored site. The average baffle dike direct radiation level for SFY 2004 was 51 mR/y; corresponding to 6 μ R/h. 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.

Summary statistics for SFY 2004, including data comparisons between KDHE and WCNOG are contained in tables I and II. The ratio of KDHE results to WCNOG results ranged from 1 to 5. A summary of comparison data may be found in Tables III and IV. Data tables, graphs, and maps are also attached.

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Table 1. ERS Program summary report for SFY 2004

Type of Sample	Number of Sampling Stations	Total Samples Collected
Air (particulate and iodine)	5	519
Direct Radiation	31	620
Surface Water	4	33
Ground Water	3	3
Drinking Water	1	7
Sediments	7	7
Random Sediments	12	17
Aquatic Vegetation	5	5
Random Aquatic Vegetation	6	7
Milk	1	3
Fish	2	13
Game Animals/Domestic Meat	0	2
Soil	5	5
Random Soil	10	10
Terrestrial Vegetation	7	7
Random Terrestrial Vegetation	10	10
Grand Total	109	1266

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Table II. ERS Program summary statistics SFY 2004

Description	Average	Standard deviation	Standard error of the mean	Min	Max	N
TLD direct radiation, mR per 90 day quarter	18.2	2.9	0.26	7.0	26.8	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	*	*	<350 (<169)	<350 (<84)	12
Coffey County Lake (Q-1/DC)	19240	609	3510 (3648)	12076 (14475)	32676 (26793)	7
Coffey County Lake (J1A/SP)	14422	522	3472(3627)	7550 (12092)	24992 (17277)	12
Ponds surrounding WCGS	355	273	*	355	355	1
Drinking water tritium (³ H), pCi/l						
LeRoy	<350	*	*	<350	<350	7
Ground water tritium (³ H), pCi/l (All Stations)	<350	*	*	<350	<350	3
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, milk, 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	259 ± 17 ¹³⁷ Cs (gamma)					
Coffey County Lake fish, wet	Walleye: 15470 ± 1281 ³ H (beta)					
^a Corresponds to 9 µR/h. ORNL/TM-7343 (1981) gives background radiation levels in Kansas ranging from 7 µR/h to 14 µR/h with an average background of 10±1 µR/h (N=6). Measurements were taken along I-70 from western Kansas to eastern Kansas. ^b Total number of TLD readings evaluated (31 locations with 3 TLDs each read 4 times per year).						

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TABLE III. ERS program data comparison^a summary statistics SFY 2004.

Description	Average	Standard Deviation	Standard error of the mean	Min	Max	N
TLD direct radiation, mR ^b	17.2 (18.4)	1.9 (1.4)	0.26 (0.2)	7 (11.4)	25.2 (22.8)	52 (51)
Airborne particulate filter and charcoal cartridge gamma isotopic analysis	Gamma isotopic analysis by both KDHE and WCNOG (Teledyne) 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 discharge cove, Q-1 (DC)	19240 (17347)	610 (374)	216 (132)	12076 (13040)	32676 (26793)	12
CCL ^c spillway, J-1A (SP)	14422 (14622)	522 (344)	151 (99)	7550 (12092)	24992 (17277)	8
JRR ^d below dam (control), N-1 (MUSH)	<350 (<154)	*	*	*	*	12
Ground water ³ H, pCi/l	<350 (<157)	*	*	*	*	3
LeRoy drinking water ³ H, H-1	<350 (<161)	*	*	*	*	7(3)
Surface, ground, and drinking water gamma isotopic analysis	Gamma isotopic analysis by both KDHE and WCNOG (Teledyne) showed 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: CCL Random Sample, 259 ± 17 ¹³⁷ Cs (gamma)					
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. Beta emitter: Composite of Walleye 15470 ± 1281 ³ H-wet (8798 ± 198 ³ H-wet),					
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.					
Milk, soil, terrestrial vegetation	Gamma isotopic analysis by both KDHE and WCNOG (Teledyne) showed that no comparable gamma emitters attributable to Wolf Creek Generating Station operation were present above the lower limits of detection in any milk, 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.

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Table IV Data comparison summary by selected analysis SFY 2004

Analysis	Average Ratio of KDHE results to WCNOC results ^a	Comments
Air Particulate Filter Gamma Isotopic	1.27 N=4	Isotope used for comparison was ⁷ Be (T _{1/2} = 53 days). WCNOC composites filters by location for quarterly analysis, KDHE analyzes a five-filter composite across all locations. Comparison was made using quarterly averages.
TLD Direct Radiation	0.93 N=52	13 collocated sites.
Surface Water ³ H	1.04± 0.08 N=24	Coffey County lake spillway and discharge canal
Bottom sediment gamma isotopic	1.29 N=6	Isotopes used for the comparison were ¹³⁷ Cs and ⁴⁰ K
Fish tritium (³ H) in tissue	1.3 N=13	WCNOC 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.

^a KDHE/WCNOC

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TABLE 1.0 KDHE weekly samples for airborne particulate radionuclides SFY 2004. Gross beta-gamma field counts in ncpm (net counts per minute). Weekly five-charcoal cartridge and five-particulate filter composite gamma isotopic analysis indicated that no gamma emitters attributable to Wolf Creek operation were present above the method detection limits. WCNOG sample location designations are denoted by parentheses.

Date	A-1 (2) Sharpe	H-1(18) East of CCL dam	L-1 Burlington	P-1 (32) New Strawn	D-1 (48) Harris control
7/3/03	288	325	302	383	396
7/10/03	1132	938	Not Collected	963	1452
7/17/03	336	469	530	251	538
7/24/03	434	394	412	320	1248
7/31/03	692	898	620	649	623
8/7/03	438	468	434	470	663
8/14/03	440	456	581	335	938
8/21/03	338	316	250	277	382
8/28/03	470	404	622	789	414
9/4/03	168	135	198	164	177
9/11/03	225	225	264	246	276
9/18/03	320	379	387	398	313
9/25/03	263	323	410	418	306
10/2/03	368	418	447	491	261
10/9/03	191	217	214	238	279
10/16/03	600	292	648	651	917
10/23/03	714	887	1012	694	860
10/30/03	290	397	361	547	287
11/6/03	335	431	415	496	318
11/13/03	374	413	465	293	522
11/20/03	391	292	309	281	303
11/27/03	410	495	243	253	1395
12/4/03	200	168	151	205	247
12/11/03	306	334	185	243	352
12/18/03	299	151	159	178	207
12/25/03	292	423	342	371	352
1/1/04	324	265	237	295	501
1/8/04	207	315	268	365	378
1/15/04	573	670	608	549	753
1/22/04	116	158	96	120	120
1/29/04	301	414	353	437	387
2/5/04	395	347	522	627	350.3
2/12/04	164	184	152	180	264.8
2/19/04	260	230	412	208	445
2/26/04	230	240	212	212	265
3/4/04	185	140	180	125	155
3/11/04	356	328	376	274	365
3/18/04	272	224	204	253	275
3/25/04	124	150	121	120	129
4/1/04	147	108	118	135	120
4/8/04	192	170	193	201	242
4/15/04	285	310	270	308	247
4/22/04	186	216	156	158	149
4/29/04	123	160	111	146	160
5/6/04	194	243	270	280	273
5/13/04	249	243	237	252	93
5/20/04	144	191	180	186	145
5/27/04	180	235	235	194	202
6/3/04	266	274	320	283	344
6/10/04	77	89	117	107	104
6/17/04	143	160	160	145	34
6/24/04	181	222	235	283	230

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. The naturally occurring radioisotope ⁷Be was detected on the particulate filter composite samples (0.06 pCi/m³ to 0.17 pCi/m³ with a mean of 0.12±0.017 pCi/m³, N=50). See Map #1.0 for sample locations.

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TABLE 2.0a Wolf Creek quarterly **direct radiation** monitoring SFY 2004. Direct radiation monitoring results in mR. Reported results include errors associated with correction factors. Exposures are normalized to a 90-day quarter. Results are expressed as the average of three TLD readings per location \pm total uncertainty (\pm_{UNC}). ^a 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	17.0 \pm 1.4	16.7 \pm 1.4	18.1 \pm 2.6	16.9 \pm 1.4
2. A-2, Sharpe	18.5 \pm 1.3	18.2 \pm 0.9	15.5 \pm 2.3	16.2 \pm 1.0
3. A-3, Forward Staging Area	18.6 \pm 1.3	14.7 \pm 0.9	18.6 \pm 1.9	16.2 \pm 1.2
4. B-1, East Sharpe	19.2 \pm 1.6	16.5 \pm 0.9	20.0 \pm 1.8	17.9 \pm 1.4
5. B-2, Waverly Control	21.3 \pm 1.3	16.9 \pm 2.0	20.9 \pm 2.5	19.0 \pm 1.8
6. C-1, near residence	18.4 \pm 2.0	17.7 \pm 1.3	18.9 \pm 2.3	18.4 \pm 2.0
7. D-1 (9), near residence	19.3 \pm 1.3	16.4 \pm 1.8	17.7 \pm 1.7	18.1 \pm 1.7
8. E-1, near residence	18.1 \pm 1.5	17.8 \pm 2.4	18.1 \pm 2.5	19.0 \pm 2.6
9. F-1, near residence	18.9 \pm 2.6	18.7 \pm 1.1	18.4 \pm 1.8	23.6 \pm 1.7
10. G-1 (14), WCNOG gate	21.8 \pm 2.1	17.6 \pm 1.0	23.4 \pm 4.4	18.5 \pm 5.1
11. H-0 (42), CCL baffle dike A	7.0 \pm 1.3	14.4 \pm 2.3	14.8 \pm 8.1	13.5 \pm 1.2
12. H-1, east of CCL dam	17.6 \pm 1.6	20.3 \pm 1.4	16.9 \pm 1.9	18.8 \pm 1.9
13. H-2, LeRoy control	16.7 \pm 1.3	18.5 \pm 1.5	17.3 \pm 2.0	18.5 \pm 1.5
14. J-1, near residence	16.2 \pm 1.3	17.4 \pm 1.5	26.8 \pm 9.8	18.8 \pm 1.5
15. K-1 (29), near residence	14.8 \pm 1.6	13.5 \pm 1.0	16.1 \pm 1.9	13.5 \pm 1.0
16. L-1 (27), near residence	18.4 \pm 1.1	18.9 \pm 0.9	17.8 \pm 1.6	20.3 \pm 0.9
17. L-2, Burlington	13.7 \pm 3.6	18.0 \pm 2.2	18.2 \pm 5.0	17.8 \pm 2.2
18. L-3, Coffey County Shop	16.3 \pm 1.4	17.0 \pm 1.2	16.7 \pm 1.7	16.2 \pm 1.8
19. M-1 (26), near residence	17.0 \pm 1.3	17.3 \pm 1.0	16.4 \pm 1.8	19.4 \pm 1.4
20. N-1, near pasture	15.9 \pm 1.3	25.3 \pm 5.4	17.6 \pm 1.7	20.0 \pm 1.3
21. P-0 (43), CCL baffle dike B	11.6 \pm 1.3	13.5 \pm 1.2	13.0 \pm 2.3	14.3 \pm 1.1
22. P-1, New Strawn	22.0 \pm 1.1	21.7 \pm 0.9	18.3 \pm 1.8	21.1 \pm 0.9
23. P-2 (40), Hartford Control	16.8 \pm 1.4	16.3 \pm 1.8	18.2 \pm 1.8	18.0 \pm 1.7
24. P-3 (45), CCL entrance	18.9 \pm 1.5	20.5 \pm 1.5	18.7 \pm 1.6	24.4 \pm 2.8
25. P-4 (46), CCL near MUDES	19.7 \pm 1.2	16.2 \pm 1.7	17.7 \pm 2.0	19.1 \pm 1.2
26. P-5, JRR public use area	18.6 \pm 1.6	19.8 \pm 1.4	19.2 \pm 2.5	23.6 \pm 1.9
27. Q-1, near residence	18.3 \pm 1.3	20.2 \pm 1.2	25.2 \pm 5.8	20.0 \pm 2.3
28. R-0 (41), Stringtown cemetery	16.4 \pm 1.6	20.2 \pm 1.2	21.6 \pm 1.6	25.2 \pm 2.5
29. R-1 (37), near residence	12.5 \pm 1.7	17.9 \pm 1.5	18.2 \pm 2.6	19.9 \pm 0.9
30. R-2 (44), CCL EEA	16.9 \pm 1.1	19.8 \pm 1.4	15.4 \pm 4.4	21.3 \pm 1.6
31. R-3, near Coffey County Airport	14.9 \pm 2.7	19.8 \pm 0.9	18.6 \pm 1.9	21.8 \pm 1.1

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TABLE 2.0b Wolf Creek quarterly **direct radiation** monitoring SFY 2004. 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.

Location	QTR 1	QTR 2	QTR 3	QTR 4
1. A-1 (1), North of WCGS	23.1	29.8	19.1	13.1
2. A-2, Sharpe	20.1	24.8	17.1	14.0
3. A-3, Forward Staging Area	23.6	23.8	16.1	11.0
4. B-1, East Sharpe	19.6	25.3	16.6	14.0
5. B-2, Waverly Control	20.1	29.8	16.6	14.5
6. C-1, near residence	21.6	24.3	15.1	12.5
7. D-1 (9), near residence	19.1	23.3	15.6	13.0
8. E-1, near residence	20.1	23.3	18.6	14.5
9. F-1, near residence	20.1	25.3	14.6	14.5
10. G-1 (14), WCNOG gate	21.6	30.8	17.6	14.0
11. H-0 (42), CCL baffle dike A	14.1	15.8	14.6	10.0
12. H-1, east of CCL dam	20.6	25.8	18.1	13.5
13. H-2, LeRoy control	18.6	23.3	15.1	12.0
14. J-1, near residence	20.1	25.8	13.6	14.0
15. K-1 (29), near residence	15.6	23.3	16.1	9.5
16. L-1 (27), near residence	18.6	23.8	15.1	13.5
17. L-2, Burlington	20.6	23.8	17.6	13.0
18. L-3, Coffey County Shop	17.6	22.8	14.6	11.5
19. M-1 (26), near residence	15.1	19.3	14.1	11.0
20. N-1, near pasture	21.6	23.3	15.6	14.0
21. P-0 (43), CCL baffle dike B	11.6	18.3	16.6	7.0
22. P-1, New Strawn	20.6	26.3	14.6	15.5
23. P-2 (40), Hartford Control	16.1	21.3	15.6	12.5
24. P-3 (45), CCL entrance	19.1	27.8	18.6	15.5
25. P-4 (46), CCL near MUDS	20.1	25.3	17.6	13.5
26. P-5, JRR public use area	20.1	25.8	16.1	12.0
27. Q-1, near residence	20.6	26.3	17.6	14.5
28. R-0 (41), Stringtown cemetery	19.1	31.8	20.1	15.0
29. R-1 (37), near residence	19.1	28.8	15.6	13.5
30. R-2 (44), CCL EEA	20.1	22.3	18.6	14.5
31. R-3, near Coffey County Airport	19.1	24.3	17.1	14.0

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TABLE 2.1 Wolf Creek collocated quarterly **direct radiation** monitoring SFY 2004. 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 (three TLD chips per badge are used for data evaluation). KDHE results are expressed as a normalized 90-day quarter average \pm total uncertainty (one standard deviation) of three TLD bulb dosimeters at each location.

Location KDHE (WCNOC)	KDHE Monitoring period	KDHE	WCNOC
1. A-1 (1)	7/8/03-10/1/03	17.0 \pm 1.4	20.6 \pm 2.8
	10/1/03-1/6/04	16.7 \pm 1.4	21.0 \pm 0.7
	1/6/04-4/2/04	18.1 \pm 2.6	18.2 \pm 1.3
	4/2/04-7/7/04	16.9 \pm 1.4	21.9 \pm 1.1
2. D-1 (9)	7/8/03-10/1/03	18.9 \pm 1.3	16.4 \pm 0.4
	10/1/03-1/6/04	16.4 \pm 1.8	18.1 \pm 1.0
	1/6/04-4/2/04	17.7 \pm 1.3	16.0 \pm 1.4
	4/2/04-7/7/04	18.1 \pm 1.7	20.3 \pm 1.4
3. G-1 (14)	7/8/03-10/1/03	21.8 \pm 2.1	17.8 \pm 1.0
	10/1/03-1/6/04	17.6 \pm 1.0	20.9 \pm 1.1
	1/6/04-4/2/04	23.4 \pm 4.4	17.6 \pm 0.6
	4/2/04-7/7/04	18.5 \pm 5.1	21.5 \pm 0.9
4. H-0 (42)	7/8/03-10/1/03	7.0 \pm 1.3	13.1 \pm 1.3
	10/1/03-1/6/04	14.4 \pm 2.3	14.4 \pm 0.5
	1/6/04-4/2/04	14.8 \pm 8.1	16.2 \pm 1.9
	4/2/04-7/7/04	13.5 \pm 1.2	17.6 \pm 2.3
5. K-1 (29)	7/8/03-10/1/03	14.8 \pm 1.6	14.4 \pm 1.9
	10/1/03-1/6/04	13.5 \pm 1.0	17.0 \pm 0.9
	1/6/04-4/2/04	16.1 \pm 1.9	17.9 \pm 4.4
	4/2/04-7/7/04	13.5 \pm 1.0	17.7 \pm 1.1
6. L-1 (27)	7/8/03-10/1/03	18.4 \pm 1.1	17.8 \pm 0.9
	10/1/03-1/6/04	18.9 \pm 0.9	20.4 \pm 1.2
	1/6/04-4/2/04	17.8 \pm 1.6	20.8 \pm 1.8
	4/2/04-7/7/04	20.3 \pm 0.9	21.7 \pm 1.3
7. M-1 (26)	7/8/03-10/1/03	16.3 \pm 1.4	16.1 \pm 0.4
	10/1/03-1/6/04	17.0 \pm 1.2	18.6 \pm 1.1
	1/6/04-4/2/04	16.7 \pm 1.7	17.1 \pm 3.0
	4/2/04-7/7/04	16.2 \pm 1.8	20.6 \pm 2.5
8. P-0 (43)	7/8/03-10/1/03	11.6 \pm 1.3	11.4 \pm 0.8
	10/1/03-1/6/04	13.5 \pm 1.2	13.7 \pm 0.8
	1/6/04-4/2/04	13.0 \pm 2.3	14.8 \pm 1.3
	4/2/04-7/7/04	14.3 \pm 1.1	17.3 \pm 2.6
9. P-2 (40)	7/8/03-10/1/03	16.8 \pm 1.4	14.6 \pm 0.9
	10/1/03-1/6/04	16.3 \pm 1.8	18.7 \pm 1.2
	1/6/04-4/2/04	18.2 \pm 1.8	17.7 \pm 2.0
	4/2/04-7/7/04	18.0 \pm 1.7	No Data
10. P-4 (46)	7/8/03-10/1/03	18.6 \pm 1.6	18.6 \pm 0.8
	10/1/03-1/6/04	19.8 \pm 1.4	19.8 \pm 1.4
	1/6/04-4/2/04	19.2 \pm 2.5	19.6 \pm 1.3
	4/2/04-7/7/04	23.6 \pm 1.9	21.0 \pm 1.6
11. R-0 (41)	7/8/03-10/1/03	16.4 \pm 1.6	18.3 \pm 1.1
	10/1/03-1/6/04	20.2 \pm 1.2	21.3 \pm 1.5
	1/6/04-4/2/04	21.6 \pm 1.6	20.1 \pm 1.4
	4/2/04-7/7/04	25.2 \pm 2.5	22.2 \pm 2.3
12. R-1 (37)	7/8/03-10/1/03	12.5 \pm 1.7	17.2 \pm 1.1
	10/1/03-1/6/04	17.9 \pm 1.5	19.1 \pm 0.8
	1/6/04-4/2/04	18.2 \pm 2.6	19.1 \pm 2.0
	4/2/04-7/7/04	19.9 \pm 0.9	20.2 \pm 1.2
13. R-2 (44)	7/8/03-10/1/03	16.9 \pm 1.1	19.8 \pm 2.9
	10/1/03-1/6/04	19.8 \pm 1.4	19.9 \pm 1.6
	1/6/04-4/2/04	15.4 \pm 4.4	19.2 \pm 0.6
	4/2/04-7/7/04	21.3 \pm 1.6	22.8 \pm 1.8

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TABLE 3.0 Wolf Creek monthly duplicate samples for waterborne radionuclides in **surface water** SFY 2004. 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). See Map #1.0 for sample locations.

Date	J-1A (Spillway)		Q-1 (Discharge Canal)		N-1 (JRR/MUSH) Control	
	KDHE	WCNOC	KDHE	WCNOC	KDHE	WCNOC
7/17/03	11957 ± 552	12960 ± 325	12076 ± 512	13040 ± 326	<350	<158
8/21/03	16671 ± 459	14720 ± 344	32676 ± 608	26793 ± 458	<350	<157
9/18/03	17857 ± 632	16308 ± 369	18348 ± 640	16721 ± 374	<350	<166
10/16/03	15263 ± 433	16192 ± 370	17194 ± 453	17551 ± 385	<350	<162
11/20/03	17429 ± 612	16419 ± 366	17457 ± 614	17807 ± 373	<350	<157
12/19/03	16259 ± 581	17277 ± 383	16639 ± 584	16699 ± 377	<350	<169
1/22/04	24992 ± 885	15876 ± 360	24395 ± 884	15697 ± 358	<350	<161
2/26/04	15001 ± 578	14337 ± 337	15137 ± 582	14475 ± 339	<350	<154
3/17/04	14573 ± 557	13175 ± 322	NA	NA	<350	<157
4/8/04	7568 ± 312	13173 ± 323	NA	NA	<350	<158
5/13/04	7948 ± 334	12932 ± 320	NA	NA	<350	<159
6/10/04	7550 ± 327	12092 ± 314	NA	NA	<350	<84

TABLE 4.0 Wolf Creek annual samples for deposition of airborne radionuclides on **surface water (PONDS)** SFY 2004. Sample results in pCi/□. 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, ⁵⁶Co, 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 isotopes attributable to WCNOC operations were found above method detection limits.*

Location	Date	Tritium (³ H)
P-1, New Strawn City Lake	3/25/04	355 ± 273

TABLE 5.0 Wolf Creek Annual samples for waterborne radionuclides in **ground water** SFY 2004. 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, ⁵⁶Co, 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 isotopes attributable to WCNOC operations were found above method detection limits.* See Map #1.0 for sample locations.

Date	L-1 (L49)	N-1 (C-10)	B-1 (B-12)
	KDHE (WCNOC)	KDHE (WCNOC)	KDHE (WCNOC)
	TRITIUM (³ H)		
8/22/03	<350 (<157)	<350 (<157)	<350 (<157)
	ALPHA + BETA		
8/22/03	<5	<6	<5

^a WCNOC results for tritium only.

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TABLE 6.0 Wolf Creek ingestion pathway quarterly samples for waterborne radionuclides in **drinking water** SFY 2004. 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 isotopes attributable to WCNOG operations were found above method detection limits.*

LEROY DRINKING WATER		
DATE	GROSS BETA	TRITIUM
7/2/03	<5	<350 (<158)
8/22/03	<5	<350
9/4/03	<5	<350
10/2/03	<5	<350 (<159)
11/20/03	<5	<350
12/22/03	<5	<350
1/23/04	<5	<350 (<161)

TABLE 7.0 Wolf Creek ingestion pathway samples for radionuclide bioaccumulation in **milk** (from airborne radionuclide deposition on pasturage with subsequent ingestion by milk producing cattle) SFY 2004. Sample is collected at Lebo, R-1 (Linsey Dairy). Lebo is a control location. Sample results in pCi/□. 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 location. *No isotopes attributable to WCNOG operations were found above method detection limits.*

Date	⁴⁰ K, natural KDHE
Lebo R-1 quarterly sample collection	
10/10/03	<88
2/12/04	1671
6/10/04	<88

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TABLE 8.0 ERS annual samples for airborne radionuclide deposition on **soil** SFY 2004. 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. WCNOG sample location designations are denoted by parenthesis. *No isotopes attributable to WCNOG operations were observed above method detection limits.*

Isotope	A-1 Sector A Sharpe KDHE 7/24/03 0.5m ²	E-1 Scott Valley Church (Control) 8/5/04 0.5m ²	H-1 East of CCL Dam Near HCA H-1 5/20/04 0.5m ²
²²⁸ Ac*	1485 ± 32	1153 ± 55	1485 ± 32
¹³⁷ Cs	179 ± 17	490 ± 44	456 ± 23
⁴⁰ K*	12798 ± 21.6	14412 ± 2328	16372 ± 799
²²⁸ Th*	2757 ± 34476	3506 ± 57028	2757 ± 34476
	P-1 (MUDS) 5/25/04 KDHE (WCNOG)	R-1 EEA 5/25/04 KDHE	
²²⁸ Ac*	1363 ± 45 (N/A)	1586 ± 32 (N/A)	
¹³⁷ Cs	528 ± 27 (413 ± 58)	463 ± 23.4 (295 ± 46.3)	
⁴⁰ K*	<828 (11673 ± 99.9.2)	16182 ± 786 (12238 ± 966.2)	
²²⁸ Th*	2142 ± 41238 (N/A)	2344 ± 29311 (N/A)	

TABLE 8.1 ERS random samples for airborne radionuclide deposition in **soil** SFY 2004. 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 WCNOG operations were found above method detection limits. See Map #7.0 for locations.*

Location	Date	¹³⁷ Cs	Isotope ⁴⁰ K
WCRS-1-A-350-11.6	Forward Staging Area, Old 50 and US-75	8/1/03	587 ± 12
WCRS-2-L-212-8.0	Kafir Road and 8 th Road	8/1/03	1170 ± 55
WCRS-3-K-197-6.0	Native Road and 11 th Road	8/1/03	1218 ± 55
WCRS-4-P-292-6.6	Ottumwa, Kansas	8/5/03	1163 ± 47
WCRS-5-B-23-9.8	Two mile south of Waverly, Kansas	11/12/03	1248 ± 42
WCRS-6-A-007-6.5	One mile south of Halls Summit, Kansas	11/12/03	183 ± 18
WCRS-7-H-161-3.8	South of Coffey County Lake on FAS 10	11/12/03	277 ± 21
WCRS-8-C-49-8.2	Verdure Road and 21 st Road	3/2/04	1277 ± 25
WCRS-9-H-163-10.5	E Street and K-57, LeRoy Kansas	3/30/04	1335 ± 29
WCRS-10-178-3.6	Former GM Dealership, Burlington, Kansas	5/28/04	1241 ± 27

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TABLE 9.0 ERS annual samples for waterborne radioisotope concentration in **bottom sediments** SFY 2004. 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	WCBS-AQ-1 (DC)	WCBS-AN-1 (JRR)
	CCL discharge cove 5/11/04 KDHE (WCNOG)	John Redmond Reservoir Control 5/11/04 KDHE (WCNOG)
²²⁸ Ac*	1667 ± 37(not reported)	1472 ± 31(not reported)
¹³⁷ Cs	246 ± 15 (202 ± 34)	142 ± 10(161± 46)
⁴⁰ K*	15655 ± 750 (12995 ± 783)	18071 ± 830(16748± 744)
²²⁶ Ra*	3614 ± 242 (not reported)	Not detected (not reported)
²²⁸ Th*	Not detected (Not reported)	Not Detected(not reported)
	WCBS-AR-1 EEA 5/11/04 KDHE (WCNOG)	
²²⁸ Ac*	1383 ± 30 (not reported)	
¹³⁷ Cs	235 ± 14(119± 31)	
⁴⁰ K*	13181 ± 624(11625± 718)	
²²⁶ Ra*	Not detected (not reported)	
²²⁸ Th*	2981 ± 37121(not reported)	

TABLE 9.1 Wolf Creek random samples for waterborne radioisotope concentration in **bottom sediments** SFY 2004. 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-K-194-1.9	Coffey County Lake	9-26-03	<52	<11
WCRBS-2-H-159-3	Coffey County Lake	9-26-03	164 ± 16	<11
WCRBS-1-L-230-1	Coffey County Lake	9-26-03	<52	<11
WCRBS-6-J-178-3.8	Coffey County Lake	11-12-03	53 ± 7	<11
WCRBS-9-J-178-3.7	3.5 miles S. of WCNOG on Wolf Creek	3-31-04	31 ± 5	<11
WCRBS-1-P-289-1.1	Coffey County Lake	6-4-04	259 ± 17	<11
WCRBS-2-P-298-1.0	Coffey County Lake	6-4-04	35 ± 5	24 ± 3
WCRBS-4-Q-310-1.6	Coffey County Lake	6-4-04	224 ± 15.5	<11
WCRBS-3-Q-318-1.5	Coffey County Lake	6-4-04	141 ± 10	68 ± 4
WCRBS-5-P-300-1.7	Coffey County Lake	6-4-04	52 ± 7	<11
WCRBS-6-P-290-1.8	Coffey County Lake	6-4-04	22 ± 3.7	<11

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TABLE 10.0 Wolf Creek annual samples for waterborne radioisotope concentration in **shoreline sediment** SFY 2004. 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. WCNOC sample location designations are denoted by parentheses.

Isotope	N-1 (JRR) John Redmond Reservoir (Control) 5-11-04 KDHE (WCNOC)	R-1 (EEA) Environmental Education Area 5-25-04 KDHE (WCNOC)	P-1 (MUDS) CCL Public Access Fishing Area 5-25-04 KDHE (WCNOC)
	²²⁸ Ac*	1231 ± 25 (Not reported)	1334 ± 31 (Not reported)
⁷ Be*	<95 (Not reported)	<95 (Not reported)	<95
¹³⁷ Cs	<8 (<45.5)	19 ± 4.8 (<34.5)	<8 (<29.3)
⁶⁰ Co	<11 (<16.6)	<11 (<35.4)	<11 (<24.1)
⁴⁰ K*	8684±427 (7948 ± 834)	13030 ± 754 (12688 ± 935)	<828 (11454 ± 730)
²²⁶ Ra*	2659 ± 204 (Not reported)	2747 ± 280 (not reported)	3398 ± 255 (Not reported)

Isotope	Q-1 (DC) CCL Discharge Cove 5-11-04 KDHE (WCNOC)
²²⁸ Ac*	<52 (Not reported)
⁷ Be*	<95 (Not reported)
¹³⁷ Cs	<11 (<27)
⁶⁰ Co	<56 (28)
⁴⁰ K*	13000±2000
²²⁶ Ra*	<828 (Not reported)

TABLE 10.1 Wolf Creek random samples for waterborne radioisotope concentration in **shoreline sediments** SFY 2004. 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-A-350-1.1	Stringtown Cemetery	7-24-03	<49	<56	
WCRSS-3-H-151-1.8	Coffey County Lake	9-26-03	<49	<56	
WCRSS-7-H-165-11.6	Neosho River South of LeRoy	11-12-03	<49	<56	
WCRSS-6-J-178-3.8	Wolf Creek North of FAS 10 (12 th Rd.)	11-12-03	53 ± 7	<56	
WCRSS-8-H-155-17.5	Neosho River at Neosho Falls	3-30-04	<49	<56	
WCRSS-1-R-335-2.9	Near 17 th Rd. Bridge	3-2-04	<49	<56	

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TABLE 11.0 Wolf Creek fish ingestion pathway duplicate samples for waterborne radioisotope bioaccumulation in fish SFY 2004. Sample results in pCi/kg-wet. Results reported at the 95% confidence level. Gamma emitting radionuclides routinely analyzed for include ⁷Be, ⁴⁰K, ⁵¹Cr, ⁵⁴Mn, ⁵⁶Co, 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. WCNOC sample location designations are denoted by parentheses.

Location	Date	Description	Isotope	
			⁴⁰ K, natural KDHE (WCNOC)	³ H KDHE (WCNOC)
N-1 (JRR) John Redmond Reservoir Below dam on Neosho River Control	11/11/03	Common Carp	3185 ± 297 (3266 ± 424)	5972 ± 1069 (<128)
		White Crappie	4284 ± 441 (3816 ± 474)	8079 ± 1111 (<129)
		Channel Catfish	4054 ± 247 (3221 ± 348)	9007 ± 1144 (<88)
Q-1 (DC) CCL Discharge Cove	7/29/03	Common Carp	3121 ± 321 (2912 ± 346)	13889 ± 1269 (6463 ± 171)
		Smallmouth Bass	6682 ± 1276 (3102 ± 362)	9427 ± 1152 (5852 ± 161)
		Channel Catfish	4253 ± 383 (3489 ± 405)	8865 ± 1126 (9267 ± 239)
		Flathead	4077 ± 374 (3013 ± 306)	8974 ± 1147 (6799 ± 176)
Q-1 (DC) CCL Discharge Cove	10/21/03	Walleye	2992 ± 297 (3726 ± 345)	15470 ± 1281 (8798 ± 198)
		Wiper	8091 ± 1553 (3081 ± 377)	9830 ± 1162 (10928 ± 243)
		White Bass	7454 ± 1426 (3302 ± 534)	10365 ± 1177 (11620 ± 234)
		Smallmouth Buffalo	4840 ± 4831 (2505 ± 395)	8859 ± 879 (10069 ± 224)
		Channel Catfish	1038 ± 222 (2633 ± 588)	10426 ± 1176 (7995 ± 188)
		White Crappie	543 ± 91 (3637 ± 533)	8925 ± 1139 (8911 ± 205)

TABLE 12.0 Wolf Creek samples for waterborne radioisotope bioaccumulation in aquatic vegetation SFY 2004. 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, 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. See Map #1.0 for sample location.

Location	Type	Date	Isotope		
			⁷ Be	⁴⁰ K	
WCAV-N-1	JRR Below the Dam	Cattails	5/25/04	2993 ± 448	20577 ± 2231
WCAV-J-1	Wolf Creek 11 th St. Bridge	Arrowhead Fern	4/29/04	4108 ± 476	4883 ± 980
WCAL-P-1	MUDS	Algae	6/3/04	406 ± 171 (355 ± 106)	2931 ± 428 (3302 ± 291)
WCAV-Q-1	Coffey County Lake Discharge Cove	Cattails	5/11/04	1086 ± 260 (<238)	34825 ± 5938 (2595.6 ± 514)
WCAV R-1	EEA	Primrose	6/3/04	406 ± 171 (432 ± 148)	32151 ± 5269 (2472 ± 291)

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TABLE 12.1 Wolf Creek random samples for waterborne radioisotope bioaccumulation in **aquatic vegetation** SFY 2004. 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, 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. See Map #8.0 for sample location.

Location	Date	Description	Isotope	
			⁷ Be	⁴⁰ K
CCL Boat Ramps	8-22-03	Pondweed	80±42.3	5200±444.2
Baffle Dike A	10-2-03	Pondweed	Not detected	11057±10804
Coffey County Lake	9-26-03	Cattails	738±136.2	12863±3165.2
Trefoil N. of 14 th	11-6-03	Pondweed	713±318	15887±1005
Behind CCL Dam	4-29-04	Algae	4108±475.7	4883±979.9
Pond near 17 th and Lynx	4-13-04	Pondweed	8219±900.9	4467±920.6
North end CCL	6-3-04	Pondweed	406 ± 171	915 ± 559

TABLE 13.0 Wolf Creek trending samples for airborne radionuclide deposition on **terrestrial vegetation** SFY 2004. 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, 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 #1.0 for sample location. WCNOC sample location designations are denoted by parentheses.

Location	Date	Description	Isotope	
			⁷ Be natural KDHE (WCNOC)	⁴⁰ K natural KDHE (WCNOC)
K-1 (NR-U1)	9-5-03	Non-irrigated corn	<35 (<61.2)	2824 ± 693.4 (3541 ± 366)
WCFV-J-1 (NRD1) Near LeRoy, crops that may be irrigated with water from the Neosho River below the confluence with Wolf Creek	9-5-03	Irrigated corn	<35 (<50.6)	2157±408.1 (2496 ± 247)
E-1 Scott Valley Church Control	8-6-03	Pasturage	2961± 539	5256 ± 8242
A-1 Sector A, Sharpe/Pasture near Sharpe	6-22-04	Pasturage	4992 ± 508	16414 ± 3153
H-1 East of CCL dam, near WCA H-1	6-22-04	Pasturage	<35	2667± 230.2
P-1 (MUDS) CCL public access area, north side of parking lot, 10 m from shore	5-25-04	Pasturage	3811 ± 518 (1567 ± 294)	1264 ± 1172 (4863 ± 636)
R-1 (EEA) CCL environmental education area	5/25/04	Pasturage	2823 ± 277 (1045 ± 354)	21128 ± 1462 (6949 ± 915)

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TABLE 13.1 ERS random samples for airborne radionuclide deposition on **terrestrial vegetation** SFY 2004. 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	Isotope	
			⁷ Be	⁴⁰ K
0.25 Mi. south of 14 th and Trefoil	7-31-03	Pasturage	646 ± 147	23328 ± 3403
Taylor's Garden, New Strawn	8-5-03	Tomatoes	Not detected	Not detected
13 th and Wayside	8-6-03	Pasturage	3641 ± 459	4989 ± 1381
Coffey County Airport	8-22-03	Brome Hay	Not detected	1279 ± 314
New Strawn Golf Course	8-22-03	Apples	1630 ± 283	5202 ± 825
17 th and Quail	8-27-03	Soybeans	1445 ± 239	13211 ± 1146
11 th and Iris	10-3-03	Red Milo	619 ± 107	3763 ± 932
One mile north of Burlington	3-31-04	Pasturage	375 ± 170	5320 ± 975
20 th and Native	6-8-04	Pasturage	4475 ± 406	16493 ± 1438
0.25 Mi. north of 18 th and Shetland	6-29-04	Wheat	1838 ± 212	3797 ± 634

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Table 14.0 KDHE RADIOCHEMISTRY LABORATORY EPA INTERCOMPARISON STUDIES

Analysis	Date	Known Value \pm Control Limit (pCi/l)	Expected Precision	KHEL Average Results \pm Uncertainty
Gross Alpha	7-3-03	70.3 \pm 30.7	17.6	67.5 \pm 1.7
	8-18-03	65.1 \pm 24.2	16.3	57.0 \pm 5.0
	11-18-03	29.5 \pm 14.1	7.38	29.8 \pm 2.25
	11-18-03	54.2 \pm 23.5	13.6	68.9 \pm 1.1
	5-18-04	38.8 \pm 16.8	9.7	42.3 \pm 1.2
Gross Beta	7-3-03	363 \pm 94	55	305 \pm 8.7
	8-18-03	31.6 \pm 8.7	5.0	31.4 \pm 2.37
	11-18-03	26.3 \pm 8.7	5.0	25.6 \pm 0.35
	11-18-03	168 \pm 44	25.2	149 \pm 2.5
	5-18-04	59.6 \pm 17.3	10	59.2 \pm 1.0
Tritium	7-3-03	1250 \pm 570	331	1480 \pm 12.3
	11-18-03	14300 \pm 2500	1430	15550 \pm 126
⁸⁹ Sr	7-3-03	31.7 \pm 8.7	5.0	26.0 \pm 0.4
	8-18-03	58.8 \pm 8.7	5.0	24.4 \pm 0.6
	11-18-03	50.4 \pm 8.7	5.0	15500 \pm 126
	2-17-04	44.9 \pm 8.7	5.0	41.0 \pm 0.7
	5-18-04	45.9 \pm 8.7	5.0	39.1 \pm 1.0
⁹⁰ Sr	7-3-03	27.4 \pm 8.7	5.0	28.7 \pm 0.7
	8-18-03	20.6 \pm 8.7	5.0	11.5 \pm 0.2
	11-18-03	10.2 \pm 8.7	5.0	10.7 \pm 0.9
	2-17-04	11.6 \pm 8.7	5.0	13.1 \pm 0.3
	5-18-04	11.6 \pm 8.7	5.0	8.7 \pm 0.6
⁶⁰ Co	7-3-03	63.8 \pm 8.7	5.0	60.9 \pm 2.5
	8-18-03	37.4 \pm 8.7	5.0	30.6 \pm 0.6
	11-18-03	27.7 \pm 8.7	5.0	27.6 \pm 1.1
	2-17-04	96.4 \pm 8.7	5.0	105 \pm 6.25
¹³⁴ Cs	7-3-03	75.7 \pm 8.7	5.0	73.9 \pm 0.6
	8-18-03	32.6 \pm 8.7	5.0	33.2 \pm 0.8
	11-18-03	23.4 \pm 8.7	5.0	22.6 \pm 0.8
	2-17-04	75.8 \pm 8.7	7.75	152 \pm 4.92
¹³⁷ Cs	7-3-03	150 \pm 13	7.5	145 \pm 3
	8-18-03	44.3 \pm 8.7	5.0	46.0 \pm 0.8
	11-18-03	64.2 \pm 8.7	5.0	61.6 \pm 0.8
	2-17-04	155 \pm 13	6.32	152 \pm 4.92
¹³³ Ba	8-18-03	20.7 \pm 8.7	5.0	23.1 \pm 0.2
	2-17-04	63.2 \pm 11.1	6.32	66.1 \pm 1.6
⁶⁵ Zn	8-18-03	60.2 \pm 10.4	6.02	68.1 \pm 1.76
	2-17-04	102 \pm 18	10.2	109 \pm 2.97
¹³¹ I	7-3-03	20.8 \pm 5.2	3.0	22.8 \pm 0.7
	2-17-04	16.6 \pm 5.2	3.0	16.5 \pm 0.5
	5-18-04	25.1 \pm 5.2	3.0	25.1 \pm 0.5

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TABLE 15.0 KHEL Radiochemistry Laboratory method detection limits SFY 2004. 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 [0.423]	****	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 15.0 continued. KHEL Radiochemistry Laboratory method detection limits SFY 2004. 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	Soil and Sedimen	Vegetation and Food products
Minimum Sample Size	1000 ml	1000 ml	Total	0.01kg	0.1 kg
Minimum Counting Time	200 min.	200 min.	200 min.	200 min.	200 min.
Method Detection Limit	pCi/L	pCi/L	pCi/wipe	pCi/kg-dry	pCi/kg-dry
⁸⁹ Sr	1	2	3	200	500
⁹⁰ Sr	1	2	4	200	500
¹³¹ I	1	****	****	****	****
²²⁸ Ra	1.2	****	0.3	60	****
Gross Beta					
	Water	Filter	Wipe		
Minimum Sample Size	200 ml	250m ³	Total	Total	
Minimum Counting Time	200 min.	100 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 16.0 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 WCNOC'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

$$LLD = 2.10 \times \left[\frac{S_b}{EY \exp(-\lambda \Delta t)} \right]$$

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/l 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.

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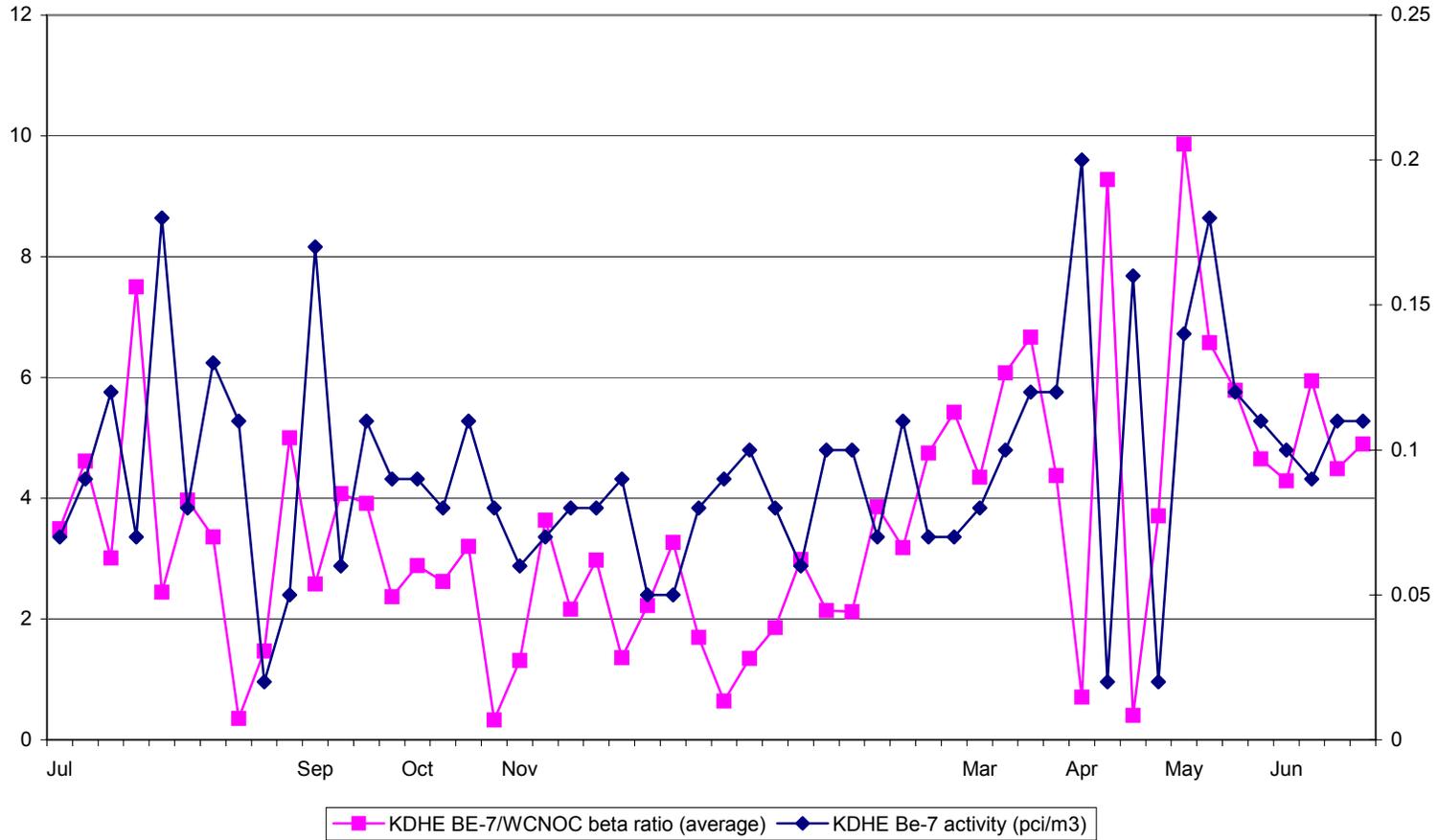


Chart 1.0 Comparison of KDHE ⁷Be activity to the ratio of KDHE ⁷Be activity to WCNOC gross beta-gamma activity.

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KDHE Average Gross Beta Gamma Count (cpm)

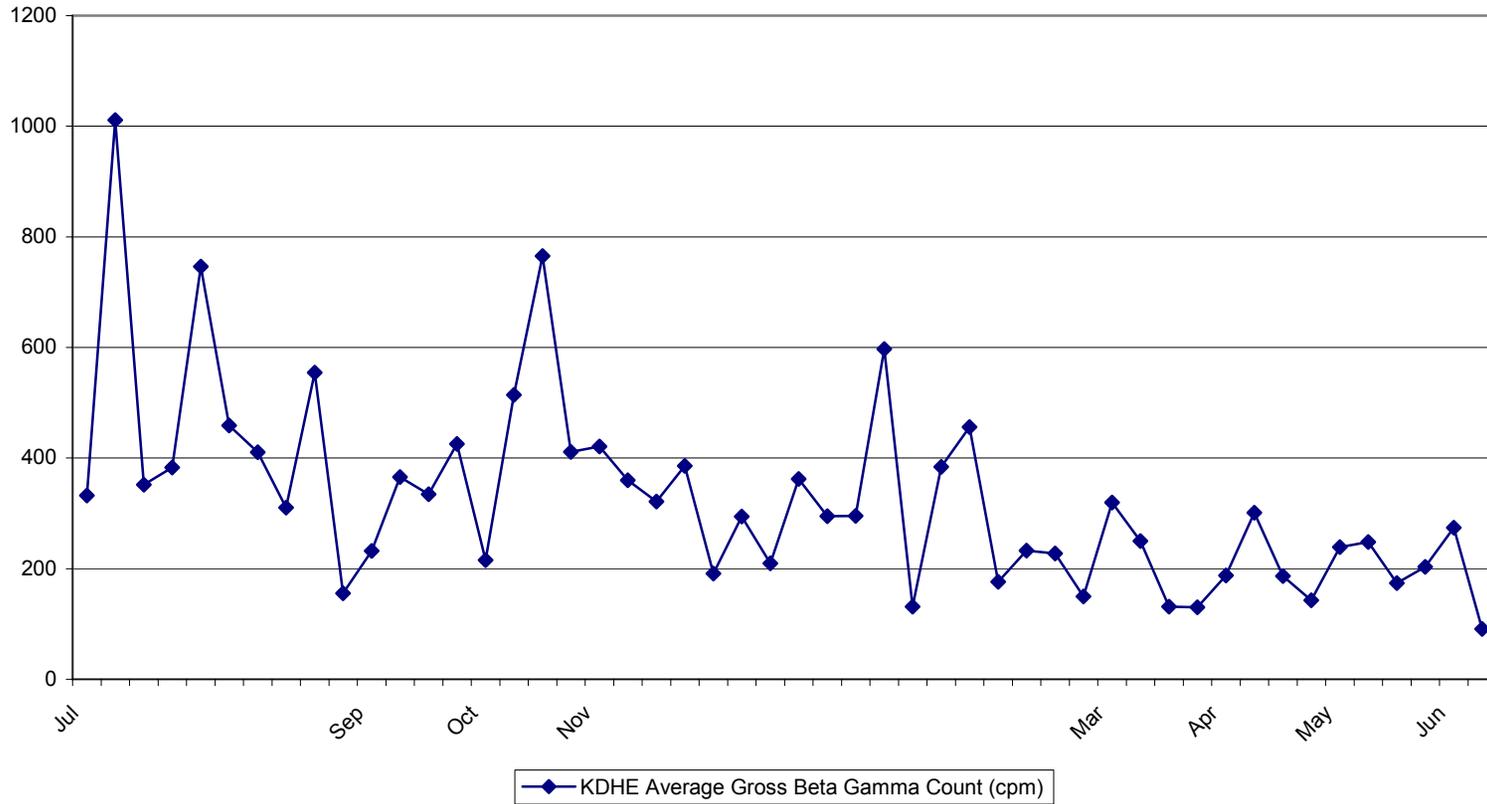


Chart 1.1 KDHE Average Gross Beta Count

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KDHE Quarterly TLD Averages by Sector
 mR/Hr

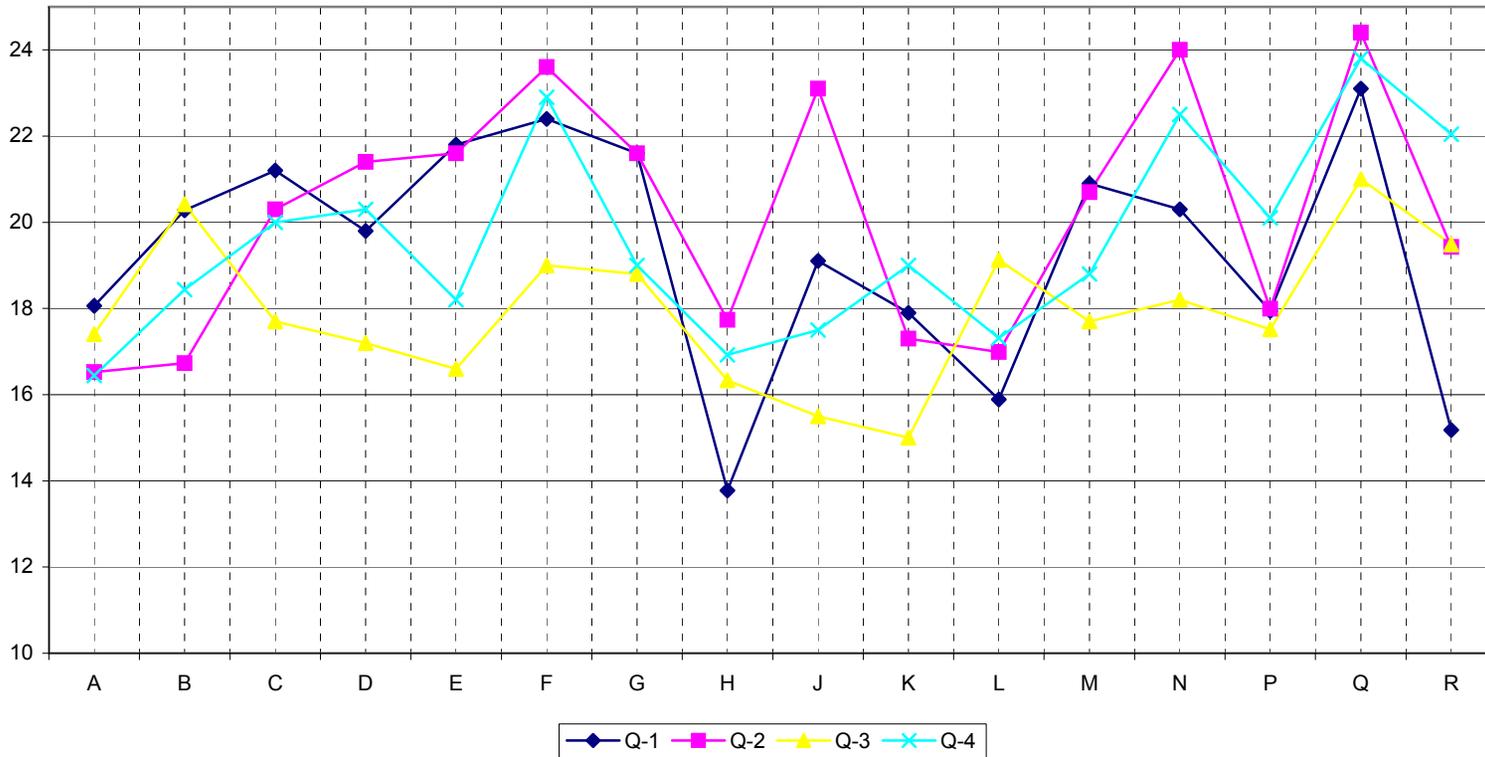


Chart 2.0 KDHE TLD Averages by Sector (All Stations)

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Quarterly Direct Radiation Monitoring
Collocated Sites (By Sector)

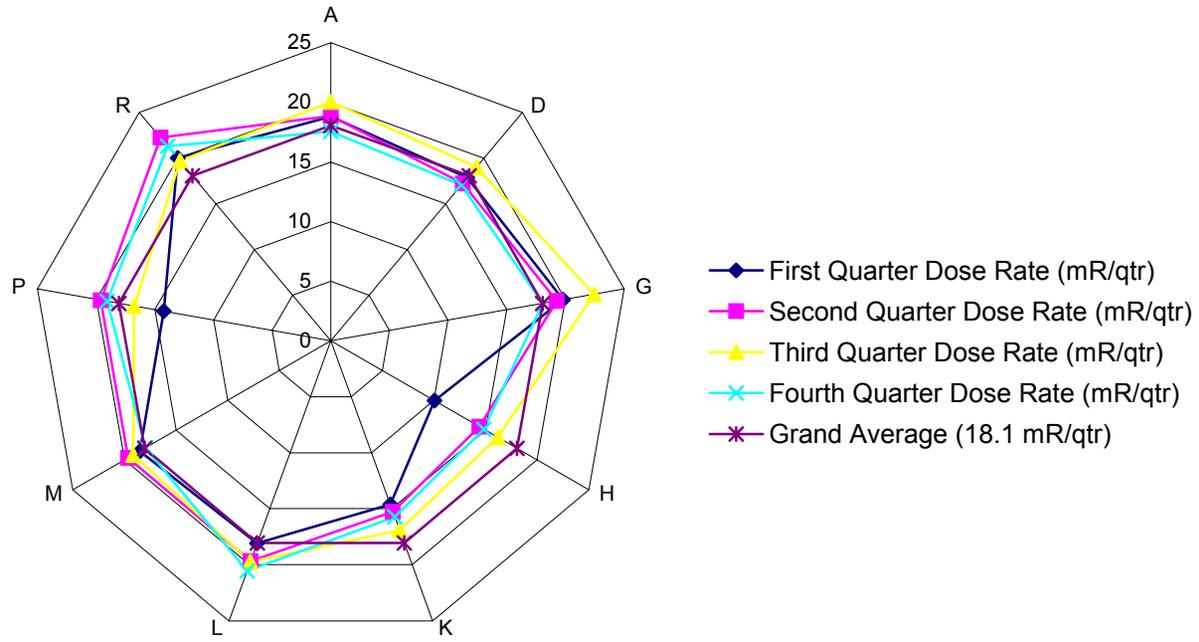


Chart 2.1 Quarterly Direct Radiation Monitoring Results for Collocated TLD Sites

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KDHE vs. WCNOC Direct Radiation
 Average By Sector

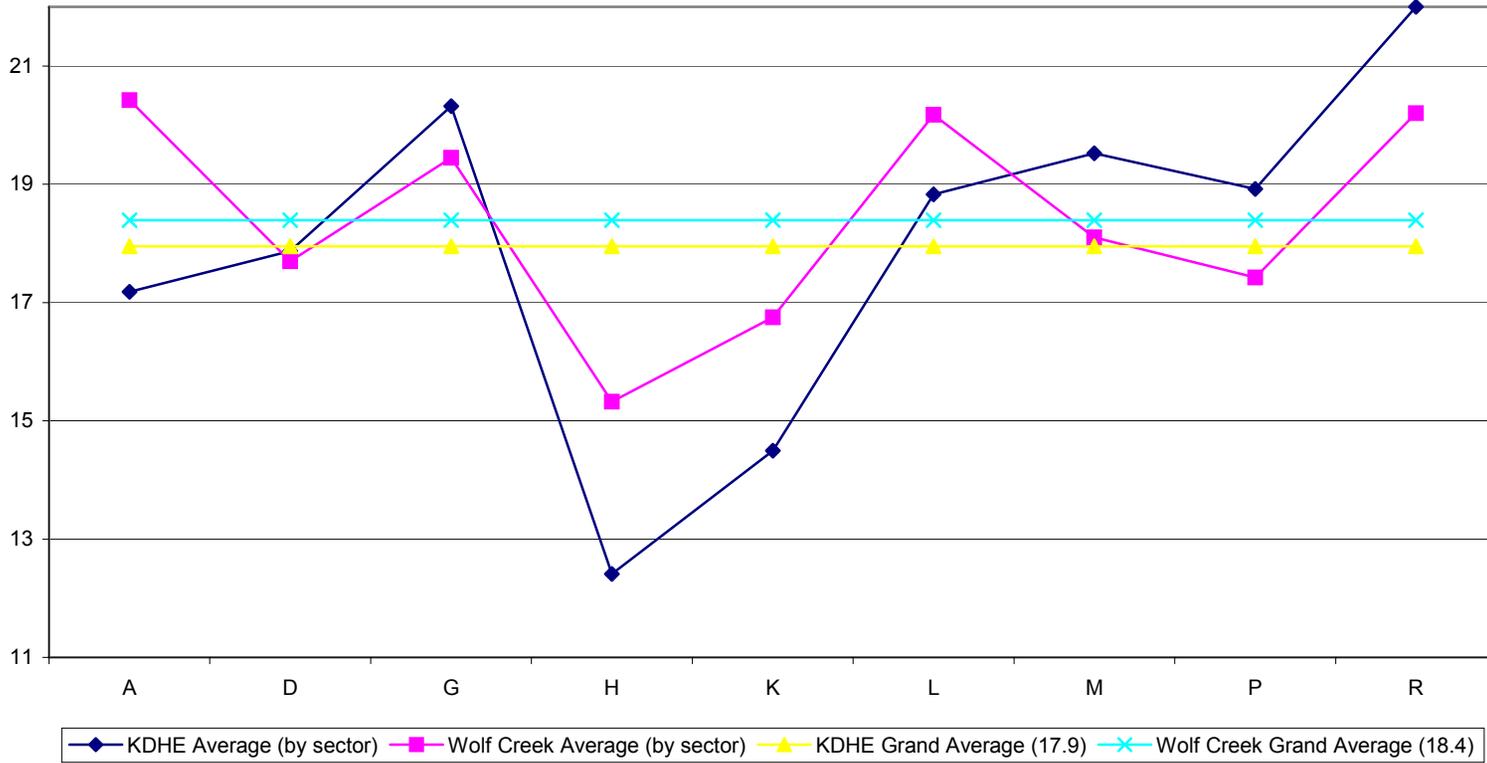


Chart 2.2 Comparison of KDHE and WCNOC Direct Radiation Results

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Historical TLD Results

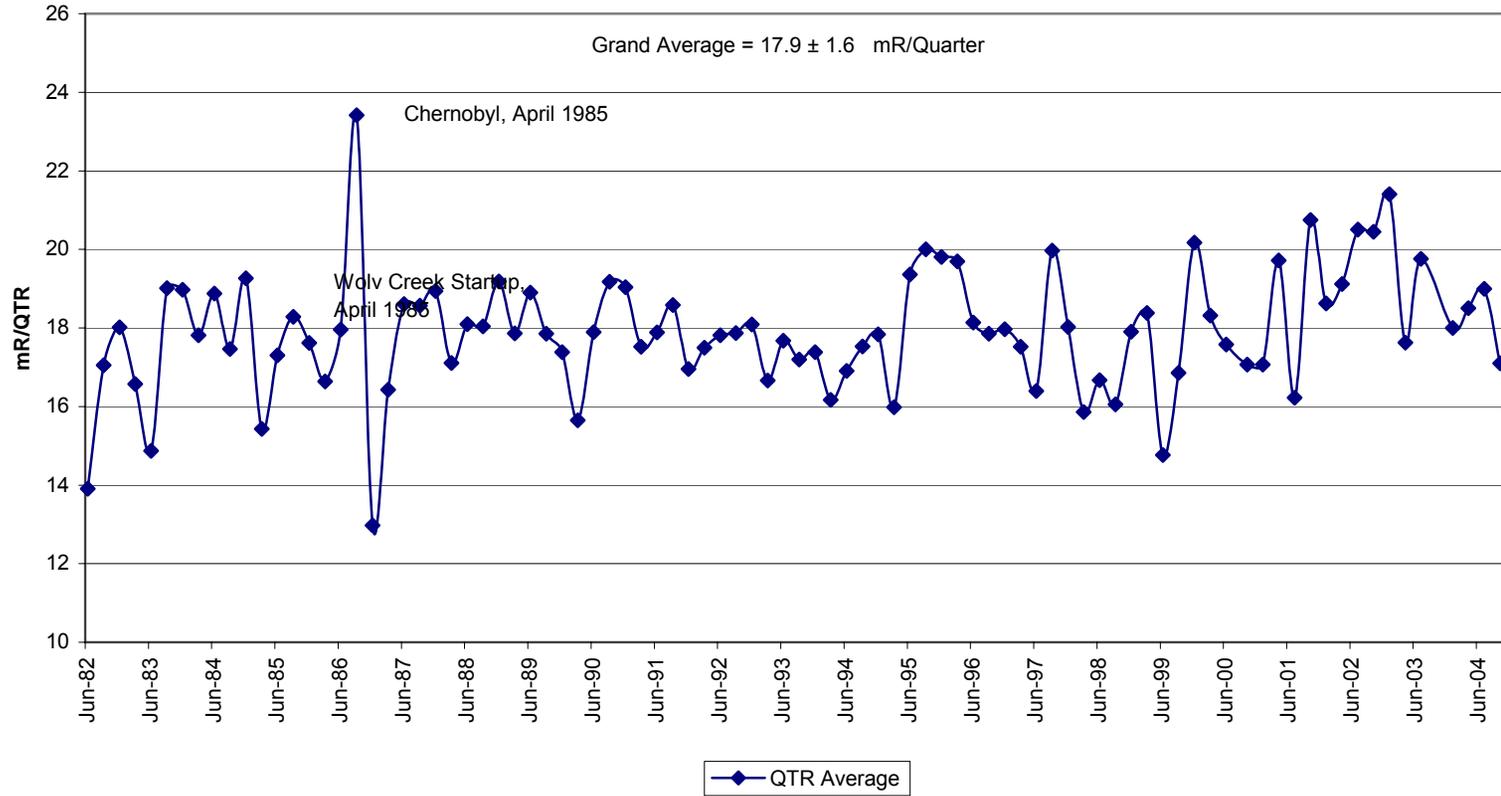


Chart 2.3 Historical Direct Radiation Monitoring Results

KDHE TLD/OSLD Comparison

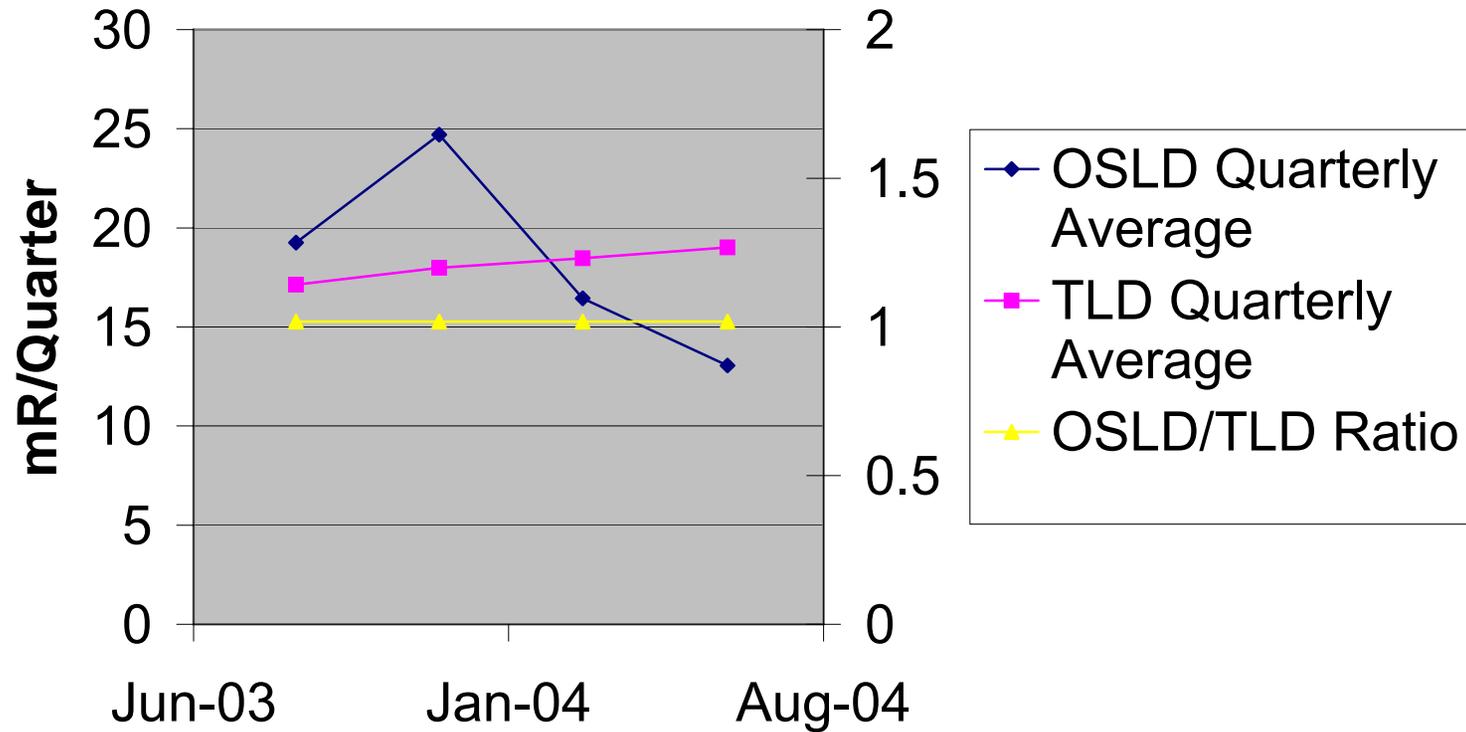


Chart 2.4 KDHE TLD/OSLD Comparison

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Wolf Creek Monthly Surface Water

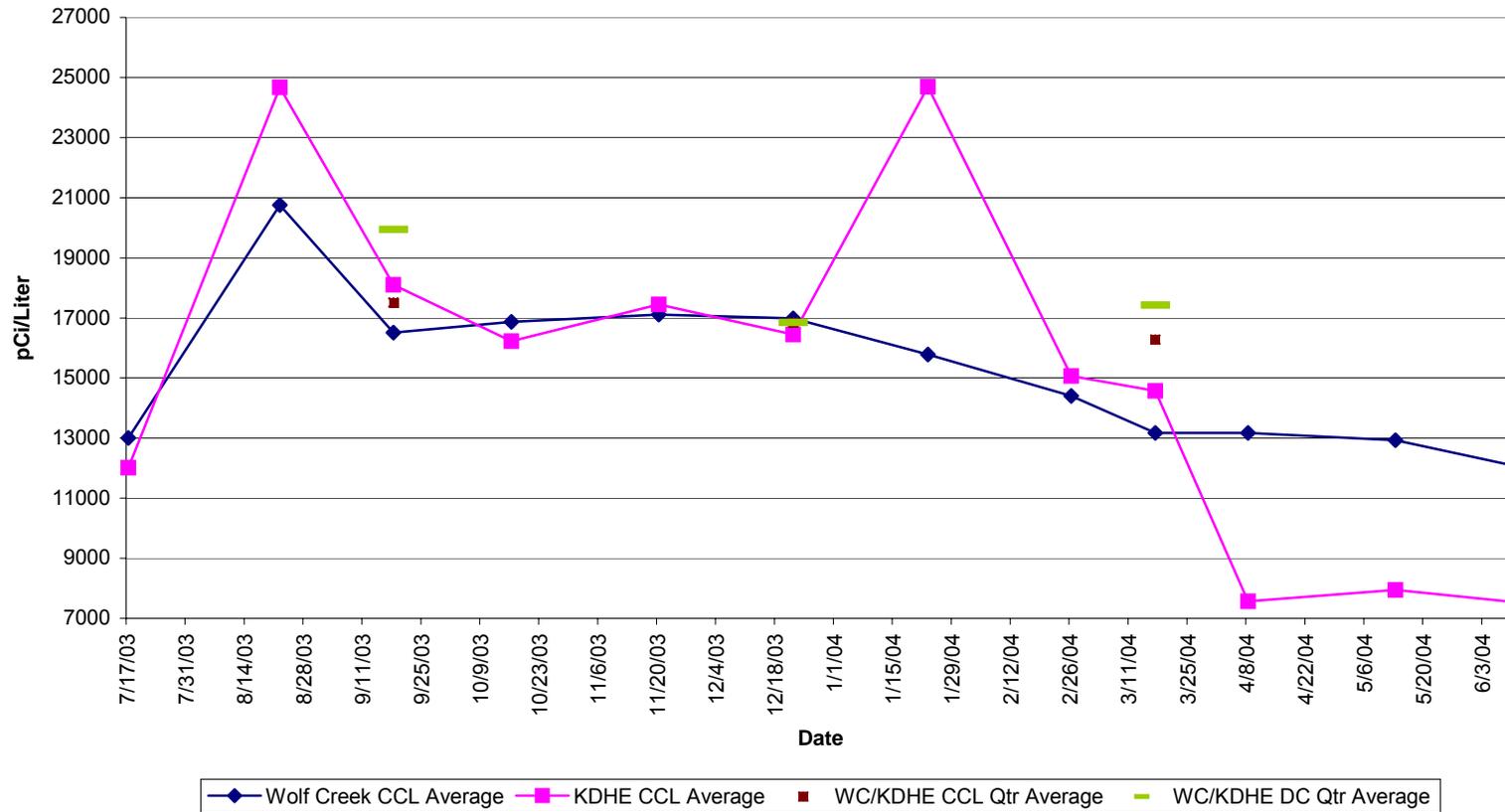


Chart 3.0 Comparison of Surface Water Tritium Levels

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Historic Surface Water Tritium
Smoothed Data

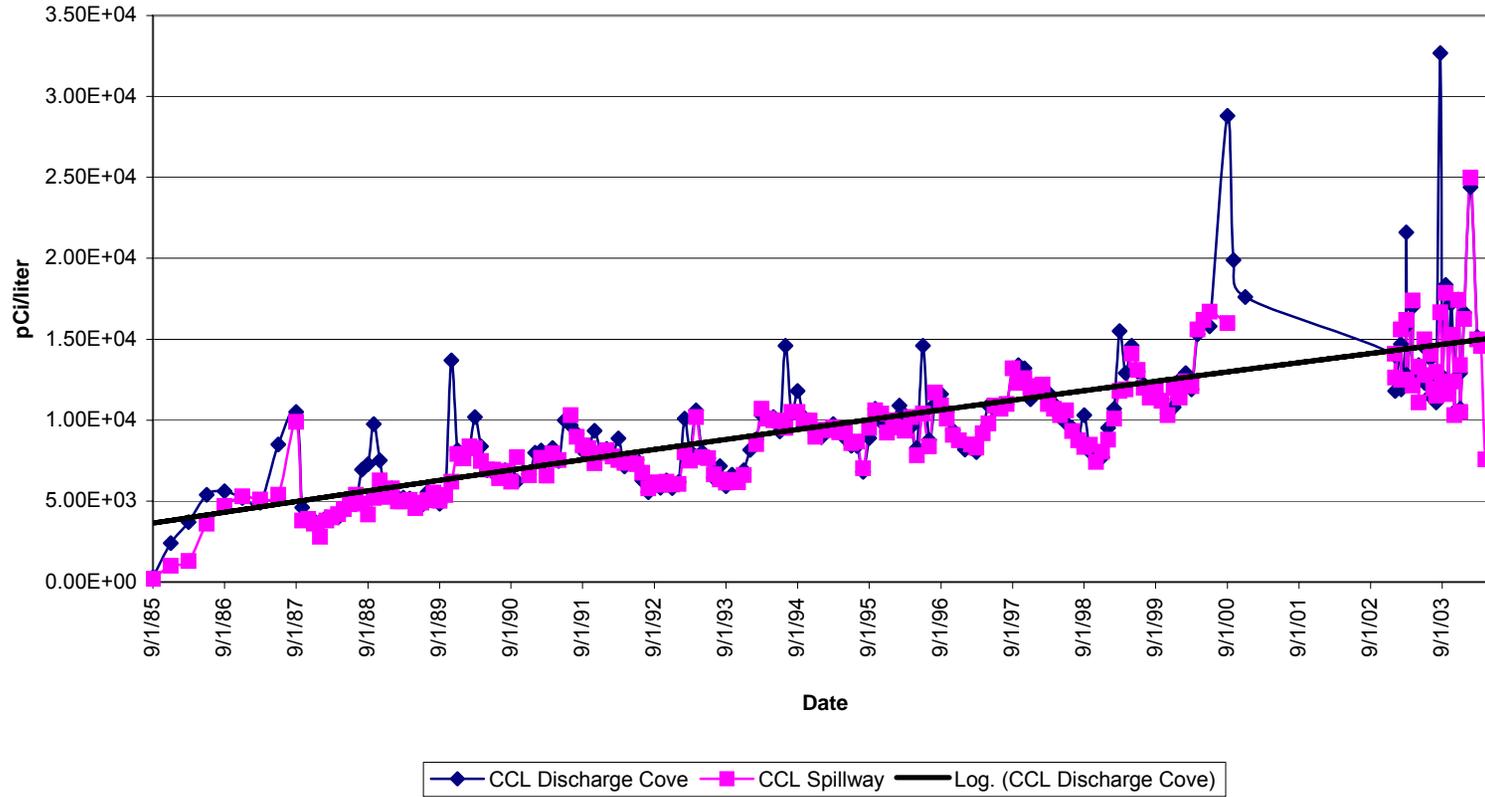


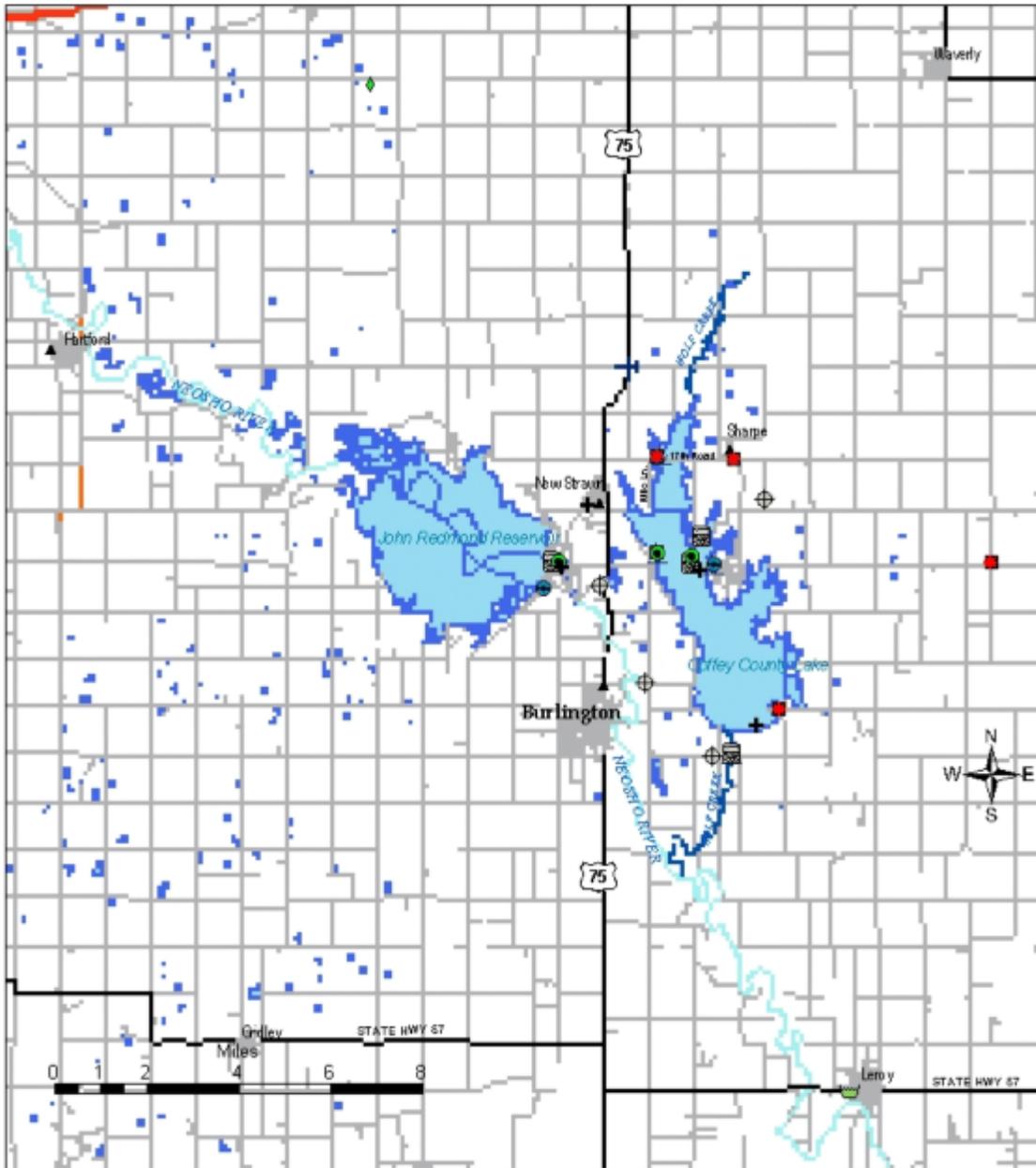
Chart 3.1 Historical Surface Water Tritium

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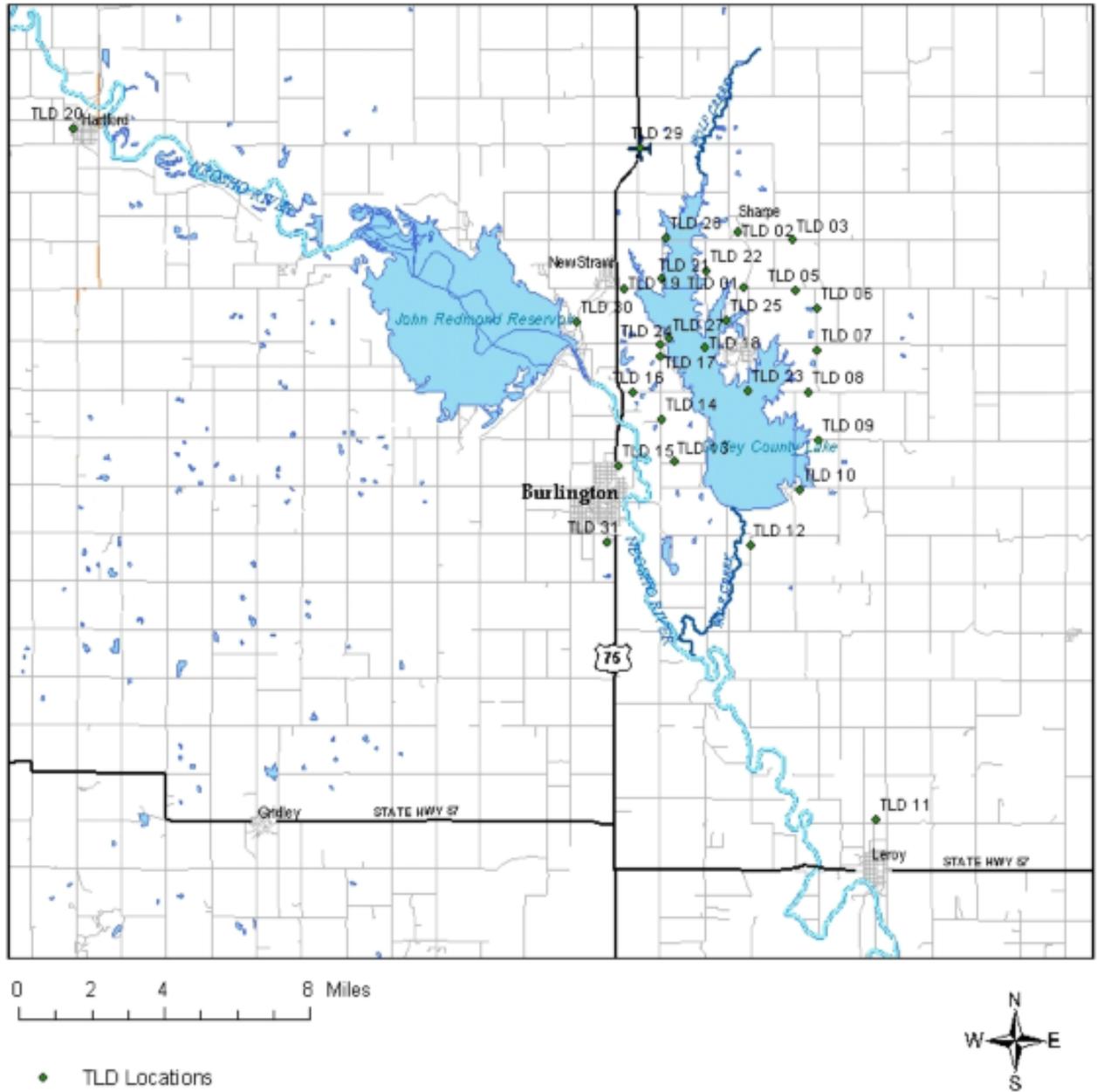


Routine Sample Locations

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

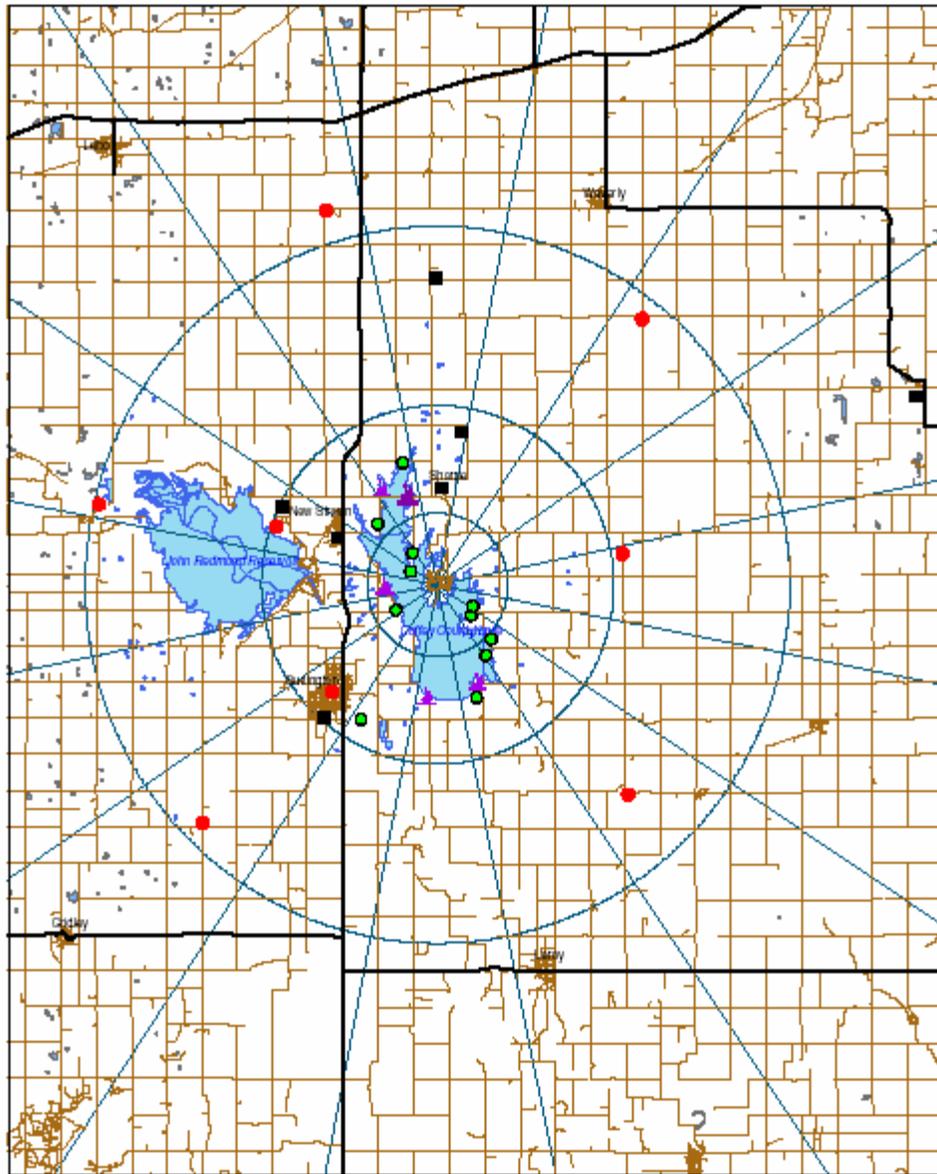
Map 1.0 Routine Sample Locations

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Map 2.0 KDHE TLD Locations

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Random Sample Locations



- Vegetation
- Soil
- Shoreline Sediment
- ▲ Aquatic Vegetation

Map 3.0 Random Sample Locations