ARKANSAS POWER AND LIGHT COMPANY

TECHNICAL ANALYSIS SECTION

900 CENTER STREET

LITTLE ROCK, ARKANSAS 72203

(501) 370-8870

TITLE: 1984 ANNUAL ENVIRONMENTAL RADIOLOGICAL MONITORING REPORT FOR ANO-1 AND ANO-2

IE25
1/1

1.0 INTRODUCTION

This report summarizes the Environmental Radiological Monitoring Program conducted for the Arkansas Nuclear One - Units 1 and 2 during the calendar year 1984. All samples analyses and data interpretation were performed by the staff of Arkansas Power and Light Company.

1.1 PLANT AND LOCATION

Arkansas Nuclear One - Units 1 and 2 are both light-water cooled pressurized water nuclear reactors located approximately 5.0 miles west of Russellville, Arkansas. ANO Unit 1 began commercial operation in December 1974 and the second unit at the same site, ANO Unit 2, followed in March 1980. Lake Dardanelle is the source of the circulating cooling water for ANO Unit 1, and ANO Unit 2 is cooled by a cooling tower, also dependent upon Lake Dardanelle water.

1.2 ENVIRONMENTAL MONITORING PROGRAM

The Environmental Monitoring Program was established based upon the Environmental Technical Specifications for ANO Unit 1. These specifications have remained essentially the same, except for the addition and deletion of sampling stations where milk, ground water, or food products are collected. The 1984 Environmental Radiological Monitoring Report was governed by environmental technical

specifications in effect through December 31, 1984. The 1984 report includes summaries, interpretations, and statistical evaluation of the results of the radiological environmental surveillance activities at ANO. Table 1-1 details the surveillance program listing sample type, frequency of collection, and the method of analysis used. Table 1-2 lists the sample location and type of samples collected at each location.

1.3 CONTROL LOCATIONS

During the calendar year 1984, the following locations were designated as control stations along with the respective sample type and analysis:

a) AP&L's Substation at Danville, Arkansas (Station #7)

1) Air Particulate

2) Air Iodine

3) Precipitation

4) Vegetation

5) Soil

6) TLD

b) Piney Creek Area (Station #16)

1) Lake Water

2) Bottom Sediment

3) Aquatic Biota (including fish)

c) R. A. Young's Dairy (Station #23)

1) Milk

2) Vegetation

2.0 INTERPRETATIONS AND CONCLUSIONS

Data collected from radiological analyses, of environmental samples collected in the area surrounding the ANO facility, indicates no detectable environmental impact in excess of design objectives as a result of liquid and gaseous discharges from the ANO site during 1984. Also, no non-routine environmental radiological monitoring reports resulting from analyses of environmental samples were submitted to the U.S. NRC during 1984.

Sample types that indicated activation or fission-produced radioisotopes present are discussed in the paragraphs below.

TABLE 1-1

SAMPLE TYPE AND ANALYSIS

I. AIR

A. Particulate

1. Continuous 7-day samples, filters changes weekly (Eberline Model RAP-1 sample pumps, Gelman 47 mm glass fiber filters, calibrated to one cubic foot per minute ($0.028m^3$/min) air sampling rate), seven (7) locations.

2. Analyses

a. Gross alpha
b. Gross beta
c. Gamma isotope on a monthly composite (each station) and on high beta levels ($\geq$100 DPM/sample)
d. Radiostrontium on quarterly composite if gamma isotopic analysis shows presence of Cs-137.

B. Iodine 131

1. Continuous 7-day samples, activated charcoal filter trap on inlet of air sampler downstream of particulate filter, changed weekly, seven (7) locations.

2. Analyses

a. Iodine-131

C. Direction Radiation

1. a. Four (4) thermoluminescent dosimeters (LiF), seven (7) locations. (six month integrated dose)

b. Two (2) thermoluminescent dosimeters (LiF), thirty-seven (37) locations. (three month integrated dose)

2. Analyses

a. Change and readout one set dosimeters quarterly at all 44 locations and one set semiannually at the first 7 locations.

D. Precipitation

1. Four (4) locations, samples collected weekly (as available).

2. Analyses

a. Gross beta
b. Gamma Isotopic

II. WATER

A. Lake Water

1. Samples (one gallon) monthly from five (5) locations (discharge canal, intake canal, and lake south of plant between discharge and intake). (Sample stations 8, 9, 10, 15, 16)

2. Analyses

a. Gross beta (monthly)
b. Gamma isotopic (monthly if gross beta exceeds 30 pCi/L and on quarterly composites)
c. Tritium (quarterly composites)
d) Radiostrontium (quarterly composites)

B. Bottom Sediments

1. Samples (~ Kg) semiannually from near the same locations as lake water. Station 15 sample to be taken in pool above dam.

2. Analyses

a. Gamma isotopic
b. Radiostrontium (annual composites)

C. Ground Water

1. Samples (one gallon) quarterly from three locations.

2. Analyses

a. Gross alpha
b. Gross beta
c. Gamma isotopic
d. Tritium

D. Russellville City Water

1. Samples (one gallon) monthly from system intake.

2. Analyses

a. Gross alpha
b. Gross beta
c. Gamma isotopic
d. Tritium (quarterly composite)
e. Radiostronium (quarterly composite)

E. Aquatic Biota

1. Semiannual samples are taken as available at or near the same sample points as lake water and bottom sediments. Samples will be as large as practicable not to exceed 2Kg.

2. Analyses

a. Gross beta (plankton)
b. Gamma isotopic (fish flesh, plankton, benthic organisms, aquatic plants)

c. Radiostrontium (benthic organisms, aquatic plants)

F. Fish Bone

1. Annual sample (~500g bone) in the Fall. Sampled as in E.1 above.

2. Analyses

a. Strontium 89-90

III. TERRESTRIAL

A. Milk

1. One gallon samples will be taken monthly from farms or dairies within a ten-mile radius of plant.

2.

Analyses	Frequency
a. Iodine-131	Monthly
b. Strontium 89, 90	Quarterly
c. Gamma isotopic	Monthly

B. Vegetation

1. Samples (~1Kg) of grass and leafy portions of other vegetation in the vicinity of the seven air sampling locations are taken in the Spring, Summer, and Fall seasons.

2. Similar samples of pasturage vegetation of dairies of farms sampled for milk within a ten-mile radius of the plant will be taken at time coinciding with those of 1 above.

3. Food crops and leafy vegetables in the vicinity of the plant shall be collected as available at harvest time.

4. Analyses

   a. Radioiodine (upon collection) by gamma analysis
   b. Gamma isotopic

C. Soil

1. Samples (~1.5 liters) are taken at each of the air sampler sites semiannual.

2. Analyses

   a. Gamma isotopic
   b. Strontium 89-90 determined annually

TABLE 1-2

SAMPLE LOCATION AND SCHEDULE

Sample Station #	Direction and Distance from Plant	Sample Station Location	Sample Types	Sample Frequency	Remarks
1	92° - 0.5 miles	Near Meteorology on site	1) Air Sample 2) TLD 3) Soil Sample 4) Vegetation 5) Precipitation	1) Weekly 2) Quarterly 2) Semiannually 3) Semiannually 4) 3 times/year 5) Weekly, as available	1) 7-day continuous-weekly 2) Readout and record at stated frequency 3) Spring and Fall 4) Spring, Summer and Fall
2	235° - 0.5 miles	Near AP&L lodge site	1) Air Sample 2) TLD 3) Soil Sample 4) Vegetation	1) Weekly 2) Quarterly 2) Semiannually 3) Semiannually 4) 3 times/year	1) 7-day continuous-weekly 2) Readout and record at stated frequency 3) Spring and Fall 4) Spring, Summer and Fall
3	4° - 0.4 miles	South of Hershel Bennet home	1) Air Sample 2) TLD 3) Soil Sample 4) Vegetation 5) Precipitation	1) Weekly 2) Quarterly 2) Semiannually 3) Semiannually 4) 3 times/year 5) Weekly, as available	1) 7-day continuous-weekly 2) Readout and record at stated frequency 3) Spring and Fall 4) Spring, Summer and Fall
4	171° - 0.4 miles	Near the May Cemetery	1) Air Sample 2) TLD 3) Soil Sample 4) Vegetation	1) Weekly 2) quarterly 2) Semiannually 3) Semiannually 4) 3 times/year	1) 7-day continuous-weekly 2) Readout and record at stated frequency 3) Spring and Fall 4) Spring, Summer and Fall

TABLE 1-2 (Cont'd)

SAMPLE LOCATION AND SCHEDULE

Sample Station #	Direction and Distance from Plant	Sample Station Location	Sample Types	Sample Frequency	Remarks
5	298° - 8.5 miles	At Ray Walter's residence, Knoxville, Johnson County	1) Air Sample 2) TLD 3) Soil Sample 4) Vegetation 5) Precipitation	1) Weekly 2) Quarterly 2) Semiannually 3) Semiannually 4) 3 times/year 5) Weekly, as available	1) 7-day continuous-weekly 2) Readout and record at state frequency 3) Spring and Fall 4) Spring, Summer, and Fall
6	109° - 6.8 miles	At AP&L's Russellville Local Office	1) Air Sample 2) TLD 3) Soil Sample 4) Vegetation	1) Weekly 2) Quarterly 2) Semiannually 3) Semiannually 4) 3 times/year	1) 7-day continuous-weekly 2) Readout and record at state frequency 3) Spring and Fall 4) Spring, Summer, and Fall
7	209° - 19.3 miles	At AP&L Sub-station in Danville, Yell County	1) Air Sample 2) TLD 3) Soil Sample 4) Vegetation 5) Precipitation	1) Weekly 2) Quarterly 2) Semiannually 3) Semiannually 4) 3 times/year 5) Weekly, as available	1) 7-day continuous weekly 2) Readout and record at state frequency 3) Spring and Fall 4) Spring, Summer, and Fall
8	180° - 0.1 miles	Mouth of Discharge Canal	1) Lake Water 2) Aquatic Biota 3) Bottom Sediments	1) Monthly 2) Semiannually 3) Semiannually	1) Record status of plant discharge operations 2) Summer and Winter 3) Summer and Winter
9	160° - 1.8 miles	South of Bunker Hill near Main River Channel	1) Lake Water 2) Aquatic Biota 3) Bottom Sediments	1) Monthly 2) Semiannually 3) Semiannually	1) Record status of plant discharge operations 2) Summer and Winter 3) Summer and Winter

TABLE 1-2 (Cont'd)

SAMPLE LOCATION AND SCHEDULE

Sample Station #	Direction and Distance from Plant	Sample Station Location	Sample Types	Sample Frequency	Remarks
10	90° - 1.0 miles	Mouth of inlet Canal	1) Lake Water	1) Monthly	1) Record status of plant discharge operations
			2) Aquatic Biota	2) Semiannually	2) Summer and Winter
			3) Bottom Sediments	3) Semiannually	3) Summer and Winter
14	65° - 5.8 miles	Inlet to City Water System from Illinois Bayou	1) City of Russellville Water Supply	1) Monthly	
15	150° - 5.0 miles	Discharge of Dardanelle Dam Pool above Dardanelle Dam	1) Lake Water	1) Monthly	1) Record status of plant discharge operations
			2) Bottom Sediments	2) Semiannually	
			3) Aquatic Biota	3) Semiannually	
16	295°F - 6.0 miles	Pine Creek Area	1) Lake Water	1) Monthly	
			2) Bottom Sediment	2) Semiannually	
			3) Aquatic Biota	3) Semiannually	
19	99° - 5.0 miles	Arkansas Tech. Dairy	1) Milk	1) Monthly	2) Spring, Summer and Fall
			2) Pasturage	2) 3 times/year	
20	290° - 8.0 miles	Odom-Meyers Dairy	1) Milk	1) Monthly	2) Spring, Summer and Fall
			2) Pasturage	2) 3 times/year	
23	73° - 12 miles	R. A. Young Dairy	1) Milk	1) Monthly	2) Spring, Summer and Fall
			2) Pasturage	2) 3 times/year	
29	25° - 7.0 miles	Harold Steuber Dairy	1) Milk	1) Monthly	1) Alternate to station #37
			2) Pasturage	2) 3 times/year	2) Spring, Summer, Fall

TABLE 1-2 (Cont'd)

SAMPLE LOCATION AND SCHEDULE

Sample Station #	Direction and Distance from Plant	Sample Station Location	Sample Types	Sample Frequency	Remarks
32	155° - 0.8 miles	Clifton Stewart's residence, front yard Russellville	1) Ground Water	1) Quarterly	
			2) Food Crop	2) 3 times/year	2) Collected during harvest season
33	98° - 4.8 miles	Ouita Lake Recreation Area of Illinois Bayou off Dyke Road Pump near boat ramp	1) Ground Water	1) Quarterly	
Alt.	235° - 3.5 miles	Delaware Recreation area	1) Ground Water	1) Quarterly	
34	295° - 6.6 miles	Flat Rock Recreation area	1) Ground Water	1) Quarterly	
35	35° - 1.2 miles	Tom Cook Residence	1) Leafy and Tuberous Vegetables	1) Seasonal	
37	8° - 7.5 miles	L. Steuber's Dairy	1) Milk 2) Pasturage	1) Monthly 2) 3 times/year	2) Spring, Summer and Fall

NOTE: These sample stations will be determined as per Specification 4.2.10 and will be reported in the Operating Report as per Specification 5.6.1

*Alternate Dairies may be substituted when those listed are not available.

TABLE 1-3

TLD LOCATIONS

AP&L-TLD-NO.	Location Relative to ANO
1	0.5 miles 92°
2	0.5 miles 235°
3	0.4 miles 4°
4	0.4 miles 171°
5	8.5 miles 298°
6	6.8 miles 109°
7	19.3 miles 209°
8	1.8 miles 313°
9	1.2 miles 308°
10	0.8 miles 136°
11	2.3 miles 108°
12	3.3 miles 60°
13	1.4 miles 48°
14	1.4 miles 24°
15	1.5 miles 343°
16	1.9 miles 315°
17	17.2 miles 305°

TABLE 1-3 (Cont'd)

TLD LOCATIONS

AP&L-TLD-NO.	Location Relative to ANO
18	5.8 miles 291°
19	4.8 miles 313°
20	4.2 miles 338°
21	5.5 miles 338°
22	3.5 miles 12°
23	3.5 miles 48°
24	3.3 miles 62°
25	9.2 miles 47°
26	5.6 miles 78°
27	5.7 miles 103°
28	8.5 miles 115°
29	7.5 miles 118°
30	4.6 miles 245°
31	2.7 miles 253°
32	4.8 miles 274°
33	3.8 miles 231°
34	2.8 miles 207°
35	3.1 miles 186°
36	4.3 miles 166°
37	8.5 miles 152°
38	5.8 miles 195°
39	19.2 miles 178°

TABLE 1-3 (Cont'd)

TLD LOCATIONS

AP&L-TLD-NO.	Location Relative to TMI-NO
40	21.8 miles 151°
41	3.3 miles 134°
42	5.2 miles 127°
43	17.5 miles 106°
44	13.0 miles 314°

TABLE 1.4

AQUATIC SAMPLING LOCATIONS AND FREQUENCIES

Sample Type	Sample Frequency	Sample Station # *
Plankton	Quarterly	Areas A, B, C, D
Benthic Organisms	Quarterly	Areas A, B, C, D
Gill Net Survey	Semiannually	Areas A, B, C, D
Shoreline Seine (Mussels)	Semiannually	Areas A, B, C, D
Water	Monthly	Areas A, B, C, D

*Sample Station Numbers used by Ark. Tech University for sampling purposes.

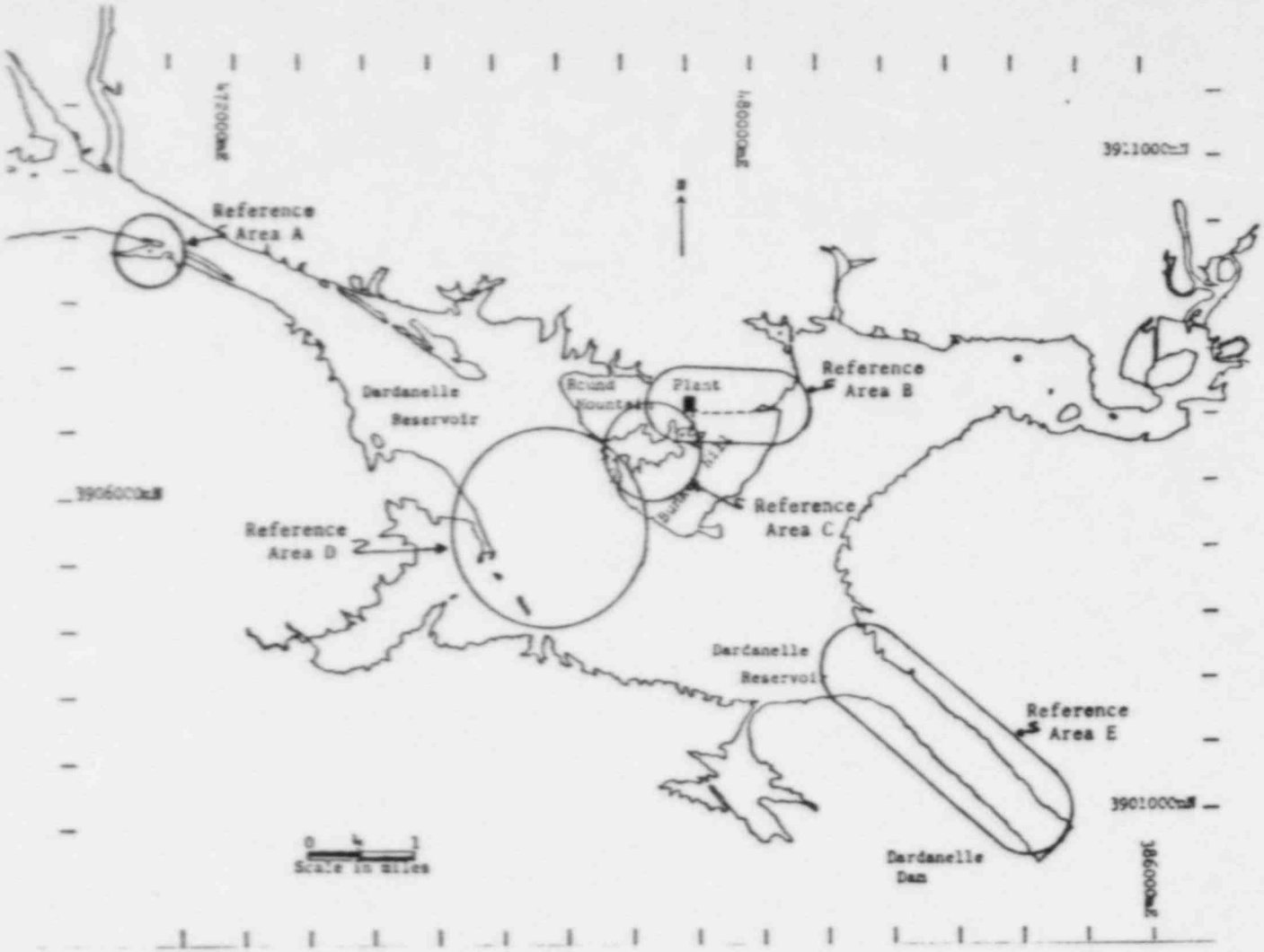


FIGURE 1.1 AQUATIC SAMPLING POINTS

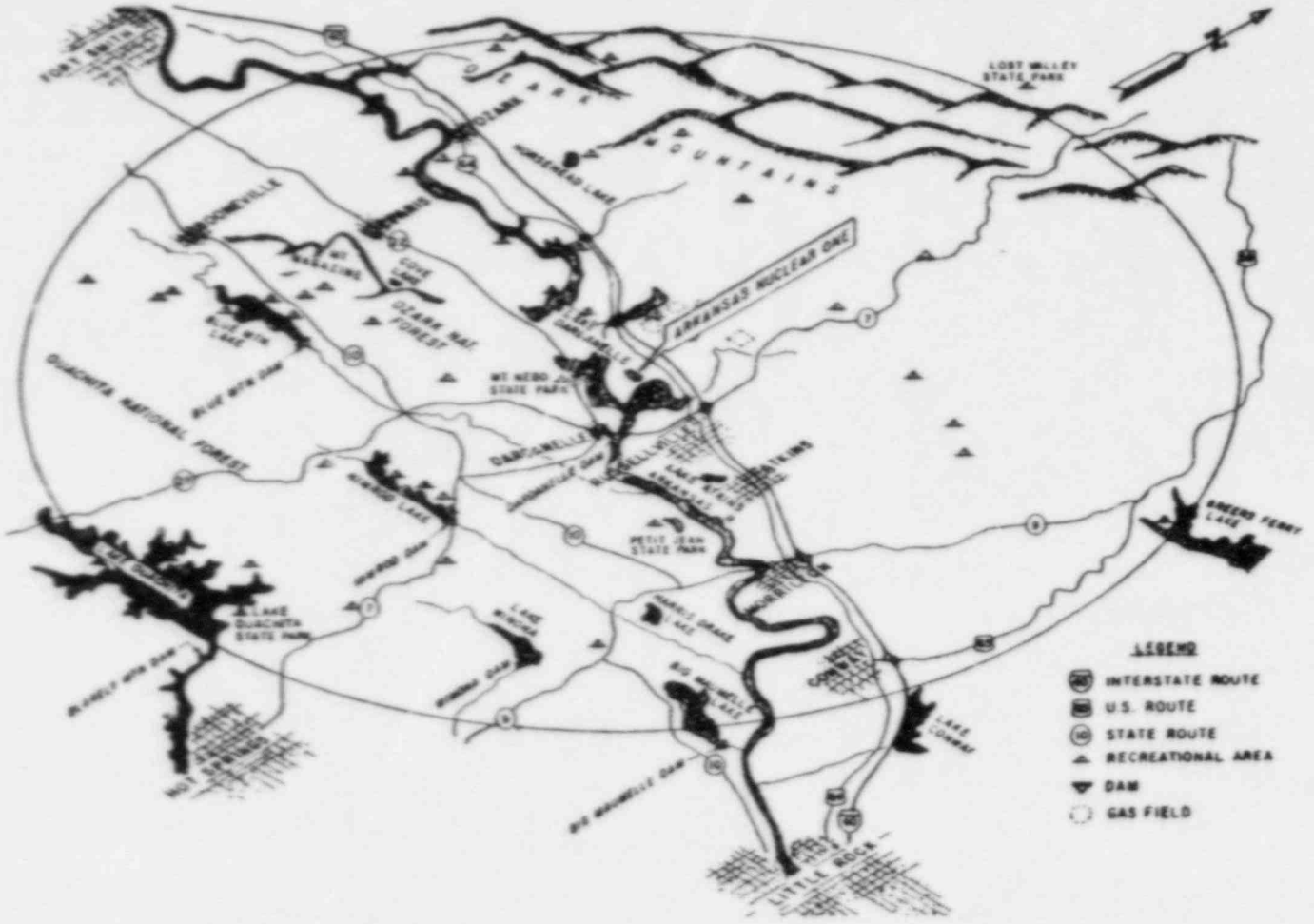


FIGURE 1.2 AREA WITHIN 50 MILES OF ARKANSAS NUCLEAR ONE

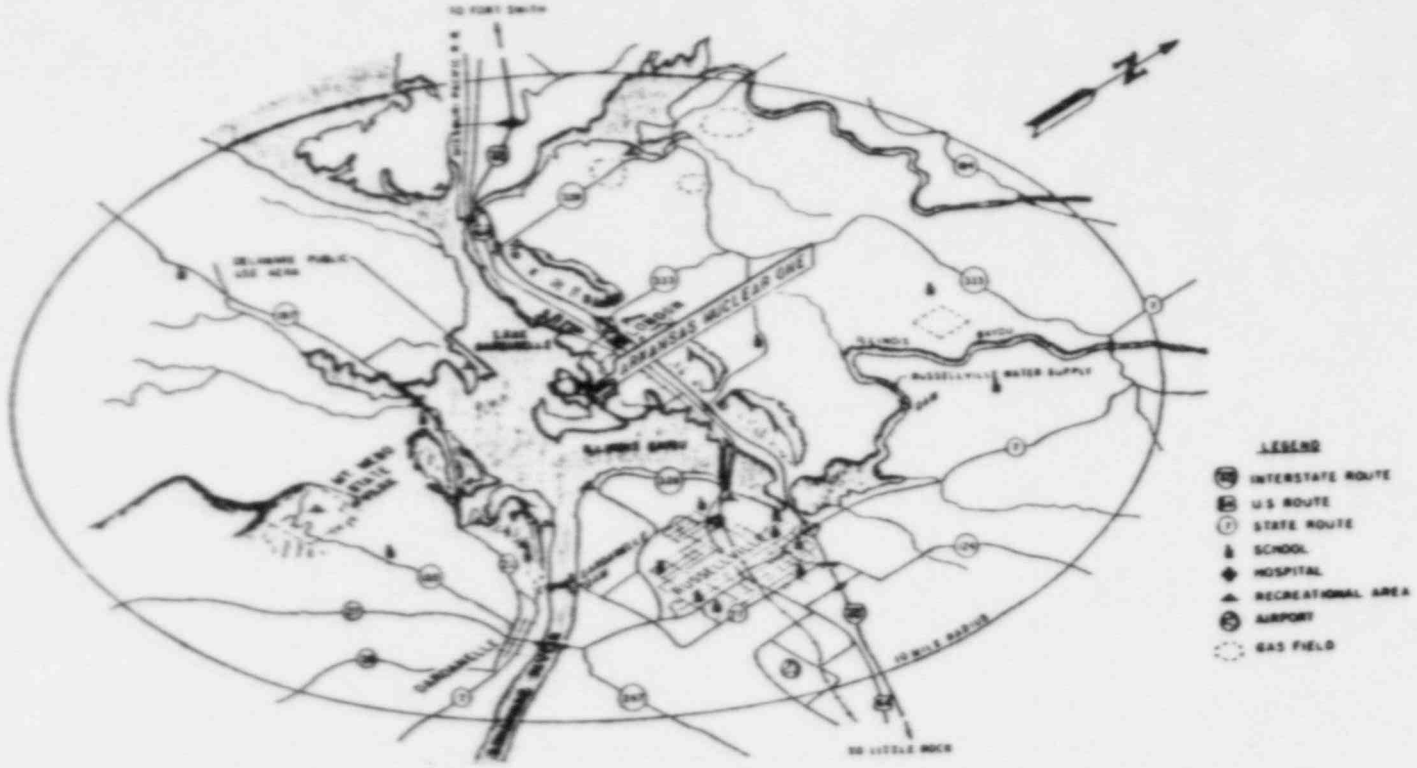
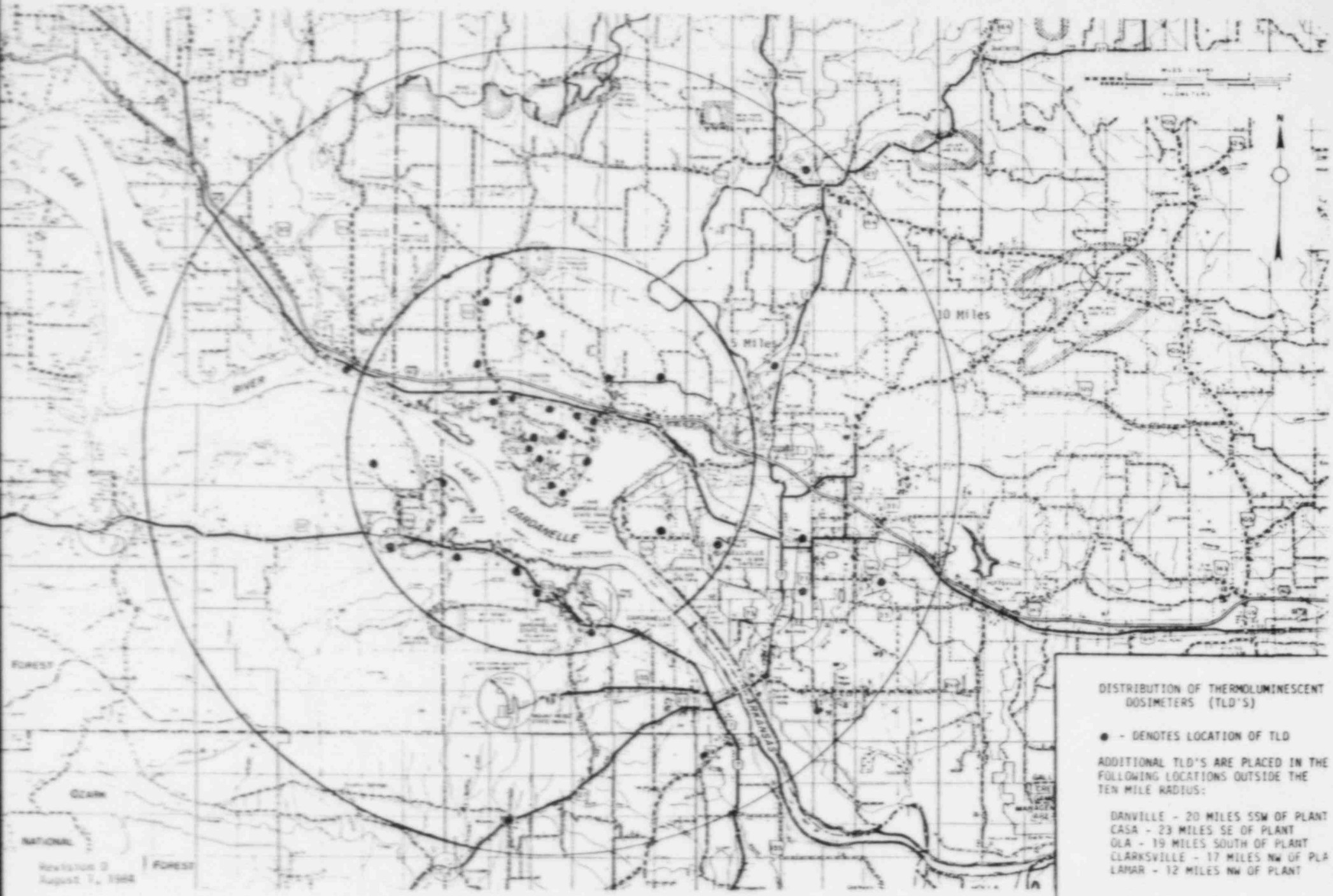


FIGURE 1.3 AREA WITHIN 10 MILES OF ARKANSAS NUCLEAR ONE

FIGURE 1.4



Revision 0
August 7, 1998

2.1 SAMPLES ASSOCIATED WITH AIR MONITORING

None of the 312 samples collected from indicator locations for radioiodine in air (using activated charcoal filters) indicated iodine-131 activities greater than the lower limit of detection, which is 0.050 pCi per cubic meter of air.

Also, none of the 77 monthly composites of air particulate filters analyzed in the calendar year 1984, including the control air particulate samples from Danville, Arkansas indicated the presence of radioactive fission or activation products.

TLD data collected for the calendar year 1984 is divided into two categories. The first category includes the lithium fluoride (LiF) TLDs which were collected and read quarterly, and the second category includes (LiF) TLDs which were collected and read semiannually. The quarterly TLD data for 1984 indicated a total yearly average dose for the forty-three indicator locations to be 68 mrem per year compared to the total yearly average dose of 70 mrem for 1983 and 63 mrem for 1982. The control location at Danville, Arkansas (109° - 19.3 miles) indicated a total dose, based upon quarterly TLDs, of 67 mrem per year for 1984 compared to 56 mrem for 1983 and 59 mrem per year for 1982. Table 2.1.1 lists the total yearly average dose for the indicator location for the calendar years of 1981, 1982, 1983, and 1984 compared to the total dose of background radiation (control station), also based upon quarterly TLD reports.

TABLE 2.1.1

DIRECT RADIATION MEASURED BY

QUARTERLY LITHIUM FLUORIDE DOSIMETERS INDICATOR LOCATIONS

1981 (mrem/year	1982 (mrem/year)	1983 (mrem/year)	1984 (mrem/year)
64	63	70	68

CONTROL OR BACKGROUND LOCATION

1981 (mrem/year)	1982 (mrem/year)	1983 (mrem/year)	1984 (mrem/year)
60	59	56	67

The difference between the indicator locations and the control location for 1984 quarterly TLDs results is not statistically significant. The standard deviation for the indicator locations is 5.1 mrem annual dose. For a one sample t-test, (i.e., a single control compared to all indicator locations), a t-value of 0.77 is obtained. This t-value does not indicate a significant difference between the control and indicator locations at the 95% confidence level. A t-value of greater than 1.96 would be necessary to indicate a significant difference.

Factors other than statistical fluctuations that may affect the variation in recorded dose include variations of up to 15% in response of the TLD chips to the same radiation exposure, different soil types at monitoring locations, and varying heights above ground level for TLD placement.

The TLDs collected every six months during 1984 indicated slightly lower readings than the quarterly TLDs, which is consistent with TLD readings recorded in 1983, 1982, 1981, and 1980. The lower dose measurement for the dosimeters deployed in the field for six months compared to the quarterly readings is attributed to "fading" of the lithium fluoride chips. The TLDs collected every six months indicated a total yearly average dose for the indicator locations of 56 mrem, compared to 57 mrem per year in 1983 and 48 mrem per year in 1982. The six-month TLDs are located at six indicator locations and one control location. The control location indicated a total dose, base upon TLDs collected and read semiannually, of 61 mrem, compared to 58 mrem in 1983.

The small difference in six month 1984 TLD data between indicator locations and control location is not significant. The standard deviation for the indicator locations is 10.6 mrem annual dose. A t-value of -0.75 is calculated for a single sample t-test comparing the indicator locations to the control. At the 95% confidence level at t-value of greater than 2.20 would be necessary to indicate any statistically significant difference.

None of the 126 rain samples collected and analyzed in 1984, as in 1982 and 1983, indicated the presence of radioactive fission or activation products. Analyses performed were gamma spectrometry and gross beta.

2.2 SAMPLES ASSOCIATED WITH WATER MONITORING

Lake water samples are collected from five different sample sites in Lake Dardanelle monthly, plus the Arkansas Department of Health and Arkansas Power and Light Company split a surface water sample from the ANO Discharge Canal and Piney Bay monthly. Each laboratory analyzes the sample of gamma emitters. One surface water sample with measurable quantities of plant related gamma-emitting radionuclides was collected from the ANO Discharge Canal. This surface water grab sample was collected by and split with the Arkansas Department of Health on May 8, 1984 at 10:59 a.m. Approximately 35 pCi/l of Co-58 and 13 pCi/l of Co-60 were detected in the May 1984 split sample from the ANO Discharge Canal. No dose calculation was calculated for this sample since this area of Lake Dardanelle is not a source of drinking water.

As in previous years, bottom sediments collected from the ANO Discharge Canal (0.1 mile 180°) during 1984 indicated the greatest concentration of radionuclides attributable to ANO operations. To determine the maximum whole body dose exposure from sediments, dose calculations were performed according to the mathematical model for determining external dose from sediment given by U.S. Nuclear Regulatory Commission Regulatory Guide 1.109. Tables 2.2.1 and Table 2.2.2 give the results of these calculations for samples collected from the ANO Discharge Canal in February and August 1984. The maximum external dose to the skin from sediments for all measurable radionuclides was approximately 0.20 mrem per year, and the maximum whole body dose was approximately 0.16 mrem per year.

According to ANO Technical Specifications, the design objectives for the dose to the whole body or any organ of an individual is 5 mrem per year as the result of release of liquid wastes. The value of 0.2 mrem per year for maximum whole body dose or maximum external dose to skin of a teenager is well within the design objective criteria.

The 1984 fish samples collected include the three categories listed in previous annual environmental radiological reports: 1) bottom feeder fish, usually buffalo and carp, 2) carnivorous fish, usually catfish, crappie and bass, and 3) plankton feeder fish, usually shad. Edible portions of bottom feeder and carnivorous fish and whole plankton feeder fish are analyzed by gamma spectrometry for radionuclides. The highest level of reactor-produced radionuclides attributed to operations at ANO were found in whole plankton feeder fish collected September 4, 1984 from the ANO Discharge Canal (0.1 mile 180°).

TABLE 2.2.1

CALCULATION OF MAXIMUM ANNUAL DOSE TO MAN FROM BOTTOM SEDIMENT SAMPLE

022584BS08

(2/25/84)

ANO Discharge Canal

Isotope	Activity (pCi/Kg)	Dose to Skin (mrem/yr)	Dose to Whole Body (mrem/yr)
Mn-54	76	0.001	0.001
Co-58	187	0.004	0.004
Co-60	1701	0.091	0.078
Cs-134	854	0.032	0.027
Cs-137	4805	0.063	0.054
	TOTAL	0.191	0.164

NOTE: Dose calculations made according to the guidance of Nuclear Regulatory Commission Regulatory Guide 1.109, using the equation:

$$R(\text{mrem/yr}) = C(\text{pCi/Kg})(40\ \text{Kg/m}^2) \bullet U(\text{hr/yr}) \bullet D(\text{mrem/hr per pCi/m}^2)$$

Where: R is the annual dose to an organ or whole body

C is concentration of a particular nuclide,

U is the maximum exposure time (67 hours for teen),

D is the dose factor

TABLE 2.2.2

CALCULATION OF MAXIMUM ANNUAL DOSE TO MAN FROM BOTTOM SEDIMENT SAMPLE

080484BS08

(8/4/84)

ANO Discharge Canal

Isotope	Activity (pCi/Kg)	Dose to Skin (mrem/yr)	Dose to Whole Body (mrem/yr)
Mn-54	44	0.001	0.001
Co-58	76	0.002	0.001
Co-60	1170	0.062	0.053
Cs-134	731	0.027	0.024
Cs-137	4033	0.053	0.045
	TOTAL	0.145	0.124

NOTE: Dose calculations made according to the guidance of Nuclear Regulatory Commission Regulatory Guide 1.109, using the equation:

$$R(\text{mrem/yr}) = C(\text{pCi/Kg})(40\ \text{Kg/m}^2) \bullet U(\text{hr/yr}) \bullet D(\text{mrem/hr per pCi/m}^2)$$

Where: R is the annual dose to an organ or whole body

C is concentration of a particular nuclide,

U is the maximum exposure time (67 hours for teen),

D is the dose factor

Dose calculations based upon the plankton feeder fish radioisotope concentrations were found according to the mathematical model for determining maximum total dose to total body from fish consumption given by the U.S. NRC Regulatory Guide 1.109. Although, shad are forage for carnivorous fish species, for this calculation it was assumed that shad serve as human food. Table 2.2.9 identifies the radioisotopes found in the plankton feeder fish, the amount of radioactivity present, and the contribution of the total maximum calculated dose for either whole body or specific body organs. According to these calculations, the maximum dose to adults to total body from plankton feeder fish consumption is about 1.1 mrem per year to the liver. The value of 1.1 mrem per year is well within the design objective criteria of 5 mrem per unit as defined in the ANO Technical Specifications for liquid wastes.

Tables 2.2.3 through 2.2.10 identifies all radioisotopes found in eight fish samples collected and analyzed in 1984. According to dose calculations given in U.S. NRC Regulatory Guide 1.109, the bottom feeder fish collected from the ANO Discharge Canal on September 4, 1984 revealed the highest dose from edible fish samples collected in 1984. The calculated maximum organ dose was 0.61 mrem per year (liver).

In addition to the fish samples described above, edible portions of fish were collected by the Arkansas Department of Health, on May 10 and October 4, 1984. Edible portions of fish collected from the ANO Discharge Canal October 4, 1984 contained the highest levels of reactor-produced radionuclides for these split fish samples. In Table 2.2.3 and 2.2.4, dose calculations were performed according to

the mathematical model given by U.S. NRC Regulatory Guide 1.109. The highest calculated dose to adults from consumption of fish split with the Arkansas Department of Health is 0.32 mrem per year (liver).

Table No. 2.2.11 is a listing of concentrations of radionuclides detected in sport fish tissue samples split with the Arkansas Department of Health collected during the calendar years 1978, 1979, 1980, 1981, 1982, 1983, and 1984. Figures 2.2.1 and 2.2.1 graphically depicit the Cs-134 and Cs-137 concentrations given in Table 2.2.11.

The Spearman rank-correlation test was applied to the Cs-134 and Cs-137 activity concentrations in sport fish tissue given in Table 2.2.11. Data of sample collection and activity concentration was ranked and the correlation calculated to determine if a significant increasing trend of activity concentration versus time has occurred during the seven year period of 1978 through 1984. The calculated Spearman ranked-correlation coefficient for Cs-134 is 0.372. At the 95% confidence level the Spearman coefficient would have to be greater than 0.506 for twelve observations to indicate a positive correlation of Cs-134 activity concentration with time. Similarly, the Spearman coeficient for Cs-137 is 0.503. The Spearman rank-correlation coefficient for Cs-139 approaches the 95% confidence level for indication of increasing activity concentration with time. Additional data collected in 1985 will provide a greater data base to evaluate the activity concentration of Cs-137 in fish tissue with time. (William Volk, Applied Statistics for Engineers, 2nd Edition, McGraw-Hill, new Yrok, 1969, P. 366-368).

TABLE 2.2.11

COMPARISON OF GAMMA-EMITTING RADIONUCLIDES IN SPORT FISH FROM THE ANO DISCHARGE CANAL

Radionuclide	Date and Activity (pCi/Kg)											
	May 78	Oct 78	June 79	Oct 79	May 80	Dec 81	July 82	Dec 82	Apr 83	Nov 83	May 84	Oct 84
Co-58		13		46								
Cs-134		40	29	19			58	24	41	47	29	28
Cs-137	65	95	86	41	12	18	141	75	127	143	94	101
Xe-133										171	266	

FIGURE 2.2.1

Cs-134 IN SPORT FISH TISSUE

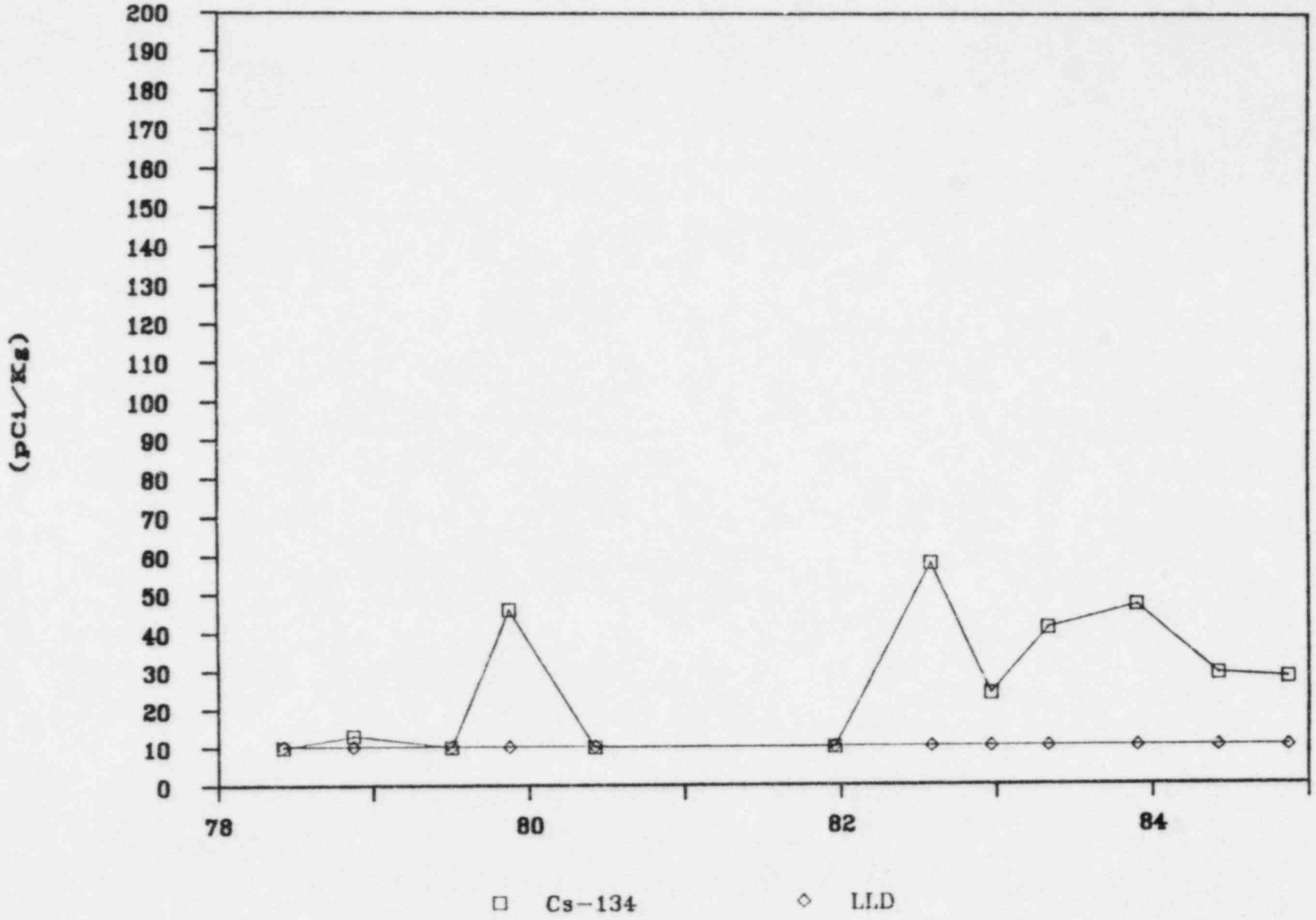
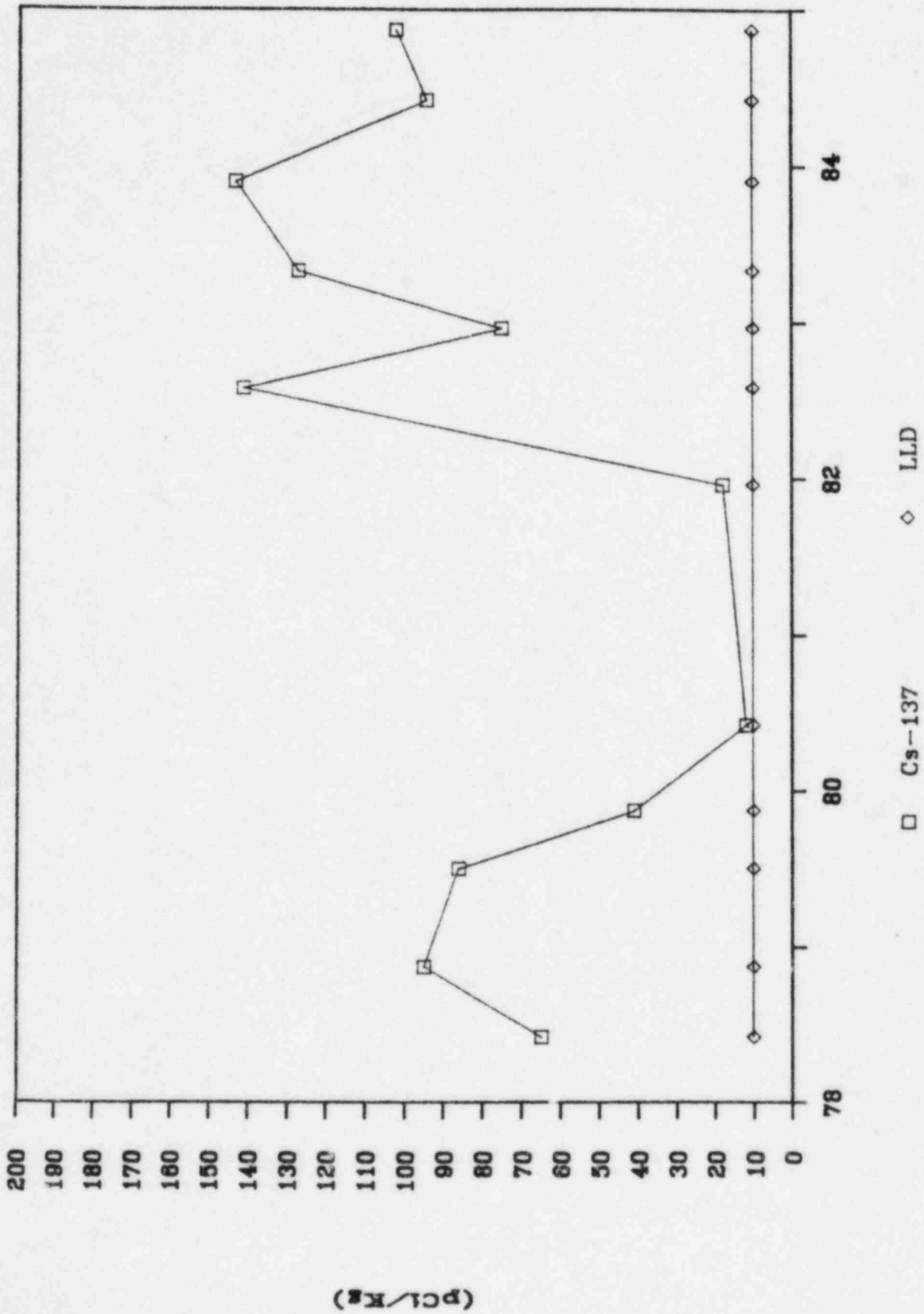


FIGURE 2.2.2

Cs-137 IN SPORT FISH TISSUE



Whole mollusks samples were collected in April and October 1984. Samples of mollusks caged in the ANO Discharge Canal (0.1 mile 180°) indicated reactor-produced radionuclides present. Reactor-produced radionuclides found include Cobalt-58, Cesium-134, and Cesium-137. Radionuclide concentrations in mollusks are comparable to fish concentrations discussed above.

2.3 SAMPLES ASSOCIATED WITH TERRESTRIAL MONITORING

Milk samples were collected by the split with the Arkansas Department of Health in all twelve months of 1984. Three indicator locations for collection of milk at dairies and one control location, the R.A. Young Diary (12.0 miles 73°), were active during 1984.

Monthly milk samples are analyzed for Iodine-131 by concentrating the iodine with anion exchange resin and counting the concentrated iodine sample in a low-background alpha/beta counting system.

No gamma emitting radionuclides were detected by gamma spectrometry in milk samples collected in 1984, including the R.A. Young Dairy, the control dairy.

Strontium-89 and Strontium-90 analyses in milk produced average strontium activities at indicator locations equivalent to 1983, 1982 and 1981 levels.

TABLE 2.2.3

CALCULATION OF MAXIMUM ANNUAL DOSE

TO MAN FROM EDIBLE FISH SAMPLE SPLIT W/ADH

051084FC08-S

(5/10/84)

ANO Discharge Canal

Isotope	Activity (pCi/Kg)	Annual Organ Dose to Adult (mrem/yr)
Cs-134	29	0.09 (Liver)
Cs-137	94	0.21 (Liver)
TOTAL		0.30 (Liver)

NOTE: Dose calculations made according to the guidance of Nuclear Regulatory Commission Regulatory Guide 1.109, using the equation:

$$R(mrem/yr) = C(pCi/Kg) \bullet U(Kg/yr) \bullet D(mrem/pCi)$$

Where: R is the annual dose to an organ or whole body

C is concentration of a particular nuclide

U is the maximum intake of fish for adult (21 Kg/yr)

D is the dose factor

TABLE 2.2.4

CALCULATION OF MAXIMUM ANNUAL DOSE

TO MAN FROM AND EDIBLE FISH SAMPLE SPLIT W/ADH

100484FC08-S

(10/4/84)

ANO Discharge Canal

Isotope	Activity (pCi/Kg)	Annual Organ Dose to Adult (mrem/yr)
Cs-134	28	0.09 (Liver)
Cs-137	102	0.23 (Liver)
Total		0.32 (Liver)

NOTE: Dose calculations made according to the guidance of Nuclear Regulatory Commission Regulatory Guide 1.109, using the equation:

$$R(mrem/yr) = C(pCi/Kg) \bullet U(Kg/yr) \bullet D(mrem/pCi)$$

Where: R is the annual dose to an organ or whole body

C is concentration of a particular nuclide

U is the maximum intake of fish for adult (21 Kg/yr)

D is the dose factor

TABLE 2.2.5

CALCULATION OF MAXIMUM ANNUAL DOSE

TO MAN FROM CARNIVOROUS FISH SAMPLE

052484FC08

(5/24/84)

ANO Discharge Canal

Isotope	Activity (pCi/Kg)	Annual Organ Dose to Adult (mrem/yr)
Cs-137	48	0.10 (Liver)
Total		0.10 (Liver)

NOTE: Dose calculations made according to the guidance of Nuclear Regulatory Commission Regulatory Guide 1.109, using the equation:

$$R(\text{mrem/yr}) = C(\text{pCi/Kg}) \bullet U(\text{Kg/yr}) \bullet D(\text{mrem/pCi})$$

Where: R is the annual dose to an organ or whole body

C is concentration of a particular nuclide

U is the maximum intake of fish for adult (21 Kg/yr)

D is the dose factor

TABLE 2.2.6

CALCULATION OF MAXIMUM ANNUAL DOSE

TO MAN FROM CARNIVOROUS FISH SAMPLE

090484FC08

(9/4/84)

ANO Discharge Canal

Isotope	Actiivty (pCi/Kg)	Annual Organ Dose to Adult (mrem/yr)
Cs-134	51	0.16 (Liver)
Cs-137	176	0.40 (Liver)
Total		0.56 (Liver)

NOTE: Dose calculations made according to the guidance of Nuclear Regulatory Commission Regulatory Guide 1.109, using the equation:

$$R(mrem/yr) = C(pCi/Kg) \bullet U(Kg/yr) \bullet D(mrem/pCi)$$

Where: R is the annual dose to an organ or whole body

C is concentration of a particular nuclide

U is the maximum intake of fish for adult (21 Kg/yr)

D is the dose factor

TABLE 2.2.7

CALCULATION OF MAXIMUM ANNUAL DOSE

TO MAN FROM BOTTOM FEEDER FISH SAMPLE

052484FB08

(5/24/84)

ANO Discharge Canal

Isotope	Activity (pCi/Kg)	Annual Organ Dose to Adult (mrem/yr)
Cs-134	20	0.06 (Liver)
Cs-137	84	0.19 (Liver)
Total		0.25 (Liver)

NOTE: Dose calculations made according to the guidance of Nuclear Regulatory Commission Regulatory Guide 1.109, using the equation:

$$R(mrem/yr) = C(pci/Kg) \bullet U(Kg/yr) \bullet D(mrem/pCi)$$

Where: R is the annual dose to an organ or whole body

C is concentration of a particular nuclide

U is the maximum intake of fish for adult (21 Kg/yr)

D is the dose factor

TABLE 2.2.8

CALCULATION OF MAXIMUM ANNUAL DOSE

TO MAN FROM BOTTOM FEEDER FISH SAMPLE

090484FB08

(9/4/84)

ANO Discharge Canal

Isotope	Activity (pCi/Kg)	Annual Organ Dose to Adult (mrem/yr)
Cs-134	49	0.15 (Liver)
Cs-137	202	0.46 (Liver)
Total		0.61 (Liver)

NOTE: Dose calculations made according to the guidance of Nuclear Regulatory Commission Regulatory Guide 1.109, using the equation:

$$R(\text{mrem/yr}) = C(\text{pCi/Kg}) \bullet U(\text{Kg/yr}) \bullet D(\text{mrem/pCi})$$

Where: R is the annual dose to an organ or whole body

C is concentration of a particular nuclide

U is the maximum intake of fish for adult (21 Kg/yr)

D is the dose factor

TABLE 2.2.9

CALCULATION OF MAXIMUM ANNUAL DOSE

TO MAN FROM PLANKTON FEEDER FISH SAMPLE

090484FP08

(9/4/84)

ANO Discharge Canal

Isotope	Activity (pCi/Kg)	Annual Organ Dose to Adult (mrem/yr)	
Co-58	56	0.02 (GI-LLI)	* (Liver)
Co-60	55	0.05 (GI-LLI)	* (Liver)
Cs-134	93	0.01 (GI-LLI)	0.29 (Liver)
Cs-137	314	0.01 (GI-LLI)	0.72 (Liver)
Total		0.09 (GI-LLI)	1.01 (Liver)

NOTE: Dose calculations made according to the guidance of Nuclear Regulatory Commission Regulatory Guide 1.109, using the equation:

$$R(\text{mrem/yr}) = C(\text{pCi/Kg}) \bullet U(\text{Kg/yr}) \bullet D(\text{mrem/pCi})$$

Where: R is the annual dose to an organ or whole body

C is concentration of a particular nuclide

U is the maximum intake of fish for adult (21 Kg/yr)

D is the dose factor

*Calculated dose for this isotope is less than 0.01 mrem/yr.

TABLE 2.2.10

CALCULATION OF MAXIMUM ANNUAL DOSE

TO MAN FROM PLANKTON FEEDER FISH SAMPLE

052484FP08

(5/24/84)

ANO Discharge Canal

Isotope	Activity (pCi/Kg)	Annual Organ dose to Adult (mrem/yr)
Cs-134	24	0.07 (Liver)
Cs-137	73	0.17 (Liver)
Total		0.24 (Liver)

NOTE: Dose Calculations made according to the guidance of Nuclear Regulatory Commission Regulatory Guide 1.109, using the equation:

$$R(mrem/yr) = C(pCi/Kg) \bullet U(Kg/yr) \bullet D(mrem/pCi)$$

Where: R is the annual dose to an organ or whole body

C is concentration of a particular nuclide

U is the maximum intake of fish for adult (21 Kg/yr)

D is the dose factor

Vegetation samples were divided into two categories in 1984, pasturage vegetation and garden products vegetation. Of the 33 pasturage samples collected and analyzed in 1984, cesium-137 was the only gamma emitting radionuclide determined in pasturage samples. Cesium-137 was detected in two samples from indicator locations and in one control sample from Danville, AR. Garden products vegetation was collected in May, June, July, August, and September 1984 from two gardens. Garden vegetation collected and analyzed included cabbage, head lettuce, spinach, and leaf lettuce. No gamma emitting radionuclides were detected in any garden products vegetation during 1984.

Soil samples were collected in May and November 1984 from seven sampling stations each time. Cesium-137 was detected in all fourteen soil samples. Due to its wide spread presence international fallout is the probable source of this fission produced radionuclide. Manganese-54 was detected in the soil sample taken in May 1984 at sampling site no. 2 (0.5 miles 235°); however, the activity concentration was less than the "a prior" LLD for this isotope. Only cesium-137 was detected at this location during the November 1984 sampling period.

2.4 SAMPLES NOT COLLECTED IN 1984

Caged mollusks were sampled in 1984 as representatives of benthic organisms. It is impossible to place a cage at location 15, the Dardanelle Dam area, because of the water depth. Naturally occurring benthos are not present in quantities sufficient for analysis, therefore, no benthic organisms were analyzed at sample station No. 15.

Most of the caged mollusks in the ANO Discharge Canal collected in October, 1984 were dead upon retrieval and only the shells remained. Gamma analysis was performed on the shells of these dead mollusks.

The April 1984 air particulate composites (7 composite samples collected for four weeks) were accidentally destroyed by Strontium analysis before gamma spectrometry was performed. However, gross alpha and gross beta analysis of each individual air particulate sample indicated no results higher than usual from the April 1984 air particulate samples.

On January 11, 1984, precipitations samples at sample stations No. 5 and No. 7 were frozen, and again on January 19, 1984, precipitation samples were frozen at sample stations No. 1, 3, 5, and 7. Freezing prevents removal of the sample from the sample collection device.

Air sampling equipment was not functional upon return to collect weekly air particulate and air iodine samples at the following dates and locations:

August 1, 1984 - Sample Station No. 3

September 19 1984 - Sample Stations No. 1 and 4

November 11, 1984 - Sample Station No. 7

November 28, 1984 - Sample Station No. 7

December 12, 1984 - Sample Station No. 7

December 26, 1984 - Sample Station No. 5

2.5 COMPARISON OF RESULTS OF EPA CROSS-CHECK PROGRAM

The Technical Analysis Section of Arkansas Power and Light Company participates in the U.S. Environmental Protection Agency's Environmental Radioactivity Laboratory Intercomparison Studies Program. The major objective of this program is to assist laboratories involved in environmental radiation measurements to develop and maintain both an intra-laboratory and an inter-laboratory quality control program. This is partially accomplished through a laboratory intercomparison studies program involving environmental media (milk, water and air) and a variety of radionuclides with activities at or near environmental levels.

During the calendar year 1983, the following sample types were received and analyzed:

1) Gross Alpha-Beta in Water - A one-liter sample for the analysis of gross alpha and gross beta activity.

2) Gamma in Water - A one-liter sample containing chromium-51, zinc-65, cobalt-60, ruthenium-106, cesium-134 and cesium-137.

3) Tritium in Water - A twenty-five ml sample containing tritium.

4) Iodine-131 in Water - four-liter sample containing iodine-131.

5) Strontium in Water - A one-liter sample containing strontium-89 and strontium-90.

6) EPA Blind in Water - A one-liter blind sample containing a mixture of radionuclides.

7) Milk - Four-liter milk sample containing potassium, strontium-89, strontium-90, iodine-131, cesium-137 and barium-140.

8) Air - A two-inch diameter air filter is distributed quarterly for gross alpha, gross beta, cesium-137 and strontium-90 analyses.

9) Low-Level Water - A four-liter sample containing very low quantities of I-131.

10) Low-Level Milk - A four-liter sample containing very low quantities of I-131.

A report listing the results of the analysis containing the laboratory standard deviation, calculation of the normalized range, normalized deviation, sample standard deviation, and the grand average of all laboratories is mailed after each participating laboratory performs three independent determinations for each radionuclide involved in the study.

Table 2.5.1 lists the various analyses that are performed, the radioactivity levels found in the EPA cross-check samples, and one standard deviation for a single determination.

If the Technical Analysis Section Environmental Laboratory results differ by more than 3 standard deviations from the known results given in the EPA cross-check reports, the instrument and procedure are checked for error.

Table 2.5.2 lists the date of preparation, types of EPA cross-check samples received, the total number of analyses performed, the average sample standard deviation based upon three independent determinations for each radionuclide in each sample, and the number of standard deviations the AP&L lab differed from the known value.

Most of the results were well within three standard deviations of the known values supplied by the U.S. EPA.

Results from analyses for strontium-90 in EPA milk samples were outside the control limit of 3 standard deviations for the June 22 and October 26, 1984 samples. Radiostrontium analyses have been deleted from the monitoring program for 1985 and the investigation to identify the source of the disagreement with the EPA values has been discontinued.

Gross beta results in EPA air filters differed from the known values by approximately 3 standard deviations in the August 24 and November 23, 1984, samples. The mixture of isotopes in the EPA sample produces a different beta energy mix compared to the calibration source. New air filter efficiency curves for 1985 will include Sr-90 and Cs-137 to compensate for the energy differences.

TABLE 2.5.1 LABORATORY PRECISION: ONE STANDARD DEVIATION VALUES FOR VARIOUS ANALYSES

Analysis	Level	One Standard Deviation for Single Determination
Gamma Emitters	5 to 100 pCi/liter or kg	5 pCi/liter
	>100 pCi/liter or kg	5% of known value
Strontium-89	5 to 100 pCi/liter or kg	5 pCi/liter
	>100 pCi/liter or kg	5% of known value
Strontium-90	2 to 30 pCi/liter or kg	1.5 pCi/liter
	>30 pCi/liter of kg	5% of known value
Potassium	≥0.1 g/liter or kg	5% of known value
Gross Alpha	≤20 pCi/liter	5 pCi/liter
	>20 pCi/liter	25% of known value
Gross Beta	≤100 pCi/liter	5 pCi/liter
>100 pCi/liter	5% of known value	
Tritium	<4,000 pCi/liter	ls (pCi/liter) = 169.85 x (known)^{0933}
	>4,000 pCi/liter	10% of known value
Radium-226, Radium-228	≤0.1 pCi/liter	15% of known value
Iodine-131	≤55 pCi/liter	6 pCi/liter
	>55 pCi/liter	10% of known value

TABLE 2.5.2

U. S. EPA CROSS-CHECK PROGRAM 1984

EPA Preparation	Date EPA Issued Results	Media	Nuclide	EPA Results	AP&L Results	Norm Dev Known	Warning Action
02/03/84	03/23/84	Water	Cr-51	40± 8.7	37± 1.9	-1.2	
			Co-60	10± 8.7	10± 2.3	-0.1	
			Zn-64	50± 8.7	47± 6.3	-0.9	
			Ru-106	61± 8.7	50± 1.8	-3.7	***
			Cs-134	31± 8.7	25± 3.6	-2.1	**
			Cs-137	16± 8.7	15± 2.6	-0.3	
02/10/84	03/22/84	Water	H-3	2383± 607	2540± 280	0.8	
03/02/84	06/19/84	Milk	I-131	6± 1.6	7± 1.4	1.9	
03/23/84	06/07/84	Air Filter	Gross γ	15± 8.7	49± 2.4	-1.6	
			Gross B	51± 8.7	49± 2.4	-0.7	
			Sr-90	21± 2.6	19± 2.9	-2.7	**
			CS-137	10± 8.7	10± 1.2	0.0	
04/06/84	05/31/84	Water	I-131	6± 1.5	3± 0.9	-5.8	***
04/13/84	05/17/84	Water	H-3	3508± 630	3653± 280	0.7	
05/18/84	05/25/84	Water	Gross α	3± 8.7	4± 1.1	0.3	
			Gross B	6± 8.7	6± 1.1	0.1	
06/01/84	07/23/84	Water	Cr-51	66± 8.7	61± 16.5	-1.7	
			Co-60	31± 8.7	29± 2.7	-0.8	
			Zn-65	63± 8.7	60± 5.6	-0.9	
			Ru-106	29± 8.7	27± 12.6	-0.8	
			Cs-134	47± 8.7	41± 3.0	-2.1	**
			Cs-137	37± 8.7	35± 2.7	-0.8	
06/22/84	10/08/84	Milk	Sr-89	25± 8.7	20± 4.6	-1.6	
			Sr-90	17± 2.6	12±	-6.2	***
			I-131	43± 10.4	39± 3.1	-1.3	
			Cs-137	35± 8.7	34± 3.3	-0.3	
			K	1496± 130	1547± 3.3	1.2	

TABLE 2.5.2

U. S. EPA CROSS-CHECK PROGRAM 1984

EPA Preparation	Date EPA Issued Results	Media	Nuclide	EPA Results	AP&L Results	Norm Dev Known	Warning Action
04/22/84	07/09/84	Water Blind	Gross α	35± 15.2	27± 3.2	-1.6	
			Gross B	147± 12.7	137± 4.0	-2.4	
			Co-60	30± 8.7	29± 2.6	-0.3	
			Sr-89	23± 8.7	10± 6.2	-4.5	***
			Sr-90	26± 2.6	23± 4.1	-3.5	***
			Cs-134	30± 8.7	25± 2.1	-1.7	
			Cs-137	26± 8.7	25± 2.1	0.3	
			Ra-226	4.0± 1.04	--		
			Ra-228	8.3± 2.16	--		
			U	15± 10.4	--		
08/03/84	11/19/84	Water	I-131	34± 10.4	34± 4.0	-0.1	
08/07/84	10/08/84	Water	H-3	2817± 617	3160± 183	1.7	
09/07/84	12/06/84	Water	Sr-89	34± 8.7	22± 6.8	-4.3	***
			Sr-90	19± 2.6	19± 4.7	-0.4	
09/21/84	12/17/84	Water	Gross α	5.0± 8.7	3± .8	-0.7	
			Gross B	16.0± 8.7	13± 1.4	-1.3	
10/05/84	12/06/84	Water	Cr-51	40± 8.7	32± 15.1	-2.7	**
			Co-60	20± 8.7	20± 2.2	-0.1	
			Zn-65	147± 8.7	144± 7.2	-0.9	
			Ru-106	47± 8.7	43± 14.2	-1.4	
			Cs-134	31± 8.7	31± 2.6	-0.1	
			Cs-137	24± 8.7	26± 2.3	0.5	
10/26/84	01/28/85	Water Blind	Gross α	14± 8.7	11± 1.3	-1.0	
			Gross B	64± 8.7	54± 1.6	-3.7	***
			Co-60	14± 8.7	15± 1.6	0.2	
			Sr-89	11± 8.7	4± 2.9	-2.5	**
			Sr-90	12± 2.6	12± 2.2	0.0	
			Cs-134	2± 8.7	<10		
			Cs-137	14± 8.7	15± 1.5	0.3	
			Ra-226	3.0± 8.0	--	--	
			Ra-228	2.1± .5	--	--	
			U	5± 10.4	--	--	
10/26/84	01/21/85	Milk	Sr-89	22± 8.7	22± 3.8	-0.1	
			Sr-90	16± 2.6	7± 3.1	-10.8	***
			I-131	42± 10.4	37± 4.2	-1.4	
			Cs-137	32± 8.7	30± 3.5	-0.7	
			K	1517± 131	1493±	-0.5	

TABLE 2.5.2

U. S. EPA CROSS-CHECK PROGRAM 1984

EPA Preparation	Date EPA Issued Results	Media	Nuclide	EPA Results	AP&L Results	Norm Dev Known	Warning Action
11/16/84	01/07/85	Water	Gross α	7± 8.7	5± .9	0.7	
			Gross B	20± 8.7	20± 1.6	0.0	
11/23/84	03/04/85	Air Filter	Gross γ	15± 8.7	18± 1	0.8	
			Gross B	52± 8.7	44± 1.3	-2.9	**
			Sr-90	21± 2.6		--	
			Cs-137	10± 8.7	9± 0.4	-0.3	
08/24/84	11/19/84	Air Filter	Gross γ	17± 8.7	18± 1	0.1	
			Gross B	51± 8.7	42± 1.4	-3.1	***
			Sr-90	18± 2.4	15± 2.2	-2.3	
			Cs-137	16± 8.7	13± 0.5	-0.9	

** outside the warning limit of ±2 sigma

*** outside the control limit of ±3 sigma

3.0 PROGRAM TECHNICAL DESCRIPTION

3.1 SAMPLE HANDLING AND TREATMENT

Once a representative sample is collected and delivered to the laboratory, the laboratory staff is responsible for properly treating and storing the sample. Often samples collected in an environmental survey require treatment because they are not physically ready for analysis. Treatment of the sample after it is received depends on the sample itself and the analyses to be performed on it. Most treatment and handling techniques have been established and well known for many years.

Water Samples

Generally, water samples are acidified when collected. If tritium analysis is to be performed, portions for these analyses are separated before acid is added. Samples for tritium analyses should not be stored in polyethylene bottles for more than 3 or 4 months because water can evaporate through the polyethylene. If the samples are to be stored for any length of time, carrier or complexing agents should be added to prevent adsorption of trace metals on the storage containers.

Air Filters

The air filter must be handled with care when heavy dust loadings is observed because particulate matter is easily removed from the filter. Air filters are often received by the laboratory in envelopes; some extremely low-level analyses may require analysis of the envelope in which the sample arrived as well as the sample itself.

Milk

Milk samples are refrigerated until analyses can be performed. If the analyses will be delayed for more than a few days, a preservative (formalin) is added to inhibit bacterial growth and retard spoilage. Milk samples that are to be analyzed for ^{131}I have 100 ml formalin added to avoid binding of the iodine that may occur with smaller levels of formalin.

Soil and Bottom Sediments

Soil samples are dried, pulverized, and sieved to pass a 200 mesh sieve before analysis. Further thorough mixing is required to ensure a homogeneous sample.

Other Samples

Perishable samples are preserved by refrigeration or freezing. Vegetation and other samples may need to be dried, pulverized, or ashed before analysis.

3.2 GROSS BETA ANALYSIS OF SAMPLES

Air Particulates

At least 24 hours after collection, allowing for the radon isotopes and radon daughter products to decay, the filters are counted in a low background alpah-beta counter.

Calculations of the results, the two sigma error and the lower limit of detection (LLD).

$$\text{RESULT } (pCi/m^3) = (N/T - B/t)/(2.22 \bullet V \bullet E)$$

$$\text{TWO SIGMA ERROR } (pCi/m^3) = 2\sqrt{(N/T^2) + (B/t^2)}/(2.22 \bullet V \bullet E)$$

$$\text{LLD } (pCi/m^3) = 4.66\sqrt{(B)}/(2.22 \bullet V \bullet E \bullet t)$$

where:

- N = Gross counts of sample including blank
- B = Counts of blank
- E = Counting efficiency

T	=	Number of minutes sample was counted
t	=	Number of minutes blank was counted
V	=	Sample aliquot size (cubic meters)

3.3 DETERMINATION OF GROSS ALPHA AND/OR GROSS BETA ACTIVITY IN WATER SAMPLES

(SUSPENDED AND DISSOLVED PORTIONS)

This describes the process used to measure the overall alpha and beta radioactivity of water samples without identifying the radioactive species present. No chemical separation techniques are involved. Two hundred ml of the sample is evaporated in a beaker at approximately 100°C. The residue is transferred and dried and in a 2-inch stainless steel planchet.

The planchets are counted for 100 minutes in a low-background alpha-beta counting system. Calculation of activity includes a self-absorption correction for counter efficiency based on the weight of residue on each planchet.

CALCULATION OF THE SAMPLE ACTIVITY OR OF THE MDA

Result (pCi/l) $= (N/T - B/T)/(2.22 \bullet V \bullet E)$

Two Sigma Error (pCi/l) $= 2\sqrt{(N/T^2)+(B/t^2)}/(2.22 \bullet V \bullet E)$

LLD (pCi/l) $= 4.66\sqrt{(B)}/(2.22 \bullet V \bullet E \bullet t)$

where: N = total counts from sample (counts)

T = counting time for sample (minutes)

B/t = background rate of counter (cpm)

2.22 = $\frac{\text{dpm}}{\text{pCi}}$

V = volume of sample analyzed (liters)

E = efficiency of the counter

If the net activity (N/T - B/t) is equal to or is less than the counting error, the activity on the collection date is below the limits of detection and is designated less than the Lower Limit of Detection (LLD)

3.4 ANALYSIS OF WATER SAMPLES FOR TRITIUM

Five milliliters of water is added to 15 ml of liquid scintillation solution in a 25 ml vial. The sample is inserted into a Liquid Scintillation Spectrometer and counted for 500 minutes.

Calculations of the results, the two sigma error and the lower limit of detection (LLD).

$$\text{RESULT (pCi/l=ℓ)} = (N/T) - (B/t_B)/(2.22 \bullet V \bullet E)$$

$$\text{TWO SIGMA ERROR (pCi/ℓ)} = 2\sqrt{(N/^2) + (B/t_b^{\,2})} \div (2.22 \bullet V \bullet E)$$

$$\text{LLD (pCi/ℓ)} = \frac{4.66\sqrt{B}}{2.22 \bullet E \bullet V \bullet t_b}$$

where:

N	=	Gross counts of sample
B	=	Counts of blank
E	=	Counting efficiency
T	=	Number of minutes sample was counted
t_b	=	Number of minutes blank was counted
V	=	Sample aliquot size (ℓ)

3.5 ANALYSIS OF SAMPLES FOR IODINE-131

Milk or Water

Up to four liters of sample are thoroughly mixed with a stable iodine carrier solution. The sample is then allowed to flow through an anion exchange resin column to remove iodine from the sample. The iodine is then stripped from the resin with sodium hypochlorite solution, is reduced with hydroxylamine hydrochloride and is extracted into carbon tetrachloride as free iodine. It is then back-extracted into sodium bisulfite solution and is precipitated as silver iodide. The precipitate is weighed for chemical yield and is mounted on a stainless steel planchet for low-level beta counting. The chemical yield is corrected by measuring the stable iodide content of the milk or the water with a specific ion electrode.

Calculations of the results, two sigma error and the lower limit of detetection (LLD) in pCi/ℓ:

RESULT $= (N/\Delta t - B)/2.22 \bullet E \bullet V \bullet Y \bullet \exp(-\lambda \Delta t_2)$

TWO SIGMA ERROR $= (2\sqrt{(N/\Delta t + B/\Delta t)} \div (2.22 \bullet E \bullet V \bullet Y \bullet \exp(-\lambda \Delta t_2))$

LLD $= (4.66\sqrt{B/\Delta t}) \div (2.22 \bullet E \bullet V \bullet Y \bullet \exp(-\lambda \Delta t_2))$

where:

N	=	total counts from sample (counts)
Δt	=	counting time for sample (min)
B	=	background rate of counter (cpm)
2.22	-	dpm/pCi

V	= volume or weight of sample analyzed
Y	= chemical yield of the mount of sample counted
$\exp(-\lambda\Delta t_2)$	= decay factor from the time of collection to the counting date
E	= efficiency of the counter for I-131, corrected for self absorption effects

3.6 GAMMA SPECTROMETRY OF SAMPLES

Milk and Water

A 3.5 liter Marinelli beaker is filled with a representative aliquot of the sample. The sample is then counted for a minimum of 450 minutes with a shielded Ge(Li) detector coupled to a multi-channel analyzer.

Vegetation, Food and Garden Crops, and Fish

As much as possible a vegetation food, or garden crop sample, without drying, is loaded into a tared 3.5 liter Marinelli beaker and weighed. The sample is then counted for a minimum of 450 minutes with a shielded Ge(Li) detector coupled to a computer-based data acquisition system which performs pulse height analysis. As much as possible (up to the total sample) of the edible portion of a fish is loaded into a tared Marinelli beaker and weighed. The sample is then counted for a minimum of 450 minutes with a shielded Ge(Li) detector coupled to a computer-based data acquisition system which performs pulse height analysis.

Soils and Sediments

Soils and sediments are dried at low temperature, less than 100°C. The soil or sediment is loaded into a tared, standard 1.0 liter Marinelli beaker and weighed. The sample is then counted for at least six hours with a shielded Ge(Li) detector coupled to a multi-channel analyzer.

3.7 CHARCOAL CARTRIDGES

Charcoal cartridges are counted in a Marinelli Beaker, with one cartridge positioned on the face of a Ge(Li) detector and up to six cartridges on the side of the Ge(Li) detector. Each Ge(Li) detector is calibrated for both positions. The detection limit is determined for I-131 of each charcoal cartridge, assuming no positive results for I-131, for each unique cartridge from the volume of air which passed through it. If Iodine-131 is observed in the screening count of a set of cartridges, each charcoal cartridge is then counted separately, positioned on the face of the detector. A separate counting geometry has also been established for each Ge(Li) detector.

Air Particulate

The four or five (depending on the calendar month) air particulate filters for a monthly composite for each field station are stacked one on top of another and then counted for at least four hours with a shielded Ge(Li) detector coupled to a multi-channel analyzer.

A computer software program defines peaks by certain changes in the slope of the spectrum. The program also compares the energy of each peak with a library of peaks for isotope identification and then performs the radioactivity calculation using the appropriate fractional

gamma ray abundance, half life, detector efficiency, and net counts in the peak region. The calculation of results, two sigma error and the lower limit of detection (LLD) in pCi/volume or pCi/mass:

RESULT = $(S-B)/(2.22 \bullet T \bullet E \bullet V \bullet F)$

TWO SIGMA ERROR = $(2\sqrt{S+B})/(2.22 \bullet T \bullet E \bullet V \bullet F)$

LLD = $(4.66\sqrt{B})/(2.22 \bullet T \bullet E \bullet V \bullet F)$

where:

	S	= Area, in counts, of sample peak and background (region of spectrum of interest)
	B	= Background area, in counts, under sample peak, determined by a linear interpolation of the representative backgrounds on either side of the peak.
	T	= length of time in minutes the samples was counted
	2.22	= dpm/pCi
	E	= detector efficiency for energy of interest and geometry of sample
	V	= sample aliquot size (liters, cubic meters, kilograms, or grams)
	F	= Fractional gamma abundance (specific for each emitted gamma

3.8 TERMINOLOGY OF QUALITY CONTROL OF DATA

mean: The sum of the test results divided by the number of results taken; that is, $X = \sum X_i/n$, where X = mean, X_i = individual result,

and n = number of results

precision: A measure of the reproducibility among replicate observations.

variance: The sum of the squares of deviations of the test results from the mean after division by one less than the total number of results; that is, $VAR = \sum_{i=1}^{n}(X - X_i)^2/(n - 1)$.

standard deviation: The square root of the variance; that is,

$$\sigma = (VAR)^{\frac{1}{2}} = \left[\sum_{i=1}^{n}(X - X_i)^2/(n - 1)\right]^{\frac{1}{2}}$$

range: The difference between the highest test result and the lowest test results in a set of observations.

accuracy: A measure of the agreement between observed and accepted values.

systematic error: Errors that may be traced to the personal errors of the analyst instrumental errors, errors that inherently are in the analytical methodology, or a combination of these. Accuracy is a measure of type of or error.

random error: The necessity for making estimations is inherent in the process of collecting data for the measurement of any quantity. For this reason, any measurement will be uncertain, in an amount that depends on the relative magnitude of the estimations involved in its evaluation. Careful experimental design can reduce this uncertainty; however, small irreducible variations will remain. Since radioactive decay is a random process, any counting measurement will have a random error associated with it. Precision measures this type of variability or error.

bias: The difference between the average of a set of test results and the accepted value. Bias usually is indicated only when a consistent difference is observed over time and can be corrected for by the application of appropriate correction factors. Bias is a measure of the systematic error.

3.9 LLD CALCULATION

The LLD is the smallest concentration of radioactive material in a sample that will be detected with 95% probability with only 5% probability of falsely concluding its presence.

For a particular measurement system (which may include radiochemical separation):

$$LLD = \frac{4.66(s_b)}{E \bullet V \bullet 2.22 \bullet Y \bullet \exp(-\lambda\Delta t)}$$

where:

LLD is the lower limit of detection as defined above (as pCi 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 (as counts per minute)

E is the counting efficiency (as counts per transformation)

V is the sample size (in units of mass or volume)

2.22 is the number of transformation per minute per picocurie

Y is the fractional radiochemical yield (when applicable)

λ is the radioactive decay constant for the particular radionuclide

Δt is the elapsed time between sample collection and analysis

The value of s_b used in the calculation of the LLD for a detection system shall be based on the actual observed variance of the background counting rate or of the counting rate of the blank samples (as appropriate) rather than on an unverified theoretically predicted variance. In calculating the LLD for a radionuclide determined by gamma-ray spectrometry, the background shall include the typical contributions of other radionuclides normally present in the sample (e.g., potassium-40 in milk samples). (See Table 3.9.1)

TABLE 3.9.1

DETECTION LIMITS

	Air Particulate (pCi/m^3)	Fish (pCi/kg)(c)	Mollusks (pCi/kg)(c)	Vegetation (pCi/kg)(d)	Soil and Bottom Sed. (pCi/kg)	Water (pCi/ℓ)	Milk (pCi/ℓ)
H^3	---	---	---	---	---	400	---
Be^7	4×10^{-2}	70	70	400	300	50	50
K^{40}	3×10^{-2}	100	100	725	250	85	85
Mn^{54}	4×10^{-3}	10	10	50	25	5	5
Co^{58}	4×10^{-3}	10	10	50	35	10	10
Fe^{59}	1×10^{-2}	25	25	115	75	15	15
Co^{60}	4×10^{-3}	10	10	65	35	10	10
Zn^{65}	1×10^{-2}	20	20	120	70	15	15
Sr^{89}	2×10^{-3}	4000	4000	--	1500	5	5
Sr^{90}	4×10^{-4}	1000	1000	--	300	1	1
Zr^{95}-Nb^{95}	5×10^{-3}	15	15	50	35	10	10
Ru^{106}	3×10^{-2}	70	70	450	260	50	50
I^{131}(a)	10^{-2}	50	50	100	180	10	10
I^{131}(b)						0.5	0.5
Cs^{134}	4×10^{-3}	10	10	50	30	10	10
Cs^{137}	3×10^{-3}	10	10	50	30	5	5
Ba^{140}	3×10^{-2}	20	20	60	100	10	10
Ce^{144}	2×10^{-2}	60	60	400	250	45	45

(a) Gamma Isotopic Analysis
(b) Radiochemical Seperation
(c) Wet Weight
(d) Dry Weight

LLD's are for average sample quantities and holding times and based upon methodologies and instrumentation utilized during 1984.

4.0 DATA SUMMARY TABLES

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY ANO-1 AND ANO-2 DOCKET NO. 50-313 AND 50-368

LOCATION OF FACILITY POPE, ARKANSAS REPORTING PERIOD JAN. - DEC.,1984

(COUNTY, STATE)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL # OF ANALYSIS	TYPE	LLD	ALL IND. LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DIST. (MI)	# DIR. (DEG)	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
I. AIR									
A. Particulate (pCi/m3)	364	GROSS A	0.003	0.0016 (168/312) (0.0006 - 0.010)	# 6 6.8	109	0.0018 (28/52) (0.0009 - 0.010)	0.0017 (29/52) (0.0008 - 0.0076)	0
	364	GROSS B	0.002	0.019 (306/312) (0.002 - 0.053)	# 1 0.5	92	0.020 (51/52) (0.002 - 0.053)	0.021 (52/52) (0.0034 - 0.051)	0
	84	GAMMA		<LLD	-		<LLD	<LLD	0
	28	SR-89	0.002	0.0006 (14/ 24) (0.0003- 0.0012)	# 5 8.5	298	0.0009 (4/ 4) (0.0005 - 0.0011)	0.0006 (3/ 4) (0.0004 - 0.0008)	0
	28	SR-90	0.004	<LLD	-		<LLD	<LLD	0

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY ANO-1 AND ANO-2 DOCKET NO. 50-313 AND 50-368

LOCATION OF FACILITY POPE, ARKANSAS REPORTING PERIOD JAN. - DEC.,1984

(COUNTY, STATE)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL # OF ANALYSIS	TYPE	LLD	ALL IND. LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME	DIST. (MI)	DIR. (DEG)	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
I. AIR										
	GAMMA 364		0.05	<LLD	-			<LLD	<LLD	0
B. I-131 by Gamma (pCi/m3)										

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY ANO-1 AND ANO-2 DOCKET NO. 50-313 AND 50-368

LOCATION OF FACILITY POPE, ARKANSAS REPORTING PERIOD JAN. - DEC.,1984

(COUNTY, STATE)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL # OF ANALYSIS	TYPE	LLD	ALL IND. LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DIST. (MI)	DIR. (DEG)	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
I. AIR									
C. Direct Radiation	TLDS 176		5.	17.1 (172/172) (11.0 - 46.0)	#117 17.2	305	26.5 (4/ 4) (13.0 - 46.0)	16.8 (4/ 4) (13.0 - 22.0)	0
(area/quarter)									
I. AIR	TLDS 14		5.	28.2 (12/ 12) (17.0 - 44.0)	# 5 8.5	298	32.0 (2/ 2) (21.0 - 43.0)	30.5 (2/ 2) (19.0 - 42.0)	0
C. Direct Radiation									
(area/6 months)									

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY ANO-1 AND ANO-2 DOCKET NO. 50-313 AND 50-368

LOCATION OF FACILITY POPE, ARKANSAS REPORTING PERIOD JAN. - DEC.,1984

(COUNTY, STATE)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL # TYPE OF ANALYSIS	LLD	ALL IND. LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DIST. & DIR. (MI) (DEG)	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
I. AIR							
B. Precipitation (pCi/l)	GROSS A 126	3.	2.1 (13/ 94) (0.9 - 5.5)	# 3 0.4 4	2.4 (5/31) (1.2 - 5.5)	1.6 (10/32) (1.1 - 3.4)	0
	GROSS B 126	5.	4.6 (54/ 94) (2.0 - 10.8)	# 5 8.5 298	5.3 (17/31) (2.2 - 10.8)	6.3 (18/32) (2.1 - 15.6)	0
	GAMMA 126		<LLD	-	<LLD	<LLD	0
	(see Table 3.9.1 for LLD's)						

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY ANO-1 AND ANO-2 DOCKET NO. 50-313 AND 50-368

LOCATION OF FACILITY POPE, ARKANSAS REPORTING PERIOD JAN. - DEC.,1984

(COUNTY, STATE)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL # OF ANALYSIS	TYPE	LLD	ALL IND. LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME	DIST. (MI)	DIR. (DEG)	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
II. WATER										
	GROSS A	60	3.	2.0 (2/ 48) (0.9 - 3.2)	# 9	1.8	160	3.2 (1/12)	<LLD	0
A. Lake Water										
(pCi/l)	GROSS B	60	5.	4.9 (33/ 48) (2.8 - 10.4)	#10	1.0	90	5.7 (8/12) (2.9 - 10.4)	4.3 (7/12) (2.3 - 7.0)	0
	GAMMA	32		<LLD	-			<LLD	<LLD	0
	(see Table 3.9.1 for LLD's)									
	SR-89	20	5.	2.4 (8/ 16) (1.2 - 3.6)	# 8	0.1	180	3.6 (1/ 4)	1.6 (1/ 4)	0
	SR-90	20	1.	1.1 (5/ 16) (0.5 - 1.9)	# 8	0.1	180	1.9 (1/ 4)	0.6 (1/ 4)	0
	H-3	21	400.	1153.3 (3/ 17) (226. - 2410.)	# 8	0.1	180	1616.9 (2/ 5) (823. - 2410.)	<LLD	0

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY ANO-1 AND ANO-2 DOCKET NO. 50-313 AND 50-368

LOCATION OF FACILITY POPE, ARKANSAS REPORTING PERIOD JAN. - DEC.,1984

(COUNTY, STATE)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL # OF ANALYSIS	TYPE	LLD	ALL IND. LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DIST. (MI)	DIR. (DEG)	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
II. WATER									
B. Bottom Sediments (pCi/Kg)	GAMMA 10								
		MN-54	25.	37.0 (4/ 8) (6.4 - 76.1)	8 0.1	180	60.0 (2/ 2) (43.8 - 76.1)	<LLD	0
		CO-58	35.	103.5 (3/ 8) (47.3 - 186.)	8 0.1	180	131.6 (2/ 2) (76.5 - 186.)	<LLD	0
		CO-60	35.	841.7 (4/ 8) (38.8 - 1700.)	8 0.1	180	1430. (2/ 2) (1170. - 1700.)	129.6 (2/ 2) (52.4 - 206.)	0
		CS-134	30.	257.3 (5/ 8) (60.5 - 853.)	8 0.1	180	466.0 (2/ 2) (78.1 - 853.)	117.9 (2/ 2) (110. - 125.)	0
		CS-137	30.	1590. (7/ 8) (237. - 4800.)	8 0.1	180	4410. (2/ 2) (4030. - 4800.)	526.0 (2/ 2) (438. - 613.)	0
Sr-89/90 activity units are in pCi/g of sediment ash.	SR-89 5		1.5	0.2 (1/ 4)	8 0.1	180	0.2 (1/ 1)	<LLD	0
	SR-90 5		0.3	0.2 (2/ 4) (0.1 - 0.2)	15 5.0	150	0.2 (1/ 1)	<LLD	0

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY ANO-1 AND ANO-2 DOCKET NO. 50-313 AND 50-368

LOCATION OF FACILITY POPE, ARKANSAS REPORTING PERIOD JAN. - DEC.,1984

(COUNTY, STATE)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL # OF ANALYSIS	TYPE	LLD	ALL IND. LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DIST. (MI) DIR. (DEG) MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
II. WATER							
	GROSS A	15	3.	9.4 (1/ 15)	#32 0.8 115 9.4 (1/ 5)	<LLD	0
C. Ground Water							
(pCi/l)	GROSS B	15	5.	2.9 (4/ 15) (2.3 - 4.2)	#33 4.8 98 3.5 (2/ 5) (2.7 - 4.2)	<LLD	0
	GAMMA (see Table 3.9.1 for LLD'S)	15		<LLD	- <LLD	<LLD	0
	H-3	15	400.	<LLD	- <LLD	<LLD	0

177

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY ANO-1 AND ANO-2 DOCKET NO. 50-313 AND 50-368

LOCATION OF FACILITY POPE, ARKANSAS REPORTING PERIOD JAN. - DEC.,1984

(COUNTY, STATE)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL # TYPE OF ANALYSIS	LLD	ALL IND. LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DIST. & DIR. (MI) (DEG) MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
II. WATER						
	GROSS A 24	3.	<LLD	- <LLD	<LLD	0
D. Russellville City Water						
(pCi/l)	GROSS B 24	5.	3.3 (6/ 12) (2.5 - 4.4)	#14 5.8 65 3.3 (6/12) (2.5 - 4.4)	4.3 (7/12) (2.3 - 7.0)	0
	GAMMA 24 (SEE TABLE 3.9.1 FOR LLD'S)		<LLD	- <LLD	<LLD	0
	SR-89 8	5.	4.1 (2/ 4) (1.1 - 7.0)	#14 5.8 65 4.1 (2/ 4) (1.1 - 7.0)	1.6 (1/ 4)	0
	SR-90 8	1.	<LLD	<LLD	0.6 (1/ 4)	0
	H-3 8	400.	<LLD	- <LLD	<LLD	0

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY ANO-1 AND ANO-2 DOCKET NO. 50-313 AND 50-368

LOCATION OF FACILITY POPE, ARKANSAS REPORTING PERIOD JAN. - DEC.,1984

(COUNTY, STATE)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL # TYPE OF ANALYSIS	LLD	ALL IND. LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DIST. & DIR. (MI) (DEG)	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
II. WATER							
	GAMMA 10						
	CS-134	10.	33.3 (2/ 8)	# 8	50.9 (1/ 2)	<LLD	0
E. Aquatic Biota			(15.6 - 50.9)	0.1 180			
1.) Carnivorous							
Fish	CS-137	10.	59.2 (8/ 8)	# 8	112. (2/ 2)	<LLD	0
			(25.2 - 176.)	0.1 180	(48.3 - 176.)		
(Wet Weight) (pCi/kg)							

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY ANO-1 AND ANO-2 DOCKET NO. 50-313 AND 50-368

LOCATION OF FACILITY POPE, ARKANSAS REPORTING PERIOD JAN. - DEC.,1984

(COUNTY, STATE)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL # OF ANALYSIS	TYPE	LLD	ALL IND. LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DIST. (MI) & DIR. (DEG)	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
II. WATER	GAMMA 10							
	CS-134		10.	26.0 (3/ 8) (9.1 - 49.0)	# 8 0.1 180	34.5 (2/ 2) (19.9 - 49.0)	<LLD	0
E. Aquatic Biota								
2.) Bottom Feeder Fish	CS-137		10.	58.3 (8/ 8) (11.4 - 202.)	# 8 0.1 180	143.4 (2/ 2) (84.4 - 202.)	30.1 (2/ 2) (15.5 - 44.8)	0
(Wet Weight) (pCi/Kg)								

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY
NAME OF FACILITY ANO-1 AND ANO-2 DOCKET NO. 50-313 AND 50-368
LOCATION OF FACILITY POPE, ARKANSAS REPORTING PERIOD JAN. - DEC.,1984
(COUNTY, STATE)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL & TYPE OF ANALYSIS	LLD	ALL IND. LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DIST. & DIR. (MI) (DEG)	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
II. WATER							
	GAMMA 10						
	CO-58	10.	55.5 (1/ 8)	# 8 0.1 180	55.5 (1/ 2)	<LLD	0
E. Aquatic Biota							
3.) Plankton Feeder Fish	CO-60	10.	55.0 (1/ 8)	# 8 0.1 180	55.0 (1/ 2)	<LLD	0
(Wet Weight) (pCi/Kg)							
	CS-134	10.	41.5 (4/ 8) (20.1 - 93.3)	# 8 0.1 180	58.7 (2/ 2) (24.0 - 93.3)	<LLD	0
	CS-137	10.	82.3 (8/ 8) (20.2 - 313.)	# 8 0.1 180	193.3 (2/ 2) (73.0 - 313.)	23.9 (2/ 2) (18.4 - 29.4)	0

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY ANO-1 AND ANO-2 DOCKET NO. 50-313 AND 50-368

LOCATION OF FACILITY POPE, ARKANSAS REPORTING PERIOD JAN. - DEC.,1984

(COUNTY, STATE)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL & TYPE OF ANALYSIS	LLD	ALL IND. LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DIST. (MI) & DIR. (DEG)	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
II. WATER							
	GAMMA 4						
	XE-133	50.	265. (1/ 2)	# 8 0.1 180	265. (1/ 2)	<LLD	0
E. Aquatic Biota							
4.) Edible portion of carnivorous fish split with Ark. Dept. of Health	CS-134	10.	28.8 (2/ 2) (28.2 - 29.3)	# 8 0.1 180	28.8 (2/ 2) (28.2 - 29.3)	<LLD	0
	CS-137	10.	98.0 (2/ 2) (94.1 - 101.)	# 8 0.1 180	98.0 (2/ 2) (94.1 - 101.)	<LLD	0
(Wet Weight) (pCi/Kg)							

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY
NAME OF FACILITY ANO-1 AND ANO-2 DOCKET NO. 50-313 AND 50-368
LOCATION OF FACILITY POPE, ARKANSAS REPORTING PERIOD JAN. - DEC.,1984
(COUNTY, STATE)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL # TYPE OF ANALYSIS	LLD	ALL IND. LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DIST. (MI) DIR. (DEG) MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
II. WATER						
E. Aquatic Biota	GAMMA 8					
5.) Mollusks	CO-58	10.	43.5 (1/ 6)	# 8 0.1 180	43.5 (1/ 2)	<LLD	0
(Wet weight of whole mollusks) (pCi/Kg)	CS-134	10.	93.8 (1/ 6)	# 8 0.1 180	93.8 (1/ 2)	<LLD	0
	CS-137	10.	101. (3/ 6) (5.9 - 261.)	# 8 0.1 180	148. (2/ 2) (35.7 - 261.)	<LLD	0

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY ANO-1 AND ANO-2 DOCKET NO. 50-313 AND 50-368

LOCATION OF FACILITY POPE, ARKANSAS REPORTING PERIOD JAN. - DEC.,1984

(COUNTY, STATE)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL # TYPE OF ANALYSIS	LLD	ALL IND. LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DIST. & DIR. (MI) (DEG)	LOCATION WITH HIGHEST ANNUAL MEAN MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
II. WATER							
	GROSS A 10	5.	<LLD		<LLD	1.6 (1/ 2)	0
E. Aquatic Biota							
	GROSS B 10	5.	4.7 (5/ 8) (3.7 - 7.1)	# 8 0.1 180	5.4 (2/ 2) (3.7 - 7.1)	7.4 (2/ 2) (4.8 - 10.0)	0
6.) Plankton							
(Filtered and dried)							
	GAMMA 10		<LLD	-	<LLD	<LLD	0
(pCi/l)							

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY ANO-1 AND ANO-2 DOCKET NO. 50-313 AND 50-368

LOCATION OF FACILITY POPE, ARKANSAS REPORTING PERIOD JAN. - DEC.,1984

(COUNTY, STATE)

EXPOSURE PATHWAY (UNIT OF MEASUREMENT)	TOTAL # TYPE OF ANALYSIS	LLD	ALL IND. LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DIST. & DIR. (MI) (DEG)	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NR
II. WATER							
	SR-89 4	4.	1.5 (1/ 3)	#10 1.0 90	1.5 (1/ 1)	<LLD	0
E. Aquatic Biota							
Mollusk Shells (pCi/g of ash)	SR-90 4	1.	3.3 (3/ 3) (3.0 - 3.6)	#10 1.0 90	3.6 (1/ 1)	2.6 (1/ 1)	0

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY ANO-1 AND ANO-2 DOCKET NO. 50-313 AND 50-368

LOCATION OF FACILITY POPE, ARKANSAS REPORTING PERIOD JAN. - DEC.,1984

(COUNTY, STATE)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL # OF ANALYSIS	TYPE	LLD	ALL IND. LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DIST. (MI) & DIR. (DEG)	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
II. WATER								
	SR-89	5	4.	<LLD		<LLD	1.6 (1/ 1)	0
F. Fish Bone								
1.) Carnivorous Fish	SR-90	5	1.	1.1 (4/ 4) (0.9 - 1.2)	# 9 1.8 160	1.2 (1/ 1)	0.8 (1/ 1)	0
(pCi/g of ash)								

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY ANO-1 AND ANO-2 DOCKET NO. 50-313 AND 50-368

LOCATION OF FACILITY POPE, ARKANSAS REPORTING PERIOD JAN. - DEC.,1984

(COUNTY, STATE)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL # OF ANALYSIS	TYPE	LLD	ALL IND. LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DIST. & DIR. (MI) (DEG)	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
II. WATER								
	SR-89	5	4.	1.1 (2/ 4) (1.0 - 1.3)	# 9 1.8 160	1.3 (1/ 1)	<LLD	0
F. Fish Bone								
2.) Bottom Feeder Fish	SR-90	5	1.	2.5 (4/ 4) (1.8 - 4.1)	#15 5.0 150	4.1 (1/ 1)	1.9 (1/ 1)	0
(pCi/g of ash)								

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY ANO-1 AND ANO-2 DOCKET NO. 50-313 AND 50-368

LOCATION OF FACILITY POPE, ARKANSAS REPORTING PERIOD JAN. - DEC.,1984

(COUNTY, STATE)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL # OF ANALYSIS	TYPE	LLD	ALL IND. LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DIST. (MI) & DIR. (DEG)	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
II. WATER								
	SR-89	4	4.	0.9 (1/ 4)	#10 1.0 90	0.9 (1/ 1)	<LLD	0
F. Fish Bone								
3.) Plankton Feeder Fish	SR-90	4	1.	0.9 (4/ 4) (0.8 - 1.')	# 8 0.1 180	1.1 (1/ 1)	<LLD	0
(pCi/g of ash)								

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY ANO-1 AND ANO-2 DOCKET NO. 50-313 AND 50-368

LOCATION OF FACILITY POPE, ARKANSAS REPORTING PERIOD JAN. - DEC.,1984

(COUNTY, STATE)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL & TYPE OF ANALYSIS	LLD	ALL IND. LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DIST. & DIR. (MI) (DEG)	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
II. WATER							
G. Lake Water Split with Ark. Dept. of Health	GAMMA 23						
	CO-58	10.	34.9 (1/ 12)	# 8 0.1 180	34.9 (1/12)	<LLD	0
(pCi/l)	CO-60	10.	13.1 (1/ 12)	# 8 0.1 180	13.1 (1/12)	<LLD	0

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY ANO-1 AND ANO-2 DOCKET NO. 50-313 AND 50-368

LOCATION OF FACILITY POPE, ARKANSAS REPORTING PERIOD JAN. - DEC.,1984

(COUNTY, STATE)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL # TYPE OF ANALYSIS	LLD	ALL IND. LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DIST. & DIR. (MI) (DEG)	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
III. TERRESTRIAL				-			
A. Milk (pCi/l)	GAMMA 48 (see Table 3.9.1 for LLD's)		<LLD		<LLD	<LLD	0
	I-131 48	0.5	0.4 (8/ 36) (0.2 - 0.9)	#37 7.5 30	0.6 (2/12) (0.2 - 0.9)	0.3 (3/12) (0.1 - 0.6)	0
I-131 by chemical separation	SR-89 48	5.	2.7 (24/ 36) (1.3 - 6.3)	#37 7.5 30	3.6 (7/12) (1.4 - 6.3)	3.7 (8/12) (1.5 - 5.8)	0
	SR-90 48	2.	3.0 (34/ 36) (1.2 - 8.7)	#37 7.5 30	4.5 (12/12) (2.6 - 8.7)	4.6 (12/12) (1.7 - 7.6)	0

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY ANO-1 AND ANO-2 DOCKET NO. 50-313 AND 50-368

LOCATION OF FACILITY POPE, ARKANSAS REPORTING PERIOD JAN. - DEC.,1984

(COUNTY, STATE)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL & TYPE OF ANALYSIS	LLD	ALL IND. LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DIST. (MI) & DIR. (DEG)	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
III. TERRESTRIAL							
B. Vegetation	GAMMA 33 CS-137	50.	22.3 (2/ 27) (21.3 - 23.2)	# 4 0.4 171	23.2 (1/ 3)	39.2 (1/ 6)	0
1. Pasturage (Dry Weight) (pCi/Kg)							
B. Vegetation	GAMMA 10		<LLD	-	<LLD	<LLD	0
1. Food Crops including Cabbage, Tomatoes, Lettuce, Spinich. (see Table 3.9.1 for LLD's) (pCi/Kg)							

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY ANO-1 AND ANO-2 DOCKET NO. 50-313 AND 50-368

LOCATION OF FACILITY POPE, ARKANSAS REPORTING PERIOD JAN. - DEC.,1984

(COUNTY, STATE)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL # OF ANALYSIS	TYPE	LLD	ALL IND. LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DIST. (MI)	# DIR. (DEG)	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
III. TERRESTRIAL									
	GAMMA	14							
	MN-54		25.	7.1 (1/ 12)	0.5	# 2 235	7.1 (1/ 2)	<LLD	0
C. Soil									
(Dry Weight)									
(pCi/Kg)	CS-137		30.	377. (12/ 12) (68.1 - 1380.)	6.8	# 6 109	772.7 (2/ 2) (156. - 1380.)	448.3 (2/ 2) (382. - 504.)	0
Sr-89/90 Activity units are in pCi/g of soil ash.	SR-89	7	1.5	0.4 (1/ 6)	6.8	# 6 109	0.4 (1/ 1)	<LLD	0
	SR-90	7	0.3	<LLD	-		<LLD	<LLD	0

5.0 MILK ANIMAL SURVEY

SURVEY OF MILK-PRODUCING ANIMALS WITHIN AN

AREA OF TEN (10) MILES OF ARKANSAS NUCLEAR ONE

September 2-7, 1984

In accordance with Environmental Technical Specification 4.2.10, a survey was conducted September 6-7, 1984 to determine the location of animals which produce milk for human consumption. Milk-producing animals (milk cows) are divided into two categories defined as:

1. Class A Dairies - Dairies in which milk is intended primarily for human consumption as Grade A milk.
2. Individual Milk Cows - Family cows in which the milk is intended primarily for home use. None were identified during this survey.

CLASS A DAIRIES WITHIN A 10-MILE RADIUS OF ANO

	DAIRY	NO. OF COWS	AZIMUTH-DISTANCE
1.	Ark. Tech. Univ. Dairy	44	99° - 5.0
2.	Bill Harms Dairy	60	21° - 7.75
3.	R. Meyer Dairy	48	290° - 8.0
4.	R. A. Young Dairy (CONTROL)	50	73° - 12.0
5.	Harold Steuber	70	25° - 7.0
6.	Lawrence Steuber	55	358° - 7.5
7.	Buddy Boxnick	60	23° - 7.0
8.	Robberson Dairy	60	183° - 10.5

SURVEY OF MILK-PRODUCING ANIMALS WITHIN AN

AREA OF TEN (10) MILES OF ARKANSAS NUCLEAR ONE

June 19-20, 1984

In accordance with Environmental Technical Specification 4.2.10, a survey was conducted June 19-20, 1984 to determine the location of animals which produce milk for human consumption. Milk-producing animals (milk cows) are divided into two categories defined as:

1. Class A Dairies - Dairies in which milk is intended primarily for human consumption as Grade A milk.
2. Individual Milk Cows - Family cows in which the milk is intended primarily for home use. None were identified during this survey.

CLASS A DAIRIES WITHIN A 10-MILE RADIUS OF ANO

	DAIRY	NO. OF COWS	AZIMUTH-DISTANCE
1.	Ark. Tech. Univ. Dairy	45	99° - 5.0
2.	Bill Harms Dairy	60	21° - 7.75
3.	R. Meyer Dairy	50	290° - 8.0
4.	R. A. Young Dairy (CONTROL)	50	73° - 12.0
5.	Harold Steuber	70	25° - 7.0
6.	Lawrence Steuber	50	385° - 7.5
7.	Buddy Boxnick	60	23° - 7.0
8.	Robberson Dairy	60	183° - 10.5

ARKANSAS POWER & LIGHT COMPANY
POST OFFICE BOX 551 LITTLE ROCK, ARKANSAS 72203 (501) 371-4000

April 30, 1985

ØCANØ485Ø9

Office of Inspection & Enforcement
U. S. Nuclear Regulatory Commission
611 Ryan Drive
Suite 1000
Arlington, TX 76011

SUBJECT: Arkansas Nuclear One - Units 1 & 2
Docket Nos. 50-313 and 50-368
License Nos. DPR-51 and NPF-6
Annual Environmental Monitoring Report

Gentlemen:

In accordance with Arkansas Nuclear One - Units 1&2 Environmental Technical Specification 5.6.1, and Regulatory Guide 10.1 Item 177, attached is the Annual Environmental Monitoring Report for 1985.

Very truly yours,

J. Ted Enos
Manager, Licensing

JTE:RJS:ds

cc: U. S. Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20555

85-284

IE25
1/1