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April 29, 1994

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Gentlemen:

DOCKET NUMBER 50-483
CALLAWAY PLANT
FACILITY OPERATING LICENSE NPF-30
1993 ANNUAL ENVIRONMENTAL OPERATING REPORT

Please find enclosed the 1993 Annual Environmental Operating Report for the Callaway Plant. This report is submitted in accordance with Section 6.9.1.6 of the Technical Specifications and Appendix B to the Callaway Plant Operating License.

Very truly yours,

Donald F. Schnell

Donald F. Schnell

NGS/kea

Enclosure

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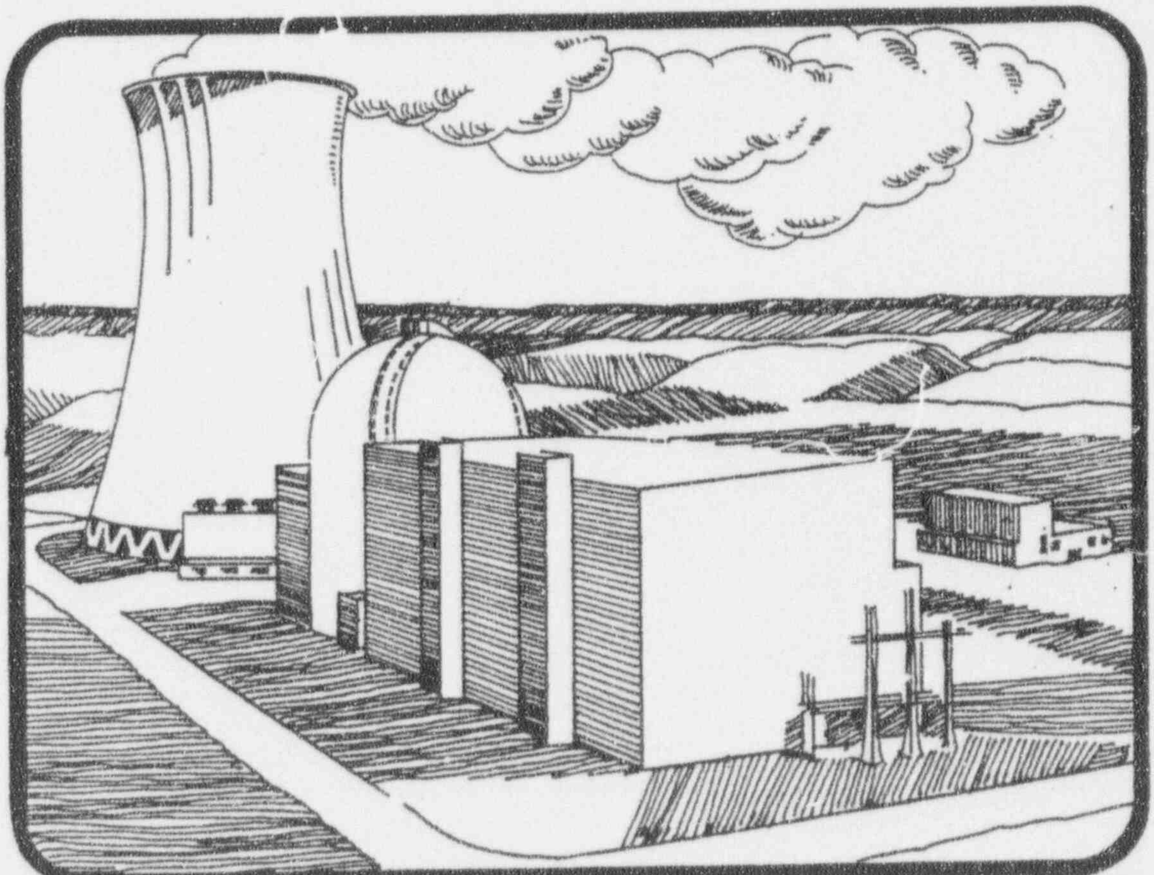
CALLAWAY PLANT

ANNUAL ENVIRONMENTAL OPERATING REPORT

1993



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UNION ELECTRIC

CALLAWAY PLANT

ANNUAL ENVIRONMENTAL OPERATING REPORT

1993

DOCKET NO. 50-483

UNION ELECTRIC

TABLE OF CONTENTS

1.0 INTRODUCTION

In accordance with Appendix B, Section 5.4.1 of the Callaway Plant Operating License, the following report was prepared by Union Electric on all changes in plant design, operation, tests or experiments which could have involved a potentially significant unreviewed environmental question in accordance with Section 3.1 of Appendix B.

The report covers all plant modifications/changes completed January 1, 1993, through December 31, 1993.

During 1993 there were ten plant modifications/ changes that could have involved a potentially significant unreviewed environmental question. The interpretations and conclusions regarding these plant modification/changes along with a description of the changes are presented below.

2.0 ENVIRONMENTAL EVALUATIONS

2.1 Callaway Modification Package 91-1056

2.1.1 Description of Change

This change involved construction of two concrete pads on the plant south side of the radwaste building and the plant west side of the turbine building. The concrete pad next to the radwaste building is enclosed by an eight foot chain link fence and will be used for temporary storage of radioactive waste. The other concrete pad will be a laydown area for a temporary cooling tower.

2.1.2 Evaluation of Change

The construction of two concrete pads did not result in a significant increase in any adverse environmental impacts, since all measurable non-radiological environmental effects were confined to the area previously disturbed during site preparation and plant construction. Therefore, this change does not constitute an unreviewed environmental question per Section 3.1 of Appendix B to the Callaway Plant Operating License.

SECTION 3.0

RADIOLOGICAL ENVIRONMENTAL MONITORING

UNION ELECTRIC COMPANY

ST. LOUIS, MISSOURI

CALLAWAY PLANT

SECTION 3.0

RADIOLOGICAL ENVIRONMENTAL

MONITORING PROGRAM

ANNUAL REPORT

1993

CONTENTS

TABLES

FIGURES

Abstract

This report presents the Callaway Plant Radiological Environmental Monitcring Program (REMP) data obtained from analysis of environmental samples collected in 1993.

Evaluation of radiation levels in the environs around Union Electric Company's (UEC) Callaway Plant involved sampling at strategic points in various exposure pathways. The following types of samples were collected and analyzed: milk, vegetation, surface water, well water, bottom sediment, shoreline sediment, fish, airborne particulates, airborne radioiodine, direct radiation (TLD), soil and wetlands.

Analytical results are presented and discussed along with other pertinent information. Possible trends and anomalous results, as interpreted by Union Electric Company personnel, are discussed.

1.0 Introduction

This report presents an analysis of the results of the REMP conducted during 1993 for Union Electric Company, Callaway Plant.

In accordance with federal and state regulations and the desire to maintain the quality of the local environment, UEC began its radiological monitoring program in April, 1982.

The objectives of the REMP are to monitor potential critical pathways of radioeffluent to man and determine the radiological impact on the environment caused by operation of Callaway Plant.

Callaway Plant consists of one 1239 MWe pressurized water reactor, which achieved initial criticality on October 2, 1984. The plant is located on a plateau approximately ten miles southeast of the City of Fulton in Callaway County, Missouri and approximately eighty miles west of the St. Louis metropolitan area. The Missouri River flows by the site in an easterly direction approximately five miles south of the site at its closest point.

2.0 Radiological Environment Monitoring Program

2.1 Program Design

The purpose of the operational REMP at Callaway Plant is to assess the impact of plant operation on the environment. For this purpose samples are collected from waterborne, airborne, ingestion and direct radiation pathways. Sampling media are selected which are likely to show effects of plant effluents and which are sensitive to changes in radioactivity levels. The types of sample media collected are: milk, surface water, groundwater, shoreline sediment, bottom sediment, soil, wetlands, fish, vegetation, airborne particulate, airborne radioiodine and direct radiation (TLD).

Samples are collected by Union Electric personnel and shipped to Teledyne Isotopes Midwest Laboratory (TIML) for analysis. TLD's are analyzed by Union Electric Personnel. The data obtained are reported monthly and summarized in the annual report.

Environmental sample locations are divided into two types, indicator and control. Indicator samples are those collected from locations which would be expected

Abstract

This report presents the Callaway Plant Radiological Environmental Monitoring Program (REMP) data obtained from analysis of environmental samples collected in 1993.

Evaluation of radiation levels in the environs around Union Electric Company's (UEC) Callaway Plant involved sampling at strategic points in various exposure pathways. The following types of samples were collected and analyzed: milk, vegetation, surface water, well water, bottom sediment, shoreline sediment, fish, airborne particulates, airborne radioiodine, direct radiation (TLD), soil and wetlands.

Analytical results are presented and discussed along with other pertinent information. Possible trends and anomalous results, as interpreted by Union Electric Company personnel, are discussed.

to manifest plant effects, if any. Control samples are collected at locations which are expected to be unaffected by plant operation.

2.2 Program Description

Sample locations for the REMP are shown in Figures 1 and 2. Table I describes the sample locations, direction and distance from the plant, which are control and which are indicator locations, and the types of samples collected at each location. Sample collection frequencies for each of the monitoring locations are given in Table II. The collections and analyses that comprise the program are described in the following pages.

Identification of sample type codes used in Table I are as follows:

Code	Sample Collected
AIO	Air Iodine
APT	Air Particulate
AQF	Fish
AQS	Sediment
FPL	Leafy Green Vegetables
IDM	TLD
MLK	Milk
SOL	Soil
SWA	Surface Water
WWA	Ground Water

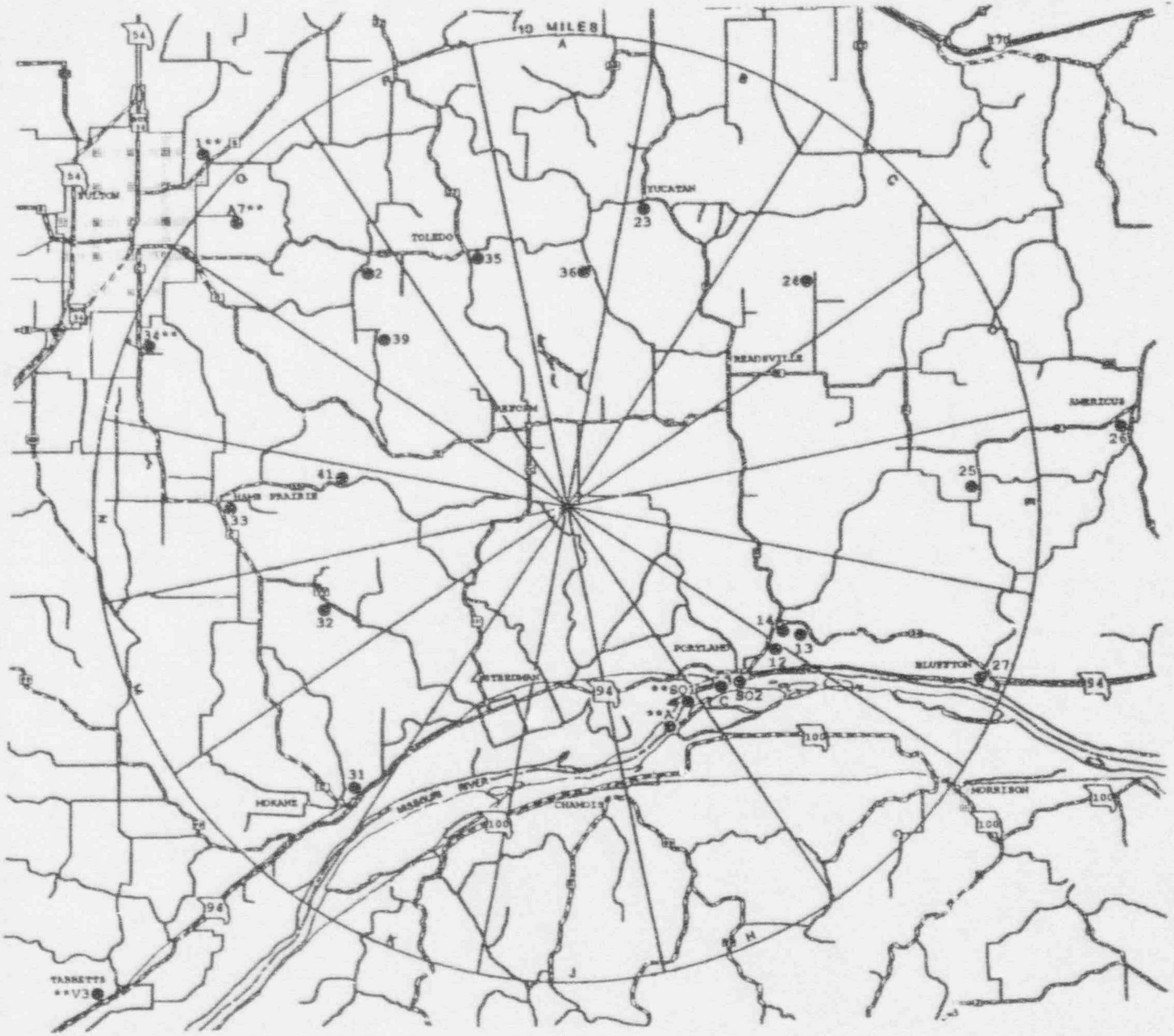
2.2.1 Waterborne Pathway

Surface Water

Monthly composite samples of surface water from the Missouri River are collected from one indicator location (SO2) and from one control location (SO1). The samples are analyzed for tritium and by gamma spectrometry.

Ground Water

Ground water samples are collected monthly from two on-site wells (F05 and F15) and one off-site well used for drinking water (D01). The on-site ground water samples are collected using a manual grab sampler which is lowered into the well. The off-site ground water sample is collected from a faucet after allowing the line to flush for two minutes. Ground water samples are analyzed for Tritium and gamma emitting nuclides.



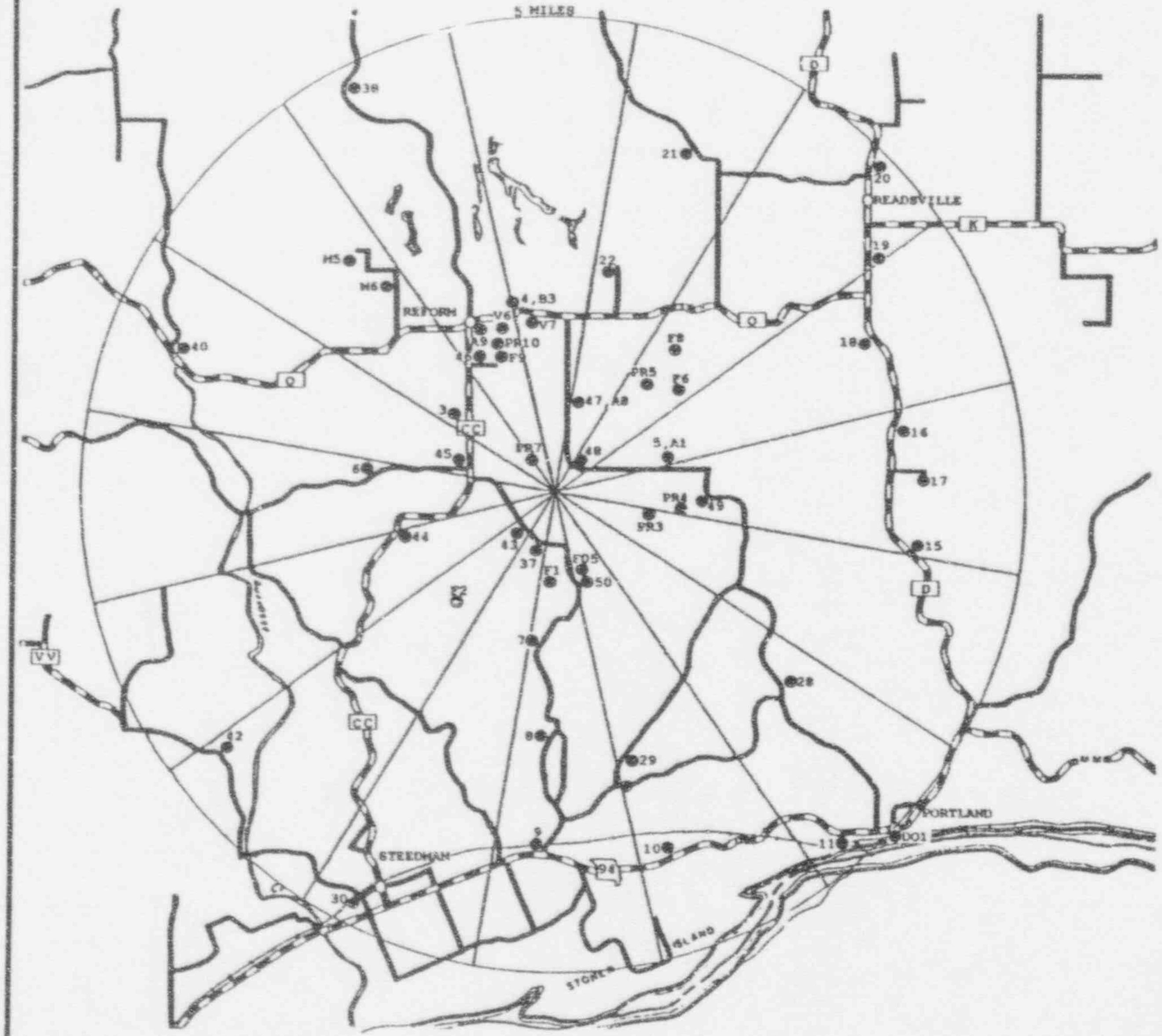
• Collection Locations

** Control Location

UNION ELECTIRC CO.
CALLAWAY PLANT

DISTANT
COLLECTION LOCATIONS

FIGURE 1



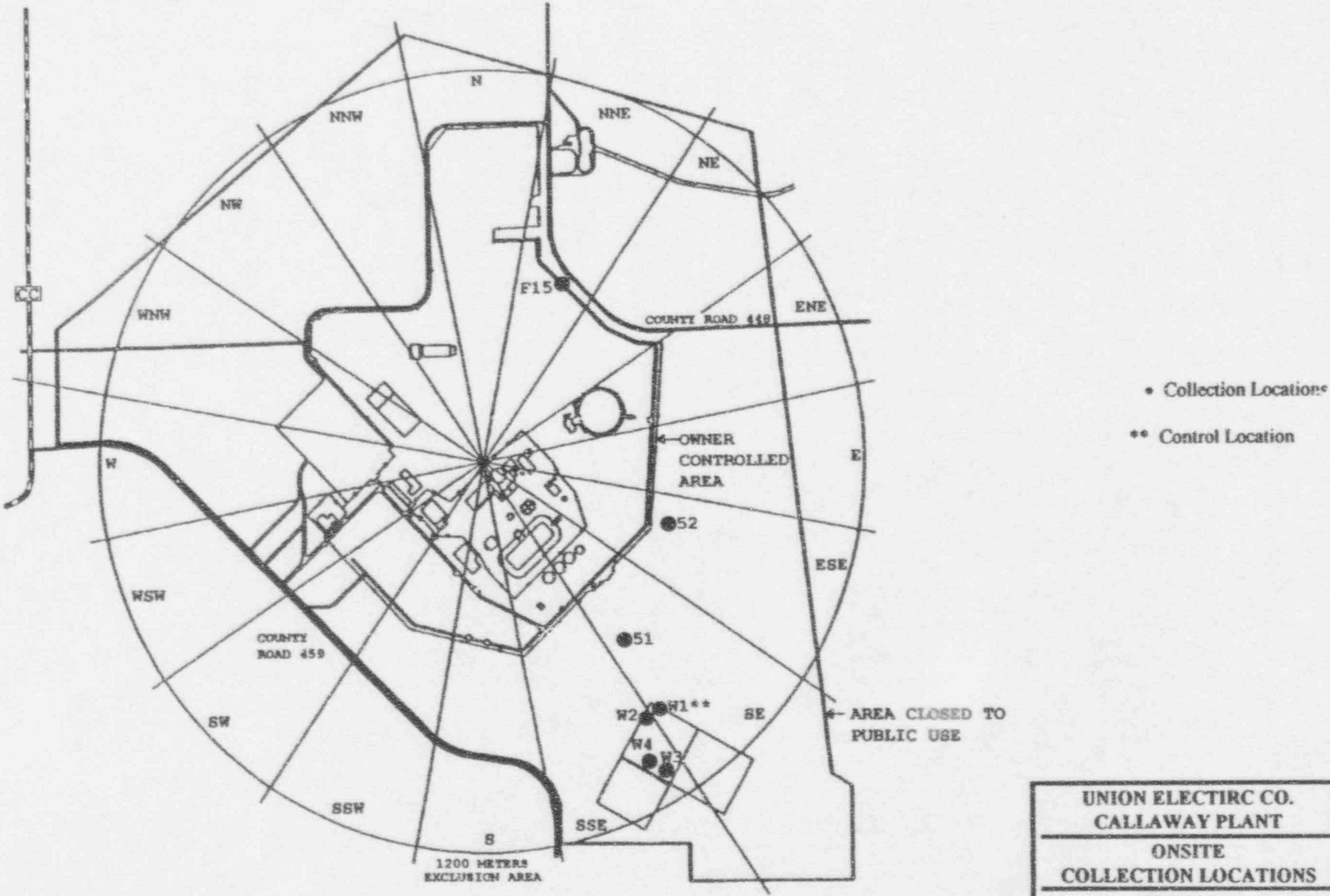
• Collection Location

•• Control Location

UNION ELECTIRC CO.
CALLAWAY PLANT

NEAR SITE
COLLECTION LOCATIONS

FIGURE 2



UNION ELECTIRC CO.
CALLAWAY PLANT

ONSITE
COLLECTION LOCATIONS

FIGURE 3

TABLE I

SAMPLING LOCATIONS

Location Code	Description	Sample Types
1**	11 mi NW, City Limits of Fulton on Hwy Z, 0.8 mi East of Business 54.	IDM
2	6.6 mi NW; County Road 111, 0.6 mi South of Hwy UU, Callaway Electric Cooperative Utility Pole No. 17571.	IDM
3	1.3 mi NW; 0.1 mi West of Hwy CC on Gravel Road, 0.8 mi South Hwy O, Callaway Electric Cooperative Utility Pole No. 18559.	IDM
4,B3	1.9 mi N;0.3 mi East of the O and CC Junction, Callaway Electric Cooperative Utility Pole No. 18892.	IDM,APT,AIO
5,A1	1.3 mi ENE; Primary Meteorological Tower.	IDM,APT,AIO
6	2.0 mi W; County Road 428, 1.2 mi West of Hwy CC, Callaway Electric Cooperative Utility Pole No. 18609.	IDM
7	1.3 mi S; County Road 459, 2.6 mi North of Hwy 94, Callaway Electric Cooperative Utility Pole No. 35097	IDM
8	2.9 mi S; County Road 459, 1.4 mi North of Hwy 94, Callaway Electrical Cooperative Utility Pole No. 06823.	IDM
9	3.7 mi S; NW Side of the County Road 459 and 94 Junction, Callaway Electric Cooperative Utility Pole No. 06754.	IDM
10	4.0 mi SSE; Hwy 94, 1.8 mi East of County Road 459, Callaway Electric Cooperative Utility Pole No. 12182.	IDM
11	4.8 mi SE; City of Portland, Callaway Electric Cooperative Utility Pole No. 12112.	IDM
12	5.3 mi SE; Hwy 94, 0.6 mi South of Hwy D, Utility Pole on East side on Hwy.	IDM
13	5.6 mi ESE; Hwy 94, 0.75 mi East of Hwy D, Kingdom Telephone Pole No. 2X1.	IDM

TABLE I (Cont'd.)

SAMPLING LOCATIONS

Location Code	Description	Sample Types
14	5.0 mi ESE; SE Side of Intersection D and 94, Callaway Electric Cooperative Utility Pole No. 11940.	IDM
15	4.2 mi ESE; Hwy D, 2.5 mi North of Hwy 94, Callaway Electric Cooperative Utility Pole No. 27379.	IDM
16	4.1 mi ENE; Hwy D, 3.6 mi North of Hwy 94, Callaway Electric Cooperative Utility Pole No. 12976.	IDM
17	4.0 mi E; County Road 4053, 0.3 mi East of Hwy 94, Kingdom Telephone Company Pole No. 3X12.	IDM
18	3.8 mi ENE; Hwy D, 0.4 mi South of O, Callaway Electric Cooperative Utility Pole No. 12952.	IDM
19	4.2 mi NE; Hwy D, 0.3 mi North of Hwy 0, Callaway Electric Cooperative Utility Pole No. 12918.	IDM
20	4.8 mi NE; City of Readsville, Callaway Electric Cooperative Utility Pole No. 12830.	IDM
21	4.0 mi NNE; County Road 155, 1.9 mi North of Hwy 0, Callaway Electric Cooperative Utility Pole No. 19100.	IDM
22	2.5 mi NNE; County Road 150, 0.5 mi North of Hwy 0, Callaway Electric Cooperative Utility Pole No. 19002.	
23	6.7 mi NNE; City of Yucation, Callaway Electric Cooperative Utility Pole No. 12670	IDM
24	7.0 mi NE; County Road 191, 2.1 mi North of Hwy K, Callaway Electric Cooperative Utility Pole No. 12498.	IDM

TABLE I (Cont'd.)

SAMPLING LOCATIONS

Location Code	Description	Sample Types
25	8.7 mi E; County Road 289, 0.3 mi South of County Road 287, Callaway Electric Cooperative Utility Pole No. 11295.	IDM
26	12.1 mi E; Town of Americus, Callaway Electric Cooperative Utility Pole No. 11159.	IDM
27	9.5 mi ESE; Town of Bluffton, Callaway Electric Cooperative Utility Pole No. 11496.	IDM
28	3.3 mi SE; County Road 469, 2.0 mi North of Hwy 94, Callaway Electric Cooperative Utility Pole No. 06896.	IDM
29	2.7 mi SSW; County Road 448, 1.2 mi North of County Road 459, Callaway Electric Cooperative Utility Pole No. 06851.	IDM
30	4.6 mi SSE; W side of County Road 447 and 463 Junction, Kingdom Telephone Company Pole No. 2K1.	IDM
31	7.6 Mi SW; City of Mokane, Callaway Electric Cooperative Utility Pole No. 06039.	IDM
32	5.4 mi WSW; Hwy VV, 0.6 mi West of County Road 447, Callaway Electric Cooperative Utility Pole No. 27031.	IDM
33	7.3 mi W; City of Hams Prairie, SE of Hwy C and AD Junction.	IDM
34**	9.7 mi WNW; NE Side of Hwy C and County Road 408 Junction.	IDM
35	5.8 mi NNW; City of Toledo, Callaway Electric Cooperative Utility Pole No. 17684.	IDM
36	5.2 mi N; County Road 155, 0.8 mi South of County Road 132, Callaway Electric Cooperative Utility Pole No. 19137.	IDM

TABLE I (Cont'd.)

SAMPLING LOCATIONS

Location Code	Description	Sample Types
37	0.7 mi SSW; County Road 459, 0.9 mi South of Hwy CC, Callaway Electric Cooperative Utility Pole No. 35077.	IDM
38	4.8 mi NNW; County Road 133, 1.5 mi South of Hwy UU, Callaway Electric Cooperative Utility Pole No. 34708.	IDM
39	5.4 mi NW; County Road 112, 0.7 mi East of County Road 111, Callaway Electric Cooperative Utility Pole No. 17516.	IDM
40	4.2 mi WNW; NE Side of County Road 112 and Hwy O, Callaway Electric Cooperative Utility Pole No. 06326.	IDM
41	4.8 mi W; Hwy AD, 2.8 mi East of Hwy C, Callaway Electric Cooperative Utility Pole No. 18239.	IDM
42	4.4 mi SW; County Road 447, 2.6 mi North of County Road 463, Callaway Electric Cooperative Utility Pole No. 06326.	IDM
43	0.5 mi SW; County Road 459, 0.7 mi South of Hwy CC, Callaway Electric Cooperative Utility Pole No. 35073.	IDM
44	1.7 mi WSW; Hwy CC, 1.0 mi South of County Road 459, Callaway Electric Cooperative Utility Pole No. 18769.	IDM
45	1.0 mi WNW; County Road 428, 0.1 mi West of Hwy CC, Callaway Electric Cooperative Utility Pole No. 18580.	IDM
46	1.5 mi NNW; NE Side of Hwy CC and County Road 466 Intersection, Callaway Electric Cooperative Utility Pole No. 28242.	IDM
47	0.9 mi NNE; County Road 448, 0.9 mi South of Hwy O, Callaway Electric Cooperative Utility Pole No. 28151.	IDM

TABLE I (Cont'd.)

SAMPLING LOCATIONS

Location Code	Description	Sample Types
48	0.4 mi NE; County Road 448, 1.5 mi South of Hwy 0, Plant Security Sign Post.	IDM
49	1.7 mi E; County Road 448, Callaway Electric Cooperative Utility Pole No. 06959, Reform Wildlife Management Parking Area.	IDM
50	0.9 mi SSE; County Road 459, 3.3 mi North of Hwy 94, Callaway Electric Cooperative Utility Pole No. 35086.	IDM
51	0.7 mi SE; Located in the "Y" of the Railroad Spur, NW of Sludge Lagoon.	IDM
52	0.4 mi ESE; Light Pole Near the East Plant Security Fence.	IDM
A7**	9.5 mi NW; C. Bartley Farm.	APT,AIO
A8	0.9 mi NNE; County Road 448, 0.9 miles South of Hwy 0.	APT,AIO
A9 APT,AIO	1.7 mi NNW; Community of Reform.	
D01	5.1 mi SE; Holzhouser Grocery Store/Tavern (Portland, MO).	WWA
F05	1.0 mi SSE; Onsite Groundwater Monitoring Well.	WWA
F15	5.5 mi NE; Onsite Groundwater Monitoring Well.	WWA
M1**	12.3 mi WSW; Green's Farm.	MLK
M5	3.1 mi NW; Schneider Farm.	MLK
M6	2.7 mi NW; Pierce Farm	MLK
V3**	15.0 mi SW; Beazley Farm.	FPL,SOL
V6	1.8 mi NNW; Becker Farm.	FPL
V7	1.8 mi N; Meehan Farm.	FPL

TABLE I (Cont'd.)

SAMPLING LOCATIONS

Location Code	Description	Sample Types
A**	4.9 mi SSE; 0.6 River Miles Upstream of Discharge North Bank.	AQS,AQF
C	5.1 mi SE; 1.0 River Miles Downstream of Discharge North Bank.	AQS,AQF
S01**	4.8 mi SE; 84 feet Upstream of Discharge North Bank.	SWA
S02	5.2 mi SE; 1.1 River Miles Downstream of Discharge North Bank.	SWA
F1	0.98 mi S; Callaway Plant Forest Ecology Plot F1.	SOL
F2	1.64 mi SW; Callaway Plant Forest Ecology Plot F2.	SOL
F6	1.72 mi NE; Callaway Plant Forest Ecology Plot F6.	SOL
F8	1.50 mi NE; Callaway Plant Forest Ecology Plot F8.	SOL
F9	1.45 mi NNW; Callaway Plant Forest Ecology Plot F9.	SOL
PR3	1.02 mi ESE; Callaway Plant Prairie Ecology Plot PR3.	SOL
PR4	1.34 mi ESE; Callaway Plant Prairie Ecology Plot PR4.	SOL
PR5	1.89 mi NE; Callaway Plant Prairie Ecology Plot PR5.	SOL
PR7	0.45 mi NNW; Callaway Plant Prairie Ecology Plot PR7.	SOL
PR10	1.55 mi NNW; Callaway Plant Prairie Ecology Plot PR10	SOL

TABLE I (Cont'd.)

SAMPLING LOCATIONS

Location Code	Description	Sample Types
W1**	0.61 mi SE; Callaway Plant Wetlands, High Ground	SOL
W2	0.60 mi SE; Callaway Plant Wetlands, Inlet Area	SOL
W3	0.72 mi SSE; Callaway Plant Wetlands, Discharge Area	SOL
W4	0.68 mi SSE; Callaway Plant Wetlands, SW Bank	SOL

*All distances are measured from the center line of the reactor
**Control locations

TABLE II

COLLECTION SCHEDULE

Collection Site	Air Particulates	Air Radioiodine	Well Water	Surface Water	Sediment	Fish	Milk	Vegetation	Soil
A1, Primary Meteorological Tower	W	W							
A7, C. Bartley Farm	W	W							
A8, County Rd. 448, 0.9 miles South of Hwy O	W	W							
A9, Community of Reform	W	W							
B3, 0.6 miles East of O and CC Junction	W	W							
D01, Holzhouser Grocery Store/Tavern			Q						
F05, Onsite Groundwater Monitoring Well			Q						
F15, Onsite Groundwater Monitoring Well			Q						
M1, Green's Farm							SM/M		
M5, Schneider Farm							SM/M		
M,6, Pierce farm							SM/M		

Q=Quarterly W=Weekly M=Monthly SM/M=Semi Monthly when cows are on Pasture, Monthly otherwise A=Annually SA = Semi Annually

TABLE II (Cont'd.)

COLLECTION SCHEDULE

Collection Site	Air Particulates	Air Radioiodine	Well Water	Surface Water	Sediment	Fish	Milk	Vegetation	Soil
V3, Beazley Farm								M	A
V6, Becker Farm								M	
V7, Meehan Farm								M	
A,0.6 River miles Upstream of Discharge North Bank					SA	SA			
C,1.0 River miles Downstream of Discharge North Bank					SA	SA			
S01, 84 feet Upstream of Discharge North Bank				M					
S02, 1.1 River miles Downstream of Discharge North Bank				M					
F1, Callaway Plant Forest Ecology plot F1									A
F2, Callaway Plant Forest Ecology Plot F2									A

Q=Quarterly W=Weekly M=Monthly SM/M=Semi Monthly when cows are on Pasture, Monthly otherwise A=Annually SA = Semi Annually

TABLE II (Cont'd.)

COLLECTION SCHEDULE

Collection Site	Air Particulates	Air Radioiodine	Well Water	Surface Water	Sediment	Fish	Milk	Vegetation	Soil
F6, Callaway Plant Forest Ecology Plot F6									A
F8, Callaway Plant Forest Ecology Plot F8									A
F9, Callaway Plant Forest Ecology Plot F9									A
PR3, Callaway Plant Prairie Ecology Plot PR3									A
PR4, Callaway Plant Prairie Ecology Plot PR4									A
PR5, Callaway Plant Prairie Ecology Plant PR5									A
PR7, Callaway Plant Prairie Ecology Plot PR7									A
PR10, Callaway Plant Prairie Ecology Plot PR10									A

Q=Quarterly W=Weekly M=Monthly SM/M=Semi Monthly when cows are on Pasture, Monthly otherwise A=Annually SA = Semi Annually

TABLE II (Cont'd.)

COLLECTION SCHEDULE

Collection Site	Air Particulates	Air Radioiodine	Well Water	Surface Water	Sediment	Fish	Milk	Vegetation	Soil
W1, Callaway Wetlands, High Ground									A
W2, Callaway Wetlands, Inlet Area									A
W3, Callaway Wetlands, Discharge Area									A
W4, Callaway Wetlands, Southwest Bank									A

Q=Quarterly W=Weekly M=Monthly SM/M=Semi Monthly when cows are on Pasture, Monthly otherwise A=Annually SA = Semi Annually

Bottom Sediment

Bottom sediment samples are collected semi-annually from one indicator location (C) and one control location (A). The samples are taken from water at least 2 meters deep to prevent influence of bank erosion. A Ponar dredge is used to obtain the samples, all of which consist of the uppermost layer of sediment. Each sample is placed, without preservative, in a plastic bag and sealed. Bottom sediment samples are analyzed for gamma emitting isotopes.

Shoreline Sediment

Shoreline sediment samples are collected semi-annually at the same locations as bottom sediment. The samples are collected within two feet of the waters edge and consist of 2 six inch diameter by two inch deep sediment plugs. Each sample is placed in a plastic bag and sealed. Shoreline sediment samples are analyzed for gamma emitting isotopes.

Wetlands Soil

Wetlands Soil Samples are collected annually from 3 indicator locations (W2, W3, and W4) and one control location (W1). Two 6 inch square soil plugs consisting of the uppermost two-inch layer of soil are taken at each location. The samples are placed in plastic bags and sealed. Wetlands soil samples are analyzed for gross alpha, gross beta, and gamma emitting isotopes.

2.2.2 Airborne Pathway

Airborne Particulates

Airborne particulate samples are collected on a 47mm diameter glass fiber filter type A/E (99 percent removal efficiency at 1 micron particulate) at a volumetric rate of one and one half cubic feet per minute at five locations. The particulate filters are collected weekly and shipped to TIML for analyses. The filters are analyzed for gross beta activity approximately five days after collection to allow for decay of naturally-occurring short-lived radionuclides. Quarterly composites of filters by location are gamma-scanned and analyzed for Strontium-89 and Strontium-90. Four of the five locations are indicator locations (A1, A8, A9, and B3) and one location is a control location (A7). One of the indicators (A9) is located at the community with the highest D/Q.

Airborne Iodine

Each air sampler is equipped with a charcoal cartridge in-line after the particulate filter holder. The charcoal cartridge at each location is collected at the same time as the particulate filter and analyzed for Iodine-131 within eight days after collection.

2.2.3 Ingestion Pathway

Milk

Two gallon milk samples are collected semi-monthly during the pasture season (April through September) and monthly during the winter from one goat and one cow milk location near the Plant (M5 and M6) and one cow milk location away from the Plant (M1). Milk samples are shipped in ice to be received by TIML within 48 hours of collection. Analyses for Iodine-131, elemental calcium, Strontium-89, Strontium-90, and gamma emitting nuclides are performed on all milk samples.

Fish

The five most abundant recreational or commercial fish species are collected semi-annually from one indicator location (C) and one control location (A). Fish samples are filleted and are analyzed for Strontium-89, Strontium-90 and gamma emitting isotopes.

Vegetation

Monthly, during the growing season, green leafy vegetation is collected from two indicator locations (V6 and V7) and from one control location (V1). Vegetation samples consist of mustard greens, turnip greens, cabbage, lettuce, and spinach. The vegetation samples are analyzed for gross alpha, gross beta, Iodine-131, and by gamma spectrometry.

Soil

Once a year soil samples are collected from ten indicator locations (F1, F2, PR3, PR4, PR5, F6, PR7, F8, F9, and PR10) and one control location (V3). To ensure only the most recent deposition is sampled, the uppermost two-inch layer of soil is taken at each location. Samples consist of 2 six inch square soil plugs. The litter at the surface and the root mat is considered part of the sample. The samples are placed in plastic bags and sealed. Each soil sample is analyzed for gross alpha, gross beta, and gamma emitting isotopes.

2.2.4 Direct Radiation

Thermoluminescent Dosimetry

Thermoluminescent Dosimetry (TLD) is employed to determine direct radiation levels in and around the Callaway site. Panasonic model UD-814 TLD's sealed in plastic bags are placed in polypropylene mesh cylindrical holders at fifty two locations and exchanged quarterly and annually. Fifty of the fifty-two locations are indicators (2 through 33 and 35 through 52) and two locations are controls (1 and 34).

2.3 Program Execution

The program was executed as described in the preceding section with the following exceptions;

Surface Water

1. Sampler equipment malfunctions resulted in an inoperable upstream composite sampler (S01) from 04/13/93 to 12/31/93.

2. The downstream composite sampler (S02) was inoperable from 01/01/93 to 01/14/93 due to a kinked sample line and from 06/24/93 to 12/31/93 due to sampler equipment malfunction and subsequent Missouri River flooding of the sampler in July, 1993.

While the composite samplers were inoperable, daily grab samples were taken and composited monthly, except as noted below:

3. The daily grab samples at location S02 were not collected during the months of July and August and on 09/02/93, 09/19/93 and 09/24/93 due to flooding. The location was either inaccessible or the water within reach of the bank was stagnant and not representative. It also contained a significant amount of decaying matter posing a potential health hazard.

4. Location S01 daily grab samples were not collected on 09/12/93 and 09/24/93 because of access restrictions from flooding.

Airborne

1. Airborne particulate and iodine sample results from location A8 for the collection periods ending 05/13/93 and 06/24/93 are questionable because sampler power was not operational during the entire sampling period. The sampler hour meter showed sampler operation of 85 hours and 10 hours, respectively.

2. The sample head vibrated loose from the sample pump at location A8, making airborne particulate and iodine sample results for the collection period ending 09/02/93 questionable.

3. There were no airborne particulate or iodine samples from A7 for the collection period ending 09/02/93 due to a malfunction of sampling equipment.

4. Airborne particulate and iodine sample results from location A1 for the collection period ending 09/02/93 are questionable because sampler power was not operational during the entire sampling period. The sampler hour meter showed sampler operation of 77 hours.

Milk

1. No milk samples were available from location M5B during the month of December. Goats were not producing during this month.

2. No milk sample was available from location M1 for the collection period ending 04/15/93 due to nursing calf.

Vegetation

1. No green leafy vegetation samples were available from location V3 during the months of May, June, August, and November because of extreme weather conditions which did not promote plant growth.

2. There were no green leafy vegetation samples collected from location V7 in May, June, August and November due to lack of plant growth.

3. Green leafy vegetation was unavailable from location V6 for the months of September, October, and November due to lack of plant growth.

Direct Radiation

1. There was no direct radiation data from Locations 10, 41, and 49 for the first quarter because of vandalism to the TLD stations.

2. During the third quarter, locations 09, 10, and 30 were flooded and replaced August 25, 1993. This area was flooded again during September and locations 09, 10, 27, 30, and 31 were damaged. Also location 41 was lost due to vandalism and location 21 TLD's were rain soaked making the element response questionable.

3. The annual TLD from location 41 was found missing from the sample holder during collection.

2.4 Analytical Procedures

Analytical procedures and counting methods employed by the contractor Laboratory follow those recommended by the U.S. Public Health Service publication, Radioassay Procedures for Environmental Samples, January 1967; and the U.S. Atomic Energy Commission Health and Safety Laboratory, HASL Procedures Manual, (HASL-300), 1972.

A synopsis of the routinely used analytical procedures for sample analyses is presented below.

2.4.1 Airborne

2.4.1.1 Gross Beta

The glass fiber filter type A/E (99 percent removal efficiency at 1 micron particulate), is placed into a stainless steel planchet and counted for gross beta radioactivity using a proportional counter.

2.4.1.2 Gamma Spectrometry

Filters are composited according to location and counted using a germanium detector which is coupled to a computer based, multi-channel analyzer. The resulting spectrum is then analyzed by the computer and specific nuclides, if present, identified and quantified.

2.4.1.3 Strontium-89 and Strontium-90

The composited filters, with stable strontium and barium carriers added, are leached in nitric acid to bring deposits into solution. After filtration, filtrate is reduced in volume by evaporation. The residue is purified by adding iron and rare earth carriers and precipitating them as hydroxides. After a second strontium nitrate precipitation from nitric acid, the nitrates are dissolved in acid again with added yttrium carrier and are stored for ingrowth. The yttrium is precipitated as hydroxide and separated from strontium with the strontium being in the supernate. Each fraction is precipitated separately as an oxalate (yttrium) and carbonate (strontium) and collected on a No. 42 (2.4 cm) Whatman filter. The filters are counted using a low background proportional counter and the Strontium-90 activity is calculated from the oxalate data. The Strontium-89 activity is determined by subtracting the previously calculated Strontium-90 activity from the measured gross strontium activity calculated from the carbonate.

2.4.1.4 Iodine-131

Each Charcoal cartridge is placed on the germanium detector and counted. A peak of 0.36 MeV is used to calculate the concentration at counting time. The equilibrium concentration at the end of collection is then calculated. Decay correction for the time interval between sample collection and counting is then made.

2.4.2 Direct Radiation

Direct radiation measurements are taken by UEC using Thermoluminescent Dosimeters (TLD's). The UEC program employs the Panasonic Model UD-814 TLD and Model UD-710 automatic dosimeter reader. Each dosimeter consists of three elements of $CaSO_4$:Tm and one element of $Li_2B_4O_7$:Cu. The dosimeters are sealed in a moisture resistant plastic bag and placed inside a polypropylene mesh cylindrical holder in the environment. After exposure in the environment the dosimeters are read and the exposure for the time period is determined from the $CaSO_4$:Tm elements. The $Li_2B_4O_7$:Cu element is not used to determine exposure during routine operations.

2.4.3 Vegetation

2.4.3.1 Iodine-131

A suitable aliquot of wet (as received) sample is placed into a standard calibrated container and counted using a germanium detector coupled to a computer based, multi-channel analyzer. A peak of 0.36 MeV is used to calculate the concentration at counting time. The equilibrium concentration at the end of collection is calculated by decay correcting for the time interval between sample collection and counting.

2.4.3.2 Gross Alpha and Gross Beta

A suitable aliquot of ashed sample is transferred to a two-inch ringed planchet. The planchet is counted for gross alpha and gross beta activity using a proportional counter.

2.4.3.3 Gamma Spectrometry

A suitable aliquot of wet (as received) sample is placed into a standard calibrated container and specific nuclides, if present, identified and quantified using a germanium detector coupled to a computer based, multi-channel analyzer.

2.4.4 Milk

2.4.4.1 Iodine-131

Two liters of milk containing standardized Iodine carrier are stirred with anion exchange resin for one hour. The resin is washed with NaCl and the iodine is eluted with sodium hypochlorite. Iodine in the iodate form is reduced to I_2 and the elemental iodine extracted into CCl_4, back-extracted into water, then precipitated as palladium iodide. The precipitate is counted for I-131 using a proportional counter.

2.4.4.2 Strontium-89 and Strontium-90

One liter of milk containing strontium and barium carriers is passed through a cation-exchange resin column.

Strontium, barium and calcium are eluted from the cation-exchange resin with sodium chloride solution. Following dilution of the eluate, the alkaline earths are precipitated as carbonates. The carbonates are then converted to nitrates, and strontium and barium nitrate are precipitated. The nitrate precipitate is dissolved, and barium is precipitated as the chromate, purified as the chloride, and counted for Barium-140 (if required). From the supernate, strontium is precipitated as the nitrate, dissolved in water and reprecipitated as strontium nitrate. The nitrate is converted to the carbonate, which is filtered, weighted to determine strontium carrier recovery, and counted for "total radiostrontium" using a proportional counter.

After counting total radiostrontium the second time after six to eight days, Sr-89 concentrations are calculated. If the Sr-89 concentration shows a positive result, the precipitate is dissolved, yttrium carrier added and the sample is stored for six to eight days to allow for additional yttrium ingrowth. Yttrium is separated from strontium, precipitated as yttrium oxalate and counted to determine Sr-90 concentrations.

The concentration of Sr-89 is calculated as the difference between the activity for "total radiostrontium" and the activity due to Sr-90.

2.4.4.3 Gamma Spectrometry

3.5 liters or 500 ml aliquot of milk is placed in a standard counting container and specific nuclides identified and quantified using a germanium detector coupled to a computer based, multi-channel analyzer.

2.4.4.4 Elemental Calcium

Strontium, barium, and calcium are adsorbed on cation-exchange resin, then eluted with sodium chloride solution. An aliquot of the eluate is diluted to reduce the high sodium ion concentration. From this diluted aliquot, calcium oxalate is precipitated, dissolved in dilute hydrochloric acid, and the oxalate is titrated with standardized potassium permanganate.

2.4.5 Surface and Ground Water

2.4.5.1 Tritium

A 60-70 ml aliquot of water is purified by distillation, a portion of the distillate is transferred to a counting vial and the scintillation fluid added. The contents of the vial are thoroughly mixed and counted in a liquid scintillation counter.

2.4.5.2 Gamma Spectrometry

3.5 liters or 500 ml aliquot of water is placed in a standard counting container and specific nuclides identified and quantified using the Method described in Section 2.4.1.2.

2.4.6 Fish

2.4.6.1 Gross Alpha and Gross Beta

A suitable aliquot of ashed fish sample is transferred to a two-inch ringed planchet. The planchet is counted for gross alpha and gross beta activity using a proportional counter.

2.4.6.2 Strontium-89 and Strontium-90

A suitable aliquot of ashed sample transferred to a 250 ml beaker and strontium-yttrium carriers added. The sample is leached in nitric acid and filtered. After filtration, filtrate is reduced in volume by evaporation. The residue is purified by adding iron and rare earth carriers and precipitating them as hydroxides. After a second strontium nitrate precipitation from nitric acid, the nitrates are dissolved in acid again with added yttrium carrier and are stored for ingrowth of Yttrium-90. The yttrium is precipitated as hydroxide and separated from strontium with the strontium being in the supernate. Each fraction is precipitated separately as an oxalate (yttrium) and carbonate (strontium) and collected on No. 42 (2.4 cm) Whatman filter for counting using a low background proportional counter. The Strontium-90 concentration is determined from the yttrium oxalate counting results and the Strontium-89 concentration is calculated as the difference between the strontium carbonate activity and the activity due to Strontium-90.

2.4.6.3 Gamma Spectrometry

A suitable aliquot of prepared sample is placed in a standard calibrated container and specific nuclides identified and quantified using a germanium detector coupled to a computer based, multi-channel analyzer.

2.4.7 Bottom and Shoreline Sediment

2.4.7.1 Gamma Spectrometry

A suitable aliquot of prepared sample is placed in a standard calibrated container and specific nuclides identified and quantified using a germanium detector coupled to a computer based, multi-channel analyzer.

2.4.8 Soil and Wetlands

2.4.8.1 Gross Alpha and Gross Beta

A suitable aliquot of dried sample is transferred to a two-inch ringed planchet. The planchet is counted for gross alpha and gross beta activity using a proportional counter.

2.4.8.2 Gamma Spectrometry

A suitable aliquot of prepared sample is placed in a standard calibrated container and specific nuclides identified and quantified using a germanium detector coupled to a computer based, multi-channel analyzer.

2.5 Program Modifications

During 1993 three modifications were made to the monitoring program. The first modification was addition of a new milk sampling location (M6) during the December collection period.

The second change was reinitiation of milk sampling location M5 during the December collection period. This milk sampling location was previously discontinued in October 1992.

The third change was deletion of milk samples collected from location M1 after the October collection. The milk samples were discontinued at the Farmer's request.

3.0 Isotopic Detection Limits and Activity Determinations

A discussion of the calculations used in determining detection limits and activity by the Contractor Laboratory is found in Appendix C.

Table III gives the required detection limits for radiological environmental sample analysis. For each sample type, the table lists the detection level for each isotope.

TABLE III

DETECTION CAPABILITIES FOR RADIOLOGICAL ENVIRONMENTAL SAMPLE ANALYSIS

ANALYSIS	WATER (pC/l)	AIRBORNE (pC/m^3)	FISH (pCi/kg wet)	MILK (pC/l)	FOOD PRODUCTS (pCi/kg wet)	SOIL AND SEDIMENT (pCi/kg dry)
Gross beta	4	0.01				
H-3	300					
Mn-54	15		130			
Fe-59	30		260			
Co-58,-60	15		130			
Zr-Nb-95	15*					
I-131	1	0.07		1	60	
Cs-134	15	0.05	130	15	60	150
Cs-137	18	0.06	150	18	80	180
Ba-La-140	15*			15*		

NOTE: This list does not mean only these nuclides will be detected and reported. Other peaks which are measurable and identifiable together with above nuclides, will also be identified and reported.

* Total activity, parent plus daughter activity.

4.0 Quality Control Program

To insure the validity of the data, the contractor laboratory maintains a quality control (QC) program which employs quality control checks, with documentation, of the analytical phase of its environmental monitoring studies. The program is defined in the Quality Control Program, and procedures are specified in the QC Procedures Manual.

The QC Program includes laboratory procedures designed to prevent cross-contamination and ensure accuracy and precision of analyses. The quality control checks include blind samples, duplicate samples, and spiked samples as necessary to verify laboratory analysis activities are being maintained at a high level of accuracy.

The Quality Control Program is in compliance with USNRC Regulatory Guide 4.15 and includes appropriate control charts with specified acceptance levels for instrument source checks, background, efficiency, etc. for counting equipment.

The Laboratory participates in the USEPA Interlaboratory Comparison Program (crosscheck program) by analyzing radioactive samples distributed for that purpose. The results of the crosscheck program are presented in Appendix B.

5.0 Data Interpretations

In interpreting the data, effects due to the Callaway Plant must be distinguished from those due to other sources.

The principal interpretation method used in assessment of those effects is the indicator-control concept used in the design of the monitoring program. Most sample types are collected at both indicator locations (areas potentially affected by plant operations) and control locations (areas not affected by plant discharge). A possible plant effect would be indicated if the radiation level at an indicator location was significantly larger than at the control location. The difference would have to be greater than what could be accounted for by typical fluctuations in radiation levels arising from other sources.

An additional interpretation method involves analysis for specific radionuclides present in environmental samples collected around the plant site. For certain isotopes it can be determined if the activity is the result of weapons testing or plant operations because of the different characteristic proportions in which these isotopes appear in the fission product mix produced by a nuclear reactor and that produced by a nuclear detonation.

Other means of distinguishing sources of environmental radiation can be employed in interpretation of the data. Current radiation levels can be compared with preoperational levels. Results can be related to those obtained in other parts of the country. Finally, results can be related to events known to have caused elevated levels of radiation in the environment.

6.0 Results and Discussion

Analytical results for the reporting period January to December 1993 are presented in summary form in Appendix D. For each type of analysis of each sampled medium, this table shows the annual mean and range for all indicator locations and for all control locations. Results for the location with the highest annual mean are also given.

Discussion of the results has been divided into four pathways; waterborne, airborne, ingestion, and direct radiation. The individual samples and analyses within each category provides an adequate means of estimating radiation dose to individuals from principal pathways. Data for individual samples are presented in tabular form in Appendix E.

6.1 Waterborne Pathway

The water pathway of exposure from Callaway Plant was evaluated by analyzing surface water, well water, bottom sediment, shoreline sediment and wetlands.

Surface Water

Analysis of Tritium in surface water showed detectable activity in eighteen of twenty-two samples with results ranging from 188 to 4917 pCi/l. The mean Tritium concentration at the indicator location was 294 pCi/liter and at the control location was 1761 pCi/l. The LLDs for other samples ranged from 172 to 187 pCi/l. Tritium activity at the control location appears to be due to plant discharge recirculation into the upstream intake bay probably via the fish escape openings. The control location sample point is located in the farthest upstream pump bay. This condition varies depending on river flow rate and which intake pumps are running.

No gamma emitting nuclides were detected in any surface water samples.

Levels of activity detected in indicator surface water samples during 1993 were consistent with previously accumulated radiological environmental data and indicate no influence from plant operations.

Ground Water

In ground water samples, tritium results for all thirteen samples were below the detection limit which ranged from 171 to 200 pCi/l.

No gamma emitting nuclides were detected in any ground water sample.

There was no indication of plant effects on ground water.

Bottom Sediment

Analysis of bottom sediment collected in April and October showed positive Cesium-137 activity in one sample with a concentration of 79 pCi/kg. There were no other gamma emitting nuclides detected in bottom sediment samples. The presence of Cesium-137 in bottom sediment exhibits a long term residual effect of previous atmospheric nuclear tests and not an effect from plant operations.

Shoreline Sediment

Shoreline Sediment samples were collected in April and October, 1993 and analyzed for gamma emitting isotopes. Both shoreline sediment samples collected in October showed Cesium-137 activity of 81 pCi/kg at Location A and 67 pCi/kg at Location C. There were no gamma emitting nuclides detected in shoreline sediment samples collected in April. Similar levels of Cesium-137 activity due to fallout from atmospheric nuclear testing were observed in 1984, 1985, 1987, 1988, 1989, 1990, 1991, and 1992.

Wetlands

Analysis for alpha emitters showed detectable activity in all samples, with results ranging from 13550 to 16330 pCi/kg. The average sample concentration at the indicator location was 14616 pCi/kg and at the control location was 13550 pCi/kg.

The average gross beta activity in all wetlands samples ranged from 15258 to 23262 pCi/kg. The average activity at the control location was 23262 pCi/kg and at the indicator location was 16882 pCi/kg.

Potassium-40 and Cesium-137 were the only gamma emitting isotopes detected. Potassium-40 was detected in all samples with results ranging from 10796 to 16081 pCi/kg. The average concentration for indicator locations was 13329 pCi/kg and for the control location was 14871 pCi/kg.

Three wetlands samples showed positive Cesium-137 activity with results ranging from 73 to 167 pCi/kg. The average concentration for indicator locations was 120 pCi/kg and for the control location was 114 pCi/kg.

Gross alpha and gross beta activity can be attributed to naturally occurring isotopes (e.g. Potassium-40). Cesium-137 activity present can be attributed to worldwide fallout from atmospheric nuclear testing.

6.2 Airborne Pathway

Airborne pathways of exposure from Callaway Plant were evaluated by analyzing samples of air particulate and air iodine cartridges.

Airborne Particulate

Gross beta activity in airborne particulate ranged from 0.005 to 0.068 pCi/m^3 in all samples. The average gross beta activity was identical at both indicator and control locations (0.018 pCi/m^3). The highest annual average (0.20 pCi/m^3) was measured at indicator location A8, 0.9 miles NNE of the plant.

Gamma spectral analysis of quarterly composites of air particulate filters showed Beryllium-7 in nineteen of twenty samples. The average Beryllium-7 activity for indicator locations was 0.056 pCi/m^3 and for control locations was 0.052 pCi/m^3. The presence of Beryllium-7 can be attributed to cosmic ray activity. No other gamma emitting isotopes of interest were detected in the quarterly composities.

Strontium-89 and Strontium-90 analyses performed on quarterly composites showed all activities to be below detection limits.

Levels and distribution of activity in air particulate samples are similar to previously accumulated data and indicate no influence from the plant.

Airborne Iodine

Airborne Iodine-131 results were below the detection limit of 0.07 pCi/m^3 in all samples. Thus, there was no indication of a plant effect.

6.3 Ingestion Pathway

Potential ingestion pathways of exposure for Callaway Plant were evaluated by analyzing samples of milk, fish, vegetation, and soil.

Milk

A total of sixteen analyses for Iodine-131 in milk were performed during 1993. All samples were below the LLD which ranged from 0.2 to 0.9 pCi/l.

Naturally occurring Potassium-40 was the only gamma emitting isotope found in milk samples. Concentrations ranged from 1050 to 1560 pCi/l. The average concentration for indicator locations was 1050 pCi/l and for control locations was 1356 pCi/l.

Strontium-89 results were below the LLD for all samples. The LLDs ranged from 0.5 to 2.7 pCi/l. Strontium-90 was detected in fifteen of sixteen milk samples averaging 3.9pCi/l for indicator locations and 4.5 pCi/l for control locations. The range of detectable results was 2.8 to 7.8 pCi/l.

Calcium was analyzed in all milk samples with levels ranging from 0.60 to 1.43 gm/l.

In summary, the milk data for 1993 show no radiological effects from plant operation. The presence of Strontium-90 in milk samples exhibits a long range residual effect of previous atmospheric nuclear tests.

Fish

The types of fish species collected during 1993 were: River Carpsucker, Gizzard Shad, Channel Catfish, Bigmouth Buffalo, Freshwater Drum, Largemouth Bass and Carp.

All fish samples indicated positive Potassium-40 activity with levels ranging from 2082 pCi/kg-wet to 3470 pCi/kg-wet. The mean Potassium-40 activity was 3012 pCi/kg-wet for the indicator location and 2786 pCi/kg-wet for the control location.

No Strontium-89 activity was detected in fish samples collected during 1993. Strontium-90 activity was detected in one sample collected at location C with activity of 3.2 pCi/kg-wet.

Activities detected in fish samples were consistent with levels and fluctuations of previously accumulated environmental data. Strontium-90 activity present in some samples can be attributed to worldwide fallout from atmospheric nuclear testing. It can be concluded that operation of the plant has had no effect on fish samples.

Vegetation

In 1993 there was a limited number of vegetation samples colleted because of extensive spring rains and mild summer weather conditions which did not promote plant growth. Vegetation samples collected during 1993 consisted of mustard greens, lettuce, and cabbage.

Gross alpha activity was observed in all vegetation samples with results ranging from 51 to 272 pCi/kg-wet. The average activity for indicator locations was 131 pCi/kg-wet and for the control location was 200 pCi/kg-wet.

Gross beta activity was detected in all vegetation samples with results ranging from 3427 to 5879 pCi/kg-wet. The average gross beta activity for indicator locations was 4994 pCi/kg-wet and for the control location was 4653 pCi/kg-wet.

Iodine-131 activity was below the detection limit in all samples.

Naturally occurring Potassium-40 was found in all vegetation samples. Concentrations ranged from 2826 to 7121 pCi/kg-wet and averaged 5267 and 4797 pCi/kg-wet at indicator and control locations respectively. All other gamma emitting isotopes were below their detection limit.

None of the vegetation sample results show significant differences between indicator and control locations. Levels of activity were consistent with previously accumulated data and no plant effect was indicated.

Soil

Gross alpha results ranged from 9126 to 17456 pCi/kg for all eleven samples. The mean activity for indicator locations was 13070 pCi/kg and for the control location was 11365 pCi/kg. Gross beta activity was detected in all eleven samples ranging from 20146 to 25370 pCi/kg. The average gross beta activity was 22819 and 25370 pCi/kg at indicator and control locations respectively.

Gamma spectral analysis of the soil samples showed Cesium-137 and Potassium-40 in all samples. Cesium-137 results ranged from 330 to 1825 pCi/kg. The average concentration was 1215 pCi/kg at the indicator locations and 330 pCi/kg at the control location. Potassium-40 results ranged from 10556 to 18117 pCi/kg. The average concentration for indicator locations was 12450 pCi/kg and for the control location was 18117 pCi/kg.

The gross alpha and gross beta activity can be attributed to naturally occurring isotopes (e.g. Potassium-40). Cesium-137 activity present can be attributed to worldwide fallout from atmospheric nuclear testing. The level of activity and distribution pattern is similar to previously accumulated data and indicates no influence from the plant.

6.4 Direct Radiation

All TLD results presented in this report have been normalized to a 90-day quarter (standard quarter) to eliminate apparent differences in data caused by variations in length of exposure period.

The range of quarterly TLD results for indicator locations was 9.8 to 21.3 mRem/standard quarter and 15.5 to 18.2 mRem/standard quarter for control locations. Quarterly TLD analyses yielded an average exposure level of 17.7 mRem/standard quarter at all indicator locations and an average exposure level of 16.6 mRem/standard quarter at all control locations.

The annual TLD results ranged from 12.0 to 18.9 mRem/standard quarter. The average exposure levels were nearly identical at the indicator and control locations (16.8 mRem/standard quarter and 16.1 mRem/standard quarter, respectively).

There was no significant difference between indicator and control locations for the TLD's during 1993. The exposure levels were consistent with previously accumulated data and no plant effects were indicated.

APPENDIX A

1993 LAND USE CENSUS

APPENDIX A

UNION ELECTRIC COMPANY

CALLAWAY PLANT

1993 LAND USE CENSUS

Prepared by [signature]

Approved by [signature] 3/29/94

1.0 INTRODUCTION

In accordance with Technical Specification 6.8.4.g and APA-ZZ-01003, Offsite Dose Calculation Manual, a Land Use Census is conducted annually during the growing season within a five mile radius of Callaway Plant. The purpose of the Land Use Census is to identify the location of the nearest resident, the nearest milking animal, and the nearest garden of greater than 50 m^2 producing broad leaf vegetation in each of the 16 meteorological sectors.

The 1993 Land Uses Census was conducted during July, August, and September by the Union Electric Real Estate Department. Information was collected by contacting families identified in the 1992 Land Use Census and driving roads within a 5 mile radius of Callaway Plant noting the location of the above mentioned items.

2.0 RESULTS

Results of the Land Use Census are presented in Tables 1 through 3 and discussed below. In the tables, radial direction and distance from Callaway Plant are presented for each location. The radial direction is one of the 16 different compass points. Mileage was estimated from map position for each location.

2.1 Milking Animals

Table 1 presents locations where milking animals were observed within a 5 mile radius of Callaway Plant. All milking animals, whose milk is not used for human consumption and/or not yielding milk, are identified on Table 1. Several changes in location and number of milking animals were observed during the 1993 census. The changes resulted in addition of two milk sample collection locations to the Radiological Environmental Monitoring Program (REMP) in December. However, these changes did not result in a modification to the REMP described in APA-ZZ-01003 because the number of milking animal locations necessary to satisfy the requirements for including the milk pathway were not available.

2.2 Nearest Resident

Table 2 presents the location of the nearest resident to Callaway Plant in each of the 16 meteorological sectors. There were seven changes noted in the 1993 census. None of the changes observed resulted in a change to the location of the nearest resident yielding the highest calculated dose or dose commitment.

2.3 Vegetable Gardens

Locations of the nearest vegetable garden greater than 50 m^2 producing broad leaf vegetation are presented in Table 3. Eight changes were noted during the 1993 census. The changes did not result in changes to current vegetable sampling locations. Many residents lost or could not plant gardens due to extensive rain and floods. Those that were successful showed poor production.

TABLE 1

NEAREST MILKING ANIMALS WITHIN FIVE MILES OF THE CALLAWAY PLANT

1993

Meteorological Sector	Radial Mileage	Number of Cows	Number of Goats
NNE	2.00	26	None
ENE	4.00	***	None
E	3.92	55*	None
ESE	2.28	100*	None
SE	2.38	100*	None
S	3.45	30*	None
SW	2.72	5*	None
NW	2.68	1	None
NW	3.10	5**	3

* Milk producing animals whose milk is not used for human consumption and/or milk producing animals not yielding milk.

** Milk from one cow is being used for human consumption.

*** We were unable to determine if these cows were used to provide milk for human consumption or the exact number of cows present.

TABLE 2

NEAREST RESIDENCE WITHIN FIVE MILES OF THE CALLAWAY PLANT

1993

Meteorological Sector	Radial Mileage
N	2.05
NNE	2.00
NE	2.18
ENE	4.00
E	3.92
ESE	2.28
SE	2.38
SSE	2.58
S	2.64
SSW	2.60
SW	2.57
WSW	1.18
W	1.35
WNN	2.00
NW	2.13
NNW	1.78

TABLE 3

NEAREST GARDEN WITHIN FIVE MILES OF THE CALLAWAY PLANT

1993

Meteorological Sector	Radial Mileage
N	1.76
NNE	2.00
NE	4.70
ENE	4.00
E	3.92*
ESE	2.28
SE	2.38
SSE	2.58*
S	2.64
SSW	3.05
SW	2.72
WSW	1.30
W	1.95
WNN	2.00
NW	2.68
NNW	1.78

* In this sector there were no gardens noted within five miles producing "broad leaf vegetation." The distance noted is the distance to the nearest residence.

APPENDIX B

EPA CROSS-CHECK RESULTS

1993

TABLE B1

EPA INTERCOMPARISON STUDY RESULTS
1993

SAMPLE TYPE	STUDY DATE	ANALYSIS	TIML RESULTS ± 2σ[a]	EPA RESULTS[b] 1s, N=1	CONTROL LIMITS	UNITS
WATER	JAN 1993	SR-89	15.0 ± 2.0	15.0 ± 5.0	6.3 - 23.7	pCi/l
		SR-90	10.3 ± 1.2	10.0 ± 5.0	1.3 - 18.7	pCi/l
WATER	JAN 1993	PU-239	17.5 ± 1.6	20.0 ± 2.0	16.5 - 23.5	pCi/l
WATER	JAN 1993	GR. ALPHA	17.7 ± 1.2	34.0 ± 9.0	18.4 - 49.6	pCi/l[c]
		GR. BETA	46.7 ± 3.2	44.0 ± 5.0	35.3 - 52.7	pCi/l
WATER	FEB 1993	I-131	106.0 ± 10.0	100.0 ± 10.0	82.7 - 117.3	pCi/l
WATER	FEB 1993	U	7.2 ± 1.1	7.6 ± 3.0	2.4 - 12.8	pCi/l
WATER	MAR 1993	RA-226	9.3 ± 1.3	9.8 ± 1.5	7.2 - 12.4	pCi/l
		RA-228	20.8 ± 2.2	18.5 ± 4.6	10.5 - 26.5	pCi/l
WATER A	APR 1993	GR. ALPHA	88.3 ± 8.1	95.0 ± 24.0	53.4 - 136.6	pCi/l
		RA-226	25.4 ± 1.4	24.9 ± 3.7	18.5 - 31.3	pCi/l
		RA-228	17.4 ± 1.2	19.0 ± 4.8	10.7 - 27.3	pCi/l
		U	27.8 ± 2.2	28.9 ± 3.0	23.3 - 34.1	pCi/l
WATER B	APR 1993	GR. BETA	141.7 ± 9.0	177.0 ± 27.0	130.2 - 223.8	pCi/l
		SR-89	28.7 ± 9.4	41.0 ± 5.0	32.3 - 49.7	pCi/l[c]
		SR-90	28.0 ± 3.5	29.0 ± 5.0	20.3 - 37.7	pCi/l
		CO-60	41.3 ± 1.2	39.0 ± 5.0	30.3 - 47.7	pCi/l
		CS-134	24.7 ± 1.2	27.0 ± 5.0	18.3 - 35.7	pCi/l
		CS-137	30.0 ± 0.0	32.0 ± 5.0	23.3 - 40.7	pCi/l
WATER	JUN 1993	H-3	9613.3 ± 46.2	9844.0 ± 984.0	8136.8 - 0.0	pCi/l
WATER	JUN 1993	CO-60	17.3 ± 4.6	15.0 ± 5.0	6.3 - 23.7	pCi/l
		ZN-65	114.0 ± 13.2	103.0 ± 10.0	85.7 - 120.3	pCi/l
		RU-106	108.0 ± 8.0	119.0 ± 12.0	98.2 - 139.8	pCi/l
		CS-134	5.7 ± 1.2	5.0 ± 5.0	0.0 - 13.7	pCi/l
		CS-137	6.0 ± 2.0	5.0 ± 5.0	0.0 - 13.7	pCi/l
		BA-133	101.7 ± 10.3	99.0 ± 10.0	81.7 - 116.3	pCi/l
WATER	JUL 1993	SR-89	28.3 ± 2.3	34.0 ± 5.0	25.3 - 42.7	pCi/l
		SR-90	25.0 ± 1.0	25.0 ± 5.0	16.3 - 33.7	pCi/l

TABLE B1 (Cont.)

EPA INTERCOMPARISON STUDY RESULTS
1993

SAMPLE TYPE	STUDY DATE	ANALYSIS	TIML RESULTS $\pm 2\sigma$[a]	EPA RESULTS[b] 1s, N=1	EPA RESULTS[b] CONTROL LIMITS	UNITS
WATER	JUL 1993	ALPHA	15.0 ± 2.7	15.0 ± 5.0	6.3 - 23.7	pCi/l
		BETA	41.3 ± 4.9	43.0 ± 6.9	31.0 - 55.0	pCi/l
WATER	AUG 1993	URANIUM	24.9 ± 1.4	25.3 ± 3.0	20.1 - 30.5	pCi/l
AIR FILTER	AUG 1993	ALPHA	17.0 ± 1.0	19.0 ± 5.0	10.3 - 27.7	pCi/Filter
		BETA	47.3 ± 0.6	47.0 ± 5.0	38.3 - 55.7	pCi/Filter
		SR-90	19.3 ± 0.6	19.0 ± 5.0	10.3 - 27.7	pCi/Filter
		CS-137	10.0 ± 1.0	9.0 ± 5.0	0.3 - 17.7	pCi/Filter
WATER	SEP 1993	RA-226	15.9 ± 0.7	14.9 ± 2.2	11.1 - 18.7	pCi/l
		RA-228	21.0 ± 1.6	20.4 ± 5.1	11.6 - 29.2	pCi/l
MILK	SEP 1993	I-131	125.3 ± 4.5	120.0 ± 12.0	99.2 - 140.8	pCi/l
		SR-89	19.3 ± 1.5	30.0 ± 5.0	21.3 - 38.7	pCi/l[c]
		SR-90	22.0 ± 0.0	25.0 ± 5.0	16.3 - 33.7	pCi/l
		CS-137	49.0 ± 3.0	49.0 ± 5.0	40.3 - 57.7	pCi/l
		K	1616.7 ± 37.9	1679.0 ± 84.0	1533.3 - 1824.7	mg/l
WATER	OCT 1993	I-131	116.7 ± 2.3	117.0 ± 12.0	96.2 - 137.8	pCi/l
WATER	OCT 1993	GR. ALPHA	39.7 ± 1.5	40.0 ± 10.0	22.7 - 57.3	pCi/l
		RA-226	10.6 ± 0.5	9.9 ± 1.5	7.3 - 12.5	pCi/l
		RA-228	13.2 ± 1.5	12.5 ± 3.1	7.1 - 17.9	pCi/l
		URANIUM	15.3 ± 0.6	15.1 ± 3.0	9.9 - 20.3	pCi/l
WATER	OCT 1993	BETA	52.0 ± 1.0	58.0 ± 10.0	40.7 - 75.3	pCi/l[c]
		SR-89	11.3 ± 0.6	15.0 ± 5.0	6.3 - 23.7	pCi/l
		SR-90	11.0 ± 0.0	10.0 ± 5.0	1.3 - 18.7	pCi/l
		CO-60	10.7 ± 0.6	10.0 ± 5.0	1.3 - 18.7	pCi/l
		CS-134	10.0 ± 1.0	12.0 ± 5.0	3.3 - 20.7	pCi/l
		CS-137	12.3 ± 1.2	10.0 ± 5.0	1.3 - 18.7	pCi/l
WATER	OCT 1993	ALPHA	18.3 ± 2.5	20.0 ± 5.0	11.3 - 28.7	pCi/l
		BETA	13.7 ± 0.6	15.0 ± 5.0	6.3 - 23.7	pCi/l
WATER	NOV 1993	H-3	7310.0 ± 175.2	7398.0 ± 740.0	6114.1 - 8681.9	pCi/l
WATER	NOV 1993	BA-133	75.7 ± 7.6	79.0 ± 8.0	65.1 - 92.9	pCi/l
		CO-60	30.7 ± 2.1	30.0 ± 5.0	21.3 - 38.7	pCi/l
		CS-134	51.3 ± 5.9	59.0 ± 5.0	50.3 - 67.7	pCi/l
		CS-137	41.7 ± 1.2	40.0 ± 5.0	31.3 - 48.7	pCi/l
		RU-106	163.3 ± 3.2	201.0 ± 20.0	166.3 - 235.7	pCi/l[c]
		ZN-65	157.0 ± 8.7	150.0 ± 15.0	124.0 - 176.0	pCi/l

TABLE B1 (Cont.)

EPA INTERCOMPARISON STUDY RESULTS
1993

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a Unless otherwise indicated, the TIML results are given as the mean ± 2 standard deviations for three determinations.
b EPA results are presented as the known value and expected laboratory precision (1s, 1 determination) and control limits as defined by EPA.
c See Addendum to appendix B for explanation of the reason why the sample results were outside the control limits specified by EPA.

ADDENDUM TO APPENDIX B
1993

SAMPLE TYPE	STUDY DATE	ANALYSIS	EXPLANATION
WATER	JAN 1993	GR. ALPHA	GROSS ALPHA ANALYSIS WAS REPEATED WITH SIMILAR RESULTS. AN INVESTIGATION OF POSSIBLE CAUSES FOR THE DEVIATION FROM THE EPA WAS CONDUCTED WITH NO CAUSE DISCOVERED. THE SAMPLE WAS SPIKED WITH TH-230; SO ALPHA SPEC ANALYSIS FOR TH-230 WAS PERFORMED IN TRIPLICATE WITH RESULTS OF 15.5±2.1, 13.4±1.4, AND 14.8±2.0. IT SHOULD BE NOTED THAT 66% OF ALL PARTICIPANTS FAILED THIS ANALYSIS WITH A GRAND AVERAGE OF 17.1. THIS COUPLED WITH THE SUPPORT OF THE ALPHA SPEC RESULTS LEAVES TIML CAUSE TO BELIEVE THAT THERE MAY HAVE BEEN A DILUTION ERROR AT THE EPA. IT SHOULD BE NOTED THAT ON THE NEXT GROSS ALPHA EPA CHECK, TIML REPORTED RESULTS THAT WERE EXACTLY THE KNOWN VALUE. SINCE NO APPARENT CAUSE CAN BE FOUND, AND TIML HAD OUTSTANDING RESULTS ON THE FOLLOWING SAMPLE, IT IS FELT THAT NO FURTHER INVESTIGATION IS NEEDED.
WATER	APR 1993	SR-89	THE EPA REPORT WAS RECEIVED 08-16-93. NO CAUSE FOR THE LOW RESULT FOR SR-89 WAS FOUND THE ANALYST HAS BEEN OBSERVED PERFORMING THIS PROCEDURE WITH NO NOTED DESCREPANCIES. TELEDYNE WILL CONTINUE TO MONITOR THIS PROCEDURE IN THE FUTURE. NO FURTHER ACTION IS ANTICIPATED UNLESS CONDITIONS WARRANT.

ADDENDUM TO APPENDIX B
1993

SAMPLE TYPE	STUDY DATE	ANALYSIS	EXPLANATION
MILK	SEP 1993	SR-89	REPORT WAS RECEIVED 01-18-94; AN INVESTIGATION IS UNDERWAY AS TO THE CAUSE OF THE LOW SR-89 RESULTS. IN HOUSE SPIKES HAVE BEEN PREPARED AND THE ANALYSIS IS IN PROGRESS (SEE SPM-4848 AND SPM-4849 IN FUTURE REPORTS). THERE IS NO APPARENT CAUSE OF THE LOW SR-89 RESULTS. IN-HOUSE SPIKES HAVE BEEN PREPARED AND THE ANALYSIS IS IN PROGRESS. THE ANALYST HAS BEEN OBSERVED PERFORMING THIS PROCEDURE WITH NO DISCEPANCIES NOTED. NO FURTHER ACTION IS PLANNED UNLESS THE RESULTS OF THE IN-HOUSE SPIKES SHOW A PROBLEM.
WATER	OCT 1993	BETA	SAMPLE HAS BEEN RECEIVED AND IS EITHER IN PROGRESS OR TIML IS WAITING FOR THE EPA REPORT.
WATER	NOV 1993	RU-106	THE REPORT WAS RECEIVED ON 02-14-94; THE CAUSE OF THE LOW RU-106 IS UNDER INVESTIGATION. IT SHOULD BE NOTED THAT THE GRAND AVERAGE OF ALL PARTICIPANTS IN THIS ANALYSIS WAS 175.2 pCi/L, WITH 54% OF THE PARTICIPANTS OUTSIDE OF LIMITS

APPENDIX C

Isotopic Detection Limits

And

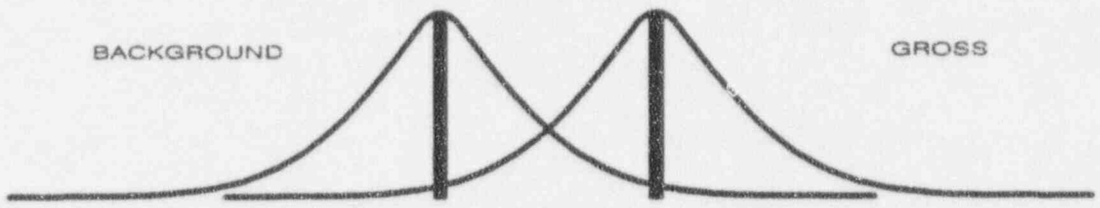
Activity Determinations

Isotopic Detection Limits and Activity Determination

Making a reasonable estimate of the limits of detection for a counting procedure or a radiochemical method is usually complicated by the presence of significant background.

It must be considered that the background is not a fixed value but a series of replicates normally distributed. The desired net activity is thus the difference between the gross sample activity and background activity distributions.

The interpretation of this difference becomes a problem if the two distributions intersect as indicated in the diagram.



If a sufficient number of replicate analyses are run, it is to be expected that results would fall in a normal Gaussian distribution. In routine analysis such replication is not carried out. Standard statistics allow an estimate of the probability of any particular deviation from the mean value. It is common practice to report the mean ± one or two standard deviations as the final result.

Analytical detection limits are governed by a number of factors including:

1. Sample Size

2. Counting Efficiency

   The fundamental quality in the measurement of a radioactive substance is the number of disintegrations per unit time. As with most physical measurements in analytical chemistry, it is seldom possible to make an absolute measurement of the disintegrations rate, but rather, it is necessary to compare the sample with one or more standards. The standards determine the counter efficiency which may then be used to convert sample counts per minute (cpm) to disintegrations per minute (dpm).

3. Background Count Rate

Any counter will show a certain counting rate without a sample in position. This background counting rate comes from several sources: 1) natural environmental radiation from the surroundings, 2) cosmic radiation, and 3) the natural radioactivity in the counter material itself. The background counting rate will depend on the amount of these types of radiation and sensitivity of the counter to radiation.

4. Background and Sample Count Time

The amount of time devoted to counting background depends on the level of the activity being measured. In general, with low level samples, this time should be about equal to that devoted to counting a sample.

5. Time Interval Between Sample Collection and Counting

Decay measurements are useful in identifying certain short-lived isotopes. This disintegration constant is one of the basic characteristics of a specific radionuclide and is readily determined, if the half-life is sufficiently short.

6. Chemical Recovery of the Analytical Procedure

Most radiochemical analyses are carried out in such a way that losses occur during the separations. These losses occur due to a large number of contaminants that may be present and interfere during chemical separations. Thus it is necessary to include a technique for estimating these losses in the development of the analytical procedure.

The following method was used to determine lower limit of detection (LLD) as per NRC Regulatory Guide 4.1, Rev. 1, "Program for Monitoring Radioactivity in the Environs of Nuclear Power Plants", and the NRC Branch Technical Position, November 1979, "An acceptable radiological Environmental Monitoring Program". The LLD is defined, for purposes of this guide, as the smallest concentration of radioactivity material in a sample that will yield a net count (above system background) that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal.

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

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

Where:

LLD = " A priori lower limit of detection as defined above (pCi per unit mass or volume).

s_b = Standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (counts per minute).

E = Counting efficiency (counts per disintegration).

V = Sample size (units of mass or volume).

2.22 = Number of disintegrations per minute per picocurie.

Y = Fractional radiochemical yield (when applicable).

λ = Radioactive decay constant for the particular radioisotope.

Δt = Elapsed time between sample collection (or end of the sample collection period) and time of counting.

The value of s_b used in the calculation of the LLD for a particular measurement system is based on the actual observed variance of the background count rate, or, the counting rate of the blank sample, (as appropriate), rather than an unverified theoretically predicated variance.

In calculating the LLD for a radionuclide determined by gamma-ray spectrometry, the background includes the typical contributions of other nuclides normally present in the samples.

Single Measurements

Each single measurement is reported as follows:

$$x \pm s$$

where: x = Value of the measurement;

s = 2σ counting uncertainty (corresponding to the 95% confidence level).

In cases where the activity is found to be below the lower limit of detection L it is reported as

$$<L$$

where L = the lower limit of detection based on 4.66σ uncertainty for a background sample.

Duplicate Analysis

1. Individual results: $x_1 \pm s_1$
   $x_2 \pm s_2$

   Reported result: $x \pm s$

   where $x = (\frac{1}{2})(x_1 + x_2)$

   $s = (\frac{1}{2})\sqrt{s_1^2 + s_2^2}$

2. Individual results: $<L_1$
   $<L_2$

   Reported results: $<L$

   where L = lower of L_1 and L_2

3. Individual results: $x \pm s$
   $<L$

   Reported results: $x \pm s$ if $x \geq l$;
   $<L$ otherwise

Computation of Average and Standard Deviations

Average and standard deviations listed in the tables are computed from all individual measurements over the period averaged; for example, an annual standard deviation would not be the average of quarterly standard deviations. The average x and standard deviation(s) of a set of n numbers $x_1, x_2 \ldots x_n$ are defined as follows:

$$\bar{x} = \frac{1}{n} \Sigma x$$

$$s = \sqrt{\frac{\Sigma (x-\bar{x})^2}{n-1}}$$

If all values in the averaging group are less than the lower limit of detection, the highest LLD is reported.

If all but one of the values are less than the lower limit of detection, the single value x and associated two sigma error is reported.

In rounding off, the following rules are followed:

1. If the figure following those to be retained is less than 5, the figure is dropped, and the retained figures are unchanged. As an example, 11.443 is rounded off to 11.44.

2. If the figure following those to be retained is greater than 5, the figure is dropped and the last retained figure is raised by 1. As an example, 11.446 is rounded off to 11.45.

3. If the figure following those to be retained is 5, and if there are not figures other than zeros beyond the five, the figure 5 is dropped, and the last-place figure retained is increased by one if it is an odd number or unchanged if an even number. As an example, 11.435 is rounded off to 11.44, while 11.425 is rounded off to 11.42.

APPENDIX D

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
ANNUAL SUMMARY
1993

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM ANNUAL SUMMARY

Name of Facility: Callaway Plant   Docket No.: 50-483

Location of Facility: Callaway County, Missouri (county, state)   Reporting Period: 1993

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	TYPE AND TOTAL NUMBER OF ANALYSES PERFORMED	LOWER LIMIT OF DETECTION[1] (LLD)	ALL INDICATOR LOCATIONS MEAN (f)[2] RANGE	LOCATION WITH HIGHEST ANNUAL MEAN: NAME DISTANCE & DIRECTION	LOCATION WITH HIGHEST ANNUAL MEAN: MEAN (f)[2] RANGE	CONTROL LOCATION MEAN (f)[2] RANGE	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
A. Waterborne Pathway							
Surface Water (pCi/l)	H-3 (22)	172.0	293.8 (5/10) (188.0 - 556.0)	4.8 mi SE; 1.1 ft upstream of discharge	1761.4 (12/12) (273.0 - 4917.0)	1761.4 (12/12) (273.0 - 4917.0)	0
	Gamma (22)	--	-- (0/24)	NA	NA	-- (0/12)	0
Ground Water (pCi/l)	H-3 (14)	171.0	-- (0/8)	NA	NA	-- (0/6)	0
	Gamma (13)	--	-- (0/8)	NA	NA	-- (0/6)	0
Bottom Sediment (pCi/kg)	Gamma (4) Cs-137	19.9	79.0 (1/2) ---	5.1 mi SE; 1.0 mi downstream of discharge	79.0 (1/2) ---	-- (0/2) --	0
Shoreline Sediment (pCi/kg)	Gamma (4) Cs-137	29.3	67.0 (1/2) --	4.9 mi SSE; 0.6 mi upstream of discharge	81.4 (1/2) --	81.4 (0/2) --	0

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM ANNUAL SUMMARY

Name of Facility: Callaway Plant Docket No.: 50-483

Location of Facility: Callaway County, Missouri (county, state) Reporting Period: 1993

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	TYPE AND TOTAL NUMBER OF ANALYSES PERFORMED	LOWER LIMIT OF DETECTION[1] (LLD)	ALL INDICATOR LOCATIONS MEAN (f)[2] RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE & DIRECTION	LOCATION WITH HIGHEST ANNUAL MEAN MEAN (f)[2] RANGE	CONTROL LOCATION MEAN (f)[2] RANGE	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
A. Waterborne Pathway (Cont.)							
Wetlands (pCi/kg)	Gross Alpha (4)		14616.0 (3/3) (13640.0 - 16330.0)	0.68 mi SSE; Wetlands SW bank	16081.0 (1/1) --	13550.0 (1/1) --	0
	Gross Beta (4)		16881.7 (3/3) (15258.0 - 19721.0)	0.61 mi SE; Wetlands, high ground	23262.0 (1/1) --	23262.0 (1/1) --	0
	Gamma (4)						
	K-40		13329.3 (3/3) (10796.0 - 16081.0)	0.68 mi SSE; Wetlands SW bank	16081.0 (1/1) --	14871.0 (1/1) --	0
	Cs-137		120.0 (2/3) (73.0 - 167.0)	0.60 mi SSE; Wetlands, inlet area	167.0 (1/1) --	114.0 (1/1) --	0

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM ANNUAL SUMMARY

Name of Facility: Callaway Plant　　Docket No.: 50-483

Location of Facility: Callaway County, Missouri (county, state)　　Reporting Period: 1993

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	TYPE AND TOTAL NUMBER OF ANALYSES PERFORMED	LOWER LIMIT OF DETECTION[1] (LLD)	ALL INDICATOR LOCATIONS MEAN (f)[2] RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE & DIRECTION	LOCATION WITH HIGHEST ANNUAL MEAN MEAN (f)[2] RANGE	CONTROL LOCATION MEAN (f)[2] RANGE	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
B. Airborne Pathway							
Airborne Particulate (pCi/m³)	Gross Beta (259)	0.003	0.018 (206/208) (0.005 - 0.045)	0.9 mi NNE; County RD 448, 0.9 mi S. of HWY O.	0.020 (51/52) (0.007 - 0.044)	0.018 (51/51) (0.006 - 0.068)	0
	Gamma (20) Be-7	0.0098	0.056 (15/16) (0.029 - 0.078)	1.9 mi N; HWY O, 0.3 mi E. of HWY O and HWY CC junction	0.060 (4/4) (0.045 - 0.076)	0.052 (4/4) (0.046 - 0.060)	0
	Sr-89 (20)	0.0002	-- (0/16)	NA	NA	-- (0/4)	0
	Sr-90 (20)	0.0002	-- (0/16)	NA	NA	-- (0/4)	0
Airborne Iodine (pCi/m³)	I-131 (259)	0.070	-- (0/208)	NA	NA	-- (0/51)	0

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM ANNUAL SUMMARY

Name of Facility: Callaway Plant Docket No.: 50-483

Location of Facility: Callaway County, Missouri (county, state) Reporting Period: 1993

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	TYPE AND TOTAL NUMBER OF ANALYSES PERFORMED	LOWER LIMIT OF DETECTION[1] (LLD)	ALL INDICATOR LOCATIONS MEAN (f)[2] RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE & DIRECTION	MEAN (f)[2] RANGE	CONTROL LOCATION MEAN (f)[2] RANGE	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
C. Ingestion Pathway							
Milk (pCi/l)	I-131 (16)	0.2	-- (0/1)	NA	NA	-- (0/15)	0
	Gamma (16)						
	K-40	---	1050.0 (1/1) --	12.3 mi WSW; cows milk Greens farm	1356.0 (15/15) (1240.0 - 1560.0)	1356.6 (15/15) (1240.0 - 1560.0)	0
	Sr-89 (16)	0.5	-- (0/1)	NA	NA	-- (0/15)	0
	Sr-90 (16)	2.9	3.9 (1/1) --	12.3 mi WSW; cows milk Greens farm	4.5 (14/15) (2.8 - 7.8)	4.5 (14/15) (2.8 - 7.8)	0
(grams/liter)	Ca (16)	---	1.03 (1/1) --	2.7 mi NW; Cows milk Pierces farm	1.03 (1/1) --	0.91 (15/15) (0.60 - 1.43)	0

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM ANNUAL SUMMARY

Name of Facility: Callaway Plant | Docket No.: 50-483

Location of Facility: Callaway County, Missouri (county, state) | Reporting Period: 1993

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	TYPE AND TOTAL NUMBER OF ANALYSES PERFORMED	LOWER LIMIT OF DETECTION[1] (LLD)	ALL INDICATOR LOCATIONS MEAN (f)[2] RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE & DIRECTION	LOCATION WITH HIGHEST ANNUAL MEAN MEAN (f)[2] RANGE	CONTROL LOCATION MEAN (f)[2] RANGE	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
C. Ingestion Pathway (Cont.)							
Fish (pCi/kg - wet)	Gamma (20) K-40	---	3012.2 (10/10) (2666.0 - 3470.0)	5.1 mi SE; 1.0 mi down-stream of discharge	3012.2 (10/10) (2666.0 - 3470.0)	2785.7 (10/10) (2082.0 - 3342.0)	0
	Sr-89 (20)	2.5	-- (0/10)	NA	NA	-- (0/10)	0
	Sr-90 (20)	1.1	3.2 (1/10) --	5.1 mi SE; 1.0 mi down-stream of discharge	3.2 (1/10) --	--- (0/10) ---	0
Vegetation (pCi/kg - wet)	Gross Alpha (8)	--	130.8 (6/6) (51.0 - 218.0)	15.0 mi SW; Beazley farm	199.5 (2/2) (127.0 - 272.0)	199.5 (2/2) (127.0 - 272.0)	0
	Gross Beta (8)	---	4993.7 (6/6) (3436.0 - 7562.0)	1.8 mi NNW; Beckers farm	5417.0 (4/4) (3436.0 - 7562.0)	4653.9 (2/2) (3427.0 - 5879.0)	0
	I-131 (8)	10.7	-- (0/6)	NA	NA	-- (0/2)	0

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM ANNUAL SUMMARY

Name of Facility: Callaway Plant   Docket No.: 50-483

Location of Facility: Callaway County, Missouri (county, state)   Reporting Period: 1993

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	TYPE AND TOTAL NUMBER OF ANALYSES PERFORMED	LOWER LIMIT OF DETECTION[1] (LLD)	ALL INDICATOR LOCATIONS MEAN (f)[2] RANGE	LOCATION WITH HIGHEST ANNUAL MEAN: NAME DISTANCE & DIRECTION	LOCATION WITH HIGHEST ANNUAL MEAN: MEAN (f)[2] RANGE	CONTROL LOCATION MEAN (f)[2] RANGE	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
C. Ingestion Pathway (Cont.)							
	Gamma (8)						
	K-40		5266.8 (6/6) (2826.0 - 7121.0)	1.8 mi NNW; Beckers farm	6010.5 (4/4) (4872.0 - 7121.0)	4797.0 (2/2) (3847.0 - 5747.0)	0
Soil (pCi/kg)	Gross Alpha (11)		13070.5 (10/10) (9126.0 - 17456.0)	1.45 mi NNW; Forest ecology plot F9	17456.0 (1/1) --	11365.0 (1/1) --	0
	Gross Beta (11)		22819.2 (10/10) (20146.0 - 25213.0)	15.0 mi SW; Beazley farm	25370.0 (1/1) --	25370.0 (1/1) --	0
	Gamma (11)						
	K-40		12450.3 (10/10) (10556.0 - 14152.0)	15.0 mi SW; Beazley fram	18117.0 (1/1) --	18117.0 (1/1) --	0
	Cs-137		1214.6 (10/10) (505.0 - 1825.0)	1.50 mi NE; Forest ecology plot F8	1825.0 (1/1) --	333.0 (1/1) --	0

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM ANNUAL SUMMARY

Name of Facility: Callaway Plant Docket No.: 50-483

Location of Facility: Callaway County, Missouri (county, state) Reporting Period: 1993

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	TYPE AND TOTAL NUMBER OF ANALYSES PERFORMED	LOWER LIMIT OF DETECTION[1] (LLD)	ALL INDICATOR LOCATIONS MEAN (f)[2] RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE & DIRECTION	MEAN (f)[2] RANGE	CONTROL LOCATION MEAN (f)[2] RANGE	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
D. DIRECT RADIATION							
Quarterly TLDs (mRem/Standard Quarter)	Gamma Dose (199)	10	17.7 (191/191) (9.8 - 21.3)	7.6 mi SW; City of Mokane	19.8 (3/3) (18.7 - 21.1)	16.6 (8/8) (15.5 - 18.2)	0
Annual TLDs (mRem/Standard Quarter)	Gamma Dose (51)	10	16.8 (49/49) (12.0 – 18.9)	2.9 mi S; County Rd.459, 1.4 mi N. HWY 94	18.9 (1/1) ---	16.1 (2/2) (15.8 – 16.4)	0

(1) The LLDs quoted are the lowest actual LLD obtained in the various media during the reporting period. The required LLDs for radiological environmental sample analysis is found in Table III. Where all nuclides were LLD for a specific media, no LLD was listed.

(2) Mean and range are based upon detectable measurements only. Fraction of detectable measurements is indicated in parentheses.

APPENDIX E

INDIVIDUAL SAMPLE RESULTS

DATA TABLES

1993

APPENDIX E

LIST OF TABLES

Definition of the term used in the data tables are as follows:

Wet Weight	A reporting unit used with organic tissue samples such as vegetation and animal samples in which the amount of sample is taken to be the weight as received from the field with no moisture removed.
Dry Weight	A reporting unit used for soil and sediment in which the amount of sample is taken to be the weight of the sample after removal of moisture by drying in an oven.
pCi/m^3	A reporting unit used with air particulate and radioiodine data which refers to the radioactivity content expressed in picocuries per cubic meter of air passed through the filter and/or the charcoal trap. Note the volume is not corrected to standard conditions.
Gamma Emitters or Gamma Isotopic	Samples were analyzed by high resolution (GeLi) gamma spectrometry. The resulting spectrum is analyzed by a computer program which scans from about 50 to 2000 keV and lists the energy peaks of any nuclides present in concentrations exceeding the sensitivity limits set for that particular sample.
Error Terms	Figures following " ± " are error terms based on counting uncertainties at the 95 percent confidence level. Values preceded by the "<" symbol were below the stated concentration at the 99 percent confidence level.
Sensitivity	In general, all analyses meet the sensitivity requirements of the program as given in Table 3.1. For the few samples that do not (because of inadequate sample quantities, analytical interference, etc.) the sensitivity actually obtained in the analysis is given.

TABLE E1

AIRBORNE IODINE-131 and GROSS BETA in AIR PARTICULATE FILTERS (pCi/m^3)
1993

COLLECTION DATE	CA-APT-A1 Vol. (M^3)	CA-APT-A1 GROSS BETA	CA-APT-A1 I-131	CA-APT-A7 Vol. (M^3)	CA-APT-A7 GROSS BETA	CA-APT-A7 I-131	CA-APT-A8 Vol. (M^3)	CA-APT-A8 GROSS BETA	CA-APT-A8 I-131	CA-APT-A9 Vol. (M^3)	CA-APT-A9 GROSS BETA	CA-APT-A9 I-131	CA-APT-B3 Vol. (M^3)	CA-APT-B3 GROSS BETA	CA-APT-B3 I-131
01/07/93	426	0.031 ± 0.003	<0.070	428	0.032 ± 0.003	<0.070	426	0.032 ± 0.003	<0.070	431	0.032 ± 0.003	<0.070	428	0.020 ± 0.002	<0.070
01/14/93	428	0.031 ± 0.003	<0.070	428	0.035 ± 0.00[illegible]	<0.070	428	0.035 ± 0.003	<0.070	426	0.037 ± 0.003	<0.070	428	0.039 ± 0.003	<0.070
01/21/93	428	0.039 ± 0.003	<0.070	426	0.035 ± 0.00[illegible]	<0.070	428	0.037 ± 0.003	<0.070	426	0.034 ± 0.003	<0.070	428	0.034 ± 0.003	<0.070
01/28/93	426	0.019 ± 0.002	<0.070	426	0.019 ± 0.002	<0.070	423	0.020 ± 0.002	<0.070	426	0.016 ± 0.002	<0.070	426	0.020 ± 0.002	<0.070
02/04/93	426	0.014 ± 0.002	<0.070	428	0.027 ± 0.003	<0.070	428	0.023 ± 0.002	<0.070	426	0.024 ± 0.002	<0.070	426	0.026 ± 0.003	<0.070
02/11/93	428	0.019 ± 0.002	<0.070	428	0.022 ± 0.002	<0.070	428	0.024 ± 0.003	<0.070	428	0.020 ± 0.002	<0.070	428	0.028 ± 0.003	<0.070
02/18/93	436	0.016 ± 0.002	<0.070	436	0.029 ± 0.003	<0.070	436	0.031 ± 0.003	<0.070	436	0.030 ± 0.003	<0.070	436	0.032 ± 0.003	<0.070
02/24/93	364	0.023 ± 0.002	<0.070	364	0.019 ± 0.002	<0.070	364	0.036 ± 0.002	<0.070	364	0.034 ± 0.002	<0.070	364	0.034 ± 0.002	<0.070
03/04/93	484	0.023 ± 0.002	<0.070	487	0.022 ± 0.002	<0.070	484	0.021 ± 0.002	<0.070	487	0.020 ± 0.002	<0.070	484	0.020 ± 0.002	<0.070
03/11/93	426	0.009 ± 0.002	<0.070	426	0.016 ± 0.002	<0.070	428	0.021 ± 0.003	<0.070	426	0.017 ± 0.002	<0.070	428	0.020 ± 0.003	<0.070
03/18/93	431	0.015 ± 0.002	<0.070	431	0.019 ± 0.002	<0.070	428	0.024 ± 0.002	<0.070	408	0.018 ± 0.002	<0.070	428	0.024 ± 0.002	<0.070
03/25/93	431	0.011 ± 0.002	<0.070	428	0.015 ± 0.002	<0.070	431	0.018 ± 0.002	<0.070	431	0.012 ± 0.002	<0.070	431	0.013 ± 0.002	<0.070
04/01/93	431	0.011 ± 0.002	<0.070	428	0.016 ± 0.002	<0.070	431	0.014 ± 0.002	<0.070	431	0.011 ± 0.002	<0.070	431	0.013 ± 0.002	<0.070
04/08/93	423	0.009 ± 0.002	<0.070	42[illegible]	0.017 ± 0.002	<0.070	423	0.018 ± 0.002	<0.070	423	0.012 ± 0.002	<0.070	426	0.018 ± 0.002	<0.070
04/16/93	489	0.005 ± 0.002	<0.070	489	0.008 ± 0.002	<0.070	489	0.010 ± 0.002	<0.070	489	0.008 ± 0.002	<0.070	489	0.008 ± 0.002	<0.070
04/22/93	367	0.014 ± 0.002	<0.070	367	0.017 ± 0.002	<0.070	367	0.021 ± 0.003	<0.070	370	0.017 ± 0.002	<0.070	367	0.017 ± 0.002	<0.070
04/29/93	423	0.010 ± 0.002	<0.070	426	0.021 ± 0.002	<0.070	426	0.019 ± 0.002	<0.070	423	0.018 ± 0.002	<0.070	423	0.023 ± 0.002	<0.070
05/06/93	431	0.007 ± 0.002	<0.070	428	0.012 ± 0.002	<0.070	428	0.012 ± 0.002	<0.070	428	0.011 ± 0.002	<0.070	431	0.013 ± 0.002	<0.070
05/13/93	433	0.016 ± 0.002	<0.070	433	0.017 ± 0.002	<0.070	217	0.028 ± 0.004	<0.070	431	0.012 ± 0.002	<0.070	431	0.014 ± 0.002	<0.070
05/20/93	431	0.009 ± 0.002	<0.070	436	0.011 ± 0.002	<0.070	418	0.014 ± 0.002	<0.070	418	0.009 ± 0.002	<0.070	433	0.012 ± 0.002	<0.070
05/27/93	421	0.013 ± 0.002	<0.070	421	0.013 ± 0.002	<0.070	421	0.012 ± 0.002	<0.070	421	0.019 ± 0.002	<0.070	421	0.014 ± 0.002	<0.070
06/03/93	428	0.014 ± 0.002	<0.070	431	0.012 ± 0.002	<0.070	431	0.014 ± 0.002	<0.070	431	0.012 ± 0.002	<0.070	431	0.012 ± 0.002	<0.070
06/10/93	426	0.016 ± 0.002	<0.070	423	0.018 ± 0.002	<0.070	426	0.014 ± 0.002	<0.070	426	0.017 ± 0.002	<0.070	426	0.011 ± 0.002	<0.070
06/17/93	433	0.013 ± 0.003	<0.070	433	0.014 ± 0.003	<0.070	433	0.011 ± 0.002	<0.070	433	0.014 ± 0.003	<0.070	433	0.010 ± 0.002	<0.070
06/24/93	426	0.017 ± 0.002	<0.070	426	0.016 ± 0.003	<0.070	428	0.013 ± 0.002	<0.070	25	<0.039	<0.290[1]	423	0.010 ± 0.002	<0.070
07/01/93	428	0.014 ± 0.002	<0.070	428	0.014 ± 0.002	<0.070	415	0.012 ± 0.002	<0.070	415	0.015 ± 0.002	<0.070	428	0.012 ± 0.002	<0.070
07/08/93	423	0.014 ± 0.002	<0.070	426	0.014 ± 0.002	<0.070	423	0.020 ± 0.002	<0.070	423	0.012 ± 0.002	<0.070	433	0.019 ± 0.002	<0.070

Notes: 1. LLD was not achieved. See section 2.3 for explanation.

TABLE E1 (Cont.)

AIRBORNE IODINE-131 and GROSS BETA in AIR PARTICULATE FILTERS (pCi/m^3) 1993

COLLECTION DATE	CA-APT-A1			CA-APT-A7			CA-APT-A8			CA-APT-A9			CA-APT-B3		
	Vol. (M^3)	GROSS BETA	I-131	Vol. (M^3)	GROSS BETA	I-131	Vol. (M^3)	GROSS BETA	I-131	Vol. (M^3)	GROSS BETA	I-131	Vol. (M^3)	GROSS BETA	I-131
07/15/93	428	0.018 ± 0.002	<0.070	428	0.012 ± 0.002	<0.070	428	0.016 ± 0.002	<0.070	433	0.012 ± 0.002	<0.070	421	0.019 ± 0.002	<0.070
07/22/93	431	0.015 ± 0.002	<0.070	428	0.016 ± 0.002	<0.070	431	0.017 ± 0.002	<0.070	428	0.009 ± 0.002	<0.070	428	0.016 ± 0.002	<0.070
07/29/93	431	0.017 ± 0.002	<0.070	431	0.020 ± 0.003	<0.070	438	0.017 ± 0.002	<0.070	431	0.015 ± 0.002	<0.070	431	0.015 ± 0.002	<0.070
08/05/93	421	0.015 ± 0.002	<0.070	426	0.017 ± 0.002	<0.070	418	<0.003	<0.070	426	0.008 ± 0.002	<0.070	426	0.015 ± 0.002	<0.070
08/12/93	431	0.016 ± 0.002	<0.070	431	0.017 ± 0.002	<0.070	431	0.013 ± 0.002	<0.070	431	0.009 ± 0.002	<0.070	431	0.018 ± 0.002	<0.070
08/19/93	415	0.021 ± 0.002	<0.070	426	0.023 ± 0.002	<0.070	423	0.018 ± 0.002	<0.070	421	0.018 ± 0.002	<0.070	426	0.022 ± 0.002	<0.070
08/26/93	296	0.032 ± 0.004	<0.070	433	0.022 ± 0.002	<0.070	433	0.016 ± 0.002	<0.070	433	0.012 ± 0.002	<0.070	433	0.020 ± 0.002	<0.070
09/02/93	196	0.045 ± 0.005	<0.070	0	ND	ND	421	0.011 ± 0.002	<0.070	421	0.011 ± 0.002	<0.070	421	0.021 ± 0.002	<0.070
09/09/93	428	0.020 ± 0.002	<0.070	426	0.015 ± 0.002	<0.070	428	0.015 ± 0.002	<0.070	426	0.011 ± 0.002	<0.070	428	0.019 ± 0.002	<0.070
09/16/93	428	0.012 ± 0.002	<0.070	428	0.013 ± 0.002	<0.070	431	0.015 ± 0.002	<0.070	433	0.006 ± 0.002	<0.070	431	0.013 ± 0.002	<0.070
09/23/93	436	0.018 ± 0.002	<0.070	438	0.013 ± 0.002	<0.070	426	0.017 ± 0.002	<0.070	438	0.010 ± 0.002	<0.070	426	0.021 ± 0.002	<0.070
09/30/93	428	0.012 ± 0.002	<0.070	428	0.006 ± 0.002	<0.070	428	0.007 ± 0.002	<0.070	428	0.007 ± 0.002	<0.070	426	0.005 ± 0.002	<0.070
10/07/93	426	0.025 ± 0.003	<0.070	426	0.010 ± 0.002	<0.070	426	0.011 ± 0.002	<0.070	426	0.006 ± 0.002	<0.070	428	0.022 ± 0.003	<0.070
10/14/93	426	0.020 ± 0.003	<0.070	423	0.010 ± 0.002	<0.070	426	0.026 ± 0.003	<0.070	426	0.014 ± 0.002	<0.070	423	0.020 ± 0.003	<0.070
10/21/93	426	0.025 ± 0.003	<0.070	426	0.013 ± 0.002	<0.070	423	0.026 ± 0.003	<0.070	423	0.011 ± 0.002	<0.070	426	0.021 ± 0.003	<0.070
10/28/93	431	0.018 ± 0.002	<0.070	433	0.010 ± 0.002	<0.070	433	0.014 ± 0.002	<0.070	433	0.010 ± 0.002	<0.070	431	0.014 ± 0.002	<0.070
11/04/93	431	0.014 ± 0.002	<0.070	428	0.068 ± 0.002	<0.070	428	0.012 ± 0.002	<0.070	431	0.009 ± 0.002	<0.070	431	0.012 ± 0.002	<0.070
11/11/93	433	0.022 ± 0.003	<0.070	436	0.012 ± 0.002	<0.070	436	0.013 ± 0.002	<0.070	433	0.009 ± 0.002	<0.070	433	0.021 ± 0.003	<0.070
11/18/93	418	0.022 ± 0.003	<0.070	408	0.012 ± 0.002	<0.070	418	0.025 ± 0.003	<0.070	418	0.015 ± 0.002	<0.070	418	0.019 ± 0.002	<0.070
11/24/93	370	0.024 ± 0.003	<0.070	370	0.013 ± 0.002	<0.070	370	0.023 ± 0.003	<0.070	370	0.014 ± 0.003	<0.070	370	0.009 ± 0.002	<0.070
12/02/93	489	0.044 ± 0.003	<0.070	487	0.020 ± 0.002	<0.070	487	0.044 ± 0.003	<0.070	489	0.018 ± 0.002	<0.070	489	0.015 ± 0.002	<0.070
12/09/93	426	0.024 ± 0.003	<0.070	428	0.012 ± 0.002	<0.070	428	0.023 ± 0.002	<0.070	426	0.018 ± 0.002	<0.070	426	0.016 ± 0.002	<0.070
12/16/93	433	0.027 ± 0.003	<0.070	431	0.013 ± 0.002	<0.070	433	0.029 ± 0.003	<0.070	433	0.025 ± 0.003	<0.070	433	0.020 ± 0.002	<0.070
12/21/93	303	0.024 ± 0.003	<0.070	308	0.014 ± 0.003	<0.070	303	0.031 ± 0.004	<0.070	303	0.021 ± 0.003	<0.070	303	0.019 ± 0.003	<0.070
12/30/93	551	0.028 ± 0.002	<0.070	548	0.013 ± 0.019	<0.070	548	0.027 ± 0.002	<0.070	548	0.022 ± 0.002	<0.070	548	0.023 ± 0.002	<0.070

Notes: 1. ND = No Data. See section 2.3 for explination.

TABLE E2

AIRBORNE PARTICULATE - QUARTERLY COMPOSITES (pCi/m^3)
1993

JANUARY - MARCH 1993					
	CA-APT-A1	CA-APT-A7	CA-APT-A8	CA-APT-A9	CA-APT-B3
Volume (Cubic Feet):	5567	5564	5563	5546	5566
Analysis					
Sr-89	<0.0003	<0.0004	<0.0003	<0.0003	<0.0003
Sr-90	<0.0002	<0.0003	<0.0002	<0.0002	<0.0002
Be-7	0.0340 ± 0.0080	0.0460 ± 0.0070	0.0590 ± 0.0140	0.0470 ± 0.0100	0.0760 ± 0.0180
Co-58	<0.0010	<0.0007	<0.0018	<0.0011	<0.0022
Co-60	<0.0010	<0.0008	<0.0017	<0.0010	<0.0005
Zr-95	<0.0016	<0.0011	<0.0031	<0.0017	<0.0036
Cs-134	<0.0009	<0.0006	<0.0015	<0.0008	<0.0017
Cs-137	<0.0007	<0.0006	<0.0016	<0.0006	<0.0018
Ba-La-140	<0.0033	<0.0019	<0.0057	<0.0033	<0.0076
Ce-144	<0.0030	<0.0022	<0.0074	<0.0032	<0.0096

APRIL - JUNE 1993					
	CA-APT-A1	CA-APT-A7	CA-APT-A8	CA-APT-A9	CA-APT-B3
Volume (Cubic Feet):	5559	5322	5133	5562	5567
Analysis					
Sr-89	<0.0005	<0.0005	<0.0006	<0.0006	<0.0005
Sr-90	<0.0002	<0.0002	<0.0003	<0.0003	<0.0002
Be-7	0.0620 ± 0.0130	0.0600 ± 0.0130	0.0780 ± 0.0150	<0.0098	0.0700 ± 0.0120
Co-58	<0.0003	<0.0010	<0.0005	<0.0003	<0.0003
Co-60	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004
Zr-95	<0.0005	<0.0004	<0.0006	<0.0006	<0.0005
Cs-134	<0.0004	<0.0003	<0.0006	<0.0006	<0.0002
Cs-137	<0.0004	<0.0005	<0.0003	<0.0003	<0.0003
Ba-La-140	<0.0031	<0.0019	<0.0020	<0.0018	<0.0018
Ce-144	<0.0023	<0.0036	<0.0035	<0.0023	<0.0038

Notes:

TABLE E2 (Cont.)

AIRBORNE PARTICULATE - QUARTERLY COMPOSITES (pCi/m^3)
1993

JULY - SEPTEMBER 1993

	CA-APT-A1	CA-APT-A7	CA-APT-A8	CA-APT-A9	CA-APT-B3
Volume (Cubic Feet):	5192	5149	5559	5572	5561
Analysis					
Sr-89	<0.0004	<0.0004	<0.0004	<0.0004	<0.0003
Sr-90	<0.0003	<0.0003	<0.0002	<0.0003	<0.0003
Be-7	0.0560 ± 0.0140	0.0520 ± 0.0150	0.0530 ± 0.0130	0.0430 ± 0.0110	0.0500 ± 0.0140
Co-58	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004
Co-60	<0.0006	<0.0006	<0.0005	<0.0005	<0.0005
Zr-95	<0.0007	<0.0008	<0.0008	<0.0009	<0.0010
Cs-134	<0.0003	<0.0007	<0.0006	<0.0004	<0.0003
Cs-137	<0.0005	<0.0006	<0.0007	<0.0005	<0.0003
Ba-La-140	<0.0020	<0.0020	<0.0019	<0.0019	<0.0019
Ce-144	<0.0041	<0.0052	<0.0048	<0.0048	<0.0037

OCTOBER - DECEMBER 1993

	CA-APT-A1	CA-APT-A7	CA-APT-A8	CA-APT-A9	CA-APT-B3
Volume (Cubic Feet):	5563	5552	5559	5559	5559
Analysis					
Sr-89	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003
Sr-90	<0.0003	<0.0003	<0.0003	<0.0002	<0.0003
Be-7	0.0660 ± 0.0140	0.0500 ± 0.0110	0.0290 ± 0.0080	0.0690 ± 0.0140	0.0450 ± 0.0120
Co-58	<0.0005	<0.0002	<0.0004	<0.0003	<0.0004
Co-60	<0.0004	<0.0003	<0.0005	<0.0008	<0.0005
Zr-95	<0.0008	<0.0022	<0.0019	<0.0020	<0.0011
Cs-134	<0.0004	<0.0007	<0.0004	<0.0007	<0.0007
Cs-137	<0.0004	<0.0003	<0.0005	<0.0006	<0.0007
Ba-La-140	<0.0014	<0.0016	<0.0009	<0.0013	<0.0014
Ce-144	<0.0040	<0.0017	<0.0039	<0.0025	<0.0017

Notes:

TABLE E3

MILK (pCi/kg dry)
1993

Analysis	CA-MLK-M1 (01/14/93)	CA-MLK-M1 (02/10/93)
I-131	<0.2	<0.2
Sr-89	<0.6	<0.8
Sr-90	3.8 ± 0.6	4.5 ± 0.8
K-40	1240.0 ± 150.0	1310.0 ± 50.0
Zn-65	<12.6	<3.5
Cs-134	<5.1	<1.3
Cs-137	<6.2	<1.4
Ba-La-140	<8.6	<14.3
Ca (g/l)	1.12	0.90

Analysis	CA-MLK-M1 (03/09/93)	CA-MLK-M1 (04/13/93)
I-131	<0.9	ND
Sr-89	<2.7	ND
Sr-90	<2.9	ND
K-40	1560.0 ± 140.0	ND
Zn-65	<19.1	ND
Cs-134	<6.8	ND
Cs-137	<7.0	ND
Ba-La-140	<8.6	ND
Ca (g/l)	1.43	ND

Notes:
ND = No Data. See section 2.3 for explanation.

TABLE E3 (Cont.)

MILK (pCi/kg dry)
1993

Analysis	CA-MLK-M1 (04/27/93)	CA-MLK-M1 (05/11/93)
I-131	<0.4	<0.5
Sr-89	<0.9	<0.7
Sr-90	3.8 ± 0.7	3.9 ± 0.7
K-40	1400.0 ± 150.0	1300.0 ± 120.0
Zn-65	<10.0	<21.0
Cs-134	<4.8	<6.9
Cs-137	<4.9	<7.9
Ba-La-140	<6.2	<8.7
Ca (g/l)	0.90	1.08

Analysis	CA-MLK-M1 (05/25/93)	CA-MLK-M1 (06/16/93)
I-131	<0.5	<0.4
Sr-89	<0.8	<0.9
Sr-90	3.2 ± 0.7	3.4 ± 0.6
K-40	1270.0 ± 170.0	1320.0 ± 170.0
Zn-65	<18.4	<8.6
Cs-134	<6.9	<6.3
Cs-137	<7.5	<7.9
Ba-La-140	<9.7	<3.0
Ca (g/l)	0.60	0.76

Notes:

TABLE E3 (Cont.)

MILK (pCi/kg dry)
1993

Analysis	CA-MLK-M1 (06/29/93)	CA-MLK-M1 (07/13/93)
I-131	<0.5	<0.4
Sr-89	<0.5	<0.6
Sr-90	4.4 ± 0.6	2.8 ± 0.6
K-40	1410.0 ± 160.0	1300.0 ± 170.0
Zn-65	<3.7	<12.7
Cs-134	<6.6	<2.8
Cs-137	<4.5	<4.1
Ba-La-140	<4.2	<3.5
Ca (g/l)	0.88	0.67

Analysis	CA-MLK-M1 (07/27/93)	CA-MLK-M1 (08/10/93)
I-131	<0.5	<0.3
Sr-89	<0.8	<0.8
Sr-90	3.8 ± 0.7	7.8 ± 0.9
K-40	1360.0 ± 170.0	1360.0 ± 160.0
Zn-65	<5.9	<14.8
Cs-134	<3.4	<5.7
Cs-137	<4.5	<7.0
Ba-La-140	<3.9	<5.9
Ca (g/l)	0.95	1.08

Notes:

TABLE E3 (Cont.)

MILK (pCi/kg dry)
1993

Analysis	CA-MLK-M1 (08/24/93)	CA-MLK-M1 (09/14/93)
I-131	<0.3	<0.4
Sr-89	<1.0	<0.9
Sr-90	5.3 ± 0.9	6.5 ± 0.9
K-40	1480.0 ± 210.0	1270.0 ± 130.0
Zn-65	<13.4	<11.4
Cs-134	<6.6	<4.6
Cs-137	<7.9	<4.7
Ba-La-140	<4.8	<6.2
Ca (g/l)	0.67	0.95

Analysis	CA-MLK-M1 (09/28/93)	CA-MLK-M1 (10/12/93)
I-131	<0.5	<0.4
Sr-89	<0.8	<0.7
Sr-90	6.3 ± 0.8	3.4 ± 0.6
K-40	1430.0 ± 200.0	1330.0 ± 150.0
Zn-65	<14.0	<13.3
Cs-134	<5.8	<4.6
Cs-137	<5.1	<5.7
Ba-La-140	<3.5	<2.2
Ca (g/l)	0.60	1.00

Notes:

TABLE E3 (Cont.)

MILK (pCi/kg dry)
1993

Analysis	CA-MLK-M1 (11/09/93)	CA-MLK-M1 (12/14/93)
I-131	ND	ND
Sr-89	ND	ND
Sr-90	ND	ND
K-40	ND	ND
Zn-65	ND	ND
Cs-134	ND	ND
Cs-137	ND	ND
Ba-La-140	ND	ND
Ca (g/l)	ND	ND

Analysis	CA-MLK-M5B (12/14/93)	CA-MLK-M6 (12/14/93)
I-131	ND	<0.3
Sr-89	ND	<0.6
Sr-90	ND	3.9 ± 0.5
K-40	ND	1050.0 ± 120.0
Zn-65	ND	<6.3
Cs-134	ND	<5.0
Cs-137	ND	<6.1
Ba-La-140	ND	<3.1
Ca (g/l)	ND	1.03

Notes:
ND = No Data. See section 2.3 for explanation.

TABLE E4

VEGETATION (pCi/kg wet)
1993

Analysis	CA-FPL-V6 CABBAGE (07/12/93)	CA-FPL-V6 LETTUCE (07/12/93)	CA-FPL-V6 MUSTARD GREENS (07/12/93)
Gross Alpha	103.0 ± 35.0	218.0 ± 103.0	120.0 ± 54.0
Gross Beta	3436.0 ± 91.0	7562.0 ± 253.0	4449.0 ± 142.0
I-131	<31.4	<40.9	<28.7
K-40	4872.0 ± 577.0	7121.0 ± 550.0	5032.0 ± 540.0
Mn-54	<23.5	<21.7	<24.8
Co-58	<22.6	<16.1	<6.7
Co-60	<21.1	<15.4	<10.6
Cs-134	<18.3	<17.6	<20.8
Cs-137	<21.8	<27.7	<20.9

Analysis	CA-FPL-V7 CABBAGE (07/13/93)	CA-FPL-V7 LETTUCE (07/13/93)	CA-FPL-V6 MUSTARD GREENS (08/09/93)
Gross Alpha	201.0 ± 97.0	51.0 ± 38.0	92.0 ± 90.0
Gross Beta	3849.0 ± 182.0	4445.0 ± 129.0	6221.0 ± 286.0
I-131	<40.5	<39.7	<15.2
K-40	2826.0 ± 420.0	4733.0 ± 570.0	7017.0 ± 410.0
Mn-54	<19.8	<29.7	<18.6
Co-58	<7.5	<18.7	<8.5
Co-60	<6.3	<21.3	<18.5
Cs-134	<19.0	<32.9	<14.2
Cs-137	<20.2	<14.3	<20.6

Notes:

TABLE E4 (Cont.)

VEGETATION (pCi/kg wet)
1993

Analysis	CA-FPL-V3 MUSTARD GREENS (09/14/93)	CA-FPL-V3 MUSTARD GREENS (10/11/93)
Gross Alpha	127.0 ± 67.0	272.0 ± 117.0
Gross Beta	3427.0 ± 154.0	5879.0 ± 251.0
I-131	<10.7	<38.2
K-40	3847.0 ± 448.0	5747.0 ± 688.0
Mn-54	<9.0	<28.0
Co-58	<7.6	<39.1
Co-60	<6.1	<20.4
Cs-134	<25.2	<14.8
Cs-137	<8.6	<12.2

Notes:

TABLE E5

SOIL (pCi/kg dry)
1993

Analysis	CA-SOL-F1 (12/08/93)	CA-SOL-F2 (12/08/93)	CA-SOL-F6 (12/08/93)
Gross Alpha	11879.0 ± 4355.0	13497.0 ± 4109.0	10577.0 ± 4037.0
Gross Beta	23517.0 ± 3296.0	25006.0 ± 3329.0	22358.0 ± 3129.0
K-40	13330.0 ± 890.0	12039.0 ± 515.0	12680.0 ± 538.0
Mn-54	<36.6	<18.8	<18.9
Co-58	<15.7	<15.7	<17.9
Co-60	<33.3	<22.5	<19.6
Cs-134	<43.9	<16.2	<20.2
Cs-137	1214.0 ± 70.0	1766.0 ± 50.0	1628.0 ± 51.0

Analysis	CA-SOL-F8 (12/08/93)	CA-SOL-F9 (12/08/93)	CA-SOL-PR10 (12/08/93)
Gross Alpha	14730.0 ± 4656.0	17456.0 ± 4947.0	16535.0 ± 4818.0
Gross Beta	25213.0 ± 3352.0	23456.0 ± 3317.0	20181.0 ± 3163.0
K-40	10556.0 ± 514.0	13226.0 ± 573.0	11771.0 ± 3163.0
Mn-54	<19.6	<19.8	<18.3
Co-58	<9.3	<17.7	<20.8
Co-60	<23.9	<22.6	<23.2
Cs-134	<16.5	<10.3	<12.1
Cs-137	1825.0 ± 55.0	1391.0 ± 50.0	1333.0 ± 50.0

Notes:

TABLE E5 (Cont.)

SOIL (pCi/kg dry)
1993

Analysis	CA-SOL-PR3 (12/08/93)	CA-SOL-PR4 (12/08/93)	CA-SOL-PR5 (12/08/93)
Gross Alpha	11941.0 ± 4317.0	13834.0 ± 4051.0	9126.0 ± 3999.0
Gross Beta	20146.0 ± 3132.0	24479.0 ± 3057.0	21734.0 ± 3183.0
K-40	11688.0 ± 523.0	12628.0 ± 550.0	14152.0 ± 850.0
Mn-54	<19.6	<18.9	<29.2
Co-58	<14.2	<22.4	<20.3
Co-60	<18.6	<8.3	<39.9
Cs-134	<11.0	<9.6	<13.5
Cs-137	610.0 ± 36.0	993.0 ± 41.0	881.0 ± 59.0

Analysis	CA-SOL-PR7 (12/08/93)	CA-SOL-V3 (12/08/93)
Gross Alpha	11130.0 ± 4263.0	11365.0 ± 4352.0
Gross Beta	22105.0 ± 3238.0	25370.0 ± 3389.0
K-40	12433.0 ± 627.0	18117.0 ± 802.0
Mn-54	<24.8	<20.5
Co-58	<34.0	<40.2
Co-60	<25.0	<28.0
Cs-134	<30.3	<41.7
Cs-137	505.0 ± 42.0	333.0 ± 42.0

Notes:
ND = No Data. See section 2.3 for explanation.

TABLE E6

WETLANDS (pCi/kg dry)
1993

Analysis	CA-SOL-W1 (12/08/93)	CA-SOL-W2 (12/08/93)
Gross Alpha	13550.0 ± 3226.0	13878.0 ± 4590.0
Gross Beta	23262.0 ± 2336.0	19721.0 ± 3192.0
K-40	14871.0 ± 660.0	16081.0 ± 727.0
Mn-54	<32.4	<25.0
Co-58	<26.9	<25.8
Co-60	<18.8	<29.4
Cs-134	<52.7	<32.0
Cs-137	114.0 ± 28.0	167.0 ± 34.0

Analysis	CA-SOL-W3 (12/08/93)	CA-SOL-W4 (12/08/93)
Gross Alpha	13640.0 ± 4511.0	16330.0 ± 4804.0
Gross Beta	15258.0 ± 2974.0	15666.0 ± 3011.0
K-40	10796.0 ± 631.0	13111.0 ± 754.0
Mn-54	<22.9	<23.5
Co-58	<16.5	<18.3
Co-60	<31.0	<37.6
Cs-134	<19.8	<16.7
Cs-137	<22.3	73.0 ± 37.0

Notes:

TABLE E7

SURFACE WATER (pCi/l)
1993

Analysis	CA-SWA-S01 (01/14/93)	CA-SWA-S02 (01/14/93)
H-3	2222 ± 152.0	<172.0
Mn-54	<6.8	<5.8
Fe-59	<14.7	<11.4
Co-58	<7.4	<5.8
Co-60	<7.3	<6.9
Zr-Nb-95	<12.0	<10.9
Cs-134	<6.2	<5.7
Cs-137	<7.5	<5.6
Ba-La-140	<11.3	<10.6

Analysis	CA-SWA-S01 (02/09/93)	CA-SWA-S02 (02/09/93)
H-3	3851 ± 187.0	<173.0
Mn-54	<5.9	<6.6
Fe-59	<12.1	<12.0
Co-58	<4.6	<6.5
Co-60	<6.6	<6.6
Zr-Nb-95	<10.3	<10.6
Cs-134	<5.4	<6.9
Cs-137	<5.6	<6.7
Ba-La-140	<8.0	<9.6

Notes:
ND = No Data. See section 2.3 for explanation.

TABLE E7 (Cont.)

SURFACE WATER (pCi/l)
1993

Analysis	CA-SWA-S01 (03/09/93)	CA-SWA-S02 (03/09/93)
H-3	2419 ± 158.0	<174.0
Mn-54	<6.3	<5.1
Fe-59	<11.7	<9.8
Co-58	<5.8	<4.9
Co-60	<6.9	<7.0
Zr-Nb-95	<10.4	<9.1
Cs-134	<6.4	<5.2
Cs-137	<6.2	<5.0
Ba-La-140	<9.8	<6.6

Analysis	CA-SWA-S01 (04/13/93)	CA-SWA-S02 (04/13/93)
H-3	1473 ± 135.0	<187.0
Mn-54	<6.3	<6.3
Fe-59	<12.7	<14.8
Co-58	<6.2	<5.9
Co-60	<6.8	<8.5
Zr-Nb-95	<10.9	<10.2
Cs-134	<5.4	<5.9
Cs-137	<5.7	<6.2
Ba-La-140	<13.5	<14.2

Notes:
ND = No Data. See section 2.3 for explanation.

TABLE E7 (Cont.)

SURFACE WATER (pCi/l)
1993

Analysis	CA-SWA-S01 (05/11/93)	CA-SWA-S02 (05/11/93)
H-3	4917 ± 211.0	<187.0
Mn-54	<6.5	<6.7
Fe-59	<12.1	<12.1
Co-58	<5.7	<6.0
Co-60	<6.9	<7.4
Zr-Nb-95	<10.7	<12.4
Cs-134	<6.7	<6.6
Cs-137	<6.2	<7.4
Ba-La-140	<10.7	<12.2

Analysis	CA-SWA-S01 (06/17/93)	CA-SWA-S02 (06/17/93)
H-3	1371 ± 134.0	194.0 ± 96.0
Mn-54	<2.4	<10.2
Fe-59	<6.3	<18.3
Co-58	<1.4	<8.0
Co-60	<4.2	<8.1
Zr-Nb-95	<9.5	<14.3
Cs-134	<3.6	<11.3
Cs-137	<3.4	<12.8
Ba-La-140	<7.0	<5.2

Notes:
ND = No Data. See section 2.3 for explanation.

TABLE E7 (Cont.)

SURFACE WATER (pCi/l)
1993

Analysis	CA-SWA-S01 (07/13/93)	CA-SWA-S02 (07/13/93)
H-3	1005 ± 131.0	ND
Mn-54	<4.1	ND
Fe-59	<5.8	ND
Co-58	<6.5	ND
Co-60	<6.0	ND
Zr-Nb-95	<12.1	ND
Cs-134	<4.6	ND
Cs-137	<4.9	ND
Ba-La-140	<8.9	ND

Analysis	CA-SWA-S01 (08/10/93)	CA-SWA-S02 (08/10/93)
H-3	273.0 ± 109.0	ND
Mn-54	<3.1	ND
Fe-59	<7.7	ND
Co-58	<4.1	ND
Co-60	<3.0	ND
Zr-Nb-95	<4.1	ND
Cs-134	<7.8	ND
Cs-137	<4.2	ND
Ba-La-140	<6.4	ND

Notes:
ND = No Data. See section 2.3 for explanation.

TABLE E7 (Cont.)

SURFACE WATER (pCi/l)
1993

Analysis	CA-SWA-S01 (09/14/93)	CA-SWA-S02 (09/14/93)
H-3	1650 ± 15.0	556.0 ± 116.0
Mn-54	<5.2	<6.4
Fe-59	<7.5	<10.9
Co-58	<7.8	<4.2
Co-60	<3.7	<6.0
Zr-Nb-95	<9.3	<7.8
Cs-134	<2.6	<8.0
Cs-137	<2.6	<7.7
Ba-La-140	<6.6	<4.3

Analysis	CA-SWA-S01 (10/12/93)	CA-SWA-S02 (10/12/93)
H-3	659.0 ± 116.0	188.0 ± 119.0
Mn-54	<1.8	<1.2
Fe-59	<3.1	<3.3
Co-58	<1.8	<2.4
Co-60	<1.8	<1.2
Zr-Nb-95	<6.6	<6.0
Cs-134	<2.1	<1.4
Cs-137	<1.9	<1.2
Ba-La-140	<8.7	<5.0

Notes:
ND = No Data. See section 2.3 for explanation.

TABLE E7 (Cont.)

SURFACE WATER (pCi/l)
1993

Analysis	CA-SWA-S01 (11/09/93)	CA-SWA-S02 (11/09/93)
H-3	855.0 ± 121.0	255.0 ± 100.0
Mn-54	<3.0	<4.1
Fe-59	<6.3	<12.3
Co-58	<5.6	<2.7
Co-60	<5.3	<4.7
Zr-Nb-95	<7.0	<5.1
Cs-134	<5.9	<3.7
Cs-137	<3.2	<2.1
Ba-La-140	<9.5	<6.8

Analysis	CA-SWA-S01 (12/14/93)	CA-SWA-S02 (12/14/93)
H-3	442.0 ± 111.0	276.0 ± 74.0
Mn-54	<5.1	<2.8
Fe-59	<10.5	<5.7
Co-58	<4.1	<5.3
Co-60	<3.2	<3.0
Zr-Nb-95	<7.0	<4.1
Cs-134	<4.2	<3.0
Cs-137	<5.3	<2.7
Ba-La-140	<3.6	<3.3

Notes:
ND = No Data. See section 2.3 for explanation.

TABLE E8

GROUND WATER (pCi/l)
1993

Analysis	CA-WWA-D01 (02/09/93)	CA-WWA-F15 (02/09/93)	CA-WWA-F05 (02/09/93)
H-3	<173.0	ND	ND
Mn-54	<7.1	ND	ND
Fe-59	<13.5	ND	ND
Co-58	<6.9	ND	ND
Co-60	<8.6	ND	ND
Zr-Nb-95	<13.5	ND	ND
Cs-134	<8.8	ND	ND
Cs-137	<6.9	ND	ND
Ba-La-140	<9.5	ND	ND

Analysis	CA-WWA-D01 (03/17/93)	CA-WWA-F15 (03/17/93)	CA-WWA-F05 (03/17/93)
H-3	<172.0	<171.0	<172.0
Mn-54	<6.6	<5.7	<6.3
Fe-59	<14.8	<11.2	<9.8
Co-58	<6.5	<4.9	<5.6
Co-60	<7.7	<6.8	<5.9
Zr-Nb-95	<10.8	<10.2	<10.1
Cs-134	<9.1	<7.6	<5.8
Cs-137	<6.1	<6.0	<6.5
Ba-La-140	<8.8	<7.6	<7.8

Notes:
ND = No Data, See section 2.3 for explanation
Additional well water samples were collected at D01 on 03/11/92 and 05/12/92.

TABLE E8 (Cont.)

GROUND WATER (pCi/l)
1993

Analysis	CA-WWA-D01 (06/08/93)	CA-WWA-F15 (06/21/93)	CA-WWA-F05 (06/21/93)
H-3	<191.0	<173.0	<177.0
Mn-54	<6.5	<9.6	<9.3
Fe-59	<14.5	<28.4	<5.6
Co-58	<5.9	<7.3	<12.1
Co-60	<4.6	<6.8	<4.8
Zr-Nb-95	<7.2	<9.6	<14.6
Cs-134	<6.9	<14.4	<12.0
Cs-137	<5.1	<9.9	<8.5
Ba-La-140	<15.0	<5.2	<6.7

Analysis	CA-WWA-D01 (06/08/93)	CA-WWA-F15 (06/24/93)	CA-WWA-F05 (06/08/93)
H-3	ND	<176.0	ND
Mn-54	ND	<3.7	ND
Fe-59	ND	<4.3	ND
Co-58	ND	<4.2	ND
Co-60	ND	<5.1	ND
Zr-Nb-95	ND	<7.3	ND
Cs-134	ND	<4.8	ND
Cs-137	ND	<2.2	ND
Ba-La-140	ND	<8.4	ND

Notes:
ND = No Data, See section 2.3 for explanation
Additional well water samples were collected at D01 on 03/11/92 and 05/12/92.

TABLE E8 (Cont.)

GROUND WATER (pCi/l)
1993

Analysis	CA-WWA-D01 (07/13/93)	CA-WWA-F15 (09/27/93)	CA-WWA-F05 (09/29/93)
H-3	<200.0	<182.0	<182.0
Mn-54	<5.5	<2.0	<1.6
Fe-59	<8.4	<3.7	<5.0
Co-58	<3.4	<3.7	<1.8
Co-60	<2.8	<2.2	<1.8
Zr-Nb-95	<8.9	<3.3	<3.5
Cs-134	<6.8	<1.9	<1.3
Cs-137	<10.1	<2.1	<1.5
Ba-La-140	<5.7	<7.7	<8.0

Analysis	CA-WWA-D01 (11/09/93)	CA-WWA-F15 (12/28/93)	CA-WWA-F05 (12/29/93)
H-3	<183.0	<193.0	<193.0
Mn-54	<2.4	<3.9	<4.8
Fe-59	<8.8	<5.4	<5.8
Co-58	<3.0	<3.9	<4.9
Co-60	<3.8	<3.1	<5.5
Zr-Nb-95	<8.1	<4.4	<8.2
Cs-134	<3.2	<3.2	<4.8
Cs-137	<4.5	<2.6	<3.3
Ba-La-140	<12.1	<3.8	<4.2

Notes:
ND = No Data, See section 2.3 for explanation
Additional well water samples were collected at D01 on 03/11/92 and 05/12/92.

TABLE E9

BOTTOM SEDIMENT (pCi/kg dry)
1993

Analysis	CA-AQS-A (04/27/93)	CA-AQS-C (04/27/93)
Mn-54	<30.0	<26.9
Fe-59	<85.5	<70.2
Co-58	<34.2	<29.7
Co-60	<42.4	<34.5
Zr-Nb-95	<60.5	<55.1
Cs-134	<42.3	<38.9
Cs-137	<28.5	79.0 ± 17.4
Ba-La-140	<143.0	<114.0

Analysis	CA-AQS-A (10/21/93)	CA-AQS-C (10/21/93)
Mn-54	<16.2	<28.2
Fe-59	<78.2	<42.1
Co-58	<11.8	<22.5
Co-60	<22.8	<25.8
Zr-Nb-95	<48.0	<56.3
Cs-134	<13.8	<16.8
Cs-137	<19.9	<27.1
Ba-La-140	<77.1	<63.5

Notes:
ND = No Data. See section 2.3 for explanation.

TABLE E10

SHORELINE SEDIMENT (pCi/kg dry)
1993

Analysis	CA-AQS-A (04/27/93)	CA-AQS-C (04/27/93)
Mn-54	<29.5	<40.6
Fe-59	<91.4	<126.0
Co-58	<34.1	<42.8
Co-60	<42.1	<53.5
Zr-Nb-95	<61.8	<77.1
Cs-134	<40.7	<55.3
Cs-137	<29.3	<36.0
Ba-La-140	<160.0	<190.0

Analysis	CA-AQS-A (10/21/93)	CA-AQS-C (10/21/93)
Mn-54	<34.2	<32.3
Fe-59	<82.9	<79.2
Co-58	<32.1	<14.5
Co-60	<31.9	<36.6
Zr-Nb-95	<79.8	<81.3
Cs-134	<24.4	<19.7
Cs-137	81.4 ± 28.7	67.0 ± 28.9
Ba-La-140	<197.0	<80.1

Notes:

TABLE E11

FISH, CA-AQF-A (pCi/kg WET)
1993

Analysis	CARP (04/27/93)	RIVER CARPSUCKER (04/27/93)	FRESHWATER DRUM (04/27/93)	BIGMOUTH BUFFALO (04/27/93)	CHANNEL CATFISH (04/27/93)
Sr-89	<2.7	<3.3	<10.4	<3.1	<5.3
Sr-90	<1.8	<2.0	<5.4	<2.1	<3.2
K-40	3342.0 ± 313.0	2650.0 ± 343.0	2940.0 ± 331.0	2740.0 ± 357.0	2082.0 ± 311.0
Mn-54	<11.8	<16.7	<14.0	<17.5	<13.5
Fe-59	<37.6	<42.9	<42.8	<49.5	<34.8
Co-58	<10.0	<16.6	<16.6	<17.9	<13.0
Co-60	<14.1	<17.3	<19.3	<22.4	<12.6
Cs-134	<10.9	<14.7	<11.8	<14.6	<11.3
Cs-137	<12.3	<12.8	<13.6	<15.1	<13.8

Analysis	BIGMOUTH BUFFALO (10/21/93)	CARP (10/21/93)	FRESHWATER DRUM (10/21/93)	RIVER CARPSUCKER (10/21/93)	LARGEMOUTH BASS (10/21/93)
Sr-89	<7.0	<4.3	<4.3	<2.7	<3.2
Sr-90	<2.5	<1.6	<1.6	<1.2	<1.1
K-40	2831.0 ± 401.0	2719.0 ± 477.0	2863.0 ± 475.0	2510.0 ± 365.0	3180.0 ± 339.0
Mn-54	<14.1	<16.6	<15.0	<16.0	<13.8
Fe-59	<31.5	<42.5	<41.5	<41.5	<42.6
Co-58	<16.1	<15.6	<14.2	<15.3	<12.2
Co-60	<12.5	<13.0	<23.9	<13.1	<15.2
Cs-134	<10.3	<18.6	<5.2	<17.5	<10.2
Cs-137	<16.3	<17.7	<7.6	<16.8	<12.6

Notes:

TABLE E11 (Cont.)

FISH, CA-AQF-C (pCi/kg WET)
1993

Analysis	CARP (04/27/93)	RIVER CARPSUCKER (04/27/93)	FRESHWATER DRUM (04/27/93)	BIGMOUTH BUFFALO (04/27/93)	CHANNEL CATFISH (04/27/93)
Sr-89	<2.5	<3.2	<3.2	<3.0	<3.6
Sr-90	<1.9	<2.1	<2.0	<1.7	<2.2
K-40	3470.0 ± 602.0	3020.0 ± 413.0	2910.0 ± 371.0	3440.0 ± 406.0	2980.0 ± 430.0
Mn-54	<28.1	<18.3	<16.0	<16.4	<18.9
Fe-59	<75.0	<64.9	<55.6	<48.5	<51.5
Co-58	<32.9	<18.7	<18.0	<16.2	<22.2
Co-60	<31.3	<23.6	<26.3	<19.2	<21.2
Cs-134	<26.5	<15.3	<13.8	<14.8	<17.2
Cs-137	<29.1	<17.2	<16.0	<14.9	<19.3

Analysis	BIGMOUTH BUFFALO (10/21/93)	CARP (10/21/93)	FRESHWATER DRUM (10/21/93)	RIVER CARPSUCKER (10/21/93)	LARGEMOUTH BASS (10/21/93)
Sr-89	<5.9	<7.3	<4.4	<5.4	<4.6
Sr-90	3.2 ± 1.5	<3.0	<1.6	<1.9	<1.7
K-40	2666.0 ± 412.0	3137.0 ± 460.0	2747.0 ± 452.0	2908.0 ± 537.0	2844.0 ± 281.0
Mn-54	<9.5	<17.0	<13.8	<14.7	<4.5
Fe-59	<30.4	<27.7	<21.2	<47.7	<29.2
Co-58	<13.1	<27.3	<8.1	<26.9	<13.9
Co-60	<12.2	<21.8	<19.9	<15.4	<12.9
Cs-134	<12.4	<19.5	<9.0	<15.9	<4.8
Cs-137	<11.9	<18.5	<19.0	<22.7	<10.8

Notes:

TABLE E12

THERMOLUMINESCENT DOSIMETRY
1993

LOCATION CODE	FIRST QUARTER FIELD TIME (DAYS)	FIRST QUARTER TOTAL EXPOSURE (MREM ± 2σ)	FIRST QUARTER NET EXPOSURE (MREM/STD QTR ± 2σ)	SECOND QUARTER FIELD TIME (DAYS)	SECOND QUARTER TOTAL EXPOSURE (MREM ± 2σ)	SECOND QUARTER NET EXPOSURE (MREM/STD QTR ± 2σ)	THIRD QUARTER FIELD TIME (DAYS)	THIRD QUARTER TOTAL EXPOSURE (MREM ± 2σ)	THIRD QUARTER NET EXPOSURE (MREM/STD QTR ± 2σ)	FOURTH QUARTER FIELD TIME (DAYS)	FOURTH QUARTER TOTAL EXPOSURE (MREM ± 2σ)	FOURTH QUARTER NET EXPOSURE (MREM/STD QTR ± 2σ)	ANNUAL FIELD TIME (DAYS)	ANNUAL TOTAL EXPOSURE (MREM ± 2σ)	ANNUAL NET EXPOSURE (MREM/STD QTR ± 2σ)
CA-IDM-01	76.0	14.1 ± 0.6	16.7 ± 0.7	86.0	16.5 ± 0.2	17.3 ± 0.3	91.1	17.4 ± 0.4	17.2 ± 0.4	97.8	19.7 ± 0.4	18.2 ± 0.4	351	64.0 ± 2.9	16.4 ± 0.8
CA-IDM-02	76.0	14.8 ± 0.8	17.5 ± 1.0	86.0	16.8 ± 0.6	17.6 ± 0.6	91.0	16.8 ± 1.1	16.6 ± 1.0	97.8	19.2 ± 0.7	17.6 ± 0.6	351	65.0 ± 3.7	16.7 ± 1.0
CA-IDM-03	73.0	14.9 ± 0.3	18.4 ± 0.3	89.0	16.9 ± 0.6	17.1 ± 0.6	91.0	17.6 ± 0.6	17.4 ± 0.6	97.0	20.7 ± 0.7	19.2 ± 0.6	350	66.4 ± 3.2	17.1 ± 0.8
CA-IDM-04	73.0	13.7 ± 1.3	16.9 ± 1.7	89.0	14.7 ± 0.5	14.9 ± 0.5	91.0	16.5 ± 2.7	16.4 ± 2.7	97.0	18.1 ± 0.5	16.8 ± 0.5	350	59.0 ± 3.1	15.2 ± 0.8
CA-IDM-05	72.0	12.7 ± 0.3	15.8 ± 0.4	90.0	14.7 ± 1.4	14.7 ± 1.4	91.1	14.1 ± 0.5	13.9 ± 0.5	97.0	18.7 ± 2.7	17.4 ± 2.5	350	57.1 ± 3.6	14.7 ± 0.9
CA-IDM-06	73.0	16.8 ± 4.5	20.7 ± 5.5	89.1	16.2 ± 0.6	16.4 ± 0.6	91.0	17.4 ± 0.2	17.3 ± 0.2	97.0	19.6 ± 1.0	18.2 ± 0.9	350	66.5 ± 3.1	17.1 ± 0.8
CA-IDM-07	73.0	15.0 ± 0.3	18.5 ± 0.4	89.0	16.7 ± 0.4	16.9 ± 0.4	91.1	17.6 ± 1.0	17.4 ± 0.9	97.0	19.3 ± 0.8	18.0 ± 0.7	350	66.1 ± 3.5	17.0 ± 0.9
CA-IDM-08	73.0	16.3 ± 0.9	20.1 ± 1.1	89.0	19.1 ± 0.4	19.3 ± 0.5	91.1	18.6 ± 0.8	18.4 ± 0.8	97.0	22.4 ± 0.6	20.8 ± 0.6	350	73.4 ± 4.9	18.9 ± 1.3
CA-IDM-09	73.0	16.3 ± 0.6	20.1 ± 0.7	89.0	18.4 ± 0.7	18.6 ± 0.7	55.1	ND	ND	83.0	18.8 ± 0.6	20.4 ± 0.6	83.0	14.8 ± 3.1	16.1 ± 3.3
CA-IDM-10	75.5	ND	ND	86.0	17.0 ± 0.9	17.8 ± 0.9	55.1	ND	ND	83.0	19.2 ± 0.6	20.9 ± 0.7	133	23.3 ± 3.0	15.8 ± 2.0
CA-IDM-11	73.0	16.3 ± 0.4	20.1 ± 0.5	89.0	19.0 ± 0.6	19.2 ± 0.7	91.1	19.6 ± 1.8	19.4 ± 1.8	97.0	21.7 ± 0.5	20.2 ± 0.4	350	72.2 ± 3.4	18.6 ± 0.9
CA-IDM-12	73.0	15.5 ± 0.4	19.1 ± 0.5	89.0	17.5 ± 0.4	17.7 ± 0.4	91.0	17.1 ± 0.5	16.9 ± 0.5	97.1	20.9 ± 0.3	19.4 ± 0.3	350	68.2 ± 4.0	17.5 ± 1.0
CA-IDM-13	73.0	15.7 ± 0.7	19.4 ± 0.8	89.0	18.6 ± 0.7	18.8 ± 0.7	91.1	18.7 ± 0.9	18.5 ± 0.9	97.0	21.9 ± 2.0	20.3 ± 1.8	350	72.7 ± 4.4	18.7 ± 1.1
CA-IDM-14	73.0	16.0 ± 0.7	19.7 ± 0.9	89.0	17.6 ± 0.5	17.8 ± 0.5	91.1	18.3 ± 0.8	18.1 ± 0.8	97.0	20.2 ± 0.5	18.8 ± 0.4	350	70.4 ± 3.7	18.1 ± 1.0
CA-IDM-15	73.0	15.2 ± 0.8	18.8 ± 1.0	89.0	16.5 ± 0.4	16.7 ± 0.4	91.1	18.0 ± 1.7	17.8 ± 1.6	97.0	20.0 ± 0.7	18.6 ± 0.6	350	65.0 ± 4.6	16.7 ± 1.2
CA-IDM-16	73.0	13.8 ± 0.3	17.0 ± 0.3	89.0	15.6 ± 0.5	15.7 ± 0.5	91.1	15.7 ± 0.7	15.5 ± 0.6	97.0	18.0 ± 0.2	16.7 ± 0.2	350	60.0 ± 4.3	15.4 ± 1.1
CA-IDM-17	73.0	14.9 ± 0.5	18.4 ± 0.6	89.0	16.7 ± 0.5	16.9 ± 0.5	91.1	17.1 ± 0.7	16.9 ± 0.7	97.0	19.1 ± 0.2	17.7 ± 0.2	350	65.0 ± 4.5	16.7 ± 1.2
CA-IDM-18	73.0	15.0 ± 0.8	18.5 ± 1.0	89.0	17.0 ± 0.4	17.1 ± 0.4	91.1	17.2 ± 0.5	17.0 ± 0.4	97.0	19.7 ± 1.0	18.3 ± 0.9	350	64.9 ± 3.7	16.7 ± 0.9
CA-IDM-19	73.0	15.4 ± 0.6	19.0 ± 0.7	89.0	17.4 ± 0.4	17.6 ± 0.4	91.1	17.8 ± 0.4	17.6 ± 0.4	97.0	20.8 ± 0.9	19.3 ± 0.9	350	67.9 ± 3.3	17.5 ± 0.8
CA-IDM-20	73.0	15.1 ± 0.4	18.7 ± 0.5	89.0	18.0 ± 0.7	18.2 ± 0.7	91.1	17.2 ± 0.7	17.0 ± 0.7	97.0	20.6 ± 0.7	19.1 ± 0.6	350	68.9 ± 4.1	17.7 ± 1.1
CA-IDM-21	73.0	15.0 ± 0.6	18.5 ± 0.7	89.0	9.7 ± 6.5	9.8 ± 6.6	91.0	16.8 ± 1.4	16.6 ± 1.4	97.0	20.2 ± 2.6	18.8 ± 2.4	350	69.1 ± 5.0	17.8 ± 1.3
CA-IDM-22	73.0	15.3 ± 0.4	18.9 ± 0.4	89.0	17.4 ± 0.7	17.6 ± 0.7	91.0	18.1 ± 0.7	17.9 ± 0.7	97.0	20.6 ± 1.0	19.1 ± 0.9	350	69.2 ± 4.0	17.8 ± 1.0
CA-IDM-23	73.0	15.1 ± 0.4	18.6 ± 0.5	89.0	18.0 ± 0.5	18.2 ± 0.5	91.0	18.1 ± 0.9	17.9 ± 0.9	97.0	20.2 ± 0.6	18.7 ± 0.5	350	64.7 ± 3.7	16.6 ± 0.9
CA-IDM-24	73.0	14.9 ± 0.6	18.4 ± 0.8	89.0	17.3 ± 0.7	17.4 ± 0.7	91.0	17.9 ± 0.7	17.7 ± 0.7	98.0	20.4 ± 0.6	18.7 ± 0.6	351	68.8 ± 4.3	17.6 ± 1.1
CA-IDM-25	73.0	16.0 ± 1.6	19.8 ± 1.9	89.0	17.3 ± 0.7	17.5 ± 0.7	91.1	17.2 ± 0.6	17.0 ± 0.6	97.0	19.8 ± 0.8	18.4 ± 0.7	350	64.7 ± 3.8	16.6 ± 1.0
CA-IDM-26	73.0	10.7 ± 0.4	13.2 ± 0.5	89.0	12.0 ± 0.4	12.1 ± 0.4	91.1	12.1 ± 0.5	12.0 ± 0.5	97.0	14.3 ± 0.4	13.2 ± 0.4	350	46.5 ± 3.4	12.0 ± 0.9

Notes: 1. ND = No Data. See section 2.3 for explanation.

TABLE E12 (Cont.)

THERMOLUMINESCENT DOSIMETRY
1993

LOCATION CODE	FIRST QUARTER FIELD TIME (DAYS)	FIRST QUARTER TOTAL EXPOSURE (MREM ± 2σ)	FIRST QUARTER NET EXPOSURE (MREM/STD QTR ± 2σ)	SECOND QUARTER FIELD TIME (DAYS)	SECOND QUARTER TOTAL EXPOSURE (MREM ± 2σ)	SECOND QUARTER NET EXPOSURE (MREM/STD QTR ± 2σ)	THIRD QUARTER FIELD TIME (DAYS)	THIRD QUARTER TOTAL EXPOSURE (MREM ± 2σ)	THIRD QUARTER NET EXPOSURE (MREM/STD QTR ± 2σ)	FOURTH QUARTER FIELD TIME (DAYS)	FOURTH QUARTER TOTAL EXPOSURE (MREM ± 2σ)	FOURTH QUARTER NET EXPOSURE (MREM/STD QTR ± 2σ)	ANNUAL FIELD TIME (DAYS)	ANNUAL TOTAL EXPOSURE (MREM ± 2σ)	ANNUAL NET EXPOSURE (MREM/STD QTR ± 2σ)
CA-IDM-27	73.0	16.1 ± 2.0	19.9 ± 2.5	89.0	17.5 ± 2.1	17.7 ± 2.1	90.6	ND	ND	82.9	19.0 ± 1.9	20.6 ± 2.0	350	67.9 ± 3.7	17.5 ± 1.0
CA-IDM-28	73.0	16.2 ± 2.4	20.0 ± 3.0	89.0	17.6 ± 2.0	17.8 ± 2.1	91.0	17.8 ± 0.9	17.6 ± 0.9	97.1	20.4 ± 1.9	18.9 ± 1.8	350	69.4 ± 4.4	17.8 ± 1.1
CA-IDM-29	73.0	14.3 ± 0.3	18.2 ± 0.4	89.0	16.0 ± 0.8	16.2 ± 0.8	91.1	14.7 ± 0.4	14.5 ± 0.4	97.0	18.8 ± 0.7	17.4 ± 0.6	350	59.4 ± 3.6	15.3 ± 0.9
CA-IDM-30	73.0	14.7 ± 0.4	18.1 ± 0.5	88.9	15.7 ± 0.5	15.9 ± 0.5	55.1	ND	ND	83.8	17.8 ± 0.7	19.1 ± 0.7	134	21.9 ± 3.3	14.7 ± 2.2
CA-IDM-31	73.0	16.0 ± 0.4	19.7 ± 0.5	88.9	18.5 ± 0.2	18.7 ± 0.2	90.5	ND	ND	83.8	19.7 ± 0.6	21.1 ± 0.7	83.8	17.3 ± 3.0	18.6 ± 3.2
CA-IDM-32	73.0	15.6 ± 0.6	19.2 ± 0.7	88.9	17.3 ± 0.6	17.5 ± 0.6	91.2	18.6 ± 0.8	18.3 ± 0.8	97.7	20.0 ± 0.6	18.4 ± 0.6	351	68.7 ± 4.3	17.6 ± 1.1
CA-IDM-33	73.0	14.6 ± 0.4	17.9 ± 0.4	88.9	18.6 ± 1.0	18.8 ± 1.0	91.2	17.3 ± 0.5	17.1 ± 0.5	97.7	23.1 ± 6.9	21.3 ± 6.3	351	69.7 ± 4.8	17.9 ± 1.2
CA-IDM-34	75.9	13.5 ± 0.5	16.0 ± 0.6	86.1	15.1 ± 0.4	15.8 ± 0.4	91.1	15.7 ± 0.6	15.5 ± 0.6	97.7	17.9 ± 0.5	16.5 ± 0.4	351	61.6 ± 3.3	15.8 ± 0.9
CA-IDM-35	76.0	14.1 ± 0.7	16.7 ± 0.8	86.0	15.4 ± 0.4	16.1 ± 0.4	91.1	16.2 ± 0.3	16.0 ± 0.3	97.8	18.3 ± 0.6	16.8 ± 0.6	351	63.1 ± 4.0	16.2 ± 1.0
CA-IDM-36	73.0	15.1 ± 0.5	18.7 ± 0.6	89.0	16.8 ± 0.4	17.0 ± 0.4	91.0	18.3 ± 0.4	18.1 ± 0.4	97.0	19.6 ± 0.6	18.2 ± 0.6	350	68.1 ± 3.5	17.5 ± 0.9
CA-IDM-37	73.0	14.8 ± 0.4	18.2 ± 0.5	89.0	16.1 ± 0.6	16.3 ± 0.6	91.1	16.2 ± 0.5	16.0 ± 0.5	97.0	18.9 ± 0.8	17.5 ± 0.8	350	67.1 ± 3.2	17.3 ± 0.8
CA-IDM-38	76.0	10.7 ± 0.4	12.7 ± 0.4	86.0	12.6 ± 0.5	13.1 ± 0.5	91.1	12.5 ± 0.4	12.3 ± 0.4	97.8	14.4 ± 0.3	13.3 ± 0.3	351	47.7 ± 3.9	12.2 ± 1.0
CA-IDM-39	76.0	14.9 ± 0.7	17.6 ± 0.8	86.0	16.4 ± 0.2	17.1 ± 0.2	91.0	17.4 ± 0.8	17.2 ± 0.8	97.8	19.6 ± 1.0	18.0 ± 0.9	351	70.4 ± 3.1	18.1 ± 0.8
CA-IDM-40	76.0	15.0 ± 0.8	17.8 ± 0.9	86.0	17.3 ± 0.4	18.1 ± 0.4	91.0	17.8 ± 1.0	17.6 ± 1.0	97.8	20.3 ± 0.9	18.7 ± 0.8	351	70.1 ± 3.2	18.0 ± 0.8
CA-IDM-41	72.5	ND	ND	86.1	16.2 ± 0.7	17.0 ± 0.7	90.5	ND	ND	97.7	19.0 ± 1.9	17.5 ± 1.7	275	ND	ND
CA-IDM-42	73.0	12.5 ± 0.5	15.4 ± 0.6	88.9	14.5 ± 0.4	14.6 ± 0.4	91.2	14.5 ± 0.2	14.3 ± 0.2	97.7	16.9 ± 0.3	15.6 ± 0.3	351	59.8 ± 3.9	15.3 ± 1.0
CA-IDM-43	73.0	14.9 ± 0.7	18.3 ± 0.8	89.0	16.1 ± 0.7	16.2 ± 0.7	91.1	16.5 ± 1.0	16.3 ± 1.0	97.0	19.3 ± 0.4	17.9 ± 0.3	350	67.1 ± 4.3	17.3 ± 1.1
CA-IDM-44	73.0	16.2 ± 3.1	19.9 ± 3.8	89.0	17.5 ± 0.3	17.7 ± 0.3	91.1	18.3 ± 0.3	18.1 ± 0.3	97.8	19.7 ± 0.9	18.1 ± 0.8	351	70.2 ± 3.5	18.0 ± 0.9
CA-IDM-45	73.0	14.8 ± 0.5	18.3 ± 0.7	89.0	17.2 ± 0.7	17.4 ± 0.7	91.0	16.7 ± 0.7	16.5 ± 0.7	97.0	19.1 ± 0.7	17.7 ± 0.6	350	64.9 ± 3.4	16.7 ± 0.9
CA-IDM-46	73.0	15.3 ± 0.5	18.8 ± 0.7	89.0	17.6 ± 0.7	17.8 ± 0.7	91.0	17.6 ± 0.4	17.4 ± 0.4	97.0	21.0 ± 1.1	19.5 ± 1.0	350	64.9 ± 5.2	16.7 ± 1.3
CA-IDM-47	73.0	15.0 ± 0.2	18.6 ± 0.2	89.0	16.5 ± 1.0	16.7 ± 1.0	91.1	16.5 ± 0.5	16.3 ± 0.5	97.0	18.6 ± 0.7	17.3 ± 0.6	350	64.7 ± 4.1	16.6 ± 1.1
CA-IDM-48	73.0	14.9 ± 0.4	18.4 ± 0.5	89.0	17.4 ± 0.5	17.6 ± 0.5	91.1	18.3 ± 0.6	18.0 ± 0.6	97.0	20.8 ± 0.6	19.3 ± 0.6	350	71.9 ± 3.7	18.5 ± 0.9
CA-IDM-49	72.6	ND	ND	89.0	16.7 ± 0.6	16.9 ± 0.6	91.1	16.7 ± 0.4	16.5 ± 0.4	97.0	19.3 ± 0.5	17.9 ± 0.5	274	47.4 ± 3.3	15.6 ± 1.1
CA-IDM-50	73.0	15.5 ± 0.3	19.1 ± 0.4	89.0	17.2 ± 0.4	17.4 ± 0.4	91.1	18.0 ± 0.4	17.8 ± 0.3	97.0	20.2 ± 0.4	18.8 ± 0.4	350	67.3 ± 3.6	17.3 ± 0.9
CA-IDM-51	72.0	14.8 ± 0.2	18.5 ± 0.3	90.0	17.1 ± 0.8	17.1 ± 0.8	91.0	17.7 ± 1.0	17.5 ± 1.0	97.2	19.9 ± 0.5	18.5 ± 0.5	350	63.4 ± 3.8	16.3 ± 1.0
CA-IDM-52	72.0	14.8 ± 0.2	18.6 ± 0.3	90.0	17.0 ± 0.6	17.0 ± 0.6	91.0	18.2 ± 0.6	18.0 ± 0.6	97.0	20.4 ± 0.6	19.0 ± 0.5	350	67.5 ± 3.1	17.4 ± 0.8

Notes: 1. ND = No Data. See section 2.3 for explanation.

SECTION 4.0

NONRADIOLOGICAL ENVIRONMENTAL MONITORING

UNION ELECTRIC COMPANY

ST. LOUIS, MISSOURI

CALLAWAY PLANT

SECTION 4.0

NONRADIOLOGICAL ENVIRONMENTAL

MONITORING PROGRAM

ANNUAL REPORT

1993

CONTENTS

1.0 INTRODUCTION

Union Electric Company (UEC) in accordance with federal regulations and the desire to maintain the quality of the local environment around the Callaway Plant has implemented an Environmental Protection Plan (EPP) contained in Appendix B of the Callaway Plant Operating License.

The objective of the EPP is to provide for protection of nonradiological environmental values during operation of the Callaway Plant.

This report describes the conduct of the EPP for the Callaway Plant during 1993.

2.0 ENVIRONMENTAL MONITORING

During 1993 an aerial infrared vegetation monitoring study was performed around the Callaway Plant by Applied Biology, Inc. This study was conducted to satisfy the last requirement of section 4.2 of Appendix B to Facility Operating License No. NPF-30.

The vegetation monitoring conducted during 1993 was the fifth operational monitoring effort. As with prior efforts, no evidence of detrimental effects from cooling tower drift was found; vegetation stress in the vicinity of the plant site was determined to be caused by natural factors. The Aerial Photographic Monitoring and Interpretation of Vegetation at Callaway, 1993 final report, prepared by Applied Biology, Inc. is included as Appendix A.

A copy of the color photographic prints and color transparencies have been sent with the 1993 Annual Environmental Operating Report to:

Mr. L. R. Wharton
Office of Nuclear Reactor Regulations
U.S. Nuclear Regulatory Commission
1 White Flint, North, Mail Stop 13E21
11555 Rockville Pike
Rockville, MD 20852

3.0 CULTURAL RESOURCES

In accordance with Sections 4.3 and 5.4 of EPP a description of the implementation of Cultural Resources requirements follows.

Union Electric has submitted an amendment request dated 2/21/92 (ULNRC-2566) which proposes to revise the Callaway Facility Operating License NPF-30, Appendix B, Environmental Protection Plan (non-radiological), by removing Sections 2.3 and 4.3, "Cultural Resources." Union Electric has developed and maintains a management plan for the protection of cultural resources on the Callaway Plant site including those within the area of potential effects. This management plan was revised and forwarded to NRC by letter dated 4/16/92 (ULNRC-2620). The amendment request provides the status and disposition of each portion of the present Appendix B which addresses cultural resources.

4.0 UNUSUAL OR IMPORTANT EVENTS

No unusual or important events reportable under EPP Section 4.1 were identified during 1993.

5.0 EPP NONCOMPLIANCES

During 1993 there were no noncompliances with the EPP.

6.0 NONROUTINE REPORTS

There were no nonroutine reports submitted in accordance with EPP, Section 5.4.2 in 1993.

APPENDIX A

AERIAL PHOTOGRAPHIC MONITORING AND INTERPRETATION OF VEGETATION AT CALLAWAY

AERIAL PHOTOGRAPHIC MONITORING AND INTERPRETATION OF VEGETATION AT CALLAWAY

AUGUST 1993

FINAL REPORT

NOVEMBER 1993

Prepared for

UNION ELECTRIC COMPANY

St. Louis, Missouri

Prepared by

APPLIED BIOLOGY, INC.

Decatur, Georgia

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Environmental information on the condition of vegetation at the Callaway site during the ninth year of plant operation was developed through infrared aerial photography, photointerpretation and ground truthing of stressed vegetation, vegetation mapping and phytopathological diagnoses of stressed vegetation during July and August, 1993.

Ten terrestrial study plots were photographed with infrared film at a scale of 1" = 250'. Residual lands were photographed at a scale of 1" = 1000'. Photointerpretation was performed based upon the differential infrared reflectance characteristics of healthy versus stressed tree cover. The infrared photographic record was then verified with a ground truthing field inspection. On-site and laboratory phytopathological diagnoses were made for stressed vegetation identified from aerial photography. A vegetation map was produced to show the location of stressed vegetation.

No evidence of the effects of drift from the cooling tower was found. Vegetation stress in the vicinity of the plant site was found to be caused by natural factors such as oak anthracnose, insect damage, lightning strike, Dutch elm disease, and beaver girdling and damming. No distributional pattern of these diseases was identified during the study. Therefore, the foliar disease found in the Callaway vegetation during 1993 can be directly attributed to natural causes and not to operation of the Callaway cooling tower.

1.0 INTRODUCTION

1.1 Purpose

Union Electric Company (UE), in response to Nuclear Regulatory Commission (NRC) mandate, has undertaken a program to monitor the potential impacts of cooling tower drift on the local flora surrounding the UE Callaway Plant in Callaway County, Missouri. The goals of the program are to establish a record of baseline and operational phase vegetation conditions at the Callaway Plant site using color infrared aerial photography, to document any naturally occurring vegetation stress, and to determine if any vegetation damage can be attributed to operation of the cooling tower. Interpretation of aerial photographs was used to prepare this information. This was supplemented by ground truthing to assure accurate interpretation of photographs and field phytopathological assessment to identify the causes of any vegetation stress encountered.

Using these investigative methods, preoperational baseline environmental information on the condition of vegetation at the Callaway Plant site was developed during July and August, 1984. Observations during the first, second, third, fifth and seventh years of plant operation were made during August, 1985; July and August, 1986; August, 1987; July, August and September, 1989; and July and August, 1991. During July and August of 1993, monitoring was performed to assess the condition of vegetation during the ninth year of plant operation. The results of these seven years of monitoring compiement other vegetation monitoring undertaken at the study site. Prior to the present program of infrared aerial photographic monitoring, classical field botany techniques were used to describe the species composition of the vegetation community at the Callaway Plant. This work was performed in 1973 - 1975, 1981, and 1983 - 1984, and concentrated on a set of permanent terrestrial study plots.

2.0 STUDY METHODS

Applied Biology, Inc. (ABI) acted as coordinator for the infrared aerial photography, photointerpretation and ground truthing of stressed vegetation, vegetation mapping and phytopathological assessment of stressed vegetation conducted at the Callaway Plant site in 1993.

2.1 Aerial Photography

Aerial photography for this project was flown from 1112 to 1148 hours on 17 July 1993 by Walker and Associates, Inc. of Fenton, Missouri. No cloud cover was present. Atmospheric conditions were haze- and dust-free. Color infrared film was exposed in a Wild RC-8 precision aerial mapping camera with 6 inch focal length lens. Ten one-hectare terrestrial study plots were photographed with 60 percent forward overlap at a scale of 1" = 250'. The residual lands of the plant site were photographed with 60 percent forward overlap and 30 percent side overlap at a scale of 1" = 1,000'. Overlapping of photo frames is used to assure adequate coverage that avoids any visual distortion or loss of infrared photograph brightness that may occur along the edges of an aerial photographic exposure. Duplicate sets of positive film transparencies and positive prints were produced in 9" by 9" format.

2.2 Photointerpretation

Analysis of color infrared aerial photographs for the presence of vegetation stress is based upon the changes in infrared foliage reflectance that occur as a result of plant stress. A number of technical sources describe the theory and application of color infrared vegetation analysis and were used as a guide for the photointerpretation in this study. Plants under stress due to insect attack, disease or environmental conditions such as drought exhibit discoloration of their foliage on color infrared film because of loss of reflectance. This decrease of infrared reflectance occurs when normally highly reflective spongy leaf mesophyll cells collapse because of plant stress (Colwell, 1956). Vegetation color differences can be used to make inferences about plant vigor (Murtha, 1982; Barrett and Curtis, 1976). Healthy deciduous trees are highly reflective of the infrared light spectrum and appear as red and magenta in color infrared photographs. Evergreen pines and cedars at the site appear in shades of reddish grey. Stressed vegetation, with leaf yellowing apparent in normal spectral color photography, appears in shades of mauve, blue-grey, yellow and white in color infrared photography. When vegetation is dead and dry, it appears as yellow and tan on color infrared photography.

Using these differential reflectances as signature guides, examination of photographs was performed with simple magnification. Trees that were possibly in stressed condition were marked on photographic prints for subsequent ground truthing.

2.3 Ground Truthing

Ground truthing of stressed vegetation was the process used to locate (with the aid of aerial photographs and topographical maps) potentially stressed trees recorded on aerial photograph prints. The condition of these trees and the assessment made during phytopathological investigations were then correlated with the infrared photographic signature in order to identify stressed trees. Ground truthing took place on 28 and 29 August 1993.

2.4 Vegetation Mapping

After photointerpretation and ground truthing, the locations of stressed or dying trees were plotted on a map of the Callaway Plant site at a scale of 1" = 2,000' (Figure 1). Individual stressed or dying trees were represented by a diamond (◆) on the vegetation map. A considerable number of the trees that were plotted on the site vegetation map were inspected for photointerpretation ground truth correlation and phytopathological appraisal.

2.5 Phytopathological Investigations

Individual trees that were located at the Callaway site from aerial photograph plotting were appraised by plant pathologist Barbara Lucas Corwin of Hallsville, Missouri. The purpose of this appraisal was to provide diagnoses of the causes of vegetation stress found on specimens at the study site. The causes of plant stresses were categorized as environmental, disease, or insect. Plant species vary in their tolerance of, or sensitivity to, adverse conditions brought about by any of the above categories. It is pertinent to note that stress symptoms in plants, especially trees, can be very similar among the categories of causes mentioned above.

Freezing and thawing, drought, flooding, lightning damage, chemical injury, mechanical injury, or high winds are all examples of environmental conditions that can result in stressed plants. These conditions may cause outright death of plants or may

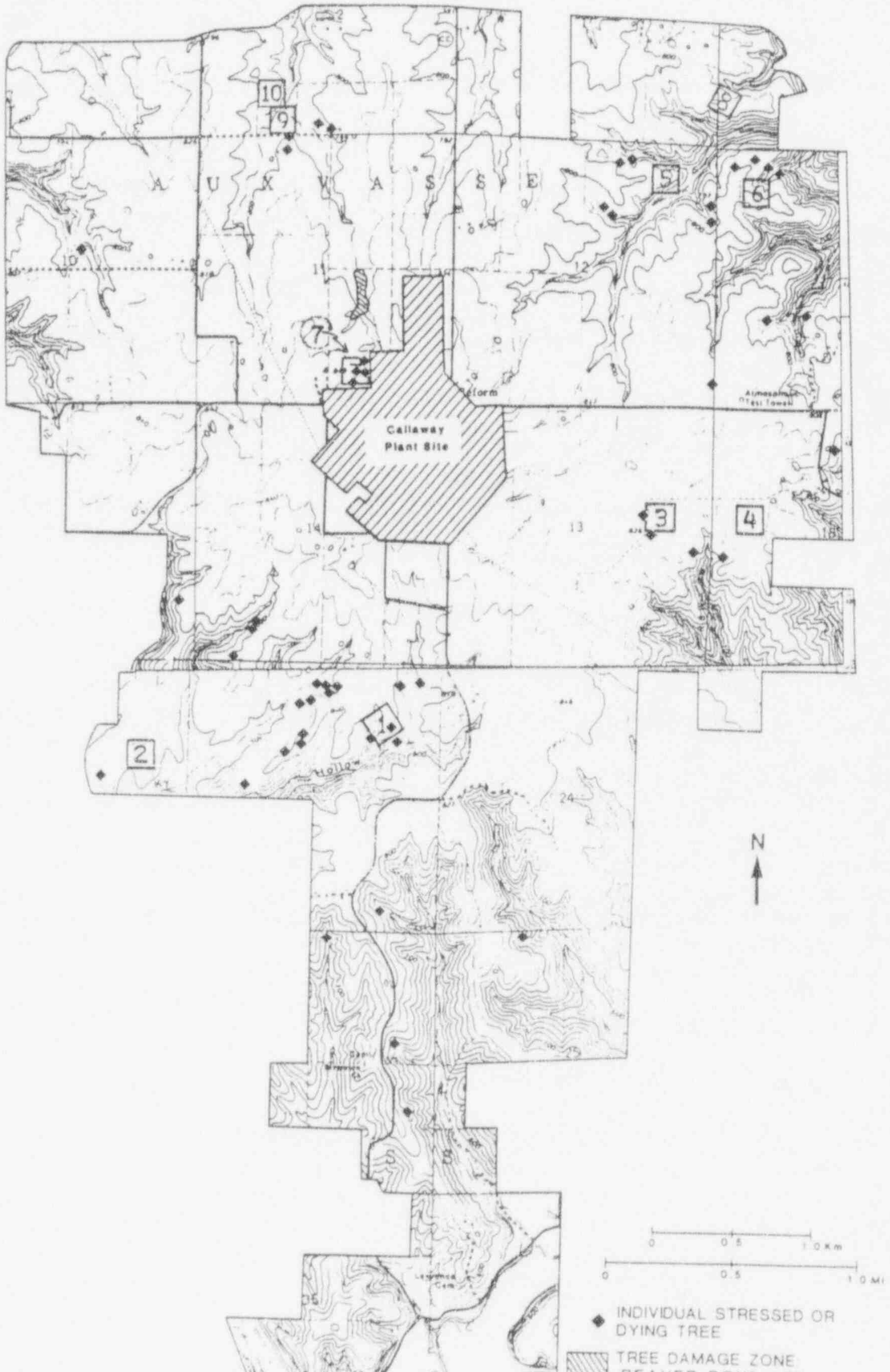


Figure 1: Location of stressed and dying trees, Callaway Plant , July - August 1993

stress them to a point where they are unable to withstand invasion by secondary disease organisms or insect pests.

Disease is a condition in plants brought about as a result of invasion of plant tissues by other living microorganisms. Primary diseases, such as oak wilt and Dutch elm disease (DED), are caused by microorganisms that can invade healthy plant tissues. These organisms consume plant-supplied water and nutrient reserves for their own growth, thereby creating a stress on the plant. Secondary diseases, such as maple decline, are caused by "disease complexes" that usually occur on plants that have already been stressed from other causes. Disease complexes are generally caused by microorganisms that by themselves cannot invade tissues of healthy plants. When plants are stressed, however, their normal resistance to invasion by insect and disease organisms is lowered. The disease-complex organisms then are able to invade plant tissues, causing further stress and/or death of the plant.

Insects may cause direct or indirect damage to plants that may result in stress. Direct damage usually is a result of feeding on plant parts such as leaves, bark (cambial layers), wood, or roots. Oviposition (egg-laying) is another type of direct damage that can restrict the flow of water or nutrients in the plant. Insects may also cause indirect damage by serving as vectors of disease-causing organisms; insects feeding on diseased plants inadvertently carry spores of disease organisms to healthy plants.

The elements that have been analyzed during diagnoses of stressed tree specimens are: history of forest management practices or herbicide application, site edaphic conditions, condition of surrounding vegetation, recent meteorological record, and inspection of tree leaves, branches, bark and roots. In addition to field observations, standard culturing procedures using twigs and small branches were carried out in the laboratory in 1984 and 1987 in an attempt to recover the causal fungus in cases of suspected fungal infestation. Samples were plated on two culture media: 1) oak wilt agar (Nutrimigen base) and 2) acid potato-dextrose agar. These laboratory procedures were inconclusive in 1984 and were not repeated in 1985 or 1986. In 1987, twig samples from two black oak specimens were again cultured in an attempt to isolate the causal fungus. The oak wilt fungus Ceratocystis fagacearum was isolated in 1987. Further attempts to isolate this fungus were not repeated in 1989, 1991 or 1993. Oak anthracnose was observed as a new, widespread disease on white oak trees in 1993. The fungus Discula quercina was confirmed by microscopic inspection as being the causative agent for this disease.

3.0 RESULTS AND DISCUSSION

3.1 Photointerpretation and Ground Truthing

Analysis of color infrared aerial photographs indicated that the vast majority of deciduous trees at the Callaway Plant site were in good health as indicated by their intense magenta reflectance. Certain deciduous trees observed across the study site displayed somewhat lighter magenta or pink coloration or a light fringed appearance on infrared aerial photographs. Ground truthing in 1993 and in previous years has revealed these trees to be species such as red maple (Acer rubrum), sycamore (Platanus occidentalis), persimmon (Diospyros virginiana), cottonwood (Populus deltoides) and mulberry (Morus rubra) that were in good health. Such trees possess a somewhat different infrared color signature than the deep magenta of the oaks and hickories that are dominant at the Callaway site. Deciduous trees that showed signs of stress reflected in shades of light pinkish mauve, grey and tan on infrared photography. These deciduous trees were plotted as individual stressed or dying trees on the site vegetation map (Figure 1). The distribution of these trees showed no apparent pattern. Ground truthing and phytopathological examination revealed that a variety of stress factors (detailed in Section 3.2) were affecting these trees. During previous years of vegetation monitoring, areas with relatively high densities of stressed, dying or dead deciduous trees were observed on the aerial photographs. These areas were recorded in past years as tree damage zones on the site vegetation map. Field inspection revealed that these zones were subject to forest management practices carried out by the Missouri Department of Conservation in which less robust tree specimens or undesired species were girdled by chain saw cutting. The culled dead and dying trees appeared as stressed aggregations on infrared aerial photography. In an area to the west of Vegetation Ecology Site 2, a number of trees appear as whitish, barren trunks on infrared aerial photography. These dead trees have been left standing on this site for some time and have been noted in the six previous annual reports on aerial photographic vegetation monitoring at the Callaway site. This area is not mapped as a tree damage zone in this 1993 report since the observed trees at this location have been dead for several years and the area is now in a process of regrowth/recovery. Selective cutting along the lowland timber edges, performed by the Missouri Department of Conservation in the general vicinity of Sites 3, 4, 5, 6, 8, 9 and 10, was noted but was not mapped during the 1989 Callaway vegetation monitoring report. Some of these trees were observed during the 1993 vegetation photointerpretation and field survey to be still standing as dead stems. During 1993 inspection of aerial photographs and on-site ground truthing, piles or rows of dead eastern redcedars (Juniperus virginiana) were noted in the general vicinity of Sites 2, 3 and 4. These piles of dead trees displayed gray or tan coloration on infrared aerial photographs. These trees were apparently cut by the Missouri Department of Conservation as part of land management activities at the Callaway site and are not plotted on the site vegetation map. Tree mortality and stress from beaver damming and girdling in the vicinity of Site 7 was first noted in 1991. This mortality and stress was observed to be more widespread in 1993 and is plotted as a tree damage zone on the site vegetation map.

Healthy eastern redcedar (Juniperus virginiana) and plantation grown white pine (Pinus strobus), both evergreen species, displayed reddish grey coloration in infrared photography. As a whole, the stand of white pine was in fairly good condition but with some ongoing lower branch dieback, perhaps due to crowding and sunlight shading.

Eastern redcedars, with the exception of those that had been cut as part of land management activities, were in good condition across the study site in general.

3.2 Phytopathological Investigations

In 1993, white oak (Quercus alba) was the predominant tree species showing signs of stress. Leaf samples of overstory trees could not be reached, but observation through field glasses revealed two types of damage. One type of damage was from a skeletonizing insect. This symptom occurs when the insect eats all leaf tissue except the veins. Additionally, leaf browning, beginning at the tip of leaf lobes and progressing inward, was evident. This symptom is very characteristic of oak anthracnose, caused by the fungus Discula quercina. White oaks are more susceptible to this fungus than other oak species (Sinclair et al., 1987). A white oak sample collected from an understory white oak was examined microscopically and anthracnose was confirmed.

Anthracnose is a general plant pathology term, used to describe leaf spots and blights and fruit rots caused by fungi in the family Melanconiales. The common characteristic of these fungi is the production of conidia (spores) in fruiting bodies just under the host epidermis. When fruiting bodies mature, the leaf epidermis ruptures and the conidia are exposed in a gelatinous matrix easily spread by rain.

Dutch elm disease (DED), caused by the fungus Ceratocystis ulmi, has been identified for several years at the Callaway site as a stress factor on American elm (Ulmus americana) trees. Diagnoses were based on visual symptoms: wilting, dieback of branches, and discoloration of the vascular system. DED is a vascular disease similar to oak wilt. It has been devastating on American elm (Ulmus americana) and other native species because it is caused by an "introduced" pathogen against which native American elms have not developed genetic resistance. Elm mortality from DED was noted in 1993 at Sites 2, 3 and 7.

Following is a site-by-site assessment of the causes of stress detected in 1993.

Site 1

Specimen 1-1 (slide 7): A white oak, visible behind the dead standing tree, is an example of the white oaks that were observed. The damage was from a combination of injury from foliar skeletonizing insect and anthracnose.

Specimen 1-2 (slide 8): White oak with foliar symptoms of anthracnose and skeletonizing insect damage.

Specimen 1-3 (no photo): White oak with foliar symptoms of anthracnose and skeletonizing insect damage.

Specimen 1-4 (no photo): White oak with foliar symptoms of anthracnose and skeletonizing insect damage.

Specimen 1-5 (slide 9): White oak with foliar symptoms of anthracnose and skeletonizing insect damage. A leaf sample taken from an understory white oak at this site was examined microscopically and anthracnose was confirmed.

Specimen 1-6 (no photo): White oak with foliar symptoms of anthracnose and skeletonizing insect damage.

Specimen 1-7 (no photo): White oak with foliar symptoms of anthracnose and skeletonizing insect damage.

Specimen 1-8 (no photo): White oak with foliar symptoms of anthracnose and skeletonizing insect damage.

Specimen 1-9 (no photo): White oak with foliar symptoms of anthracnose and skeletonizing insect damage.

Specimen 1-10 (no photo): White oak with foliar symptoms of anthracnose and skeletonizing insect damage.

Site 2

Specimen 2-1 (slides 1 and 2): Two mature white oaks with symptoms of injury from a lightning strike.

Specimen 2-2 (slides 3, 4 and 5): Elms in the understory with anthracnose disease.

Specimen 2-3 (no photo): Stressed white oak with foliar symptoms including anthracnose and some damage from a skeletonizing insect. Leaf galls caused by insects were also observed.

Specimen 2-4 no photo): White oak with foliar damage from anthracnose and a skeletonizing insect. Evidence of a leaf tying insect. Fungal leaf spots and blotches were noted on assorted understory species in this area.

Specimen 2-5 (slide 6): This specimen was a chlorotic elm along a creek bank. This stress is attributed to Dutch elm disease.

Site 3

Specimen 3-1 (no photo): White oak with foliar symptoms of athracnose and skeletonizing insect damage.

Specimen 3-2 (slide 11): Elm that appears newly dead this season. The most likely cause is Dutch elm disease.

Site 4

Specimen 4-1 (slide 10): White oak with foliar symptoms of anthracnose and skeletonizing insect damage.

Site 5

Specimens 5-1 and 5-2 (slide 18): Black oaks symptomatic of oak wilt.

Specimen 5-3 (no photo): White oak with foliar symptoms of anthracnose and skeletonizing insect damage.

Site 6

Specimen 6-1 (slides 12 and 13): White oak killed by lightning strike - also affected understory in immediate area.

Specimen 6-2 (slide 14): Basswood - anthracnose.

Specimen 6-3 (no photo): White oak with foliar symptoms of anthracnose and skeletonizing insect damage.

Specimen 6-4 (no photo): White oak with foliar symptoms of anthracnose and skeletonizing insect damage.

Specimen 6-5 (slide 15): Walnut with pale yellow foliage. Walnut foliage normally turns yellow in late summer. In Missouri, walnut is one of the first species to defoliate in the fall.

Site 7

Trees in the pine plantation at Site 7 showed no new damage in the crowns. Site 7 is also the location of a beaver pond, with death of trees caused by girdling and flooding (slides 16 and 17).

Specimens 7-1, 7-2 and 7-3 (no photo): Two dead American elms and one exhibiting major branch flagging. The most likely cause is Dutch elm disease.

Site 8

No stressed trees were identified in the general vicinity of Site 8 in 1993.

Site 9

Specimen 9-1 (no photo): Mortality of maple and an unknown tree (possibly apple) on an old home site. Tree decline in this area has been ongoing.

Site 10

No stressed trees were identified by on-site ground truthing in the general vicinity of Site 10 in 1993.

4.0 CONCLUSIONS

Oak anthracnose was noted as a new and relatively widespread disease at the Callaway site in 1993. This fungal disease was concentrated on white oak trees and is likely the result of a wet early spring followed by above normal rainfall through June and July. July 1993 was the third wettest July on record for most areas of Missouri. Tree damage from activities of a beaver colony near Site 7, first noted in 1991, was more extensive in 1993. Trees displaying symptoms of oak wilt, which had been consistently noted in previous monitoring at the Callaway site, were much less common in 1993. There was no apparent directional pattern to the distribution of diseased and stressed vegetation.

No directional patterns of stressed vegetation were noted, and no stress symptoms were found to be due to the effects of drift from the cooling tower. Overall, there was a moderate increase in the number of stressed trees discernible on infrared aerial photography in 1993 as compared to 1991, an approximate 50 percent increase over 1989, and a generally equivalent number of stressed trees in 1993 as compared to other previous years.

Most of the deciduous tree cover at the Callaway site is healthy and reflects intense magenta on infrared aerial photography. Those specimens that are stressed or dying are recognizable on color infrared photography because of their mauvish pink, grey or tan reflectance. A single tree damage zone sufficiently large to be illustrated on the topographic map of the survey site was observed at the Callaway site in 1993. Essentially all of the evergreen species at the study site (white pine and eastern redcedar) are in good condition and are recognizable by their reddish grey infrared reflectance. Some cutting and stockpiling of dead redcedars as a land management method was noted.

5.0 LITERATURE CITED

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SECTION 5.0

PLANT MODIFICATION ENVIRONMENTAL EVALUATION

UNION ELECTRIC COMPANY

ST. LOUIS, MISSOURI

CALLAWAY PLANT

SECTION 5.0

PLANT MODIFICATIONS

ENVIRONMENTAL EVALUATIONS

1993

1.0 INTRODUCTION

In accordance with Appendix B, Section 5.4.1 of the Callaway Plant Operating License, the following report was prepared by Union Electric on all changes in plant design, operation, tests or experiments which could have involved a potentially significant unreviewed environmental question in accordance with Section 3.1 of Appendix B.

The report covers all plant modifications/changes completed January 1, 1993, through December 31, 1993.

During 1993 there were ten plant modifications/ changes that could have involved a potentially significant unreviewed environmental question. The interpretations and conclusions regarding these plant modification/changes along with a description of the changes are presented below.

2.0 ENVIRONMENTAL EVALUATIONS

2.1 Callaway Modification Package 91-1056

2.1.1 Description of Change

This change involved construction of two concrete pads on the plant south side of the radwaste building and the plant west side of the turbine building. The concrete pad next to the radwaste building is enclosed by an eight foot chain link fence and will be used for temporary storage of radioactive waste. The other concrete pad will be a laydown area for a temporary cooling tower.

2.1.2 Evaluation of Change

The construction of two concrete pads did not result in a significant increase in any adverse environmental impacts, since all measurable non-radiological environmental effects were confined to the area previously disturbed during site preparation and plant construction. Therefore, this change does not constitute an unreviewed environmental question per Section 3.1 of Appendix B to the Callaway Plant Operating License.

2.2 Callaway Modification Package 92-3015

2.2.1 Description of Change

This change involved installation of piping and valves required to combine NPDES Permit outfall 003, Water Treatment Plant wastes and outfall 004, Demineralizer System wastes into Sludge Lagoon #3 to provide additional sludge storage space. This is necessary because Sludge Lagoon #2 is nearly full due to high water in the Missouri River and corresponding high mud and silt levels taken out by the Water Treatment Plant and discharged to Lagoon #2.

2.2.2 Evaluation of Change

Demineralizer system waste is treated to remove solids in Sludge Lagoon #3 and then discharged to the Missouri River through outfall 004. Water treatment plant waste is treated to remove solids in Sludge Lagoon #2, and the treated water recycled back to the head of the water treatment plant. This change allows recycling of both outfalls which reduces the total amount of water discharged from the plant.

The Missouri Department of Natural Resources (DNR) stated a NPDES Permit modification is required for discharge from the lagoon. DNR stated permission can be granted to combine the outfalls allowing Callaway to recycle waste water from these outfalls but not to discharge until the permit is modified. No DNR construction permit is required to make this modification because internal piping changes can be done without a construction permit. Also, no stormwater runoff permit is required since this change involves a land disturbance of less than five acres.

NRC's environmental impact evaluations were based on discharge of demineralizer system wastes to the river. This modification results in a decrease environmental impact over that which was evaluated in the Final Environmental Statement for Operation of Callaway Plant.

Construction involved in the installation of this change is on land previously disturbed during plant construction and does not contain any cultural resources. Therefore, this change does not constitute an unreviewed environmental question per Section 3.1 of Appendix B to the Callaway Plant Operating License.

2.3 Request for Resolution 10604

2.3.1 Description of Change

This change involves use of ozone as a cleaning and disinfecting agent for mobile laundry trailers. The mobile laundry trailer was used at Callaway Plant to process protective clothing during Refuel 6.

2.3.2 Evaluation of Change

O[illegible]e is generated using a Pure Water Oxytech Ozone [illegible]ator and fed into two mixing tanks at a rate [illegible] 0 cubic feet per hour. A portion of the ozone is dissolved in the water while the remaining ozone in the tanks is discharged to atmosphere through a charcoal bed and HEPA filter. The charcoal bed converts the ozone to oxygen. Ozone is also applied to [illegible]e washing machines to optimize the cleaning p[illegible]s. Minor amounts of ozone is discharged [illegible] the washing machines through a HEPA filter into the trailer and to the atmosphere.

Waste water from the process is routed to a holding tank once per week. The holding tank is sampled prior to sending the water to a radwaste floor drain tank. This water is then processed and discharged to the Missouri River. Due to the hold up time and short half-life for ozone, there is no ozone pre[illegible] in the water received by the radwaste floor dra[illegible] tank.

Although small quantities of ozone could be released from the trailer to the atmosphere, no permits or approval is required for this release by the Missouri Department of Natural Resources (DNR). However, DNR was notified of this temporary process being used at Callaway. Therefore, this process did not constitute an unreviewed environmental question per Section 3.1 of Appendix B to the Callaway Plant Operating License.

2.4 Request for Resolution 13922

2.4.1 Description of Change

This change involves location of a portable non-destructive decontamination facility outside the roll up doors on the plant south east corner of the radwaste building. The facility was used to decontaminate tools and other equipment using pelletized CO_2 in support of Refuel 6 activities.

2.4.2 Evaluation of Change

Temporary positioning the portable non-destructive decontamination facility outside the radwaste building does not impact any cultural resources in the area. The location of the decontamination facility was onsite in an area previously disturbed during site preparation and plant construction. Therefore, this change does not constitute an unreviewed environmental question per Section 3.1 of Appendix B to the Callaway Plant Operating License.

2.5 Plant Procedure CTP-ZZ-00450, Rev. 3

2.5.1 Description of Change

The procedure was revised to incorporate a new water treatment program for the circulating and service water systems. The new water treatment program provides the same corrosion, fouling and scaling protection without the use of zinc chloride.

2.5.2 Evaluation of Change

Implementation of the new water treatment program has a positive impact on the quality of the water discharged via cooling tower blowdown since zinc treatment is being eliminated. In addition, the polyelectrolyte used for coagulation at the water treatment plant will be BULAB 5013 instead of Western Water 226P. These two products are essentially the same.

The Missouri Department of Natural Resources was notified of our intent to implement the new water treatment program and had no objections. Therefore, this change does not constitute an unreviewed environmental question per Section 3.1 of Appendix B to the Callaway Plant Operating License.

2.6 Plant Procedure ETP-AQ-ST003, Rev. 0

2.6.1 Description of Change

This procedure describes a test to evaluate the effectiveness of ethanol amine (ETA) for pH control in the secondary system as an alternative to ammonia. The test was conducted from April 15, 1993, to October 1, 1993.

2.6.2 Evaluation of Change

During the test period ETA is stored in a single 350 gallon stainless steel container until it is diluted to 40 percent when transferred to the ammonia day tank. As ETA circulates in the secondary system a portion of it is removed by the condensate polishers. As polisher resin is regenerated, small amounts of ETA is present in the regeneration waste discharged through liquid radwaste. The expected concentration of ETA in the plant discharge is 40 ppm. ETA was not previously identified in the Callaway Plant NPDES Permit. However, the Missouri Department of Natural Resources was notified of our intent to perform this test and had no objections. Therefore, this change does not constitute an unreviewed environmental question per Section 3.1 of Appendix B to the Callaway Plant Operating License.

2.7 Plant Procedure ETP-AQ-ST003, Rev. 0

2.7.1 Description of Change

The procedure was revised to allow addition of hydrogen peroxide to the discharge monitoring tanks (DMT's) as a biocide. Hydrogen peroxide is used to reduce the algae formation in the DMT's.

2.7.2 Evaluation of Change

With the DMT full and on recirculation, 12 liters of 30 percent hydrogen peroxide is added to the tank. This correlates to an initial hydrogen peroxide concentration of approximately 10 ppm and is not allowed to exceed 12 ppm. The tank is recirculated for three hours prior to discharging to the Missouri river. Upon oxidizing various constituents present in the tank, the concentration of hydrogen peroxide is reduced considerably before discharge and has no adverse effect on the environment. Notification and/or approval by the Missouri Department of Natural Resources (DNR) is not required since DNR was previously notified of the use of hydrogen peroxide as a chemical shock and biocide treatment in water systems which could be discharged from the plant. Therefore, this change does not constitute an unreviewed environmental question per Section 3.1 of Appendix B to the Callaway Plant Operating License.

2.8 Final Safety Analysis Report Change Notice No. 92-38

2.8.1 Description of Change

This involves changes to operation of the boron recycle system, steam generator blowdown system, and secondary liquid waste system as described in FSAR Chapters 9.3.6, 10.4.8, and 10.4.10 respectfully. These changes reflect current operational philosophy for the radwaste treatment systems.

2.8.2 Evaluation of Change

The changes made to the FSAR reflect actual operation of systems within radwaste and does not change the quality of the final effluent discharged to the environment. The radwaste system was designed with a considerable amount of flexibility. Operation of the system as reflected by this change notice results in operating the equipment economically without affecting effluent quality. This change allows use of the latest technology available for radwaste processing. Therefore, this change does not constitute an unreviewed environmental question per Section 3.1 of Appendix B to the Callaway Plant Operating License.

2.9 Final Safety Analysis Report Change Notice No. 92-43

2.9.1 Description of Change

This involves changes to FSAR chapters 11.1 and 11.2 to reflect the current operation of the liquid radwaste treatment system. These changes describe current operation of the liquid radwaste treatment system and provide the needed flexibility to determine the most economical method to process liquid waste.

2.9.2 Evaluation of Change

This change reflects actual operation of the liquid radwaste system. The actual mode of processing and control includes only minor changes to liquid effluents discharged at Callaway. Increases in the total volume of water discharged are due to an increase in secondary liquid waste. These changes were previously addressed in Amendment 2 to License NPF-30 when two discharge monitoring tanks were installed. The waste holdup tank is normally processed and discharged rather than recycled to the refueling water storage tank as assumed in the original design basis. Although this results in a slight increase in the volume discharged, the actual doses to the public from liquid effluents are lower than those originally calculated. Other changes involve process changes to allow more flexibility in treatment methods so the most economical and environmental feasible methods are utilized without jeopardizing water quality.

Laboratory chemical wastes are no longer solidified but routed to the radwaste floor drain tank, processed, and discharged via discharge monitoring tanks. This waste stream was not included in the Final Environmental Statement evaluation of chemical discharges from Callaway. However, chemical wastes are identified as possible sources of water discharged from the plant in our NPDES permit application. The Missouri Department of Natural Resources has reviewed and approved the discharge of chemical wastes and the increased volumes as mentioned above. Therefore, this change does not constitute an unreviewed environmental question per Section 3.1 of Appendix B to the Callaway Plant Operating License.

2.10 Final Safety Analysis Report Change Notice No. 92-45

2.10.1 Description of Change

Changes were made to FSAR chapters 11.4 and 1.2.10 to reflect current operation of the solid radwaste treatment system. These changes provide the needed flexibility to determine the most economical method to process liquid and solid waste.

2.10.2 Evaluation of Change

This change reflects current operation of the solid radwaste system following several modifications and changes in philosophy to further reduce solid radwaste burial volume. The major change involved replacement of the stock cement solidification system with an RVR-800 system.

In addition, laboratory chemical wastes are no longer solidified but routed to the radwaste floor drain tank, processed, and discharged via discharge monitoring tanks. This waste stream was not included in the Final Environmental Statement evaluation of chemical discharges from Callaway. However, laboratory chemical wastes were identified as a possible source of water discharged from the plant in our NPDES permit application. The Missouri Department of Natural Resources has reviewed and approved discharge of laboratory chemical wastes from the Callaway Plant. The small amount of laboratory chemical waste discharged will have no adverse effect on the environment. Therefore, this change does not constitute an unreviewed environmental question per Section 3.1 of Appendix B to the Callaway Plant Operating License.