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REPORT
TO
IOWA ELECTRIC LIGHT AND POWER
CEDAR RAPIDS, IOWA

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM
FOR
THE DUANE ARNOLD ENERGY CENTER
DOCKET NO. 50-331

ANNUAL REPORT - PART I
SUMMARY AND INTERPRETATION
JANUARY - DECEMBER 1992

FOR SUBMITTAL TO
THE NUCLEAR REGULATORY COMMISSION

PREPARED AND SUBMITTED
BY
TELEDYNE ISOTOPES MIDWEST LABORATORY
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PREFACE

The staff members of the Teledyne Isotopes Midwest Laboratory were responsible for the acquisition of data presented in this report with the exception of Appendices D and E which were completed by Iowa Electric personnel. All environmental samples, with the exception of aquatic, were collected by personnel of DAEC. Aquatic samples were collected by University of Iowa Hygenic Laboratory personnel.

The report was prepared by L. G. Huebner, General Manager of the TIML, with the exception of Appendices D and E, which were prepared by Iowa Electric personnel. He was assisted in the report preparation by other staff members of the laboratory.

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1.0 INTRODUCTION

This report summarizes and interprets results of the Environmental Radiological Monitoring Program conducted by Teledyne Isotopes Midwest Laboratory at the Duane Arnold Energy Center, Cedar Rapids, Iowa, during the period January - December 1992. This Program monitors the levels of radioactivity in the air, terrestrial, and aquatic environments in order to assess the impact of the Plant on its surroundings.

Tabulation of the individual analyses made during the year are included in Part II of this report.

Duane Arnold Energy Center (DAEC) is located in Linn County on the Cedar River, Iowa, and is operated by Iowa Electric Light and Power Company. Duane Arnold Nuclear Station is a 565.7 MW(e) boiling water reactor. Initial criticality was attained on 23 March 1974. The reactor reached 100% power on 12 August 1974. Commercial operation began on 1 February 1975.

2.0 SUMMARY

The Environmental Radiological Monitoring Program required by the U.S. Nuclear Regulatory Commission (NRC) Technical Specifications for the Duane Arnold Nuclear Generating Plant is described. Results for 1992 are summarized and discussed.

Program findings show background levels of radioactivity in the environmental samples collected in the vicinity of the Duane Arnold Energy Center. No effect on the environment due to the operation of the Duane Arnold Nuclear Plant is indicated.

3.0 ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM

3.1 Program Design and Data Interpretation

The purpose of the Environmental Radiological Monitoring Program at the Duane Arnold Energy Center (DAEC) is to assess the impact of the plant on its environment. For this purpose, samples are collected from the air, terrestrial, and aquatic environments and analyzed for radioactive content. In addition, ambient gamma radiation levels are monitored by thermoluminescent dosimeters (TLDs).

Sources of environmental radiation include the following:

(1) Natural background radiation arising from cosmic rays and primordial radionuclides;

(2) Fallout from atmospheric nuclear detonations;

(3) Releases from nuclear power plants; and

(4) Industrial and medical radioactive waste.

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

A major interpretive aid in assessment of these effects is the design of the monitoring program at the DAEC which is based on the indicator-control concept. Most types of samples are collected both at indicator locations (nearby, downwind, or downstream) and at control locations (distant, upwind, or upstream). A station effect would be indicated if the radiation level at an indicator location was significantly larger than that at the control location. The difference would have to be greater than could be accounted for by typical fluctuations in radiation levels arising from other sources.

An additional interpretive technique involves analyses for specific radionuclides present in the environmental samples collected from the DAEC site. The DAEC's monitoring program includes analyses for strontium-90 and iodine-131, which are fission products, and tritium, which is produced by cosmic rays, atmospheric nuclear detonations, and also by nuclear power plants. Most samples are also analyzed for gamma-emitting isotopes with results for the following groups quantified: zirconium-95, cesium-137, and cerium-144. These three gamma-emitting isotopes were selected as radiological impact indicators because of the different characteristic proportions in which they appear in the fission product mix produced by a nuclear reactor and that produced by a nuclear detonation. Each of the three isotopes is produced in roughly equivalent amounts by a reactor: each constitutes about 10% of the total activity of fission products ten (10) days after reactor shutdown. On the other hand, ten (10) days after a nuclear explosion, the contributions of zirconium-95, cerium-144, and cesium-137 to the activity of the resulting debris are in the approximate ratio 4:1:0.03 (Eisenbud, 1963). The other group quantified consists of niobium-95, ruthenium-103 and -106, cesium-134, barium-lanthanum-140, and cerium-141. These isotopes are released in

3.1 Program Design and Data Interpretation (continued)

small quantities by nuclear power plants, but to date their major source of injection into the general environment has been atmospheric nuclear testing. Nuclides of the next group, manganese-54, cobalt-58 and-60, and zinc-65, are activation products and arise from activation of corrosion products. They are typical components of nuclear power plant effluents, but are not produced in significant quantities by nuclear detonations. Nuclides of the final group, beryllium-7, which is of cosmogenic origin, and potassium-40, a naturally-occurring isotope, were chosen as calibration monitors and should not be considered radiological impact indicators.

Characteristic properties of isotopes quantified in gamma-spectroscopic analysis are presented in Table 5.1. Other means of distinguishing sources of environmental radiation can be employed in interpreting the data. Current radiation levels can be compared with previous levels, including those measured before the Plant became operational. Results of the DAEC's Monitoring Program can be related to those obtained in other parts of the world. Finally, results can be related to events known to cause elevated levels of radiation in the environment, e.g., atmospheric nuclear detonations.

3.2 Program Description

The sampling and analysis schedule for the environmental radiological monitoring program at the DAEC is summarized in Table 5.2 and is briefly reviewed below. Table 5.3 defines the sampling location codes used in Table 5.2 and specifies for each location its type (indicator or control) and its distance, direction, and sector relative to the reactor site. The types of samples collected at each location and the frequency of collections are presented in Table 5.4 using codes defined in Table 5.5.

To monitor the air environment, airborne particulates are collected on membrane filters by continuous pumping at twelve (12) locations. Also, airborne iodine is collected by continuous pumping through charcoal filters at six (6) of these locations. Nine (9) of the twelve (12) locations are indicators and three (3) are controls (D-1, D-2, and D-13). Filters are changed and counted weekly. Particulate filters are analyzed for gross beta activity. If gross beta activity exceeds 10 times the yearly mean of the control samples gamma isotopic analysis is performed. Quarterly composites of airborne particulates from each location are gamma scanned on a germanium detector.

All charcoal filters are analyzed weekly for I-131 on all samples.

Ambient gamma radiation is monitored at twelve (12) air sampling locations. In addition, gamma radiation is monitored at thirty-two (32) special locations: seventeen (17) in a circle within 0.5 mi radius of the DAEC stack; six (6) in 22.5° sectors within 1 mi of the DAEC stack; and nine (9) in 22.5° sectors between 1 and 3 miles of the DAEC stack. Two TLDs are placed at each location and are exchanged and analyzed quarterly.

3.2 Program Description (continued)

Precipitation samples are collected monthly from one location and analyzed for gamma-emitting isotopes. Quarterly composites are analyzed for tritium.

Milk samples are collected monthly from seven (7) locations during the non-grazing season, October through April, and biweekly during the grazing season, May 1 through September 30. One of the locations is a control (D-105) and the rest are indicators. All samples are analyzed for I-131 and gamma-emitting isotopes.

For additional monitoring of the terrestrial environment, grain, hay, and broad leaf natural vegetation samples are collected annually from nine (9) locations: one control (D-105) and eight (8) indicators (D-57, D-58, D-63, D-72, D-93, D-94, D-106 and D-16). Grain, hay, and broad leaf (green leafy) vegetation samples are analyzed for gamma-emitting isotopes and at least one broad leaf vegetation is analyzed for iodine-131. When meat is slaughtered for home use, it is collected annually during or immediately following a grazing period from animals grazing on-site. The sample is analyzed for gamma-emitting isotopes. Also, potable ground water is collected quarterly from a treated municipal water system (D-53), the inlet to the municipal water treatment system (D-54), and four (4) additional ground water locations (D-55, D-57, D-58, and D-72). The samples are analyzed for gross beta and tritium. If gross beta activity exceeds 10 times yearly mean of the control samples, gamma isotopic, strontium-89, and strontium-90 analyses are performed.

Soil samples are collected once per year at two indicator locations (D-15 and D-16). The samples are analyzed for strontium-90 and gamma-emitting isotopes.

Surface water is collected monthly from five (5) river, pond, and sewage effluent locations, one (1) control (D-49) and four (4) indicator (D-50, D-51, D-99, and D-107). All monthly samples are analyzed for gamma-emitting isotopes. Tritium analyses are performed on quarterly composites from each location. In addition, all samples from Location D-107 (plant sewage discharge) are analyzed for K-40 by flame photometry.

The aquatic environment is also monitored by upstream and downstream (D-49 and D-61) semiannual collections of fish. River bottom sediment is also collected semiannually at the plant's intake and discharge (D-50 and D-51) and downstream of the sewage plant (D-107). The samples are analyzed for gamma-emitting isotopes.

3.3 Program Execution

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

(1) No TLD data were available for Location D-8 for the second quarter of 1992. The TLDs were lost in the field.

(2) No TLD data were available for Location D-41 for the fourth quarter of 1992. The TLDs were lost in the field.

(3) No milk samples were availabe from location D-93 and D-101 on 01-07-92.

3.3 Program Execution (continued)

(4) No milk samples were available from location D-101 on 02-04-92.

(5) No milk samples were available from location D-101 on 03-03-92.

(6) No milk samples were available from location D-101 on 04-07-92.

(7) No milk samples were available from location D-101 on 05-04-92 and 05-19-92.

(8) No air particulate data were available from location D-03 on 01-23-92 and 01-29-92. There was no power to the substation. No air particulate data was available from location D-11 on 03-12-92. The sample was missing due to vandalism. No air particulate/air iodine data were available from location D-15 on 04-16-92 and 04-23-92. Power was out at the substation. No air particulate datum was available from location D-03 on 11-12-92. The filter paper was missing from the holder.

3.4 Laboratory Procedures

All iodine-131 analyses in milk were made by using a sensitive radio-chemical procedure which involves separation of the element of interest by use of an ion-exchange resin and subsequent beta counting.

All gamma-spectroscopic analyses were performed with high resolution germanium detectors. Levels of iodine-131 in natural vegetation were determined by gamma spectrometry. Levels of airborne iodine-131 in charcoal samples were measured by gamma spectrometry.

Tritium levels were determined by the liquid scintillation technique.

Analytical Procedures used by TIML are specified in detail elsewhere (Teledyne Isotopes Midwest Laboratory, 1992). Procedures are based on those prescribed by the National Center for Radiological Health of the U.S. Public Health Service (U.S. Public Health Service, 1967) and by the Health and Safety Laboratory of the U.S. Atomic Energy Commission (U.S. Atomic Energy Commission, 1972).

Details of TIML's QA program are presented elsewhere (Teledyne Isotopes Midwest Laboratory, 1992). The TIML QA Program includes participation in the Interlaboratory Comparison (Crosscheck) Program. Results obtained in the crosscheck program are presented in Appendix A.

3.5 Program Modifications

There were no program modifications made in 1992.

4.0 RESULTS AND DISCUSSION

All of the scheduled collections and analyses were made on schedule except those listed in Table 5.6.

All results are summarized in Table 5.7 in a format recommended by the Nuclear Regulatory Commission in Regulatory Guide 4.8. For each type of analysis of each sample medium, this table lists the mean and range of all indicator and control locations. The locations with the highest mean and range are also shown.

The tabulated results of all measurements made in 1992 are not included in this section, although references to these results will be made in the discussion. The complete tabulation of the 1992 results is contained in Part II of the 1992 Annual Report on the Environmental Radiological Monitoring Program for the Duane Arnold Energy Center.

4.1 Atmospheric Nuclear Detonations and Nuclear Accidents

There were no reported atmospheric nuclear tests in 1992. The last reported test was conducted by the People's Republic of China on October 16, 1980. The reported yield was in the 200 kiloton to 1 megaton range.

There were no reported accidents at nuclear reactor facilities in 1992.

4.2 Program Findings

Results obtained show background levels of radioactivity in the environmental samples collected in 1992.

Airborne Particulates

The average annual gross beta concentration in airborne particulates was similar at indicator and control locations (0.022 and 0.023 pCi/m^3, respectively) and was similar to levels in 1982 (0.026 pCi/m^3, at both indicator and control locations), 1983 (0.022 and 0.024 pCi/m^3, respectively), 1984 (0.025 and 0.026 pCi/m^3, respectively), 1985 (0.024 pCi/m^3 at both locations), in 1986 (0.024 pCi/m^3, at both indicator and control locations), in 1987 (0.024 and 0.026 pCi/m^3, respectively), in 1988 (0.026 and 0.028 pCi/m^3, respectively), in 1989 (0.026 and 0.029 pCi/m^3, respectively) in 1990 (0.022 and 0.024 pCi/m^3, respectively), and in 1991 (0.023 and 0.022 pCi/m^3 respectively). The average of 0.024 pCi/m^3 for 1986 does not include the results from May 15 to June 12, 1986, which were influenced by the accident at Chernobyl.

A spring peak in beta activity had been observed almost annually for many years (Wilson et al., 1969). It had been attributed to fallout of nuclides from the stratosphere (Gold et al., 1964). It was pronounced in 1981, occurred to a lesser degree in 1982, and did not occur in 1983, 1984, 1985, 1987, 1988, 1989, 1990, 1991, or 1992. In 1986, the spring peak could not be identified because it was overshadowed by the releases of radioactivity from Chernobyl.

Airborne Particulates (continued)

Gamma spectroscopic analysis of quarterly composites of air particulate filters yielded similar results for indicator and control locations. Beryllium-7, which is produced continuously in the upper atmosphere by cosmic radiation (Arnold and Al-Salih, 1955), was detected in all samples. All other gamma-emitting isotopes were below their respective LLD limits. No plant effect was indicated.

Airborne Iodine

Weekly levels of airborne iodine-131 were below the lower limit of detection (LLD) of 0.07 pCi/m^3 in all samples with one exception (<0.11 pCi/m^3). The higher LLD was due to low volume.

Ambient Radiation (TLDs)

At twelve (12) air sampling locations, the TLD readings averaged 14.5 mR/quarter at indicator locations and 13.1 mR/quarter at control locations. At locations within 0.5 mile, 1.0 mile, and 3.0 mile radius of the stack, the measurements averaged 17.8 mR/quarter, 19.1 mR/quarter, and 17.4 mR/quarter, respectively. The average for all locations was 16.9 mR/quarter. This is slightly lower than the estimated average natural background radiation for Middle America, 19.5 mR/quarter, which is based on data on Pages 71 and 108 of the report, "Natural Background Radiation in the United States" (National Council on Radiation Protection and Measurements, 1975). The terrestrial absorbed dose (uncorrected for structural and body shielding) ranges from 8.8 to 18.8 mrad/quarter and averages 11.5 mrad/quarter for Middle America. Cosmic radiation and cosmogenic radionuclides contribute 8.0 mrad/quarter for a total average of 19.5 mrad/quarter. No plant effect was indicated.

Precipitation

In precipitation, the tritium concentration was below the LLD of 330 pCi/L in all samples. All gamma-emitting isotopes were below their respective LLDs. No plant effect was indicated.

Milk

Iodine-131 results were below the detection limit of 1.0 pCi/L in all samples.

No gamma-emitting isotopes, except naturally occurring potassium-40, were detected in any milk samples. This is consistent with the finding of the National Center for Radiological Health that most radiocontaminants in feed do not find their way into milk due to the selective metabolism of the cow. The common exceptions are radioisotopes of potassium, cesium, strontium, barium, and iodine (National Center for Radiological Health, 1968).

In summary, the milk data for 1992 show no radiological effects of the plant operation.

Ground Water

The annual mean for gross beta activity measured 3.0 pCi/L and was similar to the levels observed in 1980 through 1991. The location with the highest mean (5.4 pCi/L) was D-58, a farm 1.0 miles distant from the plant. Tritium was below the LLD of 330 pCi/L in all samples. No plant effect was indicated.

Vegetation

Iodine-131 results in broad leaf vegetation were below the LLD level of 0.060 pCi/g wet weight in all samples.

Except for potassium-40, which was observed in all samples (broadleaf vegetation, corn, and hay), all other gamma-emitting isotopes were below detection limits in all samples. No plant effect was indicated.

Soil

Strontium-90 was detected in both samples and averaged 0.040 pCi/g dry weight.

Cesium-137 was detected in one sample at a concentration of 0.26 pCi/g dry weight. Both strontium-90 and cesium-137 concentrations were similar to levels observed in 1987 (0.08 and 0.30 pCi/g dry weight, respectively), in 1988 (0.064 and 0.33 pCi/g dry weight, respectively), in 1989 (0.046 and 0.18 pCi/g dry weight, respectively), in 1990 (0.066 and 0.21 pCi/g dry weight, respectively, and in 1991 (0.064 and 0.34 pCi/g dry weight, respectively).

The only other gamma-emitting isotope detected was potassium-40 and averaged 11.0 pCi/g dry weight. No plant effect on soil was indicated.

Surface Water

Tritium was below the LLD level of 330 pCi/L in all samples.

All gamma-emitting isotopes were below their respective LLDs.

K-40 was measured at one location, D-107 (plant sewage discharge onsite). The concentration ranged from 15.8 to 30.3 pCi/L and averaged 21.0 pCi/L.

No plant effect on the radioactivity of surface water was indicated.

Fish

All gamma-emitting isotopes, except naturally-occurring potassium-40, in edible portions were below detection limits. The potassium-40 level was similar at both indicator and control locations (3.19 and 2.93 pCi/g wet weight, respectively). No plant effect on fish was indicated.

River Sediments

River sediments were collected in May and October, 1992, and analyzed for gamma-emitting isotopes. Cobalt-60 was detected in two samples from location D-107 (sewage effluent) and averaged 0.22 pCi/g dry weight. Cesium-137 was detected in one sample at a concentration of 0.062 pCi/g dry weight. Potassium-40 ranged from 5.52 to 10.34 pCi/g dry weight and averaged 7.65 pCi/g dry weight.

All other gamma-emitting isotopes were below detection limits. There was no indication of a plant effect on the environment.

NOTE: Page 11 is intentionally left out.

5.0 TABLES AND FIGURES

Table 3.1 Characteristic properties of isotopes quantified in gamma-spectroscopic analyses.

Designation	Comment	Isotope	Half-life[a]
I. Naturally occurring			
A. Cosmogenic	Produced by interaction of cosmic rays with atmosphere	Be-7	53.2 d
B. Terrestial	Primordial	K-40	1.26×10^9 y
II. Fission Products[b]	Nuclear detonations constitute the major environmental source		
A. Short-lived		I-131	8.04 d
		Ba-140	12.8 d
B. Other than short-lived		Nb-95	35.15 d
		Zr-95	65 d
		Ru-103	39.35 d
		Ru-106	368.2 d
		Cs-134	2.061 y
		Cs-137	30.174 y
		Ce-141	32.5 d
		Ce-144	284.31 d
III. Activation Products	Typically found in nuclear power plant effluents	Mn-54	312.5 d
		Fe-59	45.0 d
		Co-58	70.78 d
		Co-60	5.26 y
		Zn-65	245 d

[a] Half-lives are taken from Appendix E of Environmental Quarterly, 1 January 1978, EML-334 (U.S. Department of Energy, 1978).
[b] Includes fission-product daughters.

Table 2. Sample collection and analysis program, 1992.

Exposure Pathway and/or Sample	Sampling Location: Sample Point	Sampling Location: Description	Sampling and Collection Frequency	Type and Frequency of Analysis
Airborne Particulates	1	Cedar Rapids (C)	Continuous operation of sampler with sample collection at least once per week or as required by dust loading.	Analyze for gross beta activity more than 24 hours after filter change. Perform gamma isotopic analysis[a] on each sample having gross beta activity greater than ten times the yearly mean of the control samples. Composite weekly samples to form a quarterly composite (by location). Analyze quarterly composite for gamma isotopic.
	2	Marion (C)		
	3	Hiawatha		
	5	Palo		
	6	Center Point		
	7	Shellsburg		
	8	Urbana		
	10	Atkins		
	11	Toddville		
	13	Alburnett (C)		
	15	On-site North		
	16	On-site South		
Airborne Iodine	2	Marion (C)	Continuous operation of sampler with sample collection at least once per week.	Analyze each cartridge for iodine-131
	5	Palo		
	7	Shellsburg		
	8	Urbana		
	11	Toddville		
	15	On-site North		
Ambient Radiation	1-3, 5-8, 10,11, 13,15, 16	Air Particulate Locations	Two dosimeters continuously at each location. Both dosimeters are changed at least quarterly.	Read gamma radiation dose quarterly on one dosimeter. Anneal and repackage the second dosimeter.
	18-23, 28-32, 82-86, 91	Within 0.5 mile of Stack		

Table 2. Sample collection and analysis program, 1992 (continued)

Exposure Pathway and/or Sample	Sampling Location: Sample Point	Sampling Location: Description	Sampling and Collection Frequency	Type and Frequency of Analysis
Ambient Radiation (continued)	33-41	Within 3.0 miles of Stack	Two dosimeters continuously at each location. Both dosimeters are changed at least quarterly.	Read gamma radiation dose quarterly on one dosimeter. Anneal and repackage the second dosimeter.
	43-48	Within 1.0 mile of stack		
Surface Water	49	Lewis Access (C)	Once per month	Gamma isotopic analyses of each sample (by location)[a].
	50	Plant Intake (C)		
	51	Plant Discharge		
	99	Pleasant Creek		Composite monthly samples to form quarterly composite (by location). Analyze quarterly composite for tritium.
	107	Plant Sewage Discharge		
Ground Water (Potable)	53	Treated Municipal Water	Grab sample at least once per quarter.	Gross beta and tritium activity analysis on quarterly sample. If gross beta is greater than ten times the yearly mean of control samples, perform gamma isotopic and Sr-89 and Sr-90 analyses.
	54	Inlet to Municipal Water Treatment System		
	55	On-site well		
	57,58	Wells off-site and		
	72	within 4 km of DAEC		

[a] I-131 analysis by radiochemistry.

Table 3.2. Sample collection and analysis program, 1992 (continued).

Exposure Pathway and/or Sample	Sampling Location: Sample Point	Sampling Location: Description	Sampling and Collection Frequency	Type and Frequency of Analysis
River Sediment	50 51 107	Plant Intake (C) Plant Discharge Sewage Effluent Canal	At least once every six months	Gamma isotopic analysis of each sample.
Vegetation	16, 57, 58, 63, 72, 93, 94, 106, 105 (C)	Farms that raise food crops	Annually at harvest time. One sample of each: grain, green leafy, and forage. At least one sample should be broadleaf vegetation.	Gamma isotopic analysis of edible portions. I-131 analysis on broad leaf vegetation.
Fish	49	Cedar River upstream of DAEC not influenced by effluent (C)	One sample per 6 months (once during January through July and once during August through December).	Gamma isotopic analysis on edible portions.
	61	Downstream of DAEC in influence of effluent		

Table 3.2. Sample collection and analysis program, 1992 (continued).

Exposure Pathway and/or Sample	Sampling Location: Sample Point	Sampling Location: Description	Sampling and Collection Frequency	Type and Frequency of Analysis
Milk[b]	105	Control farm near Amana, Iowa	At least once per two weeks during the grazing season.	During the grazing season: Gamma isotopic and iodine-131 analyses of each sample.
	63, 93 94, 96, 101, 106	Dairy Farms within 10 miles of site	At least once per month during non-grazing season.	During the non-grazing season: Gamma isotopic and iodine-131 analyses of each sample.
Precipitation		On-site	Monthly	Gamma isotopic on all samples
		On-site		Tritium on quarterly composites.
Meat[c]		Onsite	Annually	Gamma Isotopic.
Soil	15, 16	Onsite	Annually	Gamma isotopic and Sr-90.

[a] Gamma isotopic analysis and analysis for gamma-emitting nuclides refer to high resolution gamma ray spectrum analysis. Any radionuclide detected at a concentration greater than the lower limit of detection (LLD) should be reported quantitatively; conversely, any radionuclide concentration less than the LLD should not be reported.

[b] The grazing season is considered to be May 1 through September 30.

[c] Meat was not collected in 1992, no animals slaughtered for home use.

Table 5.3 Sampling locations, Duane Arnold Energy Center.

Code	Type[a]	Sampling Location: Sampling Point	Sampling Location: Location Description	Sampling Location: Distance and Direction from Site Stack
D-1	C	1	Cedar Rapids	11 mi @ 135° SE
D-2	C	2	Marion	11 mi @ 125° ESE
D-3		3	Hiawatha	7 mi @ 130° SE
D-5		5	Palo	3 mi @ 200° SSW
D-6		6	Center Point	7 mi @ 0° N
D-7		7	Shellsburg	6 mi @ 255° W
D-8		8	Urbana	10 mi @ 345° NW
D-10		10	Atkins	9 mi @ 210° SSW
D-11		11	Toddville	4 mi @ 90° E
D-13	C	13	Alburnett	9 mi @ 70° ENE
D-15		15	On-site, Northwest	0.5 mi @ 305° NW
D-16		16	On-site, South	0.5 mi @ 190° SSE
D-18		18		0.5 mi NNE
D-19		19		0.5 mi NE
D-20		20		0.5 mi ENE
D-21		21		0.5 mi ENE
D-22		22		0.5 mi E
D-23		23		0.5 mi ESE
D-28		28		0.5 mi WSW
D-29		29		0.5 mi W
D-30		30		0.5 mi WNW
D-31		31		0.5 mi NW
D-32		32		0.5 mi NNW
D-33		33		3.0 mi N
D-34		34		3.0 mi NNE
D-35		35		3.0 mi NE
D-36		36		3.0 mi ENE
D-37		37		3.0 mi E
D-38		38		3.0 mi ESE
D-39		39		3.0 mi SE
D-40		40		3.0 mi SSE
D-41		41		3.0 mi S
D-43		43		1.0 mi SSW
D-44		44		1.0 mi WSW
D-45		45		1.0 mi W
D-46		46		1.0 mi WNW
D-47		47		1.0 mi WNW
D-48		48		1.0 mi NW
D-49	C	49	Lewis Access, upstream of DAEC	4.0 mi NNW

Table 5.3 Sampling locations, Duane Arnold Energy Center (continued)

Code	Type[a]	Sampling Location: Sampling Point	Sampling Location: Location Description	Sampling Location: Distance and Direction from Site Stack
D-50	C	50	Plant Intake	
D-51		51	Plant Discharge	
D-53		53	Treated Municipal Water	
D-54		54	Inlet to Municipal Water Treatment System	
D-55		55	On-site Well	
D-57		57	Farm (Off-site well)	1.0 mi WSW
D-58		58	Farm (Off-site well)	0.5 mi WSW-SW
D-61		61	0.5 mi downstream of plant discharge	
D-63		63	Farm	1.5 mi WNW
D-72		72	Farm	2.0 mi SSW
D-82		82		0.5 mi SE
D-83		83		0.5 mi SSE
D-84		84		0.5 mi S
D-85		85		0.5 mi SSW
D-86		86		0.5 mi SW
D-91		91		0.5 mi N
D-93		93	Farm	2.8 mi NNE
D-94		94	Farm	2.7 mi N
D-96		96	Farm	8.0 mi SSW
D-99		99	Pleasant Creek Lake	2.5 mi WNW
D-101		101	Farm	4.0 mi E
D-105	C	105	Farm	21.3 mi SSW
D-106		106	Farm	4.5 mi SE
D-107		107	Sewage Effluent Canal	Onsite

[a] "C" denotes control location. All other locations are indicators.

Table 5.4 Type and frequency of collection.

Location	Location Type[a]	Weekly	Monthly	Quarterly	Semi-Annually	Annually
D-1	C	AP		TLD		
D-2	C	AP,AI		TLD		
D-3		AP		TLD		
D-5		AP,AI		TLD		
D-6		AP		TLD		
D-7		AP,AI		TLD		
D-8		AP,AI		TLD		
D-10		AP		TLD		
D-11		AP,AI		TLD		
D-13	C	AP		TLD		
D-15		AP,AI		TLD		SO
D-16		AP		TLD		SO, G[b]
D-18 through D-23				TLD		
D-28 through D-41				TLD		
D-43 through D-48				TLD		
D-49	C		SW		F	
D-50	C		SW		RS	
D-51			SW		RS	
D-53			WW			
D-54			WW			
D-55			WW			
D-57			WW			G[b]
D-58			WW			G[b]
D-61					F	
D-63			M[c]			G[b]
D-72			WW			G[b]
D-82 through D-86				TLD		
D-91				TLD		
D-93			M[c]			G[b]
D-94			M[c]			G[b]
D-96			M[c]			
D-99			SW			

Table 5.4 Type and frequency of collection (continued)

Location	Location Type[a]	Weekly	Monthly	Quarterly	Semi-Annually	Annually
D-101			M[c]			
D-105	C		M[c]			G[b]
D-106			M[c]			G[b]
D-107			SW		RS	
On-site			P			ME

[a] Control locations are indicated by a "C" in this column. All other locations are indicators.
[b] Vegetation (G) includes broad leaf vegetation and grain.
[c] Monthly from October through April; weekly from May through September.

Table 5.5. Sample codes used in Table 5.4.

Code	Description
AP	Airborne Particulates
AI	Airborne Iodine
TLD	Thermoluminescent Dosimeter
P	Precipitation
M	Milk
W W	Well Water
G	Vegetation (broadleaf and grain)
ME	Meat
SO	Soil
S W	Surface Water
F	Fish
RS	River Sediment

Table 5.6. Missed collections and analyses, Duane Arnold Energy Center, 1992.

Sample	Analysis	Location	Collection Date or Period	Comments
Milk	I-131, Gamma	D-93	01-07-92	Animal dry.
Milk	I-131, Gamma	D-101	01-07-92	Animal dry.
AP	Gross Beta	D-3	01-23-92	Power out at Substation.
AP	Gross Beta	D-3	01-29-92	Power out at Substation.
Milk	I-131, Gamma	D-101	02-04-92	Animal dry.
Milk	I-131, Gamma	D-101	03-03-92	Animal dry.
AP	Gross Beta	D-11	03-12-92	Filter missing.
Milk	I-131, Gamma	D-101	04-07-92	Animal dry.
AP/AI	Gross Beta/I-131	D-15	04-16-92	Power not available
AP/AI	Gross Beta/I-131	D-15	04-23-92	Power not available
Milk	I-131, Gamma	D-101	05-04-92	Animal dry.
Milk	I-131, Gamma	D-101	05-19-92	Animal dry.
TLD	Gamma	D-8	2nd Qtr.,1992	Lost in the field.
AP	Gross Beta	D-3	11-12-92	Filter missing.
TLD	Gamma	D-41	4th Qtr.,1992	Lost in the field.

.7 Environmental Radiological Monitoring Program Summary.

Name of Facility Duane Arnold Energy Center Docket No. 50-331
Location of Facility Linn, Iowa Reporting Period January - December 1992
(County, State)

Sample Type (Units)	Type and Number of Analyses[a]		LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean Location[d]	Location with Highest Annual Mean Mean (F)[c] Range[c]	Control Locations Mean (F)[c] Range[c]	Number of Non-routine Results[e]
Airborne Particulates (pCi/m^3)	GB	618	0.004	0.022 (461/462) (0.004-0.060)	D-3[f], Hiawatha 7 mi SE	0.024 (50/52) (0.008-0.056)	0.023 (155/156) (0.004-0.057)	0
	GS	48						
	Be-7		0.012	0.064 (36/36) (0.018-0.11)	D-3, Hiawatha 7 mi SE	0.082 (4/4) (0.067-0.11)	0.060 (12/12) (0.041-0.090)	0
	Nb-95		0.0054	<LLD	-	-	<LLD	0
	Zr-95		0.0072	<LLD	-	-	<LLD	0
	Ru-103		0.0058	<LLD	-	-	<LLD	0
	Ru-106		0.029	<LLD	-	-	<LLD	0
	Cs-134		0.0028	<LLD	-	-	<LLD	0
	Cs-137		0.0026	<LLD	-	-	<LLD	0
	Ce-141		0.0057	<LLD	-	-	<LLD	0
	Ce-144		0.017	<LLD	-	-	<LLD	0
Airborne Iodine	I-131	310	0.07	<LLD	-	-	<LLD	0
TLD, AP Locations (mR/Qtr.)	Gamma	47	1	14.5 (35/35) (12.2-16.3)	D-5, Palo 3 mi SSW	15.7 (4/4) (15.4-16.1)	13.1 (12/12) (11.9-14.6)	0
TLD, Within 0.5 mi radius of stack (mR/Qtr.)	Gamma	68	1	17.8 (68/68) (12.9-24.0)	D-31, Onsite 0.5 mi NW	22.9 (4/4) (21.3-24.0)	None	0
TLD, Within 1.0 mi radius of stack (mR/Qtr.)	Gamma	24	1	19.1 (24/24) (15.7-22.8)	D-48, 1.0 mi NW	21.2 (4/4) (19.7-22.8)	None	0
TLD, Within 3.0 mi radius of stack (mR/Qtr.)	Gamma	35	1	17.4 (35/35) (13.1-22.0)	D-37, 3.0 mi E	21.2 (4/4) (20.4-22.0)	None	0

.7 Environmental Radiological Monitoring Program Summary.

Name of Facility Duane Arnold Energy Center Docket No. 50-331
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(County, State)

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean: Location[d]	Location with Highest Annual Mean: Mean (F)[c] Range[c]	Control Locations Mean (F)[c] Range[c]	Number of Non-routine Results[e]
Precipitation (pCi/L)	H-3 4	330	<LLD	-	-	None	0
	GS 12						
	Mn-54	7	<LLD	-	-	None	0
	Fe-59	16	<LLD	-	-	None	0
	Co-58	7	<LLD	-	-	None	0
	Co-60	7	<LLD	-	-	None	0
	Zn-65	14	<LLD	-	-	None	0
	Nb-95	8	<LLD	-	-	None	0
	Zr-95	12	<LLD	-	-	None	0
	I-131	36	<LLD	-	-	None	0
	Cs-134	6	<LLD	-	-	None	0
	Cs-137	6	<LLD	-	-	None	0
	Ba-140	59	<LLD	-	-	None	0
	La-140	15	<LLD	-	-	None	0
Milk (pCi/L)	I-131 119	1.0	<LLD	-	-	<LLD	0
	GS 119						
	K-40	100	1350 (101/101) (890-1920)	D-101, Farm 4.0 mi E	1720 (12/12) (1500-1920)		0
	Cs-134	15	<LLD	-	-	<LLD	0
	Cs-137	18	<LLD	-	-	<LLD	0
	Ba-140	60	<LLD	-	-	<LLD	0
	La-140	15	<LLD	-	-	<LLD	0
Ground Water (pCi/L)	Gross Beta 24	1.1	3.0 (16/24) (1.1-8.4)	D-58, Farm 1.0 mi WSW-SW	5.4 (4/4) (3.9-8.4)	None	0
	H-3 24	330	<LLD	-	-	None	0

5.7 Environmental Radiological Monitoring Program Summary.

Name of Facility Duane Arnold Energy Center Docket No. 50-331
Location of Facility Linn, Iowa Reporting Period January - December 1992
(County, State)

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean: Location[d]	Location with Highest Annual Mean: Mean (F)[c] Range[c]	Control Locations Mean (F)[c] Range[c]	Number of Non-routine Results[e]
Broad Leaf Vegetation (pCi/g wet)	I-131 8	0.060	<LLD	-	-	<LLD	0
	GS 8						
	K-40	0.5	3.74 (7/7) (1.96-10.90)	D-16, Onsite 0.5 mi SSE	10.90 (1/1)	6.30 (1/1)	0
	Mn-54	0.038	<LLD	-	-	<LLD	0
	Co-58	0.041	<LLD	-	-	<LLD	0
	Co-60	0.042	<LLD	-	-	<LLD	0
	Nb-95	0.043	<LLD	-	-	<LLD	0
	Zr-95	0.077	<LLD	-	-	<LLD	0
	Ru-103	0.039	<LLD	-	-	<LLD	0
	Ru-106	0.34	<LLD	-	-	<LLD	0
	Cs-134	0.038	<LLD	-	-	<LLD	0
	Cs-137	0.039	<LLD	-	-	<LLD	0
	Ce-141	0.064	<LLD	-	-	<LLD	0
	Ce-144	0.26	<LLD	-	-	<LLD	0
Vegetation - Corn (pCi/g wet)	GS 6						
	K-40	0.5	2.12 (5/5) (1.80-2.38)	D-105, Farm 21.3 mi SSW	2.72 (1/1)	2.72 (1/1)	0
	Mn-54	0.019	<LLD	-	-	<LLD	0
	Co-58	0.019	<LLD	-	-	<LLD	0
	Co-60	0.024	<LLD	-	-	<LLD	0
	Nb-95	0.020	<LLD	-	-	<LLD	0
	Zr-95	0.033	<LLD	-	-	<LLD	0
	Ru-103	0.018	<LLD	-	-	<LLD	0
	Ru-106	0.14	<LLD	-	-	<LLD	0
	Cs-134	0.022	<LLD	-	-	<LLD	0
	Cs-137	0.019	<LLD	-	-	<LLD	0
	Ce-141	0.024	<LLD	-	-	<LLD	0
	Ce-144	0.092	<LLD	-	-	<LLD	0

5.7 Environmental Radiological Monitoring Program Summary.

Name of Facility Duane Arnold Energy Center Docket No. 50-331
Location of Facility Linn, Iowa Reporting Period January - December 1992
(County, State)

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean: Location[d]	Location with Highest Annual Mean: Mean (F)[c] Range[c]	Control Locations Mean (F)[c] Range[c]	Number of Non-routine Results[e]
Vegetation - Hay (pCi/g wet)	GS 8						
	K-40	0.5	12.67 (7/7) (3.45-21.64)	D-57, Farm 1.0 mi WSW	21.64 (1/1)	11.90 (1/1)	0
	Mn-54	0.051	<LLD	-	-	<LLD	0
	Co-58	0.051	<LLD	-	-	<LLD	0
	Co-60	0.041	<LLD	-	-	<LLD	0
	Nb-95	0.046	<LLD	-	-	<LLD	0
	Zr-95	0.082	<LLD	-	-	<LLD	0
	Ru-103	0.040	<LLD	-	-	<LLD	0
	Ru-106	0.34	<LLD	-	-	<LLD	0
	Cs-134	0.039	<LLD	-	-	<LLD	0
	Cs-137	0.043	<LLD	-	-	<LLD	0
	Ce-141	0.065	<LLD	-	-	<LLD	0
	Ce-144	0.25	<LLD	-	-	<LLD	0
Soil (pCi/g dry)	Sr-90 2	0.01	0.040 (2/2) (0.038-0.043)	D-16, Onsite 0.5 mi SSE	0.043 (1/1)	None	0
	GS 2						
	K-40	0.5	10.95 (2/2) (10.50-11.40)	D-16, Onsite 0.5 mi SSE	11.40 (1/1)	None	0
	Mn-54	0.067	<LLD	-	-	None	0
	Co-58	0.090	<LLD	-	-	None	0
	Co-60	0.077	<LLD	-	-	None	0
	Nb-95	0.16	<LLD	-	-	None	0
	Zr-95	0.18	<LLD	-	-	None	0
	Ru-103	0.12	<LLD	-	-	None	0
	Ru-106	0.52	<LLD	-	-	None	0
	Cs-134	0.085	<LLD	-	-	None	0
	Cs-137	0.060	0.26 (1/1)	D-16, Onsite 0.5 mi SSE	0.26 (1/1)	None	0
	Co-141	0.22	<LLD	-	-	None	0
	Ce-144	0.37	<LLD	-	-	None	0

5.7 Environmental Radiological Monitoring Program Summary.

Name of Facility Duane Arnold Energy Center Docket No. 50-331
Location of Facility Linn, Iowa Reporting Period January - December 1992
(County, State)

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean: Location[d]	Location with Highest Annual Mean: Mean (F)[c] Range[c]	Control Locations Mean (F)[c] Range[c]	Number of Non-routine Results[e]
Surface Water (pCi/L)	H-3 20	330	<LLD	-	-	<LLD	0
	K-40 12	0.5	21.0 (12/12) (15.8-30.3)	D-107, On-site Sewage Effluent	21.0 (12/12) (15.8-30.3)	None	0
	I-131 60	2.0	<LLD	-	-	<LLD	0
	GS 60						
	Mn-54	15	<LLD	-	-	<LLD	0
	Fe-59	30	<LLD	-	-	<LLD	0
	Co-58	15	<LLD	-	-	<LLD	0
	Co-60	15	<LLD	-	-	<LLD	0
	Zn-65	30	<LLD	-	-	<LLD	0
	Nb-95	15	<LLD	-	-	<LLD	0
	Zr-95	30	<LLD	-	-	<LLD	0
	Cs-134	15	<LLD	-	-	<LLD	0
	Cs-137	18	<LLD	-	-	<LLD	0
	Ba-140	60	<LLD	-	-	<LLD	0
	La-140	15	<LLD	-	-	<LLD	0
River Sediments (pCi/g dry)	GS 6						
	K-40	1.0	7.20 (4/4) (5.52-9.22)	D-50, Plant Intake Onsite	8.55 (2/2) (6.76-10.34)	8.55 (2/2) (6.76-10.34)	0
	Mn-54	0.060	<LLD	-	-	<LLD	0
	Co-58	0.093	<LLD	-	-	<LLD	0
	Co-60	0.076	0.22 (2/4) (0.22-0.23)	D-107, Onsite Sewage Effluent	0.22 (2/4) (0.22-0.23)	<LLD	0
	Nb-95	0.17	<LLD	-	-	<LLD	0
	Zr-95	0.15	<LLD	-	-	<LLD	0
	Ru-103	0.11	<LLD	-	-	<LLD	0
	Ru-106	0.49	<LLD	-	-	<LLD	0
	Cs-134	0.053	<LLD	-	-	<LLD	0
	Cs-137	0.048	0.062 (1/4)	D-107, Onsite Sewage Effluent	0.062 (1/4)	<LLD	0
	Ce-141	0.18	<LLD	-	-	<LLD	0
	Ce-144	0.23	<LLD	-	-	<LLD	0

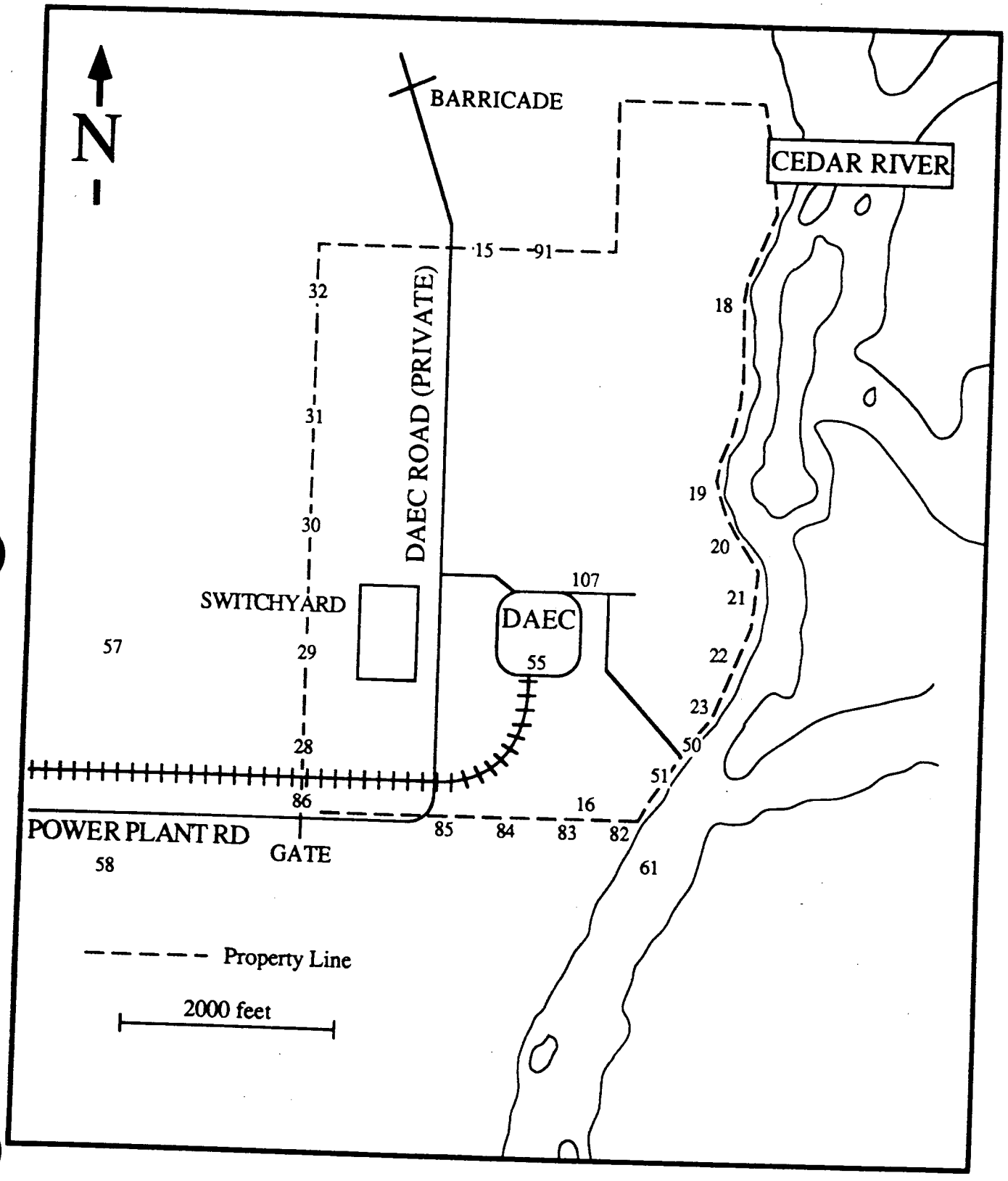
7 Environmental Radiological Monitoring Program Summary.

Name of Facility Duane Arnold Energy Center Docket No. 50-331
Location of Facility Linn, Iowa Reporting Period January - December 1992
(County, State)

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean. Location[d]	Mean (F)[c] Range[c]	Control Locations Mean (F)[c] Range[c]	Number of Non-routine Results[e]
Fish (Edible portion) (pCi/g wet)	GS 12						
	K-40	0.5	3.19 (6/6) (2.73-3.78)	D-61, Cedar River 0.5 mi downstream of discharge	3.19 (6/6) (2.73-3.78)	2.93 (6/6) (2.37-3.33)	0
	Mn-54	0.030	<LLD	-	-	<LLD	0
	Co-58	0.036	<LLD	-	-	<LLD	0
	Co-60	0.037	<LLD	-	-	<LLD	0
	Fe-59	0.10	<LLD	-	-	<LLD	0
	Zn-65	0.073	<LLD	-	-	<LLD	0
	Nb-95	0.060	<LLD	-	-	<LLD	0
	Zr-95	0.059	<LLD	-	-	<LLD	0
	Ru-103	0.044	<LLD	-	-	<LLD	0
	Ru-106	0.20	<LLD	-	-	<LLD	0
	Cs-134	0.022	<LLD	-	-	<LLD	0
	Cs-137	0.026	<LLD	-	-	<LLD	0
	Ce-141	0.12	<LLD	-	-	<LLD	0
	Ce-144	0.020	<LLD	-	-	<LLD	0

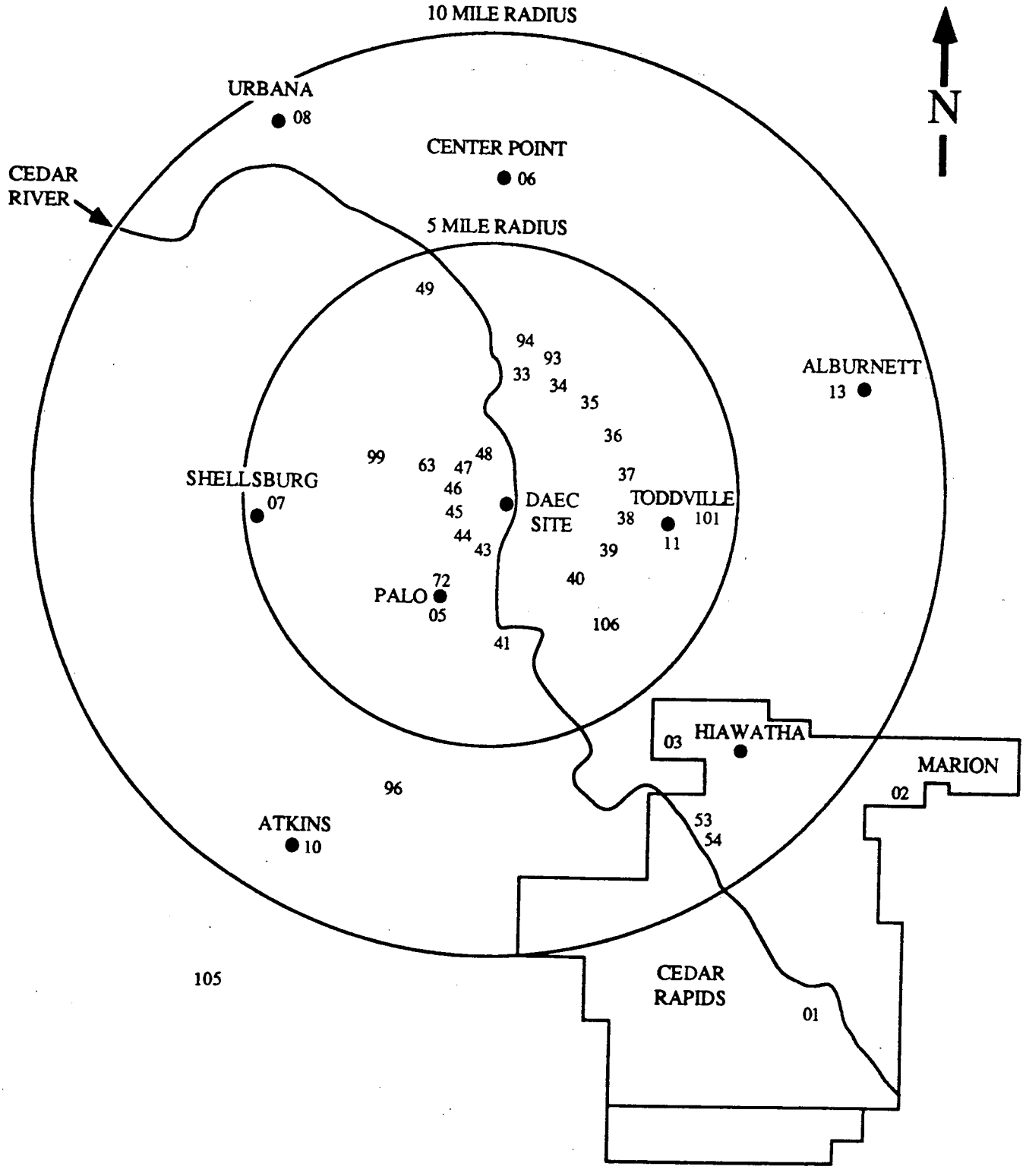
[a] GB = Gross beta; GS = Gamma scan.
[b] LLD = Nominal lower limit of detection based on 4.66 sigma error for background sample.
[c] Mean and range based upon detectable measurements only. Fraction of detectable measurements at specified locations is indicated in parentheses (F).
[d] Locations are specified by: (1) Name and code (Table 5.3); and (2) distance, direction, and sector relative to reactor site.
[e] Non-routine results are those which exceed ten times the control station value for the location. If a control station value is not available, the result is considered non-routine if it exceeds ten times the preoperational value for the location.
[f] Four locations (D-3, D-5, D-6, and D-13) had identical means of 0.024 pCi/m^3. Only D-3 is detailed in this summary table.

FIGURE 5.1
Radiological Environmental Monitoring Program
Sampling near the Duane Arnold Energy Center



See Table 5.3 for sampling locations and Table 5.4 for Type and Frequency of collection.

FIGURE 5.2
Radiological Environmental Monitoring Program
Sampling Stations Outside 0.5 miles from DAEC



See Table 5.3 for Sampling Locations and Table 5.4 for Type and Frequency of collection.

6.0 REFERENCES CITED

Arnold, J. R. and H. A. Al-Salih. 1955. Beryllium-7 Produced by Cosmic Rays. Science 121: 451-453.

Eisenbud, M. 1963. Environmental Radioactivity, McGraw-Hill, New York, New York, pp. 213, 275 and 276.

Gold, S., H. W. Barkhau, B. Shlein, and B. Kahn, 1964. Measurement of Naturally Occurring Radionuclides in Air, in the Natural Environment, University of Chicago Press, Chicago, Illinois, 369-382.

Hazleton Environmental Sciences . 1982. Environmental Radiation Monitoring for the Duane Arnold Arnold Energy Center, Annual Report - Part II, Data Tabulations and Analyses, January - December 1980.

Hazleton Environmental Sciences . 1982. Environmental Radiation Monitoring for the Duane Arnold Arnold Energy Center, Annual Report - Part II, Data Tabulations and Analyses, January - December 1981

Hazleton Environmental Sciences . 1982. Environmental Radiation Monitoring for the Duane Arnold Arnold Energy Center, Annual Report - Part II, Data Tabulations and Analyses, January - December 1982.

Hohenemser, C. M. Deicher, A. Ernst, H. Hofsass, G. Lindner, E. Racknagel. 1986. "Chernobyl," Chemtech, October 1986, pp. 596-605.

National Center for Radiological Health, 1968. Radiological Health and Data Reports, Vol. 9, Number 12, 730-746.

Teledyne Isotopes Midwest Laboratory. 1992. Analytical Procedures Manual, Revised 21. 21, August 1992.

Teledyne Isotopes Midwest Laboratory. 1992. Quality Control Program, Revision 12. 20, April 1992.

Teledyne Isotopes Midwest Laboratory. 1992. Quality Control Procedures Manual, Revision 16. 14, August 1992.

Teledyne Isotopes Midwest Laboratory. 1992. Quality Assurance Program Manual, Revision 1, 21, September 1992.

Teledyne Isotopes Midwest Laboratory. 1984. Environmental Radiological Monitoring Program for the Duane Arnold Energy Center, Annual Report - Part II, Data Tabulations and Analyses, January - December 1981.

Teledyne Isotopes Midwest Laboratory. 1985. Environmental Radiological Monitoring Program for the Duane Arnold Energy Center, Annual Report - Part II, Data Tabulations and Analyses, January - December 1984.

Teledyne Isotopes Midwest Laboratory. 1986. Environmental Radiological Monitoring Program for the Duane Arnold Energy Center, Annual Report - Part II, Data Tabulations and Analyses, January - December 1985.

Teledyne Isotopes Midwest Laboratory. 1987. Environmental Radiological Monitoring Program for the Duane Arnold Energy Center, Annual Report - Part II, Data Tabulations and Analyses, January - December 1985.

Teledyne Isotopes Midwest Laboratory. 1988. Environmental Radiological Monitoring Program for the Duane Arnold Energy Center, Annual Report - Part II, Data Tabulations and Analyses, January - December 1987.

Teledyne Isotopes Midwest Laboratory. 1989. Environmental Radiological Monitoring Program for the Duane Arnold Energy Center, Annual Report - Part II, Data Tabulations and Analyses, January - December 1988.

Teledyne Isotopes Midwest Laboratory. 1990. Environmental Radiological Monitoring Program for the Duane Arnold Energy Center, Annual Report - Part II, Data Tabulations and Analyses, January - December 1989.

Teledyne Isotopes Midwest Laboratory. 1991. Environmental Radiological Monitoring Program for the Duane Arnold Energy Center, Annual Report - Part II, Data Tabulations and Analyses, January - December 1990.

Teledyne Isotopes Midwest Laboratory. 1992. Environmental Radiological Monitoring Program for the Duane Arnold Energy Center, Annual Report - Part II, Data Tabulations and Analyses, January - December 1991.

Teledyne Isotopes Midwest Laboratory. 1993. Environmental Radiological Monitoring Program for the Duane Arnold Energy Center, Annual Report - Part II, Data Tabulations and Analyses, January - December 1992.

Wilson, D. W., G. M. Ward and J. E. Johnson. 1969. In Environmental Contamination by Radioactive Materials, International Atomic Energy Agency. p.125.

APPENDIX A

INTERLABORATORY COMPARISON PROGRAM RESULTS

NOTE: TIML participates in intercomparison studies administered by U.S. EPA Environmental Monitoring Systems Laboratory, Las Vegas, Nevada. The results are reported in Appendix A. Also reported are results of in-house spikes and blanks. Appendix A is updated quarterly; the complete Appendix is included in January, April, July and October monthly reports only. Please refer to these reports for information.

January, 1993

Appendix A

Interlaboratory Comparison Program Results

Teledyne Isotopes Midwest Laboratory (formerly Hazleton Environmental Sciences) has participated in interlaboratory comparison (crosscheck) programs since the formulation of its quality control program in December 1971. These programs are operated by agencies which supply environmental-type samples (e.g., milk or water) containing concentrations of radionuclides known to the issuing agency but not to participant laboratories. The purpose of such a program is to provide an independent check on the laboratory's analytical procedures and to alert it to any possible problems.

Participant laboratories measure the concentration of specified radionuclides and report them to the issuing agency. Several months later, the agency reports the known values to the participant laboratories and specifies control limits. Results consistently higher or lower than the known values or outside the control limits indicate a need to check the instruments or procedures used.

The results in Table A-1 were obtained through participation in the environmental sample crosscheck program for milk, water, air filters, and food samples during the period January 1988 through December 1992. This program has been conducted by the U.S. Environmental Protection Agency Intercomparison and Calibration Section, Quality Assurance Branch, Environmental Monitoring and Support Laboratory, Las Vegas, Nevada.

The results in Table A-2 were obtained for thermoluminescent dosimeters (TLDs) during the period 1976, 1977, 1979, 1980, 1984, and 1985-86 through participation in the Second, Third, Fourth, Fifth, Seventh, and Eighth International Intercomparison of Environmental Dosimeters under the sponsorships listed in Table A-2. Also Teledyne testing results are listed.

Table A-3 lists results of the analyses on in-house spiked samples.

Table A-4 lists results of the analyses on in-house "blank" samples.

Attachment B lists acceptance criteria for "spiked" samples.

Addendum to Appendix A provides explanation for out-of-limit results.

Table A-1. U.S. Environmental Protection Agency's crosscheck program, comparison of EPA and Teledyne Isotopes Midwest Laboratory results for milk, water, air filters, and food samples, 1988 through 1992.[a]

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-521	Water	Jan 1988	Sr-89	27.3±5.0	30.0±5.0	21.3-38.7
			Sr-90	15.3±1.2	15.0±1.5	12.4-17.6
STW-523	Water	Jan 1988	Gr. alpha	2.3±1.2	4.0±5.0	0.0-12.7
			Gr. beta	7.7±1.2	8.0±5.0	0.0-16.7
STF-524	Food	Jan 1988	Sr-89	44.0±4.0	46.0±5.0	37.3-54.7
			Sr-90	53.0±2.0	55.0±2.8	50.2-59.8
			I-131	102.3±4.2	102.0±10.2	84.3-119.7
			Cs-137	95.7±6.4	91.0±5.0	82.3-99.7
			K	1011±158	1230±62	1124-1336
STW-525	Water	Feb 1988	Co-60	69.3±2.3	69.0±5.0	60.3-77.7
			Zn-65	99.0±3.4	94.0±9.4	77.7-110.3
			Ru-106	92.7±14.4	105.0±10.5	86.8-123.2
			Cs-134	61.7±8.0	64.0±5.0	55.3-72.7
			Cs-137	99.7±3.0	94.0±5.0	85.3-102.7
STW-526	Water	Feb 1988	H-3	3453±103	3327±362	2700-3954
STW-527	Water	Feb 1988	Uranium	3.0±0.0	3.0±6.0	0.0-13.4
STM-528	Milk	Feb 1988	I-131	4.7±1.2	4.0±0.4	3.3-4.7
STW-529	Water	Mar 1988	Ra-226	7.1±0.6	7.6±1.1	5.6-9.6
			Ra-228	NA[e]	7.7±1.2	5.7-9.7
STW-530	Water	Mar 1988	Gr. alpha	4.3±1.2	6.0±5.0	0.0-14.7
			Gr. beta	13.3±1.3	13.0±5.0	4.3-21.7
STAF-531	Air Filter	Mar 1988	Gr. alpha	21.0±2.0	20.0±5.0	11.3-28.7
			Gr. beta	48.0±0.0	50.0±5.0	41.3-58.7
			Sr-90	16.7±1.2	17.0±1.5	14.4-19.6
			Cs-137	18.7±1.3	16.0±5.0	7.3-24.7
STW-532	Water	Apr 1988	I-131	9.0±2.0	7.5±0.8	6.2-8.8

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-533 534	Water (Blind)	Apr 1988				
	Sample A		Gr. alpha	ND[f]	46.0±11.0	27.0-65.0
			Ra-226	ND	6.4±1.0	4.7-8.1
			Ra-228	ND	5.6±0.8	4.2-7.0
			Uranium	6.0±6.0	6.0±6.0	0.0-16.4
	Sample B		Gr. beta	ND	57.0±5.0	48.3-65.7
			Sr-89	3.3±1.2	5.0±5.0	0.0-13.7
			Sr-90	5.3±1.2	5.0±1.5	2.4-7.6
			Co-60	63.3±1.3	50.0±5.0	41.3-58.7
			Cs-134	7.7±1.2	7.0±5.0	0.0-15.7
			Cs-137	8.3±1.2	7.0±5.0	0.0-15.7
STU-535	Urine	Apr 1988	H-3	6483±155	6202±620	5128-7276
STW-536	Water	Apr 1988	Sr-89	14.7±1.3	20.0±5.0	11.3-28.7
			Sr-90	20.0+2.0	20.0±1.5	17.4-22.6
STW-538	Water	Jun 1988	Cr-51	331.7±13.0	302.0±30.0	250.0-354.0
			Co-60	16.0±2.0	15.0±5.0	6.3-23.7
			Zn-65	107.7±11.4	101.0±10.0	83.7-118.3
			Ru-106	191.3±11.0	195.0±20.0	60.4-229.6
			Cs-134	18.3±4.6	20.0±5.0	11.3-28.7
			Cs-137	26.3±1.2	25.0±5.0	16.3-33.7
STW-539	Water	Jun 1988	H-3	5586±92	5565±557	4600-6530
STM-541	Milk	Jun 1988	Sr-89	33.7±11.4	40.0±5.0	31.3-48.7
			Sr-90	55.3±5.8	60.0±3.0	54.8-65.2
			I-131	103.7±3.1	94.0±9.0	78.4-109.6
			Cs-137	52.7±3.1	51.0±5.0	42.3-59.7
			K	1587±23	1600±80	1461-1739
STW-542	Water	Jul 1988	Gr. alpha	8.7±4.2	15.0±5.0	6.3-23.7
			Gr. beta	5.3±1.2	4.0±5.0	0.0-12.7
STF-543	Food	Jul 1988	Sr-89	ND[f]	33.0±5.0	24.3-41.7
			Sr-90	ND	34.0±2.0	30.5-37.5
			I-131	115.0±5.3	107.0±11.0	88.0-126.0
			Cs-137	52.7±6.4	49.0±5.0	40.3-57.7
			K	1190±66	1240±62	1133-1347

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-544	Water	Aug 1988	I-131	80.0±0.0	76.0±8.0	62.1-89.9
STW-545	Water	Aug 1988	Pu-239	11.0±0.2	10.2±1.0	8.5-11.9
STW-546	Water	Aug 1988	Uranium	6.0±0.0	6.0±6.0	0.0-16.4
STAF-547	Air Filter	Aug 1988	Gr. alpha	8.0±0.0	8.0±5.0	0.0-16.7
			Gr. beta	26.3±1.2	29.0±5.0	20.3-37.7
			Sr-90	8.0±2.0	8.0±1.5	5.4-10.6
			Cs-137	13.0±2.0	12.0±5.0	3.3-20.7
STW-548	Water	Sep 1988	Ra-226	9.3±0.5	8.4±2.6	6.2-10.6
			Ra-228	5.8±0.4	5.4±1.6	4.0-6.8
STW-549	Water	Sep 1988	Gr. alpha	7.0±2.0	8.0±5.0	0.0-16.7
			Gr. beta	11.3±1.2	10.0±5.0	1.3-18.7
STW-550	Water	Oct 1988	Cr-51	252.0±14.0	251.0±25.0	207.7-294.3
			Co-60	26.0±2.0	25.0±5.0	16.3-33.7
			Zn-65	158.3±10.2	151.0±15.0	125.0-177.0
			Ru-106	153.0±9.2	152.0±15.0	126.0-178.0
			Cs-134	28.7±5.0	25.0±5.0	16.3-33.7
			Cs-137	16.3±1.2	15.0±5.0	6.3-23.7
STW-551	Water	Oct 1988	H-3	2333±127	2316±350	1710-2927
STW-552 553	Water (Blind)	Oct 1988				
	Sample A		Gr. alpha	38.3±8.0	41.0±10.0	23.7-58.3
			Ra-226	4.5±0.5	5.0±0.8	3.6-6.4
			Ra-228	4.4±0.6	5.2±0.8	3.6-6.4
			Uranium	4.7±1.2	5.0±6.0	0.0-15.4
	Sample B		Gr. beta	51.3±3.0	54.0±5.0	45.3-62.7
			Sr-89	3.7±1.2	11.0±5.0	2.3-19.7
			Sr-90	10.7±1.2	10.0±1.5	7.4-12.6
			Cs-134	15.3±2.3	15.0±5.0	6.3-23.7
			Cs-137	16.7±1.2	15.0±5.0	6.3-23.7

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STM-554	Milk	Oct 1988	Sr-89	40.3±7.0	40.0±5.0	31.3-48.7
			Sr-90	51.0±2.0	60.0±5.0	54.8-65.2
			I-131	94.0±3.4	91.0±9.0	75.4-106.6
			Cs-137	45.0±4.0	50.0±5.0	41.3-58.7
			K	1500±45	1600±80	1461-1739
STU-555	Urine	Nov 1988	H-3	3030±209	3025±359	2403-3647
STW-556	Water	Nov 1988	Gr. alpha	9.0±3.5	9.0±5.0	0.3-17.7
			Gr. beta	9.7±1.2	9.0±5.0	0.3-17.7
STW-557	Water	Dec 1988	I-131	108.7±3.0	115.0±12.0	94.2-135.8
STW-559	Water	Jan 1989	Sr-89	40.0±8.7	40.0±5.0	31.3-48.7
			Sr-90	24.3±3.1	25.0±1.5	22.4-27.6
STW-560	Water	Jan 1989	Pu-239	5.8±1.1	4.2±0.4	3.5-4.9
STW-561	Water	Jan 1989	Gr. alpha	7.3±1.2	8.0±5.0	0.0-16.7
			Gr. beta	5.3±1.2	4.0±5.0	0.0-12.7
STW-562	Water	Feb 1989	Cr-51	245±46	235±24	193.4-276.6
			Co-60	10.0±2.0	10.0±5.0	1.3-18.7
			Zn-65	170±10	159±16	139.2-186.7
			Ru-106	181±7.6	178±18	146.8-209.2
			Cs-134	9.7±3.0	10.0±5.0	1.3-18.7
			Cs-137	11.7±1.2	10.0±5.0	1.3-18.7
STW-563	Water	Feb 1989	I-131	109.0±4.0	06.0±11.0	86.9-125.1
STW-564	Water	Feb 1989	H-3	2820±20	2754±356	2137-3371
STW-565	Water	Mar 1989	Ra-226	4.2±0.3	4.9±0.7	3.7-6.1
			Ra-228	1.9±1.0	1.7±0.3	1.2-2.2
STW-566	Water	Mar 1989	U	5.0±0.0	5.0±6.0	0.0-15.4
STAF-567	Air Filter	Mar 1989	Gr. alpha	21.7±1.2	21.0±5.0	12.3-29,7
			Gr. beta	68.3±4.2	62.0±5.0	53.3-70.7
			Sr-90	20.0±2.0	20.0±1.5	17.4-22.6
			Cs-137	21.3±1.2	20.0±5.0	11.3-28.7

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-568 569	Water (Blind)	Apr 1989				
	Sample A		Gr. alpha	22.7±2.3	29.0±7.0	16.9-41.2
			Ra-226	3.6±0.6	3.5±0.5	2.6-4.4
			Ra-228	2.6±1.0	3.6±0.5	2.7-4.5
			U	3.0±0.0	3.0±6.0	0.0-13.4
	Sample B		Gr. beta	52.3±6.1	57.0±5.0	43.3-65.7
			Sr-89	9.3±5.4	8.0±5.0	0.0-16.7
			Sr-90	7.0±0.0	8.0±1.5	5.4-10.6
			Cs-134	21.0±5.2	20.0±5.0	11.3-28.7
			Cs-137	23.0±2.0	20.0±5.0	11.3-28.7
STM-570	Milk	Apr 1989	Sr-89	26.0±10.0	39.0±5.0	30.3-47.7
			Sr-90	45.7±4.2	55.0±3.0	49.8-60.2
			Cs-137	54.0±6.9	50.0±5.0	41.3-58.7
			K-40	1521±208	1600±80	1461-1739
STW-571g	Water	May 1989	Sr-89	<0.7	6.0±5.0	0.0-14.7
			Sr-90	5.0±1.0	6.0±1.5	3.4-8.6
STW-572	Water	May 1989	Gr. alpha	24.0±2.0	30.0±8.0	16.1-43.9
			Gr. beta	49.3±15.6	50.0±5.0	41.3-58.7
STW-573	Water	Jun 1989	Ba-133	50.7±1.2	49.0±5.0	40.3-57.7
			Co-60	31.3±2.3	31.0±5.0	22.3-39.7
			Zn-65	167±10	165±17	135.6-194.4
			Ru-106	123±9.2	128±13	105.5-150.5
			Cs-134	40.3±1.2	39±5	30.3-47.7
			Cs-137	22.3±1.2	20±5	11.3-28.7
STW-574	Water	Jun 1989	H-3	4513±136	4503±450	3724-5282
STW-575	Water	Jul 1989	Ra-226	16.8±3.1	17.7±2.7	13.0-22.4
			Ra-228	13.8±3.7	18.3±2.7	13.6-23.0
STW-576	Water	Jul 1989	U	40.3±1.2	41.0±6.0	30.6±51.4
STW-577	Water	Aug 1989	I-131	84.7±5.8	83.0±8.0	69.1-96.9
STAF-579	Air Filter	Aug 1989	Gr. alpha	6.0±0.0	6.0±5.0	0.0-14.7
			Cs-137	10.3±2.3	10.0±5.0	1.3-18.7

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-580	Water	Sep 1989	Sr-89	14.7±1.2	14.0±5.0	5.3-22.7
			Sr-90	9.7±1.2	10.0±1.5	7.4-12.6
STW-581	Water	Sep 1989	Gr. alpha	5.0±0.0	4.0±5.0	0.0-12.7
			Gr. beta	8.7±2.3	6.0±5.0	0.0-14.7
STW-583	Water	Oct 1989	Ba-133	60.3±10.0	59.0±6.0	48.6-69.4
			Co-60	29.0±4.0	30.0±5.0	21.1-38.7
			Zn-65	132.3±6.0	129.0±13.0	106.5-151.5
			Ru-106	155.3±6.1	161.0±16.0	133.3-188.7
			Cs-134	30.7±6.1	29.0±5.0	20.3-37.7
			Cs-137	66.3±4.6	59.0±5.0	50.3-67.7
STW-584	Water	Oct 1989	H-3	3407±150	3496±364	2866-126
STW-585 586	Water (Blind)	Oct 1989				
	Sample A		Gr. alpha	41.7±9.4	49.0±12.0	28.2-69.8
			Ra-226	7.9±0.4	8.4±1.3	6.2-10.6
			Ra-228	4.4±0.8	4.1±0.6	3.1-5.1
			U	12.0±0.0	12.0±6.0	1.6-22.4
	Sample B		Gr. beta	31.7±2.3	32.0±5.0	23.3-40.7
			Sr-89	13.3±4.2	15.0±5.0	6.3-23.7
			Sr-90	7.0±2.0	7.0±3.0	4.4-9.6
			Cs-134	5.0±0.0	5.0±5.0	0.0-13.7
			Cs-137	7.0±0.0	5.0±5.0	0.0-13.7
STW-587	Water	Nov 1989	Ra-226	7.9±0.4	8.7±1.3	6.4-11.0
			Ra-228	8.9±1.2	9.3±1.2	6.9-11.7
STW-588	Water	Nov 1989	U	15.0±0.0	15.0±6.0	4.6-25.4
STW-589	Water	Jan 1990	Sr-89	22.7±5.0	25.0±5.0	16.3-33.7
			Sr-90	17.3±1.2	20.0±1.5	17.4-22.6
STW-591	Water	Jan 1990	Gr. alpha	10.3±3.0	12.0±5.0	3.3-20.7
			Gr. beta	12.3±1.2	12.0±5.0	3.3-20.7

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-592	Water	Jan 1990	Co-60	14.7±2.3	15±5.0	6.3-23.7
			Zn-65	135.0±6.9	139.0±14.0	114.8-163.2
			Ru-106	133.3±13.4	139.0±14.0	114.8-163.2
			Cs-134	17.3±1.2	18.0±5.0	9.3-26.7
			Cs-137	19.3±1.2	18.0±5.0	9.3-26.7
			Ba-133	78.0±0.0	74.0±7.0	61.9-86.1
STW-593	Water	Feb 1990	H-3	4827±83	4976±498	4113-5839
STW-594	Water	Mar 1990	Ra-226	5.0±0.2	4.9±0.7	4.1-5.7
			Ra-228	13.5±0.7	12.7±1.9	9.4-16.0
STW-595	Water	Mar 1990	U	4.0±0.0	4.0±6.0	0.0-14.4
STAF-596	Air Filter	Mar 1990	Gr. alpha	7.3±1.2	5.0±5.0	0.0-13.7
			Gr. beta	34.0±0.0	31.0±5.0	22.3-39.7
			Sr-90	10.0±0.0	10.0±1.5	7.4-12.6
			Cs-137	9.3±1.2	10.0±5.0	1.3-18.7
STW-597 598	Water (Blind)	Apr 1990				
	Sample A		Gr. alpha	81.0±3.5	90.0±23.0	50.1-129.9
			Ra-226	4.9±0.4	5.0±0.8	3.6-6.4
			Ra-228	10.6±0.3	10.2±1.5	7.6-12.8
			U	18.7±3.0	20.0±6.0	9.6-30.4
	Sample B		Gr. beta	51.0±10.1	52.0±5.0	43.3-60.7
			Sr-89	9.3±1.2	10.0±5.0	1.3-18.7
			Sr-90	10.3±3.1	10.0±1.5	8.3-11.7
			Cs-134	16.0±0.0	15.0±5.0	6.3-23.7
			Cs-137	19.0±2.0	15.0±5.0	6.3-23.7
STM-599	Milk	Apr 1990	Sr-89	21.7±3.1	23.0±5.0	14.3-31.7
			Sr-90	21.0±7.0	23.0±5.0	14.3-31.7
			I-131	98.7±1.2	99.0±10.0	81.7-116.3
			Cs-137	26.0±6.0	24.0±5.0	15.3-32.7
			K	1300.0±69.2	1550.0±78.0	1414.7-1685.3
STW-600	Water	May 1990	Sr-89	6.0±2.0	7.0±5.0	0.0-15.7
			Sr-90	6.7±1.2	7.0±5.0	0.0-15.7
STW-601	Water	May 1990	Gr. alpha	11.0±2.0	22.0±6.0	11.6-32.4
			Gr. beta	12.3±1.2	15.0±5.0	6.3-23.7

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-602	Water	Jun 1990	Co-60	25.3±2.3	24.0±5.0	15.3-32.7
			Zn-65	155.0±10.6	148.0±15.0	130.6-165.4
			Ru-106	202.7±17.2	210.0±21.0	173.6-246.4
			Cs-134	23.7±1.2	24.0±5.0	18.2-29.8
			Cs-137	27.7±3.1	25.0±5.0	16.3-33.7
			Ba-133	100.7±8.1	99.0±10.0	81.7-116.3
STW-603	Water	Jun 1990	H-3	2927±306	2933±358	2312-3554
STW-604	Water	Jul 1990	Ra-226	11.8±0.9	12.1±1.8	9.0-15.2
			Ra-228	4.1±1.4	5.1±1.3	2.8-7.4
STW-605	Water	Jul 1990	U	20.3±1.7	20.8±3.0	15.6-26.0
STW-606	Water	Aug 1990	I-131	43.0±1.2	39.0±6.0	28.6-49.4
STW-607	Water	Aug 1990	Pu-239	10.0±1.7	9.1±0.9	7.5-10.7
STAF-608	Air Filter	Aug 1990	Gr. alpha	14.0±0.0	10.0±5.0	1.3-18.7
			Gr. beta	65.3±1.2	62.0±5.0	53.3-70.7
			Sr-90	19.0±6.9	20.0±5.0	11.3-28.7
			Cs-137	19.0±2.0	20.0±5.0	11.3-28.7
STW-609	Water	Sep 1990	Sr-89	9.0±2.0	10.0±5.0	1.3-18.7
			Sr-90	9.0±2.0	9.0±5.0	0.3-17.7
STW-610	Water	Sep 1990	Gr. alpha	8.3±1.2	10.0±5.0	1.3-18.7
			Gr. beta	10.3±1.2	10.0±5.0	1.3-18.7
STM-611	Milk	Sep 1990	Sr-89	11.7±3.1	16.0±5.0	7.3-24.7
			Sr-90	15.0±0.0	20.0±5.0	11.3-28.7
			I-131	63.0±6.0	58.0±6.0	47.6-68.4
			Cs-137	20.0±2.0	20.0±5.0	11.3-28.7
			K	1673.3±70.2	1700.0±85.0	1552.5-1847.5
STW-612	Water	Oct 1990	Co-60	20.3±3.1	20.0±5.0	11.3-28.7
			Zn-65	115.3±12.2	115.0±12.0	94.2-135.8
			Ru-106	152.0±8.0	151.0±15.0	125.0-177.0
			Cs-134	11.0±0.0	12.0±5.0	3.3-20.7
			Cs-137	14.0±2.0	12.0±5.0	3.3-20.7
			Ba-133	116.7±9.9	110.0±11.0	90.9-129
STW-613	Water	Oct 1990	H-3	7167±330	7203±720	5954-8452

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-614 615	Water	Oct 1990				
	Sample A		Gr. alpha	68.7±7.2	62.0±16.0	34.2-89.8
			Ra-226	12.9±0.3	13.6±2.0	10.1-17.1
			Ra-228	4.2±0.6	5.0±1.3	2.7-7.3
			U	10.4±0.6	10.2±3.0	5.0-15.4
	Sample B		Gr. beta	55.0±8.7	53.0±5.0	44.3-61.7
			Sr-89	15.7±2.9	20.0±5.0	11.3-28.7
			Sr-90	12.0±2.0	15.0±5.0	6.3-23.7
			Cs-134	9.0±1.7	7.0±5.0	0.0-15.7
			Cs-137	7.7±1.2	5.0±5.0	0.0-13.7
STW-616	Water	Nov 1990	Ra-226	6.8±1.0	7.4±1.1	5.5-9.3
			Ra-228	5.3±1.7	7.7±1.9	4.4-11.0
STW-617g	Water	Nov 1990	U	35.0±0.4	35.5±3.6	29.3-41.7
STW-618	Water	Jan 1991	Sr-89	4.3±1.2	5.0±5.0	0.0 -13.7
			Sr-90	4.7±1.2	5.0±5.0	0.0-13.7
STW-619	Water	Jan 1991	Pu-239	3.6±0.2	3.3±0.3	2.8-3.8
STW-620	Water	Jan 1991	Gr. alpha	6.7±3.0	5.0±5.0	0.0-13.7
			Gr. beta	6.3±1.2	5.0±5.0	0.0-13.7
STW-621	Water	Feb 1991	Co-60	41.3±8.4	40.0±5.0	31.3-48.7
			Zn-65	166.7±19.7	149.0±15.0	123.0-175.0
			Ru-106	209.7±18.6	186.0±19.0	153.0-219.0
			Cs-134	9.0±2.0	8.0±5.0	0.0-16.7
			Cs-137	9.7±1.2	8.0±5.0	0.0-16.7
			Ba-133	85.7±9.2	75.0±8.0	61.1-88.9
STW-622	Water	Feb 1991	I-131	81.3±6.1	75.0±8.0	61.1-88.9
STW-623	Water	Feb 1991	H-3	4310.0±144.2	4418.0±442.0	3651.2-5184.8
STW-624	Water	Mar 1991	Ra-226	31.4±3.2	31.8±4.8	23.5-40.1
			Ra-228	ND[h]	21.1±5.3	11.9-30.3
STW-625	Water	Mar 1991	U	6.7±0.4	7.6±3.0	2.4-12.8

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STAF-626	Air Filter	Mar 1991	Gr. alpha	38.7±1.2	25.0±6.0	14.6-35.4
			Gr. beta	130.0±4.0	124.0±6.0	113.6-134.4
			Sr-90	35.7±1.2	40.0±5.0	31.3-48.7
			Cs-137	33.7±4.2	40.0±5.0	31.3-48.7
STW-627 628	Water	Apr 1991				
	Sample A		Gr. alpha	51.0±6.0	54.0±14.0	29.7-78.3
			Ra-226	7.0±0.8	8.0±1.2	5.9-10.1
			Ra-228	9.7±1.9	15.2±3.8	8.6-21.8
			U	27.7±2.4	29.8±3.0	24.6-35.0
	Sample B		Gr. beta	93.3±6.4	115.0±17.0	85.5-144.5
			Sr-89	21.0±3.5	28.0±5.0	19.3-36.7
			Sr-90	23.0±0.0	26.0±5.0	17.3-34.7
			Cs-134	27.3±1.2	24.0±5.0	15.3-32.7
			Cs-137	29.0±2.0	25.0±5.0	16.3-33.7
STM-629	Milk	Apr 1991	Sr-89	24.0±8.7	32.0±5.0	23.3-40.7
			Sr-90	28.0±2.0	32.0±5.0	23.3-40.7
			I-131	65.3±14.7	60.0±6.0	49.6-70.4
			Cs-137	54.7±11.0	49.0±5.0	40.3-57.7
			K	1591.7±180.1	1650.0±83.0	1506.0-1794.0
STW-630	Water	May 1991	Sr-89	40.7±2.3	39.0±5.0	30.3-47.7
			Sr-90	23.7±1.2	24.0±5.0	15.3-32.7
STW-631	Water	May 1991	Gr. alpha	27.7±5.8	24.0±6.0	13.6-34.4
			Gr. beta	46.0±0.0	46.0±5.0	37.3-54.7
STW-632	Water	Jun 1991	Co-60	11.3±1.2	10.0±5.0	1.3-18.7
			Zn-65	119.3±16.3	108.0±11.0	88.9-127.1
			Ru-106	162.3±19.0	149.0±15.0	123.0-175.0
			Cs-134	15.3±1.2	15.0±5.0	6.3-23.7
			Cs-137	16.3±1.2	14.0±5.0	5.3-22.7
			Ba-133	74.0±6.9	62.0±6.0	51.6-72.4
STW-633	Water	Jun 1991	H-3	13470.0±385.8	12480.0±1248.0	10314.8-14645.2
STW-634	Water	Jul 1991	Ra-226	14.9±0.4	15.9±2.4	11.7-20.1
			Ra-228	17.6±1.8	16.7±4.2	9.4-24.0

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-635	Water	Jul 1991	U	12.8±0.1	14.2±3.0	9.0-19.4
STW-636	Water	Aug 1991	I-131	19.3±1.2	20.0±6.0	9.6-30.4
STW-637	Water	Aug 1991	Pu-239	21.4±0.5	19.4±1.9	16.1-22.7
STAF-638	Air Filter	Aug 1991	Gr. alpha	33.0±2.0	25.0±6.0	14.6-35.4
			Gr. beta	88.7±1.2	92.0±10.0	80.4-103.6
			Sr-90	27.0±4.0	30.0±5.0	21.3-38.7
			Cs-137	26.3±1.2	30.0±5.0	21.3-38.7
STW-639	Water	Sep 1991	Sr-89	47.0±10.4	49.0±5.0	40.3-57.7
			Sr-90	24.0±2.0	25.0±5.0	16.3-33.7
STW-640	Water	Sep 1991	Gr. alpha	12.0±4.0	10.0±5.0	1.3-18.7
			Gr. beta	20.3±1.2	20.0±5.0	11.3-28.7
STM-641	Milk	Sep 1991	Sr-89	20.3±5.0	25.0±5.0	16.3-33.7
			Sr-90	19.7±3.1	25.0±5.0	16.3-33.7
			I-131	130.7±16.8	108.0±11.0	88.9-127.1
			Cs-137	33.7±3.2	30.0±5.0	21.3-38.7
			K	1743.3±340.8	1740.0±87.0	1589.1-1890.9
STW-642	Water	Oct 1991	Co-60	29.7±1.2	29.0±5.0	20.3-37.7
			Zn-65	75.7±8.3	73.0±7.0	60.9-85.1
			Ru-106	196.3±15.1	199.0±20.0	164.3-233.7
			Cs-134	9.7±1.2	10.0±5.0	1.3-18.7
			Cs-137	11.0±2.0	10.0±5.0	1.3-18.7
			Ba-133	94.7±3.1	98.0±10.0	80.7-115.3
STW-643	Water	Oct 1991	H-3	2640.0±156.2	2454.0±352.0	1843.3-3064.7
STW-644 645	Water Sample A	Oct 1991	Gr. alpha	73.0±13.1	82.0±21.0	45.6-118.4
			Ra-226	20.9±2.0	22.0±3.3	16.3-27.7
			Ra-228	19.6±2.3	22.2±5.6	12.5-31.9
			U	13.5±0.6	13.5±3.0	8.3-18.7
	Sample B		Gr. beta	55.3±3.1	65.0±10.0	47.7-82.3
			Sr-89	9.7±3.1	10.0±5.0	1.3-18.7
			Sr-90	8.7±1.2	10.0±5.0	1.3-18.7
			Co-60	20.3±1.2	20.0±5.0	11.3-28.7
			Cs-134	9.0±5.3	10.0±5.0	1.3-18.7
			Cs-137	14.7±5.0	11.0±5.0	2.3-19.7

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-646	Water	Nov 1991	Ra-226	5.6±1.2	6.5±1.0	4.8-8.2
			Ra-228	9.6±0.5	8.1±2.0	4.6-11.6
STW-647	Water	Nov 1991	U	24.7±2.3	24.9±3.0	19.7-30.1
STW-648	Water	Jan 1992	Sr-89	42.7±6.4	51.0±5.0	42.3-59.7
			Sr-90	18.3±3.1	20.0±5.0	11.3-28.7
STW-649	Water	Jan 1992	Pu-239	16.1±0.8	16.8±1.7	13.9-19.7
STW-650	Water	Jan 1992	Gr. alpha	23.7±9.2	30.0±8.0	16.1-43.9
			Gr. beta	27.7±4.2	30.0±5.0	21.3-38.7
STW-651	Water	Feb 1992	I-131	60.3±4.2	59.0±6.0	48.6-69.4
STW-652	Water	Feb 1992	Co-60	40.3±5.0	40.0±5.0	31.3-48.7
			Zn-65	148.0±15.0	150.7±6.1	122.0-174.0
			Ru-106	188.7±28.8	203.0±20.0	168.3-237.7
			Cs-134	31.7±4.2	31.0±5.0	22.3-39.7
			Cs-137	51.0±3.4	49.0±5.0	40.3-57.7
			Ba-133	79.0±3.4	76.0±8.0	62.1-89.9
STW-653	Water	Feb 1992	H-3	7714.0±119.6	7904.0±790.0	6533.4-9274.6
STW-654	Water	Mar 1992	Ra-226	9.0±0.4	10.1±1.5	7.5-12.7
			Ra-228	18.8±0.6	15.5±3.9	8.7-22.3
STW-655	Water	Mar 1992	Rn-222[i]			
STW-656	Water	Mar 1992	U	25.1±1.9	25.3±3.0	20.1-30.5
STW-657	Water	Mar 1992	Rn-222[i]			
STAF-658	Air Filter	Mar 1992	Gr. alpha	7.0±0.0	7.0±5.0	0.0-15.7
			Gr. beta	39.3±1.6	41.0±5.0	32.3-49.7
			Sr-90	13.7±1.6	15.0±5.0	6.3-23.7
			Cs-137	10.0±0.0	10.0±5.0	1.3-18.7
STW-659 660	Water Sample A	Apr 1992				
			Gr. alpha	35.7±6.1	40.0±10.0	22.7-57.3
			Ra-226	12.7±1.2	14.9±2.2	11.1-18.7
			Ra-228	14.5±2.1	14.0±3.5	7.9-20.1
			U	3.9±0.2	4.0±3.0	0.0-9.2

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-659	Water	Apr 1992				
660	Sample B		Gr. beta	113.0±7.2	140.0±21.0	103.6-176.4
			Sr-89	12.3±4.2	15.0±3.0	6.3-23.7
			Sr-90	15.0±1.2	17.0±5.0	8.3-25.7
			Co-60	61.0±4.0	56.0±5.0	47.3-64.7
			Cs-134	24.3±1.2	24.0±5.0	15.3-32.7
			Cs-137	24.0±2.0	22.0±5.0	13.3-30.7
STM-661	Milk	Apr 1992	Sr-89	25.3±7.6	38.0±5.0	29.3-46.7
			Sr-90	24.3±3.1	29.0±5.0	20.3-37.7
			I-131	78.7±9.5	78.0±8.0	64.1-91.9
			Cs-137	39.3±2.3	39.0±5.0	30.3-47.7
			K	1610.0±72.1	1710.0±86.0	1560.8-1859.2
STW-662	Water	May 1992	Sr-89	24.0±4.0	29.0±5.0	20.3-37.7
			Sr-90	6.7±1.2	8.0±5.0	0.0-16.7
STM-663	Water	May 1992	Gr. alpha	12.3±2.1	15.0±3.0	6.3-23.7
			Gr. beta	46.0±5.0	44.0±5.0	35.3-52.7
STW-664	Water	Jun 1992	Co-60	20.3±1.2	20.0±5.0	11.3-28.7
			Zn-65	103.3±10.6	99.0±10.0	81.7-116.3
			Ru-106	142.7±23.7	141.0±14.0	116.7-165.3
			Cs-134	14.3±2.3	15.0±5.0	6.3-23.7
			Cs-137	15.0±2.0	15.0±5.0	6.3-23.7
			Ba-133	92.7±11.0	98.0±10.0	80.7-115.3
STW-665	Water	Jun 1992	H-3	2153.3±144.6	2125.0±347.0	1523.0-2727.0
STW-666	Water	July 1992	Ra-226	22.3±2.2	24.9±3.7	18.5-31.3
			Ra-228	16.7±3.1	16.7±4.2	9.4-24.0
STW-667	Water	July 1992	U	3.6±0.3	4.0±3.0	0.0-9.2
STW-668	Water	August 1992	I-131	47.0±3.5	45.0±6.0	34.6-55.4
STW-669	Water	August 1992	Pu-239	8.5±0.9	9.0±0.9	7.4-10.6
STAF-670	Air Filter	August 1992	Gr. alpha	25.7±1.2	30.0±8.0	16.1-43.9
			Gr. beta	69.0±2.0	69.0±10.0	51.7-86.3
			Sr-90	26.0±4.0	25.0±5.0	16.3-33.7
			Cs-137	16.0±0.0	18.0±5.0	9.3-26.7

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-671	Water	Sept. 1992	Sr-89	16.0±4.0	20.0±5.0	11.3-28.7
			Sr-90	14.3±3.1	15.0±5.0	6.3-23.7
STW-672	Water	Sept. 1992	Gr. alpha	43.0±13.1	45.0±11.0	25.9-64.1
			Gr. beta	41.3±18.6	50.0±5.0	41.3-58.7
STM-673	Milk	Sept. 1992	Sr-89	11.0±3.5	15.0±5.0	6.3-23.7
			Sr-90	12.7±1.2	15.0±5.0	6.3-23.7
			I-131	109.7±19.4	100.0±10.0	82.7-117.3
			Cs-137	14.0±3.5	15.0±5.0	6.3-23.7
			K	1540.0±103.9	1750.0±88.0	1597.3-1902.7
STW-674	Water	Oct. 1992	Co-60	11.3±2.3	10.0±5.0	1.3-18.7
			Zn-65	169.7±25.0	148.0±15.0	122.0-174.0
			Ru-106	170.1±2.3	175.0±18.0	143.8-206.2
			Cs-134	9.7±2.3	8.0±5.0	0.0-16.7
			Cs-137	9.7±1.2	8.0±5.0	0.0-16.7
			Ba-133	80.3±9.0	74.0±7.0	61.9-86.1
STW-675	Water	Oct. 1992	H-3	5896.7±136.2	5962.0±596.0	4928.0-6996.0
STW-676 -677	Water	Oct. 1992				
	Sample A		Gr. alpha	24.7±5.0	29.0±7.0	16.9-41.1
			Ra-226	7.1±0.4	7.4±1.1	5.5-9.3
			Ra-228	11.5±1.0	10.0±2.5	5.7-14.3
			U	9.7±0.5	10.2±3.0	5.0-15.4
	Sample B		Gr. beta	42.7±8.1	53.0±10.0	35.7-70.3
			Sr-89	6.7±1.2	8.0±5.0	0.0-16.7
			Sr-90	10.0±2.0	10.0±5.0	1.3-18.7
			Co-60	15.0±2.0	15.0±5.0	6.3-23.7
			Cs-134	5.7±1.2	5.0±5.0	0.0-13.7
			Cs-137	8.0±2.0	8.0±5.0	0.0-16.7

Table A-1. (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] TIML Result ±2σ[c]	EPA Result[d] 1s, N=1	Control Limits
STW-678	Water	Nov. 1992	Ra-226	7.5±0.8	7.5±1.1	5.6-9.4
			Ra-228	5.8±0.7	5.0±1.3	2.7-7.3
STW-679	Water	Nov. 1992	U	15.5±1.1	15.2±3.0	10.0-20.4

[a] Results obtained by Teledyne Isotopes Midwest Laboratory as a participant in the environmental sample crosscheck program operated by the Intercomparison and Calibration Section, Quality Assurance Branch, Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency (EPA), Las Vegas, Nevada.

[b] All results are in pCi/l, except for elemental potassium (K) data in milk, which are in mg/l; air filter samples, which are in pCi/filter; and food, which is in mg/kg.

[c] Unless otherwise indicated, the TIML results are given as the mean ± 2 standard deviations for three determinations.

[d] USEPA results are presented as the known values and expected laboratory precision (1s, 1 determination) and control limits as defined by EPA.

[e] NA = Not analyzed.

[f] ND = No data; not analyzed due to relocation of lab.

[g] Sample was analyzed but the results not submitted to EPA because deadline was missed (all data on file).

[h] ND = No data; sample lost during analyses.

[i] ND = No data; special EPA testing.

Table A-2. Crosscheck program results, thermoluminescent dosimeters (TLDs).

Lab Code	TLD Type	Measurement	mR: Teledyne Result ±2σ[a]	mR: Known Value	mR: Average ±2σ[d] (All Participants)
2nd International Intercomparison[b]					
115-2	CaF_2:Mn Bulb	Field	17.0±1.9	17.1	16.4±7.7
		Lab	20.8±4.1	21.3	18.8±7.6
3rd International Intercomparison[e]					
115-3	CaF_2:Mn Bulb	Field	30.7±3.2	34.9±4.8	31.5±3.0
		Lab	89.6±6.4	91.7±14.6	86.2±24.0
4th International Intercomparison[f]					
115-4	CaF_2:Mn Bulb	Field	14.1±1.1	14.1±1.4	16.0±9.0
		Lab (Low)	9.3±1.3	12.2±2.4	12.0±7.4
		Lab (High)	40.4±1.4	45.8±9.2	43.9±13.2
5th International Intercomparison[g]					
115-5A	CaF_2:Mn Bulb	Field	31.4±1.8	30.0±6.0	30.2±14.6
		Lab at beginning	77.4±5.8	75.2±7.6	75.8±40.4
		Lab at the end	96.6±5.8	88.4±8.8	90.7±31.2
115-5B	LiF-100 Chips	Field	30.3±4.8	30.0±6.0	30.2±14.6
		Field at beginning	81.1±7.4	75.2±7.6	75.8±40.4
		Lab at the end	85.4±11.7	88.4±8.8	90.7±31.2
7th International Comparison[h]					
115-7A	LiF-100 Chips	Field	75.4±2.6	75.8±6.0	75.1±29.8
		Lab (Co-60)	80.0±3.5	79.9±4.0	77.9±27.6
		Lab (Cs-137)	66.6±2.5	75.0±3.8	73.0±22.2

Table A-2. Crosscheck program results, thermoluminescent dosimeters (TLDs).

Lab Code	TLD Type	Measurement	mR: Teledyne Result ±2σ[a]	mR: Known Value	mR: Average ±2σ[d] (All Participants)
115-7B	CaF_2:Mn Bulbs	Field	71.5±2.6	75.8±6.0	75.1±29.8
		Lab (Co-60)	84.8±6.4	79.9±4.0	77.9±27.6
		Lab (Cs-137)	78.8±1.6	75.0±3.8	73.0±22.2
115-7C	$CaSO_4$:Dy Cards	Field	76.8±2.7	75.8±6.0	75.1±29.8
		Lab (Co-60)	82.5±3.7	79.9±4.0	77.9±27.6
		Lab (Cs-137)	79.0±3.2	75.0±3.8	73.0±22.2
8th International Intercomparison[i]					
115-8A	LiF-100 Chips	Field Site 1	29.5±1.4	29.7±1.5	28.9±12.4
		Field Site 2	11.3±0.8	10.4±0.5	10.1±9.06
		Lab (Cs-137)	13.7±0.9	17.2±0.9	16.2±6.8
115-8B	CaF_2:Mn Bulbs	Field Site 1	32.3±1.2	29,7±1.5	28.9±12.4
		Field Site 2	9.0±1.0	10.4±0.5	10.1±9.0
		Lab (Cs-137)	15.8±0.9	17.2±0.9	16.2±6.8
115-8C	$CaSO_4$:Dy Cards	Field Site 1	32.2±0.7	29.7±1.5	28.9±12.4
		Field Site 2	10.6±0.6	10.4±0.5	10.1±9.0
		Lab (Cs-137)	18.1±0.8	17.2±0.9	16.2±6.8
Teledyne Testing					
89-1	LiF-100 Chips	Lab	21.0±0.4	22.4	–
89-2	Teledyne $CaSO_4$:Dy Cards	Lab	20.9±1.0	20.3	–

Table A-2. (continued)

Lab Code	TLD Type	Measurement	mR: Teledyne Result ±2σ[a]	mR: Known Value	mR: Average ±2σ[d] (All Participants)
Teledyne Testing					
90-1[k]	Teledyne $CaSO_4$:Dy Cards	Lab	20.6±1.4	19.6	–
90-2[l]	Teledyne $CaSO_4$:Dy Cards	Lab	100.8±4.3	100.0	–
91-1[m]	Teledyne $CaSO_4$:Dy Cards	Lab	33.4±2.0	32.0	–
			55.2±4.7	58.8	–
			87.8±6.2	85.5	–
92-1[n]	LiF-100 Chips	Lab	11.1±0.2	10.7	–
			25.6±0.5	25.4	–
			46.4±0.5	46.3	–
92-2[o]	Teledyne $CaSO_4$:Dy Cards	Lab (Reader #1)	20.1±0.1	20.1	–
			40.6±0.1	40.0	–
			60.0±1.3	60.3	–
		Lab (Reader #2)	20.3±0.3	20.1	–
			39.2±0.3	40.0	–
			60.7±0.4	60.3	–

[a] Lab result given is the mean ±2 standard deviations of three determinations.

[b] Second International Intercomparison of Environmental Dosimeters conducted in April of 1976 by the Health and Safety Laboratory (HASL), New York, New York, and the School of Public Health of the University of Texas, Houston, Texas.

[c] Value determined by sponsor of the intercomparison using continuously operated pressurized ion chamber.

[d] Mean ±2 standard deviations of results obtained by all laboratories participating in the program.

[e] Third International Intercomparison of Environmental Dosimeters conducted in summer of 1977 by Oak Ridge National Laboratory and the School of Public Health of the University of Texas, Houston, Texas.

[f] Fourth International Intercomparison of Environmental Dosimeters conducted in summer of 1979 by the School of Public Health of the University of Texas Houston, Texas.

[g] Fifth International Intercomparison of Environmental Dosimeters conducted in fall of 1980 at Idaho Falls, Idaho and sponsored by the School of Public Health of the University of Texas, Houston, Texas and Environmental Measurements Laboratory, New York, New York, U.S. Department of Energy.

Table A-2. (continued)

Lab Code	TLD Type	Measurement	mR: Teledyne Result ±2σ[a]	mR: Known Value	mR: Average ±2σ[d] (All Participants)

Footnotes (continued)

h Seventh International Intercomparison of Environmental Dosimeters conducted in the spring and summer of 1984 at Las Vegas, Nevada, and sponsored by the U.S. Department of Energy, The U.S. Nuclear Regulatory Commission, and the U.S. Environmental Protection Agency.

i Eighth International Intercomparison of Environmental Dosimeters conducted in the fall and winter of 1985-1986 at New York, New York, and sponsored by the U.S. Department of Energy.

j Chips were submitted in September 1989 and cards were submitted in November 1989 to Teledyne Isotopes, Inc., Westwood, NJ for irradiation.

k Cards were irradiated by Teledyne Isotopes, Inc., Westwood, NJ on June 19, 1990.

l Cards were irradiated by Dosimetry Associates, Inc., Northville, MI on October 30, 1990.

m Irradiated cards were provided by Teledyne Isotopes, INC., Westwood, NJ. Irradiated on October 8, 1991.

n Chips were irradiated by Teledyne Isotopes, Inc., Westwood, NJ on February 26, 1992.

o Cards were irradiated by Teledyne Isotopes, Inc., Westwood, NJ on April 1, 1992.

Table A-3. In-house spiked samples.

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L TIML Result 2s, n=3[a]	Known Activity	Expected Precision 1s, n=3[a]
QC-MI-16	Milk	Feb 1988	Sr-89	31.8±4.7	31.7±6.0	8.7
			Sr-90	25.5±2.7	27.8±3.5	5.2
			I-131	26.4±0.5	23.2±5.0	10.4
			Cs-134	23.8±2.3	24.2±6.0	8.7
			Cs-137	26.5±0.8	25.1±6.0	8.7
QC-MI-17	Milk	Feb 1988	I-131	10.6±1.2	14.3±1.6	10.4
QC-W-35	Water	Feb 1988	I-131	9.7±1.1	11.6±1.1	10.4
QC-W-36	Water	Mar 1988	I-131	10.5±1.3	11.6±1.0	10.4
QC-W-37	Water	Mar 1988	Sr-89	17.1±2.0	19.8±8.0	8.7
			Sr-90	18.7±0.9	17.3±5.0	5.2
QC-MI-18	Milk	Mar 1988	I-131	33.2±2.3	26.7±5.0	10.4
			Cs-134	31.3±2.1	30.2±5.0	8.7
			Cs-137	29.9±1.4	26.2±5.0	8.7
QC-W-38	Water	Apr 1988	I-131	17.1±1.1	14.2±5.0	10.4
QC-W-39	Water	Apr 1988	H-3	4439±31	4176±500	724
QC-W-40	Water	Apr 1988	Co-60	23.7±0.5	26.1±4.0	8.7
			Cs-134	25.4±2.6	29.2±4.5	8.7
			Cs-137	26.6±2.3	26.2±4.0	8.7
QC-W-41	Water	Jun 1988	Gr. alpha	12.3±0.4	13.1±5.0	8.7
			Gr. beta	22.6±1.0	20.1±5.0	8.7
QC-MI-19	Milk	Jul 1988	Sr-89	15.1±1.6	16.4±5.0	8.7
			Sr-90	18.0±0.6	18.3±5.0	5.2
			I-131	88.4±4.9	86.6±8.0	10.4
			Cs-137	22.7±0.8	20.8±6.0	8.7
QC-W-42	Water	Sep 1988	Sr-89	48.5±3.3	50.8±8.0	8.7
			Sr-90	10.9±1.0	11.4±3.5	5.2
QC-W-43	Water	Oct 1988	Co-60	20.9±3.2	21.4±3.5	8.7
			Cs-134	38.7±1.6	38.0±6.0	8.7
			Cs-137	19.0±2.4	21.0±3.5	8.7
QC-W-44	Water	Oct 1988	I-131	22.2±0.6	23.3±3.5	10.4

Table A-3. In-house spiked samples(continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L TIML Result 2s, n=3[a]	Known Activity	Expected Precision 1s, n=3[a]
QC-W-45	Water	Oct 1988	H-3	4109±43	4153±500	724
QC-MI-20	Milk	Oct 1988	I-131	59.8±0.9	60.6±9.0	10.4
			Cs-134	49.6±1.8	48.6±7.5	8.7
			Cs-137	25.8±4.6	24.7±4.0	8.7
QC-W-46	Water	Dec 1988	Gr. alpha	11.5±2.3	15.2±5.0	8.7
			Gr. beta	26.5±2.0	25.7±5.0	8.7
QC-MI-21	Milk	Jan 1989	Sr-89	25.5±10.3	34.0±10.0	8.7
			Sr-90	28.3±3.2	27.1±3.0	5.2
			I-131	540±13	550±20	10.4
			Cs-134	24.5±2.6	22.6±5.5	8.7
			Cs-137	24.0±0.6	20.5±5.0	8.7
QC-W-47	Water	Mar 1989	Sr-89	15.2±3.8	16.1±5.0	8.7
			Sr-90	16.4±1.7	16.9±3.0	5.2
QC-MI-22	Milk	Apr 1989	I-131	36.3±1.1	37.2±5.0	10.4
			Cs-134	20.8±2.8	20.7±8.0	8.7
			Cs-137	22.2±2.4	20.4±8.0	8.7
QC-W-48	Water	Apr 1989	Co-60	23.5±2.0	25.1±8.0	8.7
			Cs-134	24.2±1.1	25.9±8.0	8.7
			Cs-137	23.6±1.2	23.0±8.0	8.7
QC-W-49	Water	Apr 1989	I-131	37.2±3.7	37.2±5.0	10.4
QC-W-50	Water	Apr 1989	H-3	3011±59	3089±500	724
QC-W-51	Water	Jun 1989	Gr. alpha	13.0±1.8	15.0±5.0	8.7
			Gr. beta	26.0±1.2	25.5±8.0	8.7
QC-MI-23	Milk	Jul 1989	Sr-89	19.4±6.5	22.0±10.0	8.7
			Sr-90	27.6±3.5	28.6±3.0	5.2
			I-131	46.8±3.2	43.4±5.0	10.4
			Cs-134	27.4±1.8	28.3±6.0	8.7
			Cs-137	24.1±1.8	20.8±6.0	8.7
QC-MI-24	Milk	Aug 1989	Sr-89	25.4±2.7	27.2±10.0	8.7
			Sr-90	46.0±1.1	47.8±9.6	5.2
QC-W-52	Water	Sep 1989	I-131	9.6±0.3	9.7±1.9	10.4

Table A-3. In-house spiked samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L TIML Result 2s, n=3[a]	Known Activity	Expected Precision 1s, n=3[a]
QC-W-53	Water	Sep 1989	I-131	19.0±0.2	20.9±4.2	10.4
QC-W-54	Water	Sep 1989	Sr-89	25.8±4.6	24.7±4.0	8.7
			Sr-90	26.5±5.3	29.7±5.0	5.2
QC-MI-25	Milk	Oct 1989	I-131	70.0±3.3	73.5±20.0	10.4
			Cs-134	22.1±2.6	22.6±8.0	8.7
			Cs-137	29.4±1.5	27.5±8.0	8.7
QC-W-55	Water	Oct 1989	I-131	33.3±1.3	35.3±10.0	10.4
QC-W-56	Water	Oct 1989	Co-60	15.2±0.9	17.4±5.0	8.7
			Cs-134	22.1±4.4	18.9±8.0	8.7
			Cs-137	27.2±1.2	22.9±8.0	8.7
QC-W-57	Water	Oct 1989	H-3	3334±22	3379±500	724
QC-W-58	Water	Nov 1989	Sr-89	10.9±1.4[d]	11.1±1.0[d]	8.7
			Sr-90	10.4±1.0[d]	10.3±1.0[d]	5.2
QC-W-59	Water	Nov 1989	Sr-89	101.0±6.0[d]	104.1±10.5[d]	18.0
			Sr-90	98.0±3.0[d]	95.0±10.0[d]	16.4
QC-W-60	Water	Dec 1989	Gr. alpha	10.8±1.1	10.6±4.0	8.7
			Gr. beta	11.6±0.5	11.4±4.0	8.7
QC-MI-26	Milk	Jan 1990	Cs-134	19.3±1.0	20.8±8.0	8.7
			Cs-137	25.2±1.2	22.8±8.0	8.7
QC-MI-27	Milk	Feb 1990	Sr-90	18.0±1.6	18.8±5.0	5.2
QC-MI-28	Milk	Mar 1990	I-131	63.8±2.2	62.6±6.0	10.8
QC-MI-61	Water	Apr 1990	Sr-89	17.9±5.5	23.1±8.7	8.7
			Sr-90	19.4±2.5	23.5±5.2	5.2
QC-MI-29	Milk	Apr 1990	I-131	90.7±9.2	82.5±8.5	10.4
			Cs-134	18.3±1.0	19.7±5.0	8.7
			Cs-137	20.3±1.0	18.2±5.0	8.7
QC-W-62	Water	Apr 1990	Co-60	8.7±0.4	9.4±5.0	8.7
			Cs-134	20.0±0.2	19.7±5.0	8.7
			Cs-137	28.7±1.4	22.7±5.0	8.7

Table A-3. In-house spiked samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L TIML Result 2s, n=3[a]	Known Activity	Expected Precision 1s, n=3[a]
QC-W-63	Water	Apr 1990	I-131	63.5±8.0	66.0±6.7	11.4
QC-W-64	Water	Apr 1990	H-3	1941±130	1826.0±350.0	724
QC-W-65	Water	Jun 1990	Ra-226	6.4±0.2	6.9±1.0	1.8
QC-W-66	Water	Jun 1990	U	6.2±0.2	6.0±6.0	10.4
QC-MI-30	Milk	Jul 1990	Sr-89	12.8±0.4	18.4±10.0	8.7
			Sr-90	18.2±1.4	18.7±6.0	5.2
			Cs-134	46.0±1.3	49.0±5.0	8.7
			Cs-137	27.6±1.3	25.3±5.0	8.7
QC-W-68	Water	Jun 1990	Gr. alpha	9.8±0.3	10.6±6.0	8.7
			Gr. beta	11.4±0.6	11.3±7.0	8.7
QC-MI-31	Milk	Aug 1990	I-131	68.8±1.6	61.4±12.3	10.4
QC-W-69	Water	Sep 1990	Sr-89	17.7±1.6	19.2±10.0	8.7
			Sr-90	13.9±1.6	17.4±10.0	5.2
QC-MI-32	Milk	Oct 1990	I-131	34.8±0.2	32.4±6.5	8.7
			Cs-134	25.8±1.2	27.3±10.0	8.7
			Cs-137	25.3±2.0	22.4±10.0	8.7
QC-W-70	Water	Oct 1990	H-3	2355±59	2276±455	605
QC-W-71	Water	Oct 1990	I-131	55.9±0.9	51.8±10.4	10.4
QC-W-73	Water	Oct 1990	Co-60	18.3±2.7	16.8±5.0	8.7
			Cs-134	28.3±2.3	27.0±5.0	8.7
			Cs-137	22.7±1.3	22.4±5.0	8.7
QC-W-74	Water	Dec 1990	Gr. alpha	21.4±1.0	26.1±6.5	11.3
			Gr. beta	25.9±1.0	22.3±5.6	8.7

[a] n=3 unless noted otherwise.
[b] n=2
[c] n=1
[d] Concentration in pCi/mL

Table A-3. In-house spiked samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L TIML Result 2s, n=1[e]	Known Activity	Expected Precision 1s, n=1[e]
QC-MI-33	Milk	Jan 1991	Sr-89	20.7±3.3	21.6±5.0	5.0
			Sr-90	19.0±1.4	23.0±3.0	3.0
			Cs-134	22.2±1.7	19.6±5.0	5.0
			Cs-137	26.1±1.6	22.3±5.0	5.0
QC-MI-34	Milk	Feb 1991	I-131	40.7±1.8	40.1±6.0	6.0
QC-W-75	Water	Mar 1991	Sr-89	18.8±1.5	23.3±5.0	5.0
			Sr-90	16.0±0.8	17.2±3.0	3.0
QC-W-76	Water	Apr 1991	I-131	56.5±1.7	59.0±5.9	5.9
QC-W-77	Water	Apr 1991	Co-60	16.4±2.2	15.7±5.0	5.0
			Cs-134	23.8±2.5	22.6±5.0	5.0
			Cs-137	25.0±2.4	21.1±5.0	5.0
QC-W-78	Water	Apr 1991	H-3	4027±188	4080±408	408
QC-MI-35	Milk	Apr 1991	I-131	48.0±0.8	49.2±6.0	6.0
			Cs-134	19.2±2.0	22.6±5.0	5.0
			Cs-137	22.8±2.2	22.1±5.0	5.0
QC-W-79	Water	Jun 1991	Gr. alpha	7.4±0.7	7.8±5.0	5.0
			Gr. beta	11.0±0.7	11.0±5.0	5.0
QC-MI-36	Milk	Jul 1991	Sr-89	28.1±2.1	34.0±10.0	5.0
			Sr-90	11.6±0.7	11.5±3.0	3.0
			I-131	14.4±1.9	18.3±5.0	5.0
			Cs-137	34.3±3.0	35.1±5.0	5.0
QC-W-80	Water	Oct 1991	Sr-89	27.4±6.9	24.4±5.0	5.0
			Sr-90	11.7±1.4	14.1±5.0	3.0
QC-W-81	Water	Oct 1991	I-131	19.1±0.7	20.6±4.2	6.0
QC-W-82	Water	Oct 1991	Co-60	22.6±2.7	22.1±5.0	5.0
			Cs-134	15.5±1.8	17.6±5.0	5.0
			Cs-137	17.5±2.1	17.6±5.0	5.0
QC-W-83	Water	Oct 1991	H-3	4639±137	4382±438	438
QC-MI-37	Milk	Oct 1991	I-131	23.6±3.2	25.8±5.0	6.0
			Cs-134	22.7±2.8	22.1±5.0	5.0
			Cs-137	38.3±3.0	35.1±5.0	5.0
QC-W-84	Water	Dec 1991	Gr. alpha	6.2±0.6	7.8±5.0	5.0
			Gr. beta	11.0±0.7	11.0±5.0	5.0

Table A-3. In-house spiked samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L TIML Result 2s, n=1[e]	Known Activity	Expected Precision 1s, n=1[e]
QC-MI-39	Milk	Jan 1992	Sr-89	21.6±6.5	31.2±10.0	5.0
			Sr-90	38.7±1.8	42.3±8.5	4.2
			I-131	76.8±0.9	83.7±16.0	8.4
			Cs-134	42.1±5.7	49.4±10.0	5.0
			Cs-137	55.2±6.4	53.0±10.0	5.0
QC-W-85	Water	Mar 1992	Sr-89	26.2±3.1	32.0±10.0	5.0
			Sr-90	24.4±1.4	28.0±6.0	3.0
QC-W-86	Water	Apr 1992	H-3	4080±190	4027±403	403
QC-W-87	Water	Apr 1992	I-131	33.5±0.6	33.2±12.0	6.0
QC-W-88	Water	Apr 1992	Co-60	17.5±2.7	19.7±10.0	5.0
			Cs-134	28.9±2.5	33.5±10.0	5.0
			Cs-137	41.0±3.0	38.9±10.0	5.0
QC-MI-40	Milk	Apr 1992	Cs-134	58.0±2.6	55.9±10.0	5.0
			Cs-137	43.7±3.0	38.9±10.0	5.0
QC-W-41	Milk	Apr 1992	I-131	50.3±0.8	55.9±11.2	5.6
QC-W-89	Water	Jun 1992	Gr. alpha	15.3±0.8	13.6±10.0	5.0
			Gr. beta	17.2±0.9	17.6±10.0	5.0
QC-MI-42	Milk	Aug. 1992	Sr-89	41.4±5.9	51.2±10.2	5.0
			Sr-90	48.9±2.5	51.9±10.4	5.2
			Cs-134	20.1±2.8	20.2±10.0	5.0
			Cs-137	26.2±2.7	26.1±10.0	5.0
QC-W-90	Water	Sept. 1992	Sr-89	6.7±3.4	12.6±10.0	5.0
			Sr-90	16.1±1.4	15.6±6.0	3.0
QC-W-91	Water	Oct. 1992	I-131	34.9±2.2	34.9±10.0	6.0
QC-W-92	Water	Oct. 1992	Co-60	11.4±1.9	9.2±10.0	5.0
			Cs-134	18.7±2.3	14.3±10.0	5.0
			Cs-137	14.1±1.8	15.0±10.0	5.0

Table A-3. In-house spiked samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L TIML Result 2s, n=1[e]	Known Activity	Expected Precision 1s, n=1[e]
QC-W-93	Water	Oct. 1992	H-3	3704±186	3904±390	367
QC-W-94	Water	Oct. 1992	H-3	14,925±339	15,616±1,562	1562
QC-W-95	Water	Oct. 1992	I-131	64.2±2.7	67.2±10.0	6.7
QC-MI-43	Milk	Oct. 1992	I-131	19.9±1.0	21.5±6.0	6.0
			Cs-134	14.2±3.4	12.7±10.0	5.0
			Cs-137	14.1±5.2	17.1±10.0	5.0
QC-MI-44	Milk	Oct. 1992	I-131	36.1±1.2	43.0±10.0	6.0
			Cs-134	28.2±4.0	25.4±10.0	5.0
			Cs-137	38.8±5.1	34.2±10.0	5.0

[e] Starting in January 1991, all determinations are single.

Table A-4. In-house "blank" samples.

Lab Code	Sample Type	Date Collected	Analysis	Concentration (pCi/L) Results (4.66 σ)	Concentration (pCi/L) Acceptance Criteria (4.66 σ)
SPS-5386	Milk	Jan 1988	I-131	<0.1	<1
SPW-5448	"Dead" Water	Jan 1988	H-3	<177	<300
SPS-5615	Milk	Mar 1988	Cs-134	<2.4	<10
			Cs-137	<2.5	<10
			I-131	<0.3	<1
			Sr-89	<0.4	<5
			Sr-90	2.4±0.5[a]	<1
SPS-5650	D.I. Water	Mar 1988	Th-228	<0.3	<1
			Th-230	<0.04	<1
			Th-232	<0.05	<1
			U-234	<0.03	<1
			U-235	<0.03	<1
			U-238	<0.03	<1
			Am-241	<0.06	<1
			Cm-241	<0.01	<1
			Pu-238	<0.08	<1
			Pu-240	<0.02	<1
SPS-6090	Milk	Jul 1988	Sr-89	<0.5	<1
			Sr-90	1.8±0.5	<1
			I-131	<0.4	<1
			Cs-137	<0.4	<10
SPW-6209	Water	Jul 1988	Fe-55	<0.8	<1
SPW-6292	Water	Sep 1988	Sr-89	<0.7	<5
			Sr-90	<0.7	<1
SPS-6477	Milk	Oct 1988	I-131	<0.2	<1
			Cs-134	<6.1	<10
			Cs-137	<5.9	<10
SPW-6478	Water	Oct 1988	I-131	<0.2	<1
SPW-6479	Water	Oct 1988	Co-60	<5.7	<10
			Cs-134	<3.7	<10
			Cs-137	<4.3	<10
SPW-6480	Water	Oct 1988	H-3	<170	<300

Table A-4. In-house "blank" samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration (pCi/L) Results (4.66 σ)	Acceptance Criteria (4.66 σ)
SPW-6625	Water	Dec 1988	Gr. alpha	<0.7	<1
			Gr. beta	<1.9	<4
SPS-6723	Milk	Jan 1989	Sr-89	<0.6	<5
			Sr-90	1.9±0.5[a]	<1
			I-131	<0.2	<1
			Cs-134	<4.3	<10
			Cs-137	<4.4	<10
SPW-6877	Water	Mar 1989	Sr-89	<0.4	<5
			Sr-90	<0.6	<1
SPS-6963	Milk	Apr 1989	I-131	<0.3	<1
			Cs-134	<5.9	<10
			Cs-137	<6.2	<10
SPW-7561	Water	Apr 1989	H-3	<150	<300
SPW-7207	Water	Jun 1989	Ra-226	<0.2	<1
			Ra-228	<0.6	<1
SPS-7208	Milk	Jun 1989	Sr-89	<0.6	<5
			Sr-90	2.1±0.5[a]	<1
			I-131	<0.3	<1
			Cs-134	<6.4	<10
			Cs-137	<7.2	<10
SPW-7588	Water	Jun 1989	Gr. alpha	<0.2	<1
			Gr. beta	<1.0	<4
SPS-7322	Milk	Aug 1989	Sr-89	<1.4	<5
			Sr-90	4.8±1.0[a]	<1
			I-131	<0.2	<1
			Cs-134	<6.9	<10
			Cs-137	<8.2	<10
SPW-7559	Water	Sep 1989	Sr-89	<2.0	<5
			Sr-90	<0.7	<1
SPW-7560	Water	Oct 1989	I-131	<0.1	<1
SPW-7562	Water	Oct 1989	H-3	<140	<300

Table A-4. In-house "blank" samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration (pCi/L) Results (4.66 σ)	Concentration (pCi/L) Acceptance Criteria (4.66 σ)
SPS-7605	Milk	Nov 1989	I-131	<0.2	<1
			Cs-134	<8.6	<10
			Cs-137	<10	<10
SPW-7971	Water	Dec 1989	Gr. alpha	<0.4	<1
			Gr. beta	<0.8	<4
SPW-8039	Water	Jan 1990	Ra-226	<0.2	<1
SPS-8040	Milk	Jan 1990	Sr-89	<0.8	<5
			Sr-90	<1.0	<1
SPS-8208	Milk	Jan 1990	Sr-89	<0.8	<5
			Sr-90	1.6±0.5[a]	<1
			Cs-134	<3.6	<10
			Cs-137	<4.7	<10
SPS-8312	Milk	Feb 1990	Sr-89	<0.3	<5
			Sr-90	1.2±0.3[a]	<1
SPW-8312A	Water	Feb 1990	Sr-89	<0.6	<5
			Sr-90	<0.7	<5
SPS-8314	Milk	Mar 1990	I-131	<0.3	<1
SPS-8310	Milk	May 1990	I-131	<0.2	<1
			Cs-134	<4.6	<10
			Cs-137	<4.8	<10
SPW-8511A	Water	May 1990	H-3	<200	<300
SPS-8600	Milk	Jul 1990	Sr-89	<0.8	<5
			Sr-90	1.7±0.6[a]	<1
			I-131	<0.3	<1
			Cs-134	<5.0	<10
			Cs-137	<7.0	<10
SPM-8877	Milk	Aug 1990	I-131	<0.2	<1
SPW-8925	Water	Aug 1990	H-3	<200	<300

Table A-4. In-house "blank" samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration (pCi/L) Results (4.66 σ)	Concentration (pCi/L) Acceptance Criteria (4.66 σ)
SPW-8926	Water	Aug 1990	Gr. alpha	<0.3	<1
			Gr. beta	<0.7	<4
SPW-8927	Water	Aug 1990	U-234	<0.01	<1
			U-235	<0.02	<1
			U-238	<0.01	<1
SPW-8928	Water	Aug 1990	Mn-54	<4.0	<10
			Co-58	<4.1	<10
			Co-60	<2.4	<10
			Cs-134	<3.3	<10
			Cs-137	<3.7	<10
SPW-8929	Water	Aug 1990	Sr-89	<1.4	<5
			Sr-90	<0.6	<1
SPW-69	Water	Sep 1990	Sr-89	<1.8	<5
			Sr-90	<0.8	<1
SPW-106	Water	Oct 1990	H-3	<180	<300
			I-131	<0.3	<1
SPM-107	Milk	Oct 1990	I-131	<0.4	<1
			Cs-134	<3.3	<10
			Cs-137	<4.3	<10
SPW-370	Water	Oct 1990	Mn-54	<1.7	<10
			Co-58	<2.6	<10
			Co-60	<1.6	<10
			Cs-134	<1.7	<10
			Cs-137	<1.8	<10
SPW-372	Water	Dec 1990	Gr. alpha	<0.3	<1
			Gr. beta	<0.8	<4
SPS-406	Milk	Jan 1991	Sr-89	<0.4	<5
			Sr-90	1.8±0.4[a]	<1
			Cs-134	<3.7	<10
			Cs-137	<5.2	<10
SPS-421	Milk	Feb 1991	I-131	<0.3	<1
SPW-451	Water	Feb 1991	Ra-226	<0.1	<1
			Ra-228	<0.9	<1

Table A-4. In-house "blank" samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration (pCi/L) Results (4.66 σ)	Concentration (pCi/L) Acceptance Criteria (4.66 σ)
SPW-514	Water	Mar 1991	Sr-89	<1.1	<5
			Sr-90	<0.9	<1
SPW-586	Water	Apr 1991	I-131	<0.2	<1
			Co-60	<2.5	<10
			Cs-134	<2.4	<10
			Cs-137	<2.2	<10
SPS-587	Milk	Apr 1991	I-131	<0.2	<1
			Cs-134	<1.7	<10
			Cs-137	<1.9	<10
SPW-837	Water	Jun 1991	Gr. alpha	<0.6	<1
			Gr. beta	<1.1	<4
SPM-953	Milk	Jul 1991	Sr-89	<0.7	<5
			Sr-90	0.4±0.3[a]	<1
			I-131	<0.2	<1
			Cs-137	<4.9	<10
SPM-1236	Milk	Oct 1991	I-131	<0.2	<1
			Cs-134	<3.7	<10
			Cs-137	<4.6	<10
SPW-1254	Water	Oct 1991	Sr-89	<2.8	<5
			Sr-90	<0.7	<1
SPW-1256	Water	Oct 1991	I-131	<0.4	<1
			Co-60	<3.6	<10
			Cs-134	<4.0	<10
			Cs-137	<3.6	<10
SPW-1259	Water	Oct 1991	H-3	<160	<300
SPW-1444	Water	Dec 1991	Gr. alpha	<0.4	<1
			Gr. beta	<0.8	<4
SPM-1578	Milk	Jan 1992	Sr-89	<0.5	<5
			Sr-90	1.3±0.4[a]	<1
			I-131	<0.2	<1
			Cs-134	<7.2	<10
			Cs-137	<8.0	<10

Table A-4. In-house "blank" samples (continued)

Lab Code	Sample Type	Date Collected	Analysis	Concentration (pCi/L) Results (4.66 σ)	Concentration (pCi/L) Acceptance Criteria (4.66 σ)
SPW-1860	Water	Mar 1992	Sr-89	<0.6	<5
			Sr-90	<0.4	<1
SPW-2067	Water	Apr 1992	H-3	<168	<300
SPW-2114	Water	Apr 1992	C-14	<1.0	<200
SPW-2119	Milk	Apr 1992	Co-60	<6.3	<10
			Cs-134	<4.5	<10
			Cs-137	<5.4	<10
SPW-2126	Water	Apr 1992	I-131	<0.2	<1
SPM-2133	Milk	Apr 1992	I-131	<0.2	<1
SPW-2220	Water	May 1992	Co-60	<2.1	<10
			Cs-134	<2.1	<10
			Cs-137	<2.3	<10
SPW-2369	Water	Jun 1992	Gr. alpha	<0.4	<1
			Gr. beta	<0.8	<4
SPM-2500	Milk	Aug 1992	I-131	<0.4	<1
			Sr-89	<1.2	<5
			Sr-90	<0.9	<1
SPW-2666	Water	Sept. 1992	Sr-89	<0.8	<5
			Sr-90	<0.5	<1
SPW-2828	Water	Oct. 1992	Co-60	<4.8	<10
			Cs-134	<6.0	<10
			Cs-137	<6.1	<10
			I-131	<0.3	<1
			H-3	<177	<300
SPM-2829	Milk	Oct. 1992	Co-60	<9.3	<10
			Cs-134	<6.4	<10
			Cs-137	<7.2	<10
SPW-3212	Water	Oct 1992	Ra-228	<1.0	<1
SPW-3057	Water	Nov. 1992	Ra-226	<0.03	<1
SPW-3294	Water	Dec. 1992	Gr. alpha	<0.4	<1
			Gr. beta	<0.8	<4

ATTACHMENT B

ACCEPTANCE CRITERIA FOR "SPIKED" SAMPLES

LABORATORY PRECISION: ONE STANDARD DEVIATION VALUES FOR VARIOUS ANALYSES[a]

Analysis	Level	One Standard Deviation for Single Determination
Gamma Emitters	5 to 100 pCi/liter or kg >100 pCi/liter or kg	5 pCi/liter 5% of known value
Strontium-89[b]	5 to 50 pCi/liter or kg >50 pCi/liter or kg	5 pCi/liter 10% of known value
Strontium-90[b]	2 to 30 pCi/liter or kg >30 pCi/liter or kg	3.0 pCi/liter 10% of known value
Potassium	>0.1 g/liter or kg	5% of known value
Gross alpha	<20 pCi/liter >20 pCi/liter	5 pCi/liter 25% of known value
Gross beta	<100 pCi/liter >100 pCi/liter	5 pCi/liter 5% of known value
Tritium	<4,000 pCi/liter >4,000 pCi/liter	1s = (pCi/liter) = 169.85 x (known)$^{.0933}$ 10% of known value
Radium-226, -228	<0.1 pCi/liter	15% of known value
Plutonium	0.1 pCi/liter, gram, or sample	10% of known value
Iodine-131, Iodine-129[b]	<55 pCi/liter >55 pCi/liter	6 pCi/liter 10% of known value
Uranium-238, Nickel-64[b], Technetium-99[b]	<35 pCi/liter >35 pCi/liter	6 pCi/liter 15% of known value
Iron-55[b]	50 to 100 pCi/liter >100 pCi/liter	10 pCi/liter 10% of known value

[a] From EPA publication, "Environmental Radioactivity Laboratory Intercomparison Studies Program, Fiscal Year, 1981-1982, EPA-600/4-81-004.
[b] TIML limit.

ADDENDUM TO APPENDIX A

The following is an explanation of the reasons why certain samples were outside the control limit specified by the Environmental Protection Agency for the Interlaboratory Comparions Program starting January 1988.

Lab Code	Analysis	TIML Result (pCi/L)[a]	EPA Control Limit (pCi/L)[a]	Explanation
STF-524	K	1010.7±158.5[b]	1123.5-1336.5[b]	Error in transference of data. Correct data was 1105±33 mg/kg. Results in the past have been within the limits and TIML will monitor the situation in the future.
STW-532	I-131	9.0±2.0	6.2-8.8	Sample recounted after 12 days. The average result was 8.8±1.7 pCi/L (within EPA control liinits). The sample was recounted in order to check the decay. Results in the past have been within the limits and TIML will continue to monitor the situation in the future.
STW-534	Co-60	63.3±1.3	41.3-58.7	High level of Co-60 was due to contamination of beaker. Beaker was discarded upon discovery of contamination and sample was recounted. Recount results were 53.2±3.6 and 50.9±2.4 pCi/L.
STM-554	Sr-90	51.0±2.0	54.8-65.2	The cause of low result was due to very high fat content of milk. It should be noted that 63% of all participants failed this test. Also, the average for all participants was 54.0 pCi/L before the Grubb and 55.8 pCi/L after the Grubb.
STW-560	Pu-239	5.8±1.1	3.5-4.9	The cause of high results is not known though it is suspected that the standard was not properly calibrated by supplier and is under investigation. New Pu-236 standard was obtained and will be used for the next test.
STW-568	Ra-228	2.6±1.0	2.7-4.5	The cause of low results is not known. Next EPA cross check results were within the control imits. No further action is planned.

Lab Code	Analysis	TIML Result (pCi/L)[a]	EPA Control Limit (pCi/L)[a]	Explanation
STM-570	Sr-89	26.0±10.0	30.3-47.7	The cause of low results was falsely high recovery due to suspected incomplete calcium removal. Since EPA sample was used up, internal spike was prepared and analyzed. The results were within control limits (See table A-3, sample QC-MI-24). No further action is planned.
	Sr-90	45.7±4.2	49.8-60.2	
STW-589	Sr-90	17.3±1.2	17.4-22.6	Sample was reanalyzed in triplicate; results of reanalyses were 18.8±1.5 pCi/L. No further action is planned.
STM-599	K	1300.0±69.2[c]	1414.7-1685.3[c]	Sample was reanalyzed in triplicate. Results of reanalyses were 1421.7±95.3 mg/L. The cause of low results was using wrong volume.
STW-601	Gr. alpha	11.0±2.0	11.6-32.4	Sample was reanalyzed in triplicate. Results of reanalyses were 13.4±1.0 pCi/L.
STAF-626	Gr. alpha	38.7±1.2	14.6-35.4	The cause of high results is the difference in geometery between standard used in the TIML lab and EPA filter.
STW-632	Ba-133	74.0±6.9	51.6-72.4	Sample was reanalyzed. Results of the reanalyses were 63.8±6.9 pCi/L within EPA limit.
STM-641	I-131	130.7±16.8	88.9-127.1	The cause of high result is unknown. In-house spike sample was prepared with activity of I-131 68.3±6.8 pCi/L. Result of the analysis was 69.1±9.7 pCi/L.
STM-661	Sr-89	25.3±7.6	29.3-46.7	The cause of low result is unknown. Data was checked for errors. The In-house spike sample was prepared with activity of Sr-89 41.0±10.0 pCi/L. Result of the analysis was 37.2±3.6 pCi/L.

Lab Code	Analysis	TIML Result (pCi/L)[a]	EPA Control Limit (pCi/L)[a]	Explanation
STM-673	K	1540.0±103.9[c]	1597.3-1902.7	Activity was calculated using the wrong volume (3.5 L), instead of 3.25 L. Correction for volume resulted in a value of 1660.0±110.1 mg/L; within EPA control limits.

[a] Reported in pCi/L unless otherwise noted.
[c] Concentrations are reported in mg/L.

APPENDIX B

DATA REPORTING CONVENTIONS

Data Reporting Conventions

1.0. All activities except gross alpha and gross beta are decay corrected to collection time or the end of the collection period.

2.0. 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.

3.0. Duplicate analyses

3.1 Individual results: $x_1 \pm s_1$

$x_1 \pm s_2$

Reported result: $x \pm s$

where $x = (1/2)\ (x_1 \pm x_2)$

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

3.2. Individual results: $<L_1$

$<L_2$

Reported result: $<L$

where L = lower of L_1 and L_2

3.3. Individual results: $x \pm s$

$<L$

Reported result: $x \pm s$ if $x \geq L$;

$<L$ otherwise

4.0. Computation of Averages and Standard Deviations

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

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

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

4.2 Values below the highest lower limit of detection are not included in the average.

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

4.4 If all but one of the values are less than the highest LLD, the single value x and associated two sigma error is reported.

4.5 In rounding off, the following rules are followed:

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

4.5.2. 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.

4.5.3. If the figure following those to be retained is 5, and if there are no figures other than zeros beyond the five, the figure five is dropped, and the last-place figure retained is increased by one if it is an odd number or it is kept 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 C

Maximum Permissible Concentrations of Radioactivity in Air and Water Above Background in Unrestricted Areas

Table C-1. Maximum permissible concentrations of radioactivity in air and water above natural background in unrestricted areas.[a]

Air		Water	
Gross alpha	3 pCi/m^3	Strontium-89	3,000 pCi/l
Gross beta	100 pCi/m^3	Strontium-90	300 pCi/l
Iodine-131[b]	0.14 pCi/m^3	Cesium-137	20,000 pCi/l
		Barium-140	20,000 pCi/l
		Iodine-131	300 pCi/l
		Potassium-40[c]	3,000 pCi/l
		Gross alpha	30 pCi/l
		Gross beta	100 pCi/l
		Tritium	3×10^6 pCi/l

[a] Taken from Code of Federal Regulations Title 10, Part 20, Table II and appropriate footnotes. Concentrations may be averaged over a period not greater than one year.

[b] From 10 CFR 20 but adjusted by a factor of 700 to reduce the dose resulting from the air-grass-cow-milk-child pathway.

[c] A natural radionuclide.

APPENDIX D

SUMMARY OF THE LAND USE CENSUS

SUMMARY 0F 1992 LAND USE CENSUS

The 1992 Land Use Census was completed in August. It consisted of a house-by-house inspection out to three miles from the Duane Arnold Energy Center for all sectors except the NW and WNW sectors that were surveyed to five miles. The Cedar River water usage was surveyed by boat, in July. No new uses of river water were found and the main usage of the Cedar River within three miles downstream of the Duane Arnold Energy Center continues to be recreation and fishing.

The Land Use Census showed that no changes are recommended for the sampling program as no new station-receptor relationships were created. Fewer gardens were observed this year due to drought-like conditions during spring planting time. The building trend in the south south east (SSE) seen in the last four years continued. A total of 26 homes have been built or are under construction in this sector since the last census. The additions are approximately 2.9 miles from DAEC.

APPENDIX E

ANNUAL RADIATION DOSE ASSESSMENT

ANNUAL RADIATION DOSE ASSESSMENT

The annual offsite radiation dose to a member of the public was determined by assessment of environmental dosimeter results and by calculations based on monitored effluent releases.

SECTION A. DOSE CONTRIBUTION FROM DIRECT RADIATION

Direct radiation dose from the operation of DAEC was recorded by TLDs placed at locations in the surrounding environment as described in the Offsite Dose Assessment Manual (ODAM). Observations from the collected data follow:

1. Pre-operational and 1992 TLD results were compared using a paired difference test. No difference in the populations were observed at 0.5 and 1 mile using a confidence level of 99%.

2. As stated earlier in this report (Part I, page 8) no plant effect was indicated by the TLDs when dose results were compared to the estimated average natural background for Middle America.

SECTION B. ESTIMATED OFFSITE DOSE FROM EFFLUENT RELEASES

The contribution of dose to a member of the public most likely to be exposed from effluent releases was calculated by the Meteorological Information and Dose Assessment Systems (MIDAS) computer program in accordance with the ODAM. The calculation methods follow those prescribed by Reg Guide 1.109.

Results of these calculations are discussed below and shown in tabular form on page E-4:

1. There were no liquid releases in 1992.

2. The dose to air from noble gases released was 6.97E-4 mrad from gamma radiation at the SSE site boundary and 1.47E-4 mrad from beta radiation at 4022 meters WNW.

3. The total body dose equivalent to the maximally exposed individual from noble gases was 3.29E-4 mrem, at 1480 meters NW.

4. The skin dose equivalent to the maximally exposed individual from noble gases was 4.03E-4 mrem, at 1480 meters NW.

5. The maximally exposed organ due to iodines and particulates with half-lives greater than eight days was the skin of a

child at 1480 meters NW, with an estimated dose equivalent of 8.31E-3 mrem.

CONCLUSION:

No measurable dose due to operation of DAEC was detected by environmental TLDs in 1992. The calculated doses are below the regulatory limits stated in Appendix I to 10 CFR 50 and in 40 CFR 190.

ESTIMATED MAXIMUM OFFSITE INDIVIDUAL DOSES FOR 1992

TYPE	AGE GROUP	DISTANCE (METERS)	DIRECTION	DOSE OR DOSE EQUIVALENT	ANNUAL LIMIT
DIRECTION RADIATION (AS MEASURED BY TLDs)				NONE	*
LIQUIDS RELEASES				NONE	3 MREM TOTAL BODY
					10 MREM ANY ORGAN
NOBLE GAS					
GAMMA AIR DOSE		481	SSE	6.97E-4 MRAD	10 MRAD
BETA AIR DOSE		4022	WNW	1.47E-3 MRAD	20 MRAD
TOTAL BODY	ALL	1480	NW	3.29E-4 MREM	*
SKIN	ALL	1480	NW	4.03E-4 MREM	*
PARTICULATES AND IODINES					
ORGAN DOSE	CHILD-SKIN	1480	NW	8.31E-3 MREM	15 MREM

* NO STATED LIMIT, BUT WOULD BE USED TO DETERMINE COMPLIANCE WITH 40 CFR 190 LIMITS OF 25 MREM TOTAL BODY AND 75 MREM THYROID SHOULD ANY OTHER STATED LIMITS ON THIS TABLE BE EXCEEDED.