

AN ACCEPTABLE RADIOLOGICAL  
ENVIRONMENTAL MONITORING PROGRAM

Program Requirements

Environmental samples shall be collected and analyzed according to Table 1 at locations shown in Figure 1. (1) Analytical techniques used shall be such that the detection capabilities in Table 2 are achieved.

The results of the radiological environmental monitoring are intended to supplement the results of the radiological effluent monitoring by verifying that the measurable concentrations of radioactive materials and levels of radiation are not higher than expected on the basis of the effluent measurements and modeling of the environmental exposure pathways. Thus, the specified environmental monitoring program provides measurements of radiation and of radioactive materials in those exposure pathways and for those radio-nuclides which lead to the highest potential radiation exposures of individuals resulting from the station operation. The initial radiological environmental monitoring program should be conducted for the first three years of commercial operation (or other period corresponding to a maximum burnup in the initial core cycle). Following this period, program changes may be proposed based on operational experience.

The specified detection capabilities are state-of-the-art for routine environmental measurements in industrial laboratories. The LLDs for I-131 in water, milk and other food products correspond to one-quarter of the Appendix I (10 CFR Part 50) design objective dose-equivalent of 15 mrem/yr for atmospheric releases and 10 mrem/yr for liquid releases to the most sensitive organ and age group. They are based on the assumptions given in Regulatory Guide 1.109, Rev 1.

Deviations are permitted from the required sampling schedule if specimens are unobtainable due to hazardous conditions, seasonal unavailability, malfunction of automatic sampling equipment and other legitimate reasons. If specimens are unobtainable due to sampling equipment malfunction, every effort shall be made to complete corrective action prior to the end of the next sampling period. All deviations from the sampling schedule shall be documented in the annual report.

The laboratories of the licensee and licensee's contractors which perform analyses shall participate in the Environmental Protection Agency's (EPA's) Environmental Radioactivity Laboratory Intercomparisons Studies (Crosscheck) Program or equivalent program. This participation shall include all of the

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It may be necessary to require special studies on a case-by-case and site specific basis to establish the relationship between quantities of radioactive material released in effluents, the concentrations in environmental media, and the resultant doses for important pathways.

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determinations (sample medium-radionuclide combination) that are offered by EPA and that also are included in the monitoring program. The results of analysis of these crosscheck samples shall be included in the annual report.

If the results of a determination in the EPA crosscheck program (or equivalent program) are outside the specified control limits, the laboratory shall investigate the cause of the problem and take steps to correct it. The results of this investigation and corrective action shall be included in the annual report.

The requirement for the participation in the EPA crosscheck program, or similar program, is based on the need for independent checks on the precision and accuracy of the measurements of radioactive material in environmental sample matrices as part of the quality assurance program for environmental monitoring in order to demonstrate that the results are reasonably valid.

A census shall be conducted annually during the growing season to determine the location of the nearest milk animal and nearest garden greater than 50 sq. meters (500 sq. ft.) producing broad leaf vegetation in each of the 16 meteorological sectors within a distance of 8 km (5 miles).<sup>2</sup> For elevated releases as defined in Regulatory Guide 1.111, Rev. 1., the census shall also identify the locations of all milk animals, and gardens greater than 50 sq. meters producing broad leaf vegetation out to a distance of 5 km. (3 miles) for each radial sector.

If it is learned from this census that the milk animals or gardens are present at a location which yields a calculated thyroid dose greater than those previously sampled, or if the census results in changes in the location used in the radioactive effluent technical specifications for dose calculations, a written report shall be submitted to the Director of Operating Reactors, NRR (with a copy to the Director of the NRC Regional Office) within 30 days identifying the new location (distance and direction). Milk animal or garden locations resulting in higher calculated doses shall be added to the surveillance program as soon as practicable.

The sampling location having the lowest calculated dose may then be dropped from the surveillance program at the end of the grazing or growing season during which the census was conducted. Any location from which milk can no longer be obtained may be dropped from the surveillance program after

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<sup>2</sup> Broad leaf vegetation sampling may be performed at the site boundary in a sector with the highest D/Q in lieu of the garden census.

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notifying the NRC in writing that they are no longer obtainable at that location. The results of the land-use census shall be reported in the annual report.

The census of milk animals and gardens producing broad leaf vegetation is based on the requirement in Appendix I of 10 CFR Part 50 to "Identify changes in the use of unrestricted areas (e.g., for agricultural purposes) to permit modifications in monitoring programs for evaluating doses to individuals from principal pathways of exposure." The consumption of milk from animals grazing on contaminated pasture and of leafy vegetation contaminated by airborne radioiodine is a major potential source of exposure. Samples from milk animals are considered a better indicator of radioiodine in the environment than vegetation. If the census reveals milk animals are not present or are unavailable for sampling, then vegetation must be sampled.

The 50 sq. meter garden, considering 20% used for growing broad leaf vegetation (i.e., similar to lettuce and cabbage), and a vegetation yield of 2 kg/m<sup>2</sup>, will produce the 26 kg/yr assumed in Regulatory Guide 1.109, Rev 1., for child consumption of leafy vegetation. The option to consider the garden to be broad leaf vegetation at the site boundary in a sector with the highest D/Q should be conservative and that location may be used to calculate doses due to radioactive effluent releases in place of the actual locations which would be determined by the census. This option does not apply to plants with elevated releases as defined in Regulatory Guide 1.111, Rev. 1.

#### Reporting Requirement

A. Annual Environmental Operating Report, Part B, Radiological.

A report on the radiological environmental surveillance program for the previous calendar year shall be submitted to the Director of the NRC Regional Office (with a copy to the Director, Office of Nuclear Reactor Regulation) as a separate document by May 1 of each year. The period of the first report shall begin with the date of initial criticality. The reports shall include a summary (format of Table 3), interpretations, and statistical evaluation of the results of the radiological environmental surveillance activities for the report period, including a comparison with operational controls, preoperational studies (as appropriate), and previous environmental surveillance reports and an assessment of the observed impacts of the station operation on the environment.

In the event that some results are not available the report shall be submitted noting the explaining the reasons for the missing results. The missing data shall be submitted as soon as possible in a supplementary report.

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The reports shall also include the following: a summary description of the radiological environmental monitoring program including sampling methods for each sample type, size and physical characteristics of each sample type, sample preparation methods, analytical methods, and measuring equipment used; a map of all sampling locations keyed to a table giving distances and directions from one reactor; the results of land use censuses; and the results of licensee participation in the Environmental Protection Agency's Environmental Radioactivity Laboratory Intercomparisons Studies (Crosscheck) Program.

B. Nonroutine Radiological Environmental Operating Reports

"If a confirmed<sup>3</sup> measured radionuclide concentration in an environmental sampling medium averaged over any quarter sampling period exceeds the reporting level given in Table 4, a written report shall be submitted to the Director of the NRC Regional Office (with a copy to the Director, Office of Nuclear Reactor Regulation) within 30 days from the end of the quarter. If it can be demonstrated that the level is not a result of plant effluents (i.e., by comparison with control station or preoperational data) a report need not be submitted, but shall be discussed in the annual report. When more than one of the radionuclides in Table 4 are detected in the medium, the reporting level shall have been exceeded if:

$$\frac{\text{concentration (1)}}{\text{reporting level (1)}} + \frac{\text{concentration (2)}}{\text{reporting level (2)}} + \dots \geq 1$$

If radionuclides other than those in Table 4 are detected and are due from plant effluents, a reporting level is exceeded if the potential annual dose to an individual is equal to or greater than the design objective doses of 10 CFR Part 50, Appendix I. This report shall include an evaluation of any release conditions, environmental factors, or other aspects necessary to explain the anomalous result.

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<sup>3</sup> A confirmatory reanalysis of the original, a duplicate, or a new sample may be desirable, as appropriate. The results of the confirmatory analysis shall be completed at the earliest time consistent with the analysis, but in any case within 30 days.

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TABLE 1

## OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample	Number of Samples <sup>a</sup> and Locations	Sampling and Collection Frequency <sup>a</sup>	Type and Frequency and Analysis
AIRBORNE			
Radioiodine and Particulates	Samples from 3 offsite locations (in different sectors) of the highest calculated annual average ground-level D/Q.  1 sample from the vicinity of a community having the highest calculated annual average ground-level D/Q.  1 sample from a control location 15-30 km (10-20 miles) distant and in the least prevalent wind direction <sup>d</sup>	Continuous sampler operation with sample collection weekly or as required by dust loading, whichever is more frequent <sup>e</sup>	Radioiodine Cannister: analyze weekly for I-131  Particulate Sampler: Gross beta radioactivity following filter change, <sup>b</sup> composite (by location) <sup>c</sup> for gamma isotopic <sup>c</sup> quarterly
DIRECT RADIATION <sup>f</sup>	2 or more dosimeters or one instrument for measuring and recording dose rate continuously to be placed at each of the same locations as for air particulates, and at each of three additional offsite locations (different sectors) or highest calculated annual average ground-level X/Q.	Monthly or quarterly	Gamma dose monthly or quarterly

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TABLE 1 (Continued)

Exposure Pathway and/or Sample	Number of Samples <sup>a</sup> and Locations	Sampling and Collection Frequency <sup>a</sup>	Type and Frequency of Analysis
WATERBORNE			
Surface <sup>g</sup>	1 sample upstream 1 sample downstream	Composite sample <sup>h</sup> over one-month period <sup>h,i</sup>	Gamma isotopic analysis monthly. Composite for tritium analyses quarterly
Ground	Samples from 1 or 2 sources only if likely to be affected <sup>j</sup>	Quarterly	Gamma isotopic and tritium analysis quarterly
Drinking	1 sample of each of 1 to 3 of the nearest water supplies which could be affected by its discharge	Composite sample over two-week period <sup>i</sup> if I-131 analysis is performed, monthly composite otherwise	I-131 analysis on each composite when the dose calculated for the con- sumption of the water is greater than 1 mrem per year. <sup>k</sup> Composite for Gross $\beta$ and gamma isotopic analyses monthly. Compo- site for tritium analysis quarterly
Sediment from Shoreline	1 sample from a control location  1 sample from downstream area with existing or potential recreational value	Semiannually	Gamma isotopic analyses semiannually
INGESTION			
Milk	Samples from milking animals in 3 locations within 5 km distant having the highest dose potential. If there are none, then, 1 sample from milking animals in each of 3 areas between 5 to 8 km distant where doses are calculated to be greater than 1 mrem per year <sup>k</sup>	Semimonthly when ani- mals are on pasture, monthly at other times	Gamma isotopic and I-131 analysis semimonthly when animals are on pasture; monthly at other times

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TABLE 1 (Continued)

Exposure Pathway and/or Sample	Number of Samples <sup>a</sup> and Locations	Sampling and Collection Frequency <sup>a</sup>	Type and Frequency of Analysis
Milk (cont'd)	1 sample from milking animals at a control location (15-30 km distant and in the least prevalent wind direction)		
Fish and Invertebrates	1 sample of each commercially and recreationally important species in vicinity of discharge point	Sample in season, or <del>semiannually</del> if they are not seasonal	Gamma isotopic analysis on edible portions
Food Products	1 sample of same species in areas not influenced by plant discharge 1 sample of each principal class of food products from any area which is irrigated by water in which liquid plant wastes have been discharged	At time of harvest <sup>1</sup>	Gamma isotopic analysis on edible portion. I-131 analysis on broad leaf vegetation
	3 samples of broad leaf vegetation grown nearest offsite locations of highest calculated annual average ground-level D/Q if milk sampling is not performed	Monthly when available	
	1 sample of each of the similar vegetation grown 15-30 km distant in the least prevalent wind direction if milk sampling is not performed	Monthly when available	

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TABLE 1 (Continued)

- <sup>a</sup>The number, media, frequency and location of sampling may vary from site to site. It is recognized that, at times, it may not be possible or practical to obtain samples of the media of choice at the most desired location or time. In these instances suitable alternative media and locations may be chosen for the particular pathway in question and submitted for acceptance. Actual locations (distance and direction) from the site shall be provided. Refer to Regulatory Guide 4.1, "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants."
- <sup>b</sup>Particulate sample filters should be analyzed for gross beta 24 hours or more after sampling to allow for radon and thoron daughter decay. If gross beta activity in air or water is greater than ten times the mean of control samples for any medium, gamma isotopic analysis should be performed on the individual samples.
- <sup>c</sup>Gamma isotopic analysis means the identification and quantification of gamma-emitting radionuclides that may be attributable to the effluents from the facility.
- <sup>d</sup>The purpose of this sample is to obtain background information. If it is not practical to establish control locations in accordance with the distance and wind direction criteria, other sites which provide valid background data may be substituted.
- <sup>e</sup>Canisters for the collection of radioiodine in air are subject to channeling. These devices should be carefully checked before operation in the field or several should be mounted in series to prevent loss of iodine.
- <sup>f</sup>Regulatory Guide 4.13 provides minimum acceptable performance criteria for thermoluminescence dosimetry (TLD) systems used for environmental monitoring. One or more instruments, such as a pressurized ion chamber, for measuring and recording dose rate continuously may be used in place of, or in addition to, integrating dosimeters. For the purposes of this table, a thermoluminescent dosimeter may be considered to be one chip, and two or more chips in a packet may be considered as two or more dosimeters.
- <sup>g</sup>The "upstream sample" should be taken at a distance beyond significant influence of the discharge. The "downstream" sample should be taken in an area beyond but near the mixing zone. "Upstream" samples in an estuary must be taken far enough upstream to beyond the plant influence.
- <sup>h</sup>Generally, salt water is not sampled except when the receiving water is utilized for recreational activities.
- <sup>i</sup>Composite samples should be collected with equipment (or equivalent) which is capable of collecting an aliquot at time intervals which are very short (e.g., hourly) relative to the compositing period (e.g., monthly).
- <sup>j</sup>Groundwater samples should be taken when this source is tapped for drinking or irrigation purposes in areas where the hydraulic gradient or recharge properties are suitable for contamination.
- <sup>k</sup>The dose shall be calculated for the maximum organ and age group, using the methodology contained in Regulatory Guide 1.109, Rev. 1., and the actual parameters particular to the site.
- <sup>l</sup>If harvest occurs more than once a year, sampling should be performed during each discrete harvest. If harvest occurs continuously, sampling should be monthly. Attention should be paid to including samples of tuborous and root food products.

TABLE 1 (Continued)

Note: In addition to the above guidance for operational monitoring, the following material is supplied for guidance on preoperational programs.

Preoperational Environmental Surveillance Program

A Preoperational Environmental Surveillance Program should be instituted two years prior to the institution of station plant operation.

The purposes of this program are:

1. To measure background levels and their variations along the anticipated critical pathways in the area surrounding the station.
2. To train personnel
3. To evaluate procedures, equipment and techniques

The elements (sampling media and type of analysis) of both preoperational and operational programs should be essentially the same. The duration of the preoperational program, for specific media, presented in the following table should be followed:

Duration of Preoperational Sampling Program for Specific Media

<u>6 months</u>	<u>1 year</u>	<u>2 years</u>
. airborne iodine	. airborne particulates	. direct radiation
. iodine in milk (while animals are in pasture)	. milk (remaining analyses)	. fish and invertebrates
	. surface water	. food products
	. groundwater	. sediment from shoreline
	. drinking water	

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TABLE 2

Detection Capabilities for Environmental Sample Analysis<sup>a</sup>

Analysis	Lower Limit of Detection (LLD) <sup>b</sup>					
	Water (pCi/l)	Airborne Particulate or Gas (pCi/m <sup>3</sup> )	Fish (pCi/kg, wet)	Milk (pCi/l)	Food Products (pCi/kg, wet)	Sediment (pCi/kg, dry)
gross beta	2 <sup>c</sup>	1 x 10 <sup>-2</sup>				
<sup>3</sup> H	330					
<sup>54</sup> Mn	15		130			
<sup>59</sup> Fe	30		260			
<sup>58,60</sup> Co	15		130			
<sup>65</sup> Zn	30		260			
<sup>95</sup> Zr-Nb	10					
<sup>131</sup> I	0.5 <sup>d</sup>	7 x 10 <sup>-2</sup>		0.8 <sup>d</sup>	25 <sup>d,e</sup>	
<sup>134,137</sup> Cs	15	1 x 10 <sup>-2</sup>	130	15	80	150
<sup>140</sup> Ba-La	15			15		

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TABLE 2

NOTES

<sup>a</sup>Acceptable detection capabilities for thermoluminescent dosimeters used for environmental measurements are given in Regulatory Guide 4.13.

<sup>b</sup>Table 2 indicates acceptable detection capabilities for radioactive materials in environmental samples. These detection capabilities are tabulated in terms of the lower limits of detection (LLDs). The LLD is defined, for purposes of this guide, as the smallest concentration of radioactive material in a sample that will yield a net count (above system background) that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal.

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

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

where

LLD is the lower limit of detection as defined above (as pCi per unit mass or volume)

$s_b$  is the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (as counts per minute)

E is the counting efficiency (as counts per disintegration)

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

2.22 is the number of disintegrations per minute per picocurie

Y is the fractional radiochemical yield (when applicable)

$\lambda$  is the radioactive decay constant for the particular radionuclide

$\Delta t$  is the elapsed time between sample collection (or end of the sample collection period) and time of counting

The value of  $s_b$  used in the calculation of the LLD for a particular measurement system should be based on the actual observed variance of the background counting rate or of the counting rate of the blank samples (as appropriate) rather than on an unverified theoretically predicated variance. In calculating the LLD for a radionuclide determined by gamma-ray spectrometry, the background should include the typical contributions of other radionuclides normally present in the samples (e.g., potassium-40 in milk samples). Typical values of E, V, Y and  $\Delta t$  should be used in the calculation.

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It should be recognized that the LLD is defined as an a priori (before the fact) limit representing the capability of a measurement system and not as a posteriori (after the fact) limit for a particular measurement.\*

<sup>c</sup> LLD for drinking water.

<sup>d</sup> LLDs for <sup>131</sup>I in water, milk and other food products correspond to one-quarter of the Appendix I (10 CFR Part 50) design objective dose-equivalent of 15 mrem/year for atmospheric releases and 10 mrem/yr for liquid releases to the most sensitive organ and age group using the assumptions given in Regulatory Guide 1.109, Rev. 1.

<sup>e</sup> LLD for leafy vegetables.

\* For a more complete discussion of the LLD, and other detection limits, see the following:

- (1) HASL Procedures Manual, HASL-300 (revised annually).
- (2) Currie, L. A., "Limits for Qualitative Detection and Quantitative Determination - Application to Radiochemistry" Anal. Chem. 40, 586-93 (1968).
- (3) Hartwell, J. K., "Detection Limits for Radioisotopic Counting Techniques," Atlantic Richfield Hanford Company Report ARH-2537 (June 22, 1972).

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TABLE 3

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM ANNUAL SUMMARY

Name of Facility \_\_\_\_\_ Docket No. \_\_\_\_\_  
 Location of Facility \_\_\_\_\_ Reporting Period \_\_\_\_\_  
 (County, State)

Medium or Pathway Sampled (Unit of Measurement)	Type and Total Number of Analyses Performed	Lower Limit of Detection <sup>a</sup> (LLD)	All Indicator Locations Mean (f) <sup>b</sup> Range	Location with Highest Annual Mean Name Distance & Direction	Mean (f) <sup>b</sup> Range	Control locations Mean (f) <sup>b</sup> Range	Number of Nonroutine Reported Measurements
Air Particulates (pCi/m <sup>3</sup> )	Gross β 416	0.01	0.08(200/312) (0.05-2.0)	Middletown 5 miles 340°	0.10 (5/52) (0.08-2.0)	0/08 (8/104) (0.05-1.40)	1
	γ-Spec. 32						
	<sup>137</sup> Cs	0.01	0.05 (4/24) (0.03-0.13)	Smithville 2.5 miles 160°	0.08 (2/4) (0.03-2.0)	<LLD	4
	<sup>131</sup> I	0.07	0.03 (2/24) (0.01-0.08)	Podunk 4.0 miles 270°	0.05 (2/4) (0.01-0.08)	0.02 (2/4)	1
Fish pCi/kg (wet weight)	γ-Spec. 8						
	<sup>137</sup> Cs	130	<LLD	-	<LLD	90 (1/4)	0
	<sup>134</sup> Cs	130	<LLD	-	<LLD	<LLD	0
	<sup>60</sup> Co	130	120 (3/4) (90-200)	River Mile 35	See Column 4	<LLD	0

<sup>a</sup>See Table 3, note b.

<sup>b</sup>Mean and range based upon detectable measurements only. Fraction of detectable measurements at specified locations is indicated in parentheses. (f)

<sup>c</sup>Note: The example data are provided for illustrative purposes only.

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TABLE 4

## REPORTING LEVELS FOR NONROUTINE OPERATING REPORTS

Reporting Level (RL)

Analysis	Water (pCi/l)	Airborne Particulate or Gases (pCi/m <sup>3</sup> )	Fish (pCi/Kg, wet)	Milk (pCi/l)	Broad Leaf Vegetation (pCi/Kg, wet)
H-3	$3 \times 10^4$				
Mn-54	$1 \times 10^3$		$3 \times 10^4$		
Fe-59	$4 \times 10^2$		$1 \times 10^4$		
Co-58	$1 \times 10^3$		$3 \times 10^4$		
Co-60	$3 \times 10^2$		$1 \times 10^4$		
Zn-65	$3 \times 10^2$		$2 \times 10^4$		
Zr-Nb-95	$4 \times 10^2$				
I-131	2	0.9		3	$1 \times 10^2$
Cs-134	30	10	$1 \times 10^3$	60	$1 \times 10^3$
Cs-137	50	20	$2 \times 10^3$	70	$2 \times 10^3$
Ba-La-140	$2 \times 10^2$			$3 \times 10^2$	

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Figure 1

(This figure shall be of a suitable scale to show the distance and direction of each monitoring station. A key shall be provided to indicate what is sampled at each location.)

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