Radiological Data Methodologies

DOSE CALCULATION - ATMOSPHERIC RELEASE PATHWAY

Dispersion of airborne radioactive material was calculated for each of the 16 compass sectors using the CAP88-PC dose model. Site meteorology data from 1999 were used to calculate annual dispersions for the midpoint of a given sector and distance. Facility specific radionuclide release rates (in curies per year [Ci/yr]) were also used. All annual site boundary and collective dose values were generated using the CAP88-PC computer code, which calculates the total dose due to contributions from the immersion, inhalation, and ingestion pathways.

DOSE CALCULATION - FISH INGESTION PATHWAY

To estimate the effective dose equivalent from the fish consumption pathway, the following procedure was used:

- ♦ *Intake.* The average fish consumption for an individual engaged in recreational fishing in the Peconic River was based on a study done by the New York State Department of Health (NYSDOH 1996), which estimates the consumption rate at approximately 7 kg or 15 pounds per year (lbs/yr).
- ♦ *Activity in Flesh.* Radionuclide data for fish samples were all converted to picocuries per gram (pCi/g) wet weight; since this is the form in which the fish are caught and consumed.
- ♦ *Dose Factor.* DOE Order 5400.5 (1990) 50-year committed dose equivalent factors (in rem per microcurie [rem/µCi] intake) were applied. The factor for cesium-137 is 5.0E-02 rem/µCi.
- ♦ Calculation:

rem= ***Intake*** (7kg or 15 lbs. per year) ×
Activity in Flesh (µCi/kg) ×
Dose Factor (rem/µCi)

DOSE CALCULATION - DEER MEAT CONSUMPTION

This calculation is performed in exactly the same way as shown in the previous section. The same DOE Order 5400.5 dose conversion factors are used. The only change is the estimate of total pounds ingested in the course of a year. For deer meat, the consumption rate of 29 kg or 64 lbs/yr is based on the EPA Exposure Factors Handbook (EPA 1996).

RADIOLOGICAL DATA PROCESSING

Radiation events occur in a random fashion such that if a radioactive sample is counted multiple times, a distribution of results will be obtained. This spread, known as a Poisson distribution, will be centered about a mean value. If counted multiple times, the background activity of the instrument (the number of radiation events observed when no sample is present) will also be seen to have a distribution of values centered about a mean. The goal of a radiological analysis is to determine whether the sample in question contains activity in excess of the instrument or method blank background. Since the activity of the sample and the background are both Poisson distributed, subtraction of background activity from the measured sample activity results in a value, which may vary slightly from one analysis to the next. Therefore, the concept of a minimum detection limit (MDL) is established to determine the statistical likelihood that the sample contains activity that is truly greater than the instrument background.

Identifying a sample as containing activity greater than background, when it actually does not have activity present, is known as a Type I error. As with most laboratories, the BNL Analytical Services Laboratory sets its acceptance of a Type I error at 5 percent when calculating the MDL for a given analysis. That is, for any value which is greater than or equal to the MDL, there is 95 percent confidence that it represents the detection of true activity. Values, which are less than the MDL may be valid, but they have a reduced confidence associated with them. Therefore, all data are reported regardless of their value.

At very low sample activity levels, close to the instrument background, it is possible to obtain a sample result that is less than the background. When the background activity is subtracted from the sample activity to obtain a net value, a negative value results. In such a situation, a single radiation event observed during a counting period could have a significant effect on the result. Subsequent analysis may produce a net result that is positive. Therefore, all negative values are retained for

Table B-1. Typical Detection Limits for Gross Activity and Tritium Analyses.

Analysis	Matrix	Aliquot (mL)	MDL (pCi/L)
Gross alpha	water	100	4
		500	1
Gross beta	water	100	7
		500	3
Tritium	water	1	3,900
		7	380

Table B-2. Typical Minimum Detection Limits for Gamma Spectroscopy Analysis.

Nuclide	300 g soil (μCi/g)	300 ml water (μCi/mL)	12,000 ml water (μCi/mL)	3L Maranelli (μCi/mL)
Be-7	7E-8	1E-7	2E-09	1E-8
Na-22	9E-9	1E-8	2E-10	1E-9
K-40	2E-7	2E-7	4E-9	2E-8
Sc-48	1E-8	1E-8	2E-10	3E-8
Cr-51	8E-8	1E-7	2E-9	1E-8
Mn-54	8E-9	1E-8	2E-10	1E-9
Mn-56	2E-7	3E-7	5E-9	2E-8
Co-57	7E-9	9E-9	1E-10	1E-9
Co-60	1E-8	1E-8	2E-10	1E-9
Zn-65	2E-8	2E-8	5E-10	2E-9
Cs-134	1E-8	1E-8	2E-10	1E-9
Cs-137	9E-9	1E-8	2E-10	1E-9
Ra-226	3E-8	3E-8	5E-10	4E-8
Th-228	2E-8	3E-8	4E-10	1E-7
Br-82	1E-8	2E-8	3E-10	8E-8
I-131	9E-9	1E-8	2E-10	3E-9
I-133	1E-8	2E-8	3E-10	3E-9

Note:
All MDLs shown above are approximate. For gamma spectroscopy, the MDL of the analysis is dependent upon several variabales, such as the efficiency of the particular detector, the activity of the sample, etc. These factors will vary between analyses and instrumentation.

reporting as well. This data handling practice is consistent with the guidance provided in NCRP Report No. 58 (1985), *Handbook of Radioactivity Measurements Procedures* and DOE/EH-0173T (1991), *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*. Typical MDLs for the various analyses performed on environmental and effluent samples are shown in Tables B-1, B-2, and B-3.

Average values are calculated using actual analysis results, regardless of whether they are

Table B-3. Typical Detection Limits for Chemical Analyses.

Constituent	BNL	Offsite
Ag	0.025	0.010
Cd	0.0005	0.005
Cr	0.005	0.010
Cu	0.050	0.025
Fe	0.075	0.100
Hg	0.0002	0.0002
Mn	0.050	0.015
Na	1.0	5.0
Pb	0.005	0.003
Zn	0.02	0.020
Ammonia-N	NA	0.02
Nitrite-N	NA	0.01
Nitrate-N	1.0	NA
Specific Conductance	10 μmhos/cm	NA
Chlorides	4.0	NA
Sulfates	4.0	NA
1,1,1-trichloroethane	0.002	0.005
trichloroethylene	0.002	0.005
tetrachloroethylene	0.002	0.005
chloroform	0.002	0.005
chlorodibromomethane	0.002	0.005
bromodichloromethane	0.002	0.005
bromoform	0.002	0.005
benzene	0.002	0.005
toluene	0.002	0.005
xylene	0.002	0.005

Note: All concentrations in mg/L except where noted.

above or below the MDL, or even equal to zero. The uncertainty of the mean, or the 95 percent confidence interval, is determined by multiplying the population standard deviation of the mean by the $t_{(0.05)}$ statistic.

REFERENCES

DOE Order 5400.5. 1990. *Radiation Protection of the Public and the Environment.* U.S. Department of Energy, Washington, D.C. Change 2: 1-7-93.

DOE/EH-0173T. 1991. *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance.* U.S. Department of Energy, Washington, D.C.

EPA. 1996. *Food Ingestion Factors, Exposure Factors Handbook-Volume II.* EPA600P95002FB. U.S. Environmental Protection Agency. Washington, D.C.

NCRP Report No. 58. 1985. *Handbook of Radioactivity Measurements Procedures.* National Council on Radiation Protection and Measurements, Bethesda, Maryland.

NYSDOH. 1996. *Radioactive Contamination in the Peconic River.* Bureau of Environmental Radiation Protection, New York State Department of Health, Albany, New York.