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OSCAAR CALCULATIONS FOR THE HANFORD DOSE RECONSTRUCTION SCENARIO OF BIOMASS THEME 2

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OSCAAR Calculations for the Hanford Dose Reconstruction Scenario of BIOMASS Theme 2

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This report presents the results obtained from the application of the accident consequence assessment code, called OSCAAR, developed in Japan Atomic Energy Research Institute to the Hanford dose reconstruction scenario of BIOMASS Theme 2 organized by International Atomic Energy Agency. The scenario relates to an inadvertent release of ^{131}I to atmosphere from the Hanford Purex Chemical Separations Plant on 2-5 September 1963. This exercise was used to test the atmospheric dispersion and deposition models and food chain transport models for ^{131}I in OSCAAR with actual measurements and to identify the most important sources of uncertainty with respect both to the part of the assessment and to the overall assessment. The OSCAAR food chain model performed relatively well, while the atmospheric dispersion and deposition calculations made using wind data at the release height and wind fields by simple interpolation of the surrounding surface wind data indicated limited capabilities. The Monte Carlo based uncertainty and sensitivity method linked with OSCAAR successfully demonstrated its usefullness in the scenario. The method presented here also allowed the determination of the parameters that have the most important impact in accident consequence assessments.

Keywords: Accident Consequence Assessment, Model Validation, Dose Reconstruction, Atmospheric Dispersion Model, Food Chain Transport Model, Sensitivity Analysis

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* Visible Information Center Inc.

BIOMASS テーマ2のハンフォード線量再構築シナリオに対する OSCAAR コードの計算

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（2000 年 9 月 22 日受理）

本報告書は、日本原子力研究所で開発した事故影響評価コード OSCAAR を国際原子力機関が主催する BIOMASS 計画テーマ2のハンフォード線量再構築シナリオに適用した結果を記載したものである。このシナリオは米国ハンフォードのピュレックス化学分離施設で 1963 年 9 月 2~5 日に起きた ^{131}I の大気中への事故的放出に関係するものである。この解析によって、OSCAAR で用いている ^{131}I の大気中拡散·沈着及び食物連鎖移行モデルを実測データを用いて検証した。排気筒高さの気象データ及び周辺地上観測所のデータを内挿して得られた風速場から計算された大気拡散・沈着の結果は一部、予測性能に限界があったが、OSCAAR の食物連鎖移行モデルは比較的、精度のよい評価が可能であった。また、モンテ・カルロ法に基づく OSCAAR に結合された不確実さ・感度解析手法は、このシナリオ計算を通して機能が確認され、事故影響評価に最も重要な影響を与えるパラメータの決定に有用であった。

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1. INTRODUCTION

The Japan Atomic Energy Research Institute (JAERI) has developed a computer code system, OSCAAR (Off-Site Consequence Analysis code for Atmospheric Releases in reactor accidents), for assessing the off-site radiological consequences of nuclear reactor accidents. OSCAAR is primarily designed for use in probabilistic safety assessments (PSAs) of light water reactors in Japan. OSCAAR calculations, however, can be used for a wide variety of applications including siting, emergency planning, and development of design criteria and in the comparative risk studies of different energy systems.

The quality assurance of environmental assessment models and codes has recently become a more important and formal procedure. Particularly, in cases where the results of radiological assessments are used in decision making, the quality assurance procedures are essential. Model intercomparison is one of the useful procedures for quality assurance of computer code. An international exercise organized by the Commission of the European Communities (CEC) and the Nuclear Energy Agency (NEA) of the OECD has provided a good opportunity to compare the predictions of the various codes, and to identify those features of the models which lead to differences in predicted results (NEA/CEC, 1994). The results of this intercomparison indicated that OSCAAR performed well, giving predictions in good agreement with the other codes such as MACCS (USA) and COSYMA (EC). Our efforts are now mainly made upon the validation of the individual models and the verification of the whole OSCAAR code system.

For the validation of OSCAAR, the OSCAAR-CHRONIC module has been applied to the Chernobyl scenario (Scenario A4) of BIOMOVS (BIOspheric Model Validation Study) Phase I. The scenario started with daily concentrations of ^{131}I in air and requested the prediction of concentrations of ^{131}I in vegetation and milk for several locations in the northern hemisphere (Peterson et al., 1996). In this report the performance of other OSCAAR modules such as ADD, EARLY, and CHRONIC has been examined by implementing atmospheric dispersion and deposition calculations, food chain transport analysis, and dose calculations for the Hanford test scenario. This scenario was presented in the BIOMASS (BIOsphere Modelling and ASSessment Methods) project organized by the International Atomic Energy Agency (IAEA) as one of the Dose Reconstruction scenarios.

This report contains a description of the Hanford scenario in Section 2 and a detailed description of OSCAAR models in Section 3. The results and discussions of the OSCAAR application to the test scenario are given in Section 4. Section 5 provides concluding remarks.

2. BIOMASS THEME 2

BIOMASS is an IAEA's Co-ordinated Research Project (CRP) aimed at the improvement of methods for assessing the impact of radionuclides in the environment. The scope of the BIOMASS program is the scientific, experimental, and technical aspects related to the analysis and assessment of the behavior of radionuclides in the environment and their associated impacts. Special emphasis is being placed on the improvement of the accuracy of model predictions, on the improvement of modelling techniques, and on the promotion of experimental activities and field data gathering to complement assessments.

The program is designed to address important radiological issues associated with accidental and routine releases and with solid waste management. Three important areas involving environmental assessment modelling are being covered: (1) biospheric analysis in the context of radioactive waste disposal, (2) remediation of areas contaminated as a result of nuclear accidents, unrestricted releases or poor management practices and (3) reconstruction of radiation doses received due to accidental or poorly controlled releases, usually in the early years of the nuclear industry.

Theme 2 of BIOMASS, Environmental Releases, focuses on issues of dose reconstruction and remediation assessment. Dose reconstruction and evaluation of remediation alternatives both involve assessment of radionuclide releases to the environment. Such assessments make use of a great variety of information gained from site characterization studies, source term evaluation, and so on. Ultimately, however, this information has to be combined in some sort of assessment model involving assumptions about how the system has behaved (or will behave). Mathematical modelling of this type is required because it is simply not possible today to measure directly what has happened in the past or what will happen in the future.

The overall objective of BIOMASS Theme 2 is to provide an international forum to increase the credibility of and confidence in methods and models for the assessment of radiation exposure in the context of dose reconstruction and remediation activities. Consideration is being given to assessment of concentrations of radionuclides in relevant environmental media and the associated radiation doses and risks to humans.

2.1 Hanford Scenario

The Hanford test scenario is an inadvertent acute release of ^{131}I to the environment from the 60-meter stack of the Hanford Purex Chemical Separations Plant (centrally located on the 1450 square-kilometer Hanford Site) that occurred on September 2-5, 1963 (Soldat, 1965). This release resulted from the inadvertent charging of short-aged fuel elements into a dissolver of the Purex separation plant. Plant operations were shut down as soon as the abnormal release was detected. Steps were immediately taken to retain as much of the ^{131}I as possible within the plant. Laboratory analyses of stack effluent samples were made. These are provided as a possible starting point for calculations. The routine program of environmental surveillance was augmented with additional sampling. Measurements of wind velocity and temperature are made routinely at the site meteorology tower. Similar data from additional weather stations within a few hundred kilometers are also available for those who may wish to use them in dispersion modelling.

No significant rainfall occurred in the test region during the test period. No protective measures were taken following the release. No atmospheric nuclear test explosions occurred in the several month period prior to this event. Routine atmospheric releases of ^{131}I prior to and following this event were on the order of 0.1 Ci per month, or less. The pathways contributing to dose are primarily through the air and terrestrial environments (Farris et al., 1994).

A complete description of the Hanford scenario and the input information is provided in Appendix I.

2.2 Assessment Task

The possible calculational endpoints for this scenario can be separated into two groups. The first group includes quantities for which measurements exist and against which model predictions can be tested. The second group includes quantities which can only be predicted but not tested (such as radiation dose). The latter are included because they are the most common and useful endpoints in radiological assessments. For all quantities, a 90% confidence level (5% and 95%, respectively, lower and upper bound estimates) was requested to quantify the expected uncertainty in the result. These values are "subjective" confidence intervals, given the nature of the data provided for this scenario.

The following types of calculations for model testing could be performed:

- daily air concentration of ^{131}I
- average integrated air concentration
- average deposition
- total inventory over the region
- integrated concentrations in milk
- average integrated concentrations in specified vegetation
- thyroid burden of two specified children

The following calculations could be performed for model comparison purposes only:

- mean external dose to specified individuals from the overhead cloud and contaminated ground
- mean inhalation dose
- mean ingestion dose
- total dose
- estimate of the risk that results from these doses

Users were permitted to start at different points in the scenario and calculate different items from the list above. This decision depended on the needs and interests of the user and the capability of the models being examined.

3. OSCAAR MODELS

OSCAAR consists of a series of interlinked modules and data files, which are used to calculate the atmospheric dispersion and deposition of selected radionuclides for all sampled weather conditions, and the subsequent dose distributions and health effects in the exposed population. OSCAAR can consider countermeasures which might be taken to reduce the dose received by the exposed population. Several stand-alone computer codes and databases can also be used to prepare, in advance, necessary input data files for OSCAAR such as dose conversion factors, population and agricultural product distributions, and lifetime risks for exposed population. The principal endpoints of OSCAAR can be roughly divided into health effects, effects of countermeasures and economic impacts.

3.1 Atmospheric dispersion and deposition model

A multi-puff trajectory model is incorporated in the current version of the OSCAAR atmospheric dispersion and deposition module, ADD. OSCAAR-ADD originally has two kinds of grid systems for input meteorological information. The first large system is a synoptic scale Eulerian grid which has numerically analyzed wind data at standard constant pressure levels such as 950 hPa, 850 hPa and 700 hPa, provided by the Japan Meteorological Agency. The second system is a meso scale grid defined by users for surface wind and atmospheric stability data. In this test scenario, only the second system is used to calculate the transport and diffusion conditions of each released puff.

Plume rise is calculated from meteorological conditions at the release height and the vertical momentum flux using the formula for vertical jets given by Briggs (1969 and 1975). The mixing height is determined as a function of stability. Within the mixing layer a power-law wind profile is used to determine the average advecting wind over the depth of vertical distribution of activity in each puff. Each puff is assumed to have a Gaussian distribution of concentrations and to be reflected from the ground surface. The diffusion parameters, σ_y and σ_z depend on the distance traveled by the puff and the prevailing atmospheric stability. Depletion by radioactive decay, dry and wet deposition is considered along the trajectory of each puff in ADD. The effective dry deposition velocity and washout coefficient are assumed to take account of speciation of released iodine. ADD originally can handle the spatial and temporal distribution of rainfall to predict wet deposition. Hourly precipitation data at Hanford site, however, is assumed over the whole area in this calculation.

Hourly air concentrations and surface contamination at receptor points are calculated by summing the contributions from puffs in ADD. Those hourly predictions as well as the time-integrated ones are transferred to the dose calculation modules, EARLY and CHRONIC. The main assumptions in ADD are summarized in Table 1 and parameters used in atmospheric dispersion and deposition calculations are given in Table 2.

3.2 Dose calculations

Two kinds of modules are used to convert the predicted spatial and temporal distributions of activity in the atmosphere and on the ground to distributions of dose in population. The EARLY module calculates early exposure which occurs during and shortly after plume passage. External irradiation from material in the passing cloud (cloudshine), internal irradiation following inhalation of the material, and external irradiation from the deposited material (groundshine) are taken into account in EARLY within several hours to several weeks since the accident occurs. The cloudshine is basically calculated with the submersion model, but the finite cloud model based on isotropic puff assumptions (Healy and Baker, 1968) is used to estimate the irradiation at the places close to the source.

The CHRONIC module calculates the long-term groundshine doses, internal doses via inhalation of radionuclides resuspended from the ground, and internal doses via ingestion of contaminated foodstuffs. The migration of deposited material into soil as well as the radioactive decay is taken into account for the calculation of the long-term groundshine doses. The food chain model in CHRONIC is an extension of the methodology used in WASH-1400 (USNRC, 1975) and is available for important Japanese crops. It can reflect their seasonal dependence in probabilistic assessments.

CHRONIC derives the human intake of I-131 through the pasture-cow-milk pathway by:

$$I = U_m e^{-\lambda t_m} \int D \frac{r}{Y_V} e^{-(\lambda+\lambda_w)t} Q_F F_m(t) dt \qquad (1)$$

where

D = total deposition (Bq/m^2);

r/Y_V = mass interception fraction (m^2/kg-dw);

λ_w = environmental loss constant (day^{-1}) ($T_w = \ln 2/\lambda_w$) ;

Q_F = daily intake of a dairy cow (kg-dw/day);

F_m = fraction of daily intake of radioiodine secreted per liter of milk by Lengemann (1966): 0.0091 exp(0.021t) [1 - exp(-0.292t)], transfer rate;

t_m = time between milk secretion and milk consumption (day);

U_m = milk consumption rate (L/day).

CHRONIC does not treat deposition of activity as a function of time, while ADD calculates hourly time-integrated air concentrations and deposition of activity. The human intake of radionuclides for each spatial grid element is calculated from the amount of activity deposited, the concentration of activity in foods for unit deposition, and the consumption rate. Table 3 gives the main parameter values used in food chain transport calculations. CHRONIC does not explicitly calculate the concentration of activity in forage. In this scenario, however, the time-integrated concentration of I-131 in pasture grass was estimated from the following equation:

$$C_V = D\frac{r}{Y_V}\int_0^{t_e} e^{-(\lambda+\lambda_w)t}\,dt \tag{2}$$

where t_e is the time period during which vegetation is exposed to contamination. Since we use the mass interception fraction on a dry weight basis, the moisture content of pasture grass is assumed to be 10% to 75% in the comparison with the measured concentrations of I-131 in pasture.

CHRONIC also dose not have the function of predicting the thyroid burdens of I-131. For the comparison with the measurements, however, we used a three compartment model with biokinetic data for iodine for 5 and 10 years old given in ICRP Publication 56 (1989) to estimate the thyroid burdens for a four year-old boy and his eight year-old sisiter.

3.3 Dosimetry data

The internal dose conversion factors and the external dose rate conversion factors can be used in the EARLY and CHRONIC modules to determine the dose in different organs following an intake of radionuclides and exposure to external irradiation, respectively. A computer code system DOSDAC calculates these quantities from most updating data, such as radioactive decay data, atomic, anatomical and metabolic data and generates the dose conversion factors required for OSCAAR.

Estimates of the internal dose factors resulting from inhalation and ingestion of various radionuclides are made by the methods in the ICRP Publication 30 (1979) in the DOSDAC system. For external exposure the method of Kocher (1980) is used to compute the dose-rate conversion factors which concept is based on the idealized assumptions that the source region can be regarded as effectively infinite or semi-infinite in extent and that the radionuclide concentration is uniform throughout the source region. The breathing rate for the adult test persons and dose and dose-rate conversion factors for I-131 for thyroid in this calculation are given in Table 4. In this calculation we did not take account of any reduction of either external exposure due to the shielding by buildings or inhalation exposure due to the filtering by the buildings.

4. RESULTS AND DISCUSSIONS

Two sets of calculations were performed using the different meteorological data sets for the puff advection. Both results are given in Table 5 and 6, respectively. In the first approach, both hourly meteorological data at the release height of Hanford and the meso scale wind and stability fields interpolated from data at the surrounding 12 surface meteorological stations were used in the puff advection calculations. The expected uncertainties in the predicted results were estimated using parameter uncertainty analysis with a Monte Carlo technique (Homma and Saltelli, 1993). The statistical information of the parameter values in the atmospheric dispersion and deposition model given in Table 2 was taken according to expert judgment. The parameter values and distributions in the food-chain transport parameters given in Table 3 were taken from a U.S. extensive review of the literature (Hoffman and Baes, 1979). The mean and subjective confidence levels in Table 5 are based on a sample of 100 Monte Carlo simulations.

For investigating the effect of meteorological input data on the estimated deposition pattern, we used only hourly meteorological data at the release height in the puff advection calculations in the second approach. The deterministic calculation was performed to estimate the concentration of I-131 in milk and the resultant doses at each location using the mean values of the uncertain parameters in Table 2 and 3.

4.1 Air concentration

The predicted I-131 air concentrations by OSCAAD-ADD were compared with air measurements for twenty-one locations provided in the table of the scenario. The observed data are assumed to indicate both particulate and elemental iodine, and to be 65% of total iodine. Figure 1(a) shows the correlation between observed and predicted time-integrated I-131 concentrations in air by the first approach. It shows that the model tends to overestimate the predictions of I-131 air concentrations. Figure 1(b) shows the distribution of predicted to observed (P/O) ratios for the time-integrated I-131 concentrations in air for those locations except Byers Landing[1]. Since the spatial and temporal variations of air concentrations of I-131 show complicated pattern (see Figure 7(a) to Figure 7(d)), the ADD transport and dispersion calculations made using wind data at the release height and wind fields by simple interpolation of the surrounding surface wind data has some limited capabilities. While ADD predicts well in the north part of the release point, the high overpredictions are found to the west close to the release point and the northeast and east of the release point, in particular, such as White Bluffs, 100-F and Hanford along the Columbia River. This is due to the fact that the simple interpolation approach to produce the wind field has difficulties to estimate the channeling flow along the Columbia River. The comparisons between predicted and observed time dependent air concentrations of I-131 at several stations are also given in Appendix II.

[1] The latitude and longitude of Byers Landing provided in the scenario does not seem to correspond to the location of Byers Landing in the map.

Figures 2(a) and 2(b) show the correlation and P/O ratio charts by the second approach. They indicate that the model also tends to overestimate the predictions of I-131 air concentrations at the entire region. In particular, the high overprediction is found at Pasco. This is due to the fact that the released puffs during the nighttime of September 2 transported to the southeast direction and contributed to the deposition at Pasco. The spatial and temporal variations of air concentrations of I-131 shown in Figure 8(a) to 8(d) indicate the different pattern from those by the first approach. Figure 3 shows the comparison of I-131 time-integrated air concentrations at different farms between the two approaches.

4.2 Concentrations in milk

The predictions of I-131 time-integrated concentrations in milk at six locations are given in Figure 4 in the form of boxplots in which those measurements for four locations are also included. The boxplots show the 1th, 5th, 25th, 50th (median), 75th, 95th, and 99th percentile of the predicted values. Additionally, the mean of the predictions is shown by the square symbol as well as the minimum and maximum predictions. Observed monthly integrals of I-131 in milk at Farm A, Farm B, Pasco (Farm T) and Ringold (Farm K) were estimated using the simple linear interpolation for those times when no measurements were taken. The predictions of I-131 concentrations in milk seem to be in better agreement with measurements at Farm A, Farm B and Pasco except at Ringold. This may be mainly due to the overpediction of total deposition of I-131 in the case of Ringold.

4.3 Concentrations in pasture grass

As described above, OSCAAR originally does not have the function of predicting the contamination of radionuclides on pasture grass. However, in order to examine the performance of predicting the deposition of I-131, we compared the predicted I-131 concentrations in pasture grass using equation (2) with the measurements. Since measured concentrations on pasture are fresh weight as collected, the moisture content of the pasture to be assumed becomes very important. The boxplots for the time-integrated concentrations in pasture grass at six locations are given in Figure 5 together with those measurements. Observed monthly integrals of I-131 in pasture grass at Farm A, Farm B, Pasco (Farm T) and Ringold (Farm K) given in this figure were estimated using the simple linear interpolation. In the case of Farm B, the measured concentrations in pasture can be used only from September 12. The monthly integral of I-131 in pasture grass at Farm B was estimated by assuming that the fraction of activity before 12th was the same as that for Farm A. The observed values for three locations except Ringold fall within the subjective confidence interval of the prediction.

4.4 Thyroid burden

Figure 6 shows the boxplots of predicted I-131 thyroid burdens for a four-year old boy and his 8-year old sister located at Farm B on October 19 together with those measurements. The metabolic mode used in this analysis underestimates the transfer of iodine to the thyroid, but these measurements fall within a 90% confidence interval. These underpredictions may be due to the assumption that the thyroid burden was estimated at 46 days after instantaneous intake of iodine.

4.5 Dose to individuals

The mean doses to the thyroid of test persons and their confidence levels from various pathways are given in Table 5. Apparently the ingestion dose mainly from contaminated milk is the most contributor to the total dose.

4.6 Sensitivity Analysis

For each of the endpoins the SA measures in SPOP were applied to examine the sensitivity of the uncertainty in the predictions to the uncertainties in input parameters. Table 7 shows the standardized rank regression coefficients (SRRCs) for those parameters for each endpoint at Farm B. The table also shows the R^2 values, which indicates a reasonably linear relationship between the ranks of the output and the ranks of the input parameter values. The parameter uncertainties which contribute most to the uncertainty in the predicted milk concentration are found to be the deposition velocity of elemental iodine, feed to milk transfer factor, and mass interception fraction of iodine for pasture grass.

5. CONCLUSIONS

The Hanford test scenario provides a good opportunity to evaluate the performance of OSCAAR. Although it is difficult to perform a model validation over the entire set of conditions to which accident consequence assessment codes like OSCAAR may be applied, the Hanford test scenario is valuable because we can start with source terms and examine atmospheric dispersion and deposition calculations, food chain transport analysis, and dose calculations. The OSCAAR food chain model performs relatively well when the predictions of deposition are well. Since the spatial and temporal variations of air concentrations of I-131, on the other hand, show a complicated pattern, the atmospheric transport and dispersion calculations made using wind data at the release height and wind fields by simple interpolation of the surrounding surface wind data indicate limited capabilities. The Monte Carlo based uncertainty and sensitivity method has been successfully demonstrated in the dose reconstruction scenario. The method presented here also allows determination of the parameters that have a most important impact in accident consequence assessments.

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Table 1. Main assumptions used in OSCAAR-ADD

Features	Descriptions
Receptor points	32 angular segments and 21 distance bands and calculation points in the scenario
Source term	Hourly source term data in the test scenario
Meteorological data	Hourly data at the release height of Hanford and at 12 surface stations including Hanford surface observations
Wind and atmospheric stability field	Two-dimensional rectangular grid that has 16x16 grid points (30.48 km spacing). Simple $1/r^2$ interpolation of surface observations
Wind power-law profile	Power-law exponent values for surface roughness, 0.10 m as a function of Pasquill stability class by Irwin (1978)
Precipitation	Hourly precipitation data at Hanford site is used for calculating wet deposition at all receptor points
Mixing height	Spatially varying as a function of stability
Plume rise	Formulas for vertical jets by Briggs (1969,1975)
Diffusion parameters	Vertical and horizontal dispersion coefficients as a function of distance by Eimutis and Konicek (1972)
Dry deposition	Dry deposition velocity (m/sec)
Wet deposition	Washout rate (1/sec) recommended by Brenk and Vogt (1981)

Table 2. Parameter values used in atmospheric dispersion and deposition module, ADD

Variable	Description	Distribution	Mean	μ *	σ *	Units
h	Stack height	constant	60.5	-	-	m
r_0	Internal stack radius	constant	1.067	-	-	m
D	Internal stack diameter ($D = 2r_0$)	constant	2.134	-	-	m
F_S	Volumetric stack flow velocity	constant	56.63	-	-	m^3/s
W_0	Efflux speed of gases from stack ($W_0 = F_S/\pi/r_0^2$)	constant	15.83	-	-	m/s
p	Wind profile power-law exponent (z_0 = 0.10 m):					
	A	constant	0.08	-	-	-
	B		0.09	-	-	
	C		0.11	-	-	
	D		0.16	-	-	
	E		0.32	-	-	
	F		0.54	-	-	
α_p	Scaling factor for wind profile power-law exponent	normal	1.0	1.0	0.15	-
Hm	Mixing height:					
	A	constant	1600	-	-	m
	B		1200	-	-	
	C		800	-	-	
	D		560	-	-	
	E		320	-	-	
	F		200	-	-	
α_h	Scaling factor for mixing height	normal	1.0	1.0	0.21	-
α_y	Scaling factor for sigma-y	log-normal	1.0	0.0	0.13	-
α_z	Scaling factor for sigma-z	log-normal	1.0	0.0	0.13	-

fc	Fraction of iodine chemical form: reactive gas particulate organic	constant	40 25 35	- - -	- - -	%
Vg	Dry deposition velocity for iodine reactive gas: particulate: organic:	log-normal	1×10^{-2} 1×10^{-3} 1×10^{-4}	-2.0 -3.0 -4.0	0.61 0.43 0.43	m/s
Λ	Washout rate: $=aI^{b}$, I: rainfall rate (mm/h) a : reactive gas particulate organic		8×10^{-5} 1.2×10^{-4} 1×10^{-6}	- - -	- - -	s^{-1}
	b		0.6	-	-	-

* μ and σ are the mean and standard deviation, respectively, of the normally distributed parameters. If the parameter, x is log-normally distributed, μ and σ refer to those of the log-transformed parameters ($\log_{10}(x)$).

Table 3. Parameter values used in food chain transport calculations

Variable	Description	Distribution	Mean	μ *	σ *	Units
r/Y_V	Mass interception fraction for pasture grass	log-normal	2.0	0.26	0.19	m^2/kg-dw
T_W	Weathering half-life	log-normal	10.4	1.0	0.13	days
t_e	Time period during which vegetation is exposed to contamination	constant	30.0	-	-	day
f_w	water content in pasture grass	uniform	0.1-0.75			-
Q_F	Daily intake of a dairy cow	normal	9.0	9.0	2.3	kg-dw /day
F_m	Fraction of daily intake of radioiodine secreted per liter of milk:	log-normal	0.0091	-2.04	0.24	$liter^{-1}$
t_m	Time between milk secretion and milk consumption	normal	2.0	2.0	0.86	days
U_m	Milk consumption rate:					
	test persons	log-normal	0.315	-0.65	0.36	liter/day
	Man		0.377	-0.57	0.36	
	Woman		0.260	-0.73	0.36	
	Child		0.497	-0.36	0.21	
	Farm B Boy	constant	4.0			
	Farm B Girl	constant	1.0			
t_l	Time delay from harvest of leafy vegetables to human consumption	constant	5.0	-	-	day
U_l	Consumption rate of leafy vegetables:					
	test persons	constant	0.049	-	-	kg-fw/day
	Man		0.047	-	-	
	Woman		0.050	-	-	
	Child		0.0072	-	-	

* μ and σ are the mean and standard deviation, respectively, of the normally distributed parameters. If the parameter, x is log-normally distributed, μ and σ refer to those of the log-transformed parameters ($\log_{10}(x)$).

Table 4. Parameter values used in dose calculations

Variable	Description	Distribution	Mean	μ *	σ *	Units
B_r	Breathing rate for adults	constant	2.66×10^{-4}	-	-	m^3/s
DF_c	Dose rate conversion factor for thyroid for immersion in I-131 contaminated air	constant	5.65×10^{-7}	-	-	Sv/yr per Bq/m^3
DF_g	Dose rate conversion factor for thyroid for exposure 1m above I-131 contaminated ground surface	constant	1.32×10^{-8}	-	-	Sv/yr per Bq/m^2
DF_{inh}	Committed dose equivalent in thyroid per intake of unit I-131 by inhalation	constant	2.67×10^{-7}	-	-	Sv/Bq
DF_{ing}	Committed dose equivalent in thyroid per intake of unit I-131 by ingestion	constant	4.35×10^{-7}	-	-	Sv/Bq

* μ and σ are the mean and standard deviation, respectively, of the normally distributed parameters. If the parameter, x is log-normally distributed, μ and σ refer to those of the log-transformed parameters ($\log_{10}(x)$).

Table 5. Results of approach 1 (using mult-station meteorological data)

Item		Farm A	Farm B	Mesa	Ringold	Pasco	Eltopia
Total Deposition (Bq/m^2)	Upper	114.	283.	1070.	1540.	37.9	222.
	Mean	61.1	132.	356.	720.	24.9	140.
	Lower	13.1	26.5	40.8	143.	8.44	45.2
Integrated Concentrations in Milk (Bq d/l)	Upper	198.	397.	1080.	2360.	64.9	382.
	Mean	58.9	127.	337.	678.	24.6	138.
	Lower	6.29	13.3	17.8	60.8	3.44	16.5.
Integrated Concentrations in Grass (Bq d/kg f.w.)	Upper	1060.	2590.	7350.	13400.	396.	2240.
	Mean	455.	977.	2530.	5260.	185.	1030.
	Lower	75.9	13.1	172.	675.	42.4	173.

Item		Carnation			Darigold		
		Man	Woman	Child	Man	Woman	Child
Human Intake (Bq)	Upper	17.2	15.6	21.3	26.6	21.1	22.1
	Mean	5.04	3.72	6.23	7.00	4.86	8.66
	Lower	0.48	0.421	0.647	0.574	0.681	0.918

Item		Farm B	
		Boy	Girl
Thyroid Burden (Bq)	Upper	3.18	1.46
	Mean	1.01	0.467
	Lower	0.106	0.0491

Item		Farm A	Farm B	Mesa	Ringold	Pasco	Eltopia
Cloud Exposure (mSv)	Upper	4.5E-7	7.5E-7	4.5E-6	4.6E-6	2.6E-7	1.3E-6
	Mean	2.3E-7	4.5E-7	1.7E-6	2.5E-6	1.2E-7	7.0E-7
	Lower	4.1E-8	9.4E-8	4.7E-8	6.2E-7	6.8E-9	2.4E-8
Ground Exposure (mSv) 9/2 - 10/1	Upper	4.8E-5	1.2E-4	4.5E-4	6.4E-4	1.6E-5	9.3E-5
	Mean	2.6E-5	5.5E-5	1.5E-4	3.0E-4	1.0E-5	5.9E-5
	Lower	5.5E-6	1.1E-5	1.7E-5	6.0E-5	3.5E-6	1.9E-5
Inhalation Dose (mSv)	Upper	1.8E-3	3.0E-3	1.8E-2	1.8E-2	1.0E-3	5.3E-3
	Mean	9.3E-4	1.8E-3	6.7E-3	9.7E-3	4.9E-4	2.8E-3
	Lower	1.6E-4	3.7E-4	1.9E-4	2.4E-3	2.7E-5	9.5E-5
Ingestion Dose (mSv)	Upper	2.7E-2	5.6E-2	1.5E-1	3.0E-1	1.1E-2	6.8E-2
	Mean	7.2E-3	1.6E-2	4.2E-2	8.2E-2	3.0E-3	1.7E-2
	Lower	6.8E-4	1.2E-3	1.7E-3	5.8E-3	3.0E-4	1.3E-3
Total Dose (mSv) 9/2 - 10/1	Upper	2.8E-2	5.7E-2	1.7E-1	3.0E-1	1.2E-2	6.9E-2
	Mean	8.2E-3	1.7E-2	4.9E-2	9.2E-2	3.5E-3	2.0E-2
	Lower	1.5E-3	3.3E-3	2.9E-3	1.4E-2	6.5E-4	1.9E-3

Table 6. Results of approach 2 (using site meteorological data)

Item	Farm A	Farm B	Mesa	Eltopia	Pasco	Ringold
Total Deposition (Bq/m^2)	43.1	43.3	4.69	22.5	430.	257.
Integrated Concentrations in Milk (Bq d/l)	42.2	42.4	4.59	22.0	421.	252.
Item	Carnation			Darigold		
	Man	Woman	Child	Man	Woman	Child
Human Intake (Bq)	9.24	6.61	11.4	13.0	9.27	16.1
Item	Farm B					
	Boy			Girl		
Thyroid Burden (Bq)	0.287			0.135		
Item	Farm A	Farm B	Mesa	Eltopia	Pasco	Ringold
Cloud Exposure (mSv)	1.4E-7	1.4E-7	1.5E-8	7.5E-8	1.4E-6	8.6E-7
Ground Exposure (mSv) 9/2 - 10/1	1.4E-5	1.4E-5	1.6E-6	7.5E-6	1.4E-4	8.6E-5
Inhalation Dose (mSv)	5.6E-4	5.6E-4	6.0E-5	3.0E-4	5.6E-2	3.4E-3
Ingestion Dose (mSv)	5.4E-3	5.4E-3	5.8E-4	2.8E-3	5.4E-2	3.2E-2
Total Dose (mSv) 9/2 - 10/1	6.0E-3	6.0E-3	6.4E-4	3.1E-3	6.0E-2	3.5E-2

Table 7. Standardized rank regression coefficients for uncertain parameters for different output variables at Farm B

Parameter	Deposition	Grass	Milk	Total dose
α p	0.03	0.03	0.03	0.02
α h	-0.22	-0.19	-0.16	-0.16
α y	0.09	0.03	0.05	0.06
α z	0.07	0.04	0.07	0.06
Vg(G)	0.92	0.67	0.62	0.44
Vg(P)	0.06	0.08	0.05	0.04
Vg(O)	0.03	-0.02	-0.02	-0.01
r/Yv	-	0.50	0.43	0.29
Tw	-	0.12	0.15	0.15
fw	-	0.40	-	-
Qf	-	-	0.24	0.20
Fm	-	-	0.49	0.39
Tm	-	-	-	-0.08
Um	-	-	-	0.60
R^2	0.89	0.91	0.92	0.92

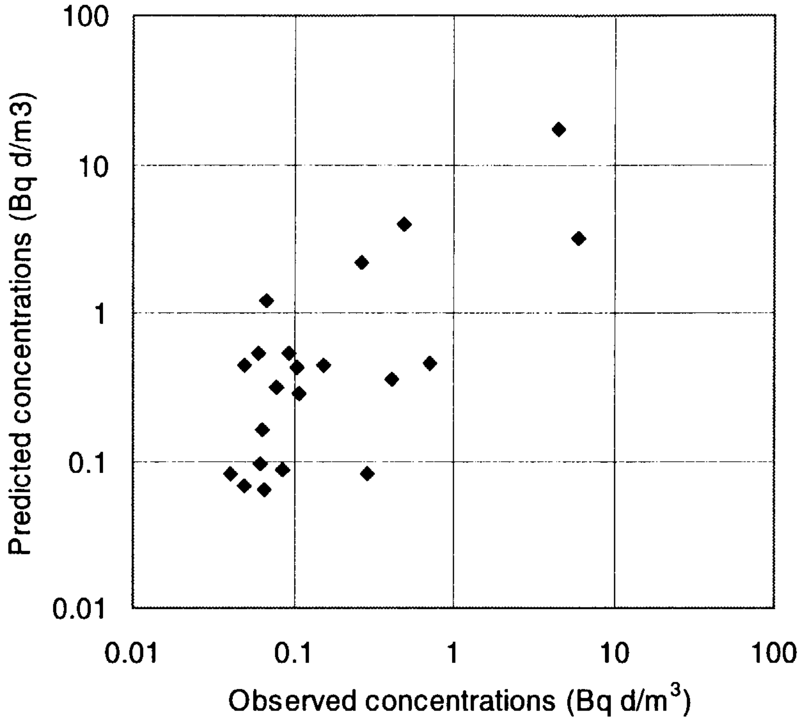

Fig. 1(a). Correlation between observed and predicted time-integrated I-131 concentrations in air.

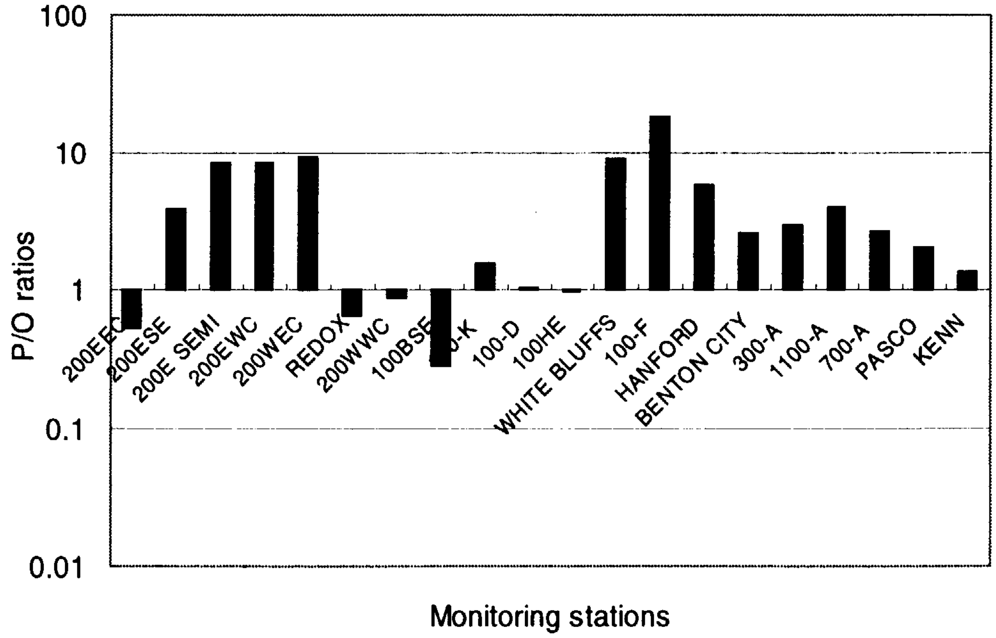

Fig. 1(b). P/O ratios of the time-integrated I-131 concentrations in air.

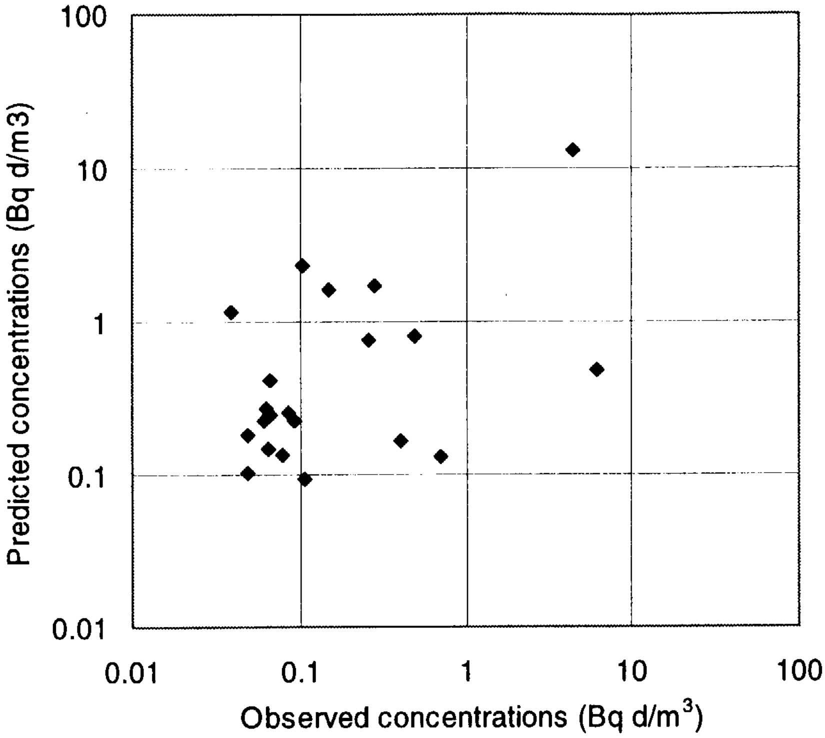

Fig. 2(a). Correlation between observed and predicted time-integrated I-131 concentrations in air.

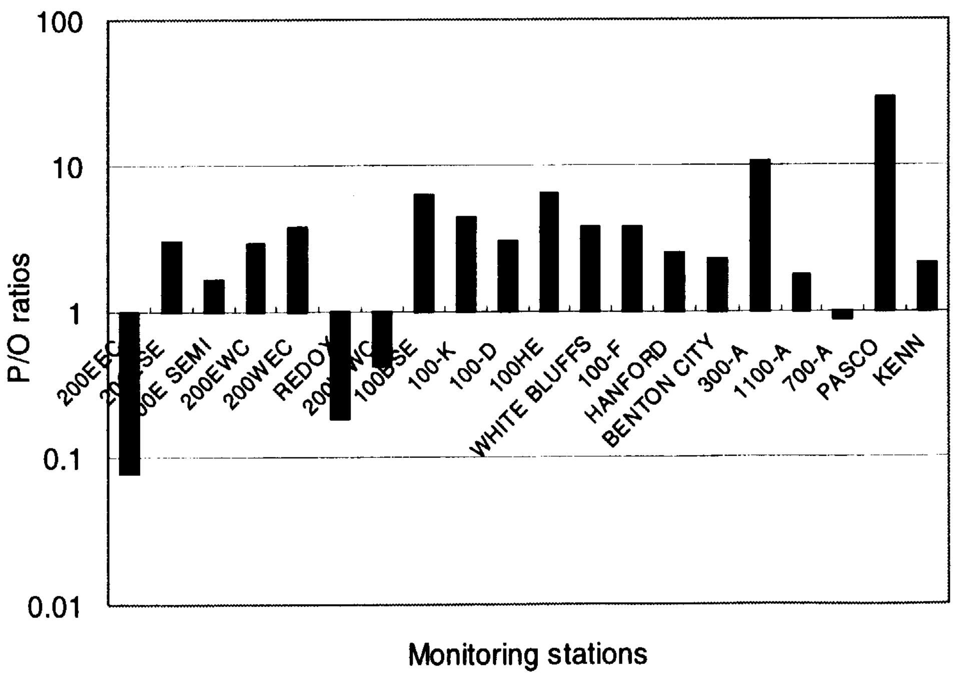

Fig. 2(b). P/O ratios of the time-integrated I-131 concentrations in air

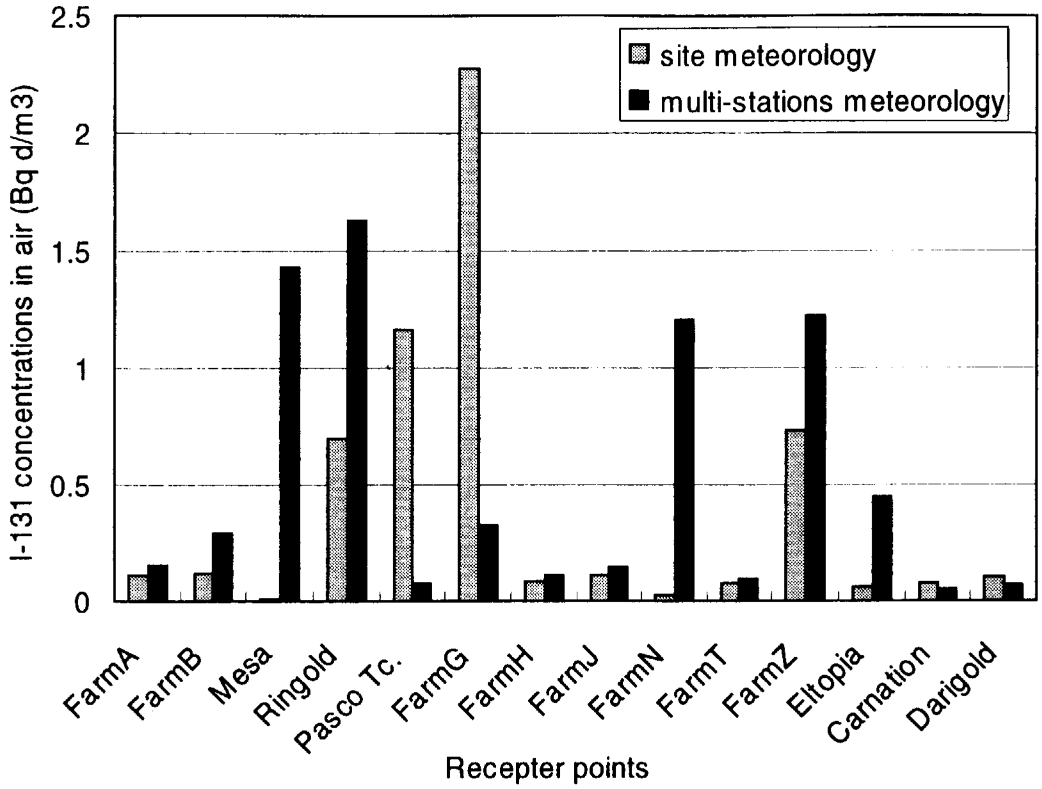

Fig. 3. Comparisons of I-131 time-integrated air concentrations between using two different meteorological data sets

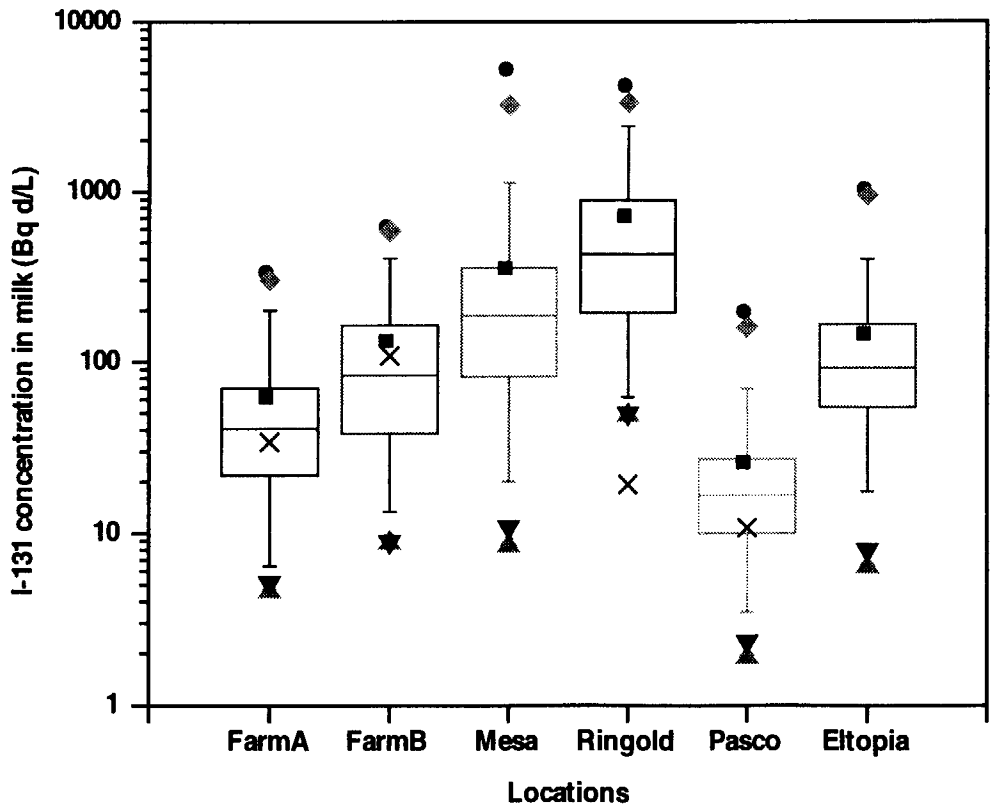

Fig. 4. Boxplots of I-131 concentration in milk at several locations

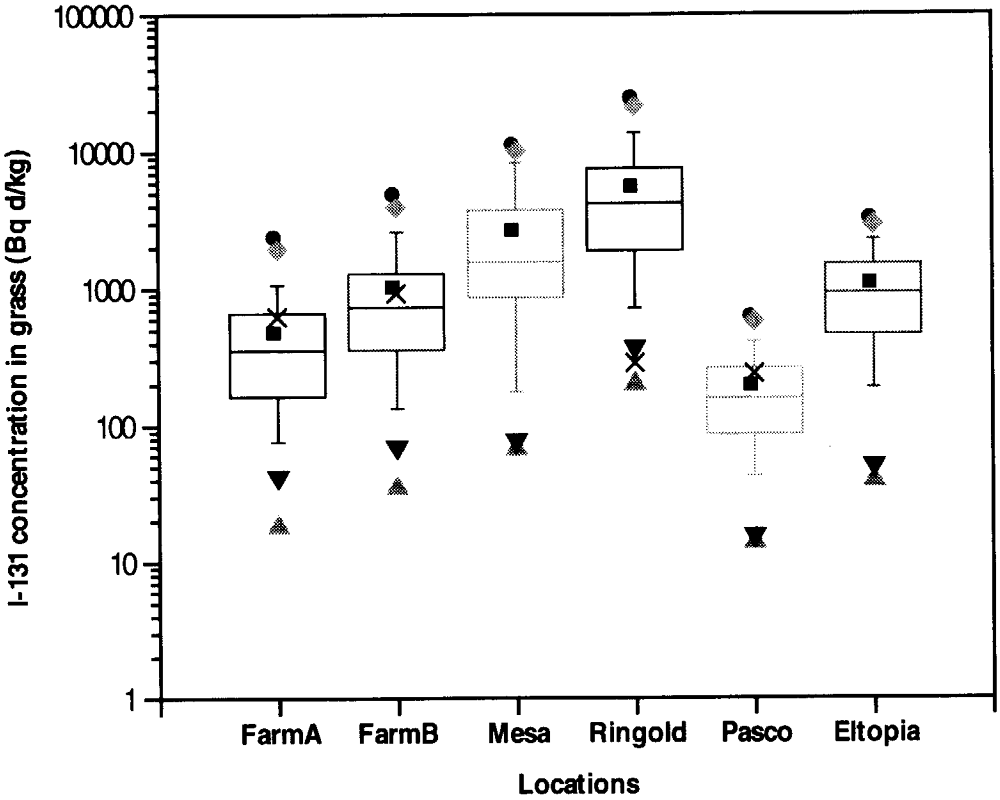

Fig. 5. Boxplots of I-131 concentration in grass at several location

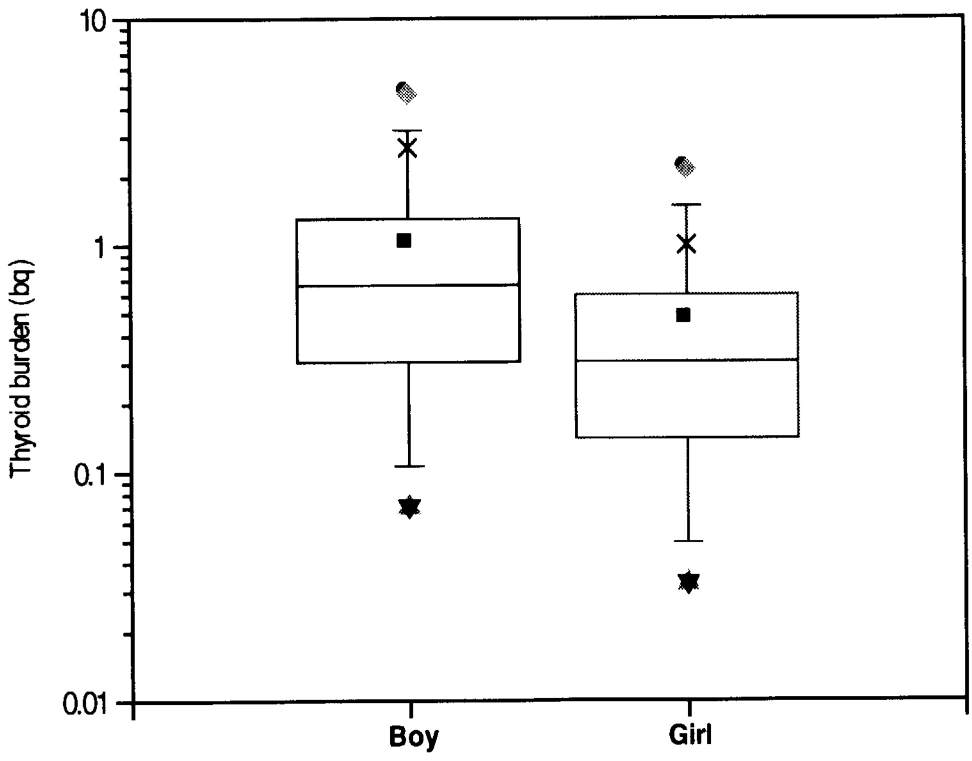

Fig. 6. Boxplots of I-131 thyroid burdens for a four-year old boy and his 8-year old sisterl.

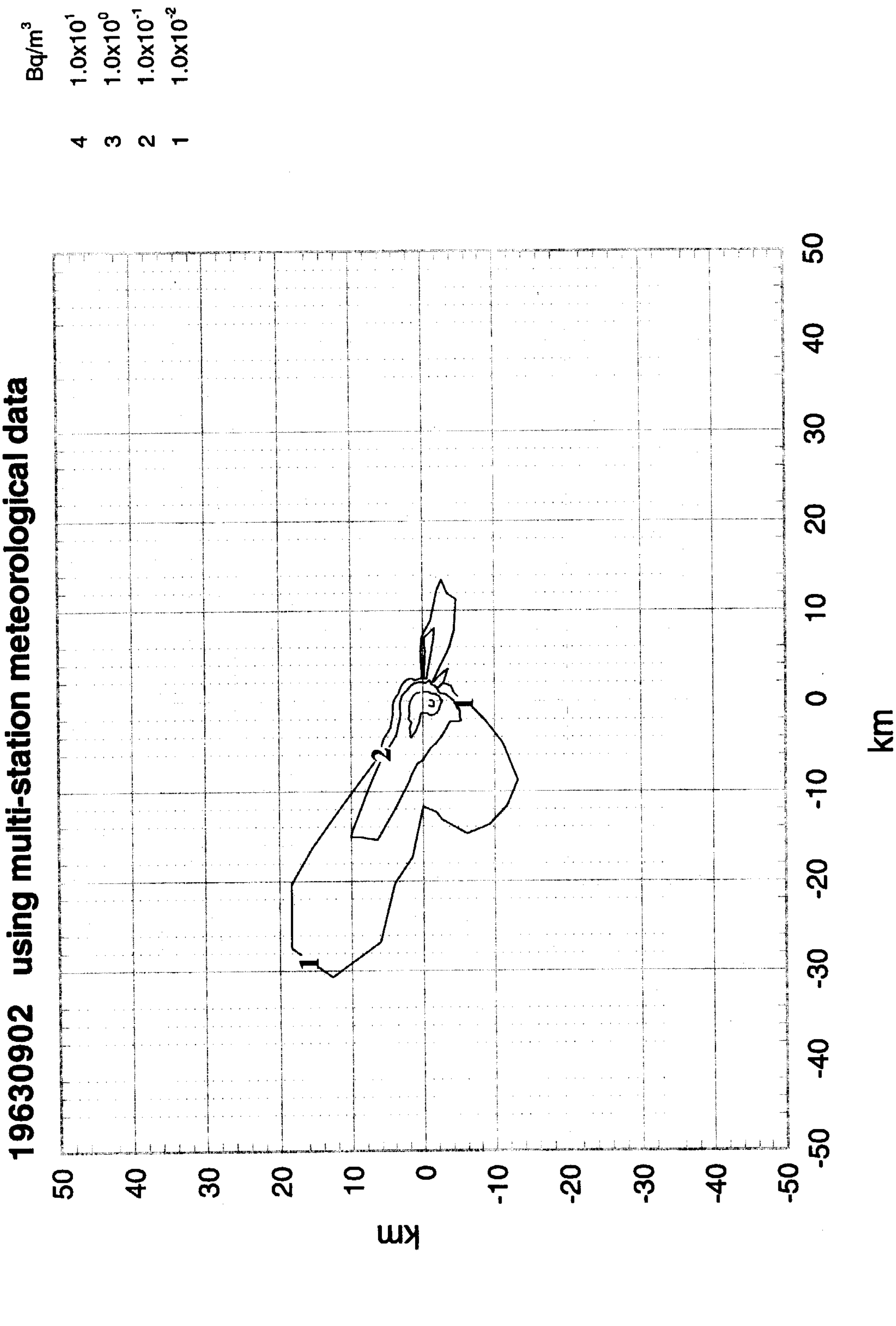

Fig. 7(a). Daily Concentration in Air of I-131

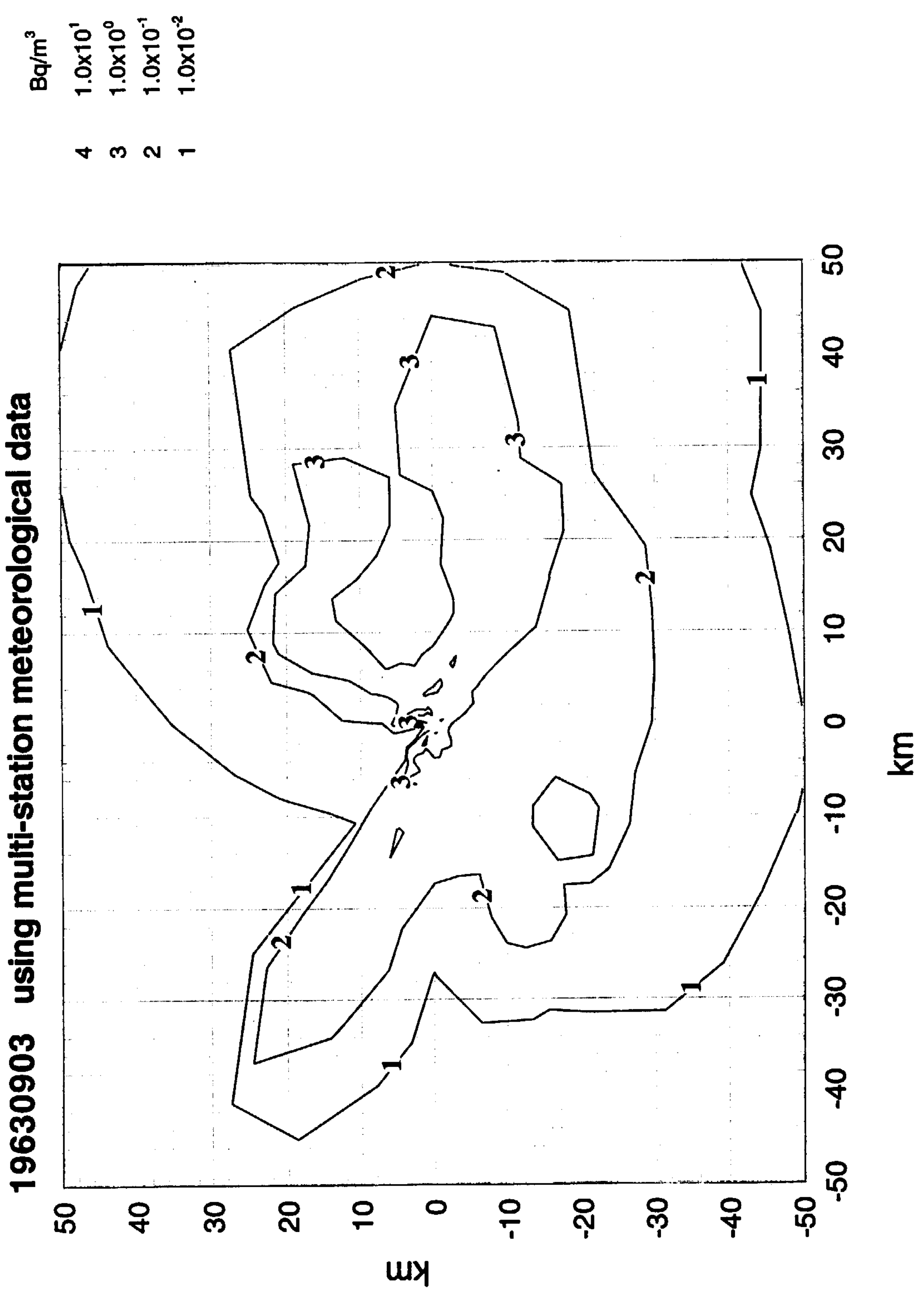

Fig. 7(b). Daily Concentration in Air of I-131

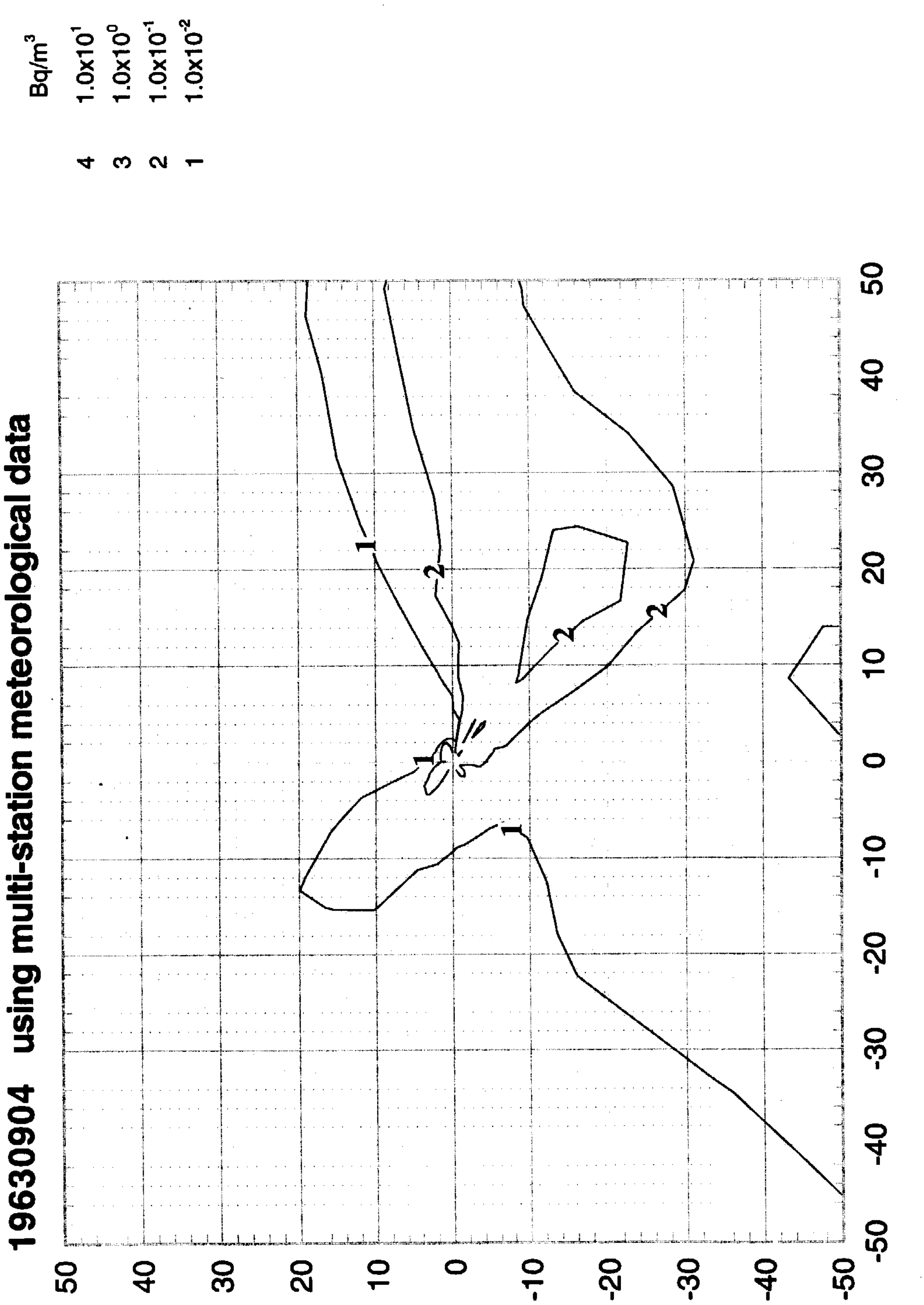

Fig. 7(c). Daily Concentration in Air of I-131

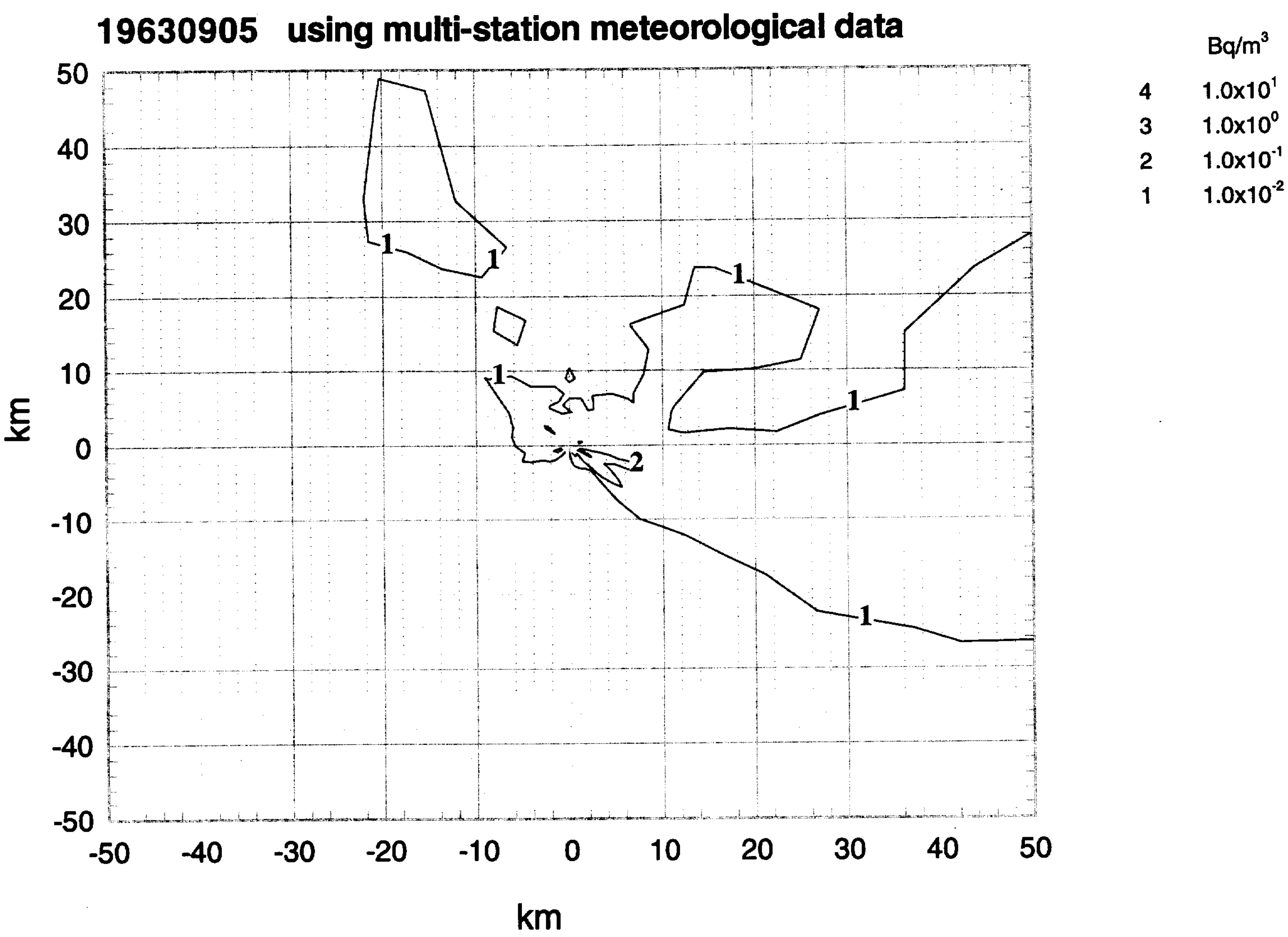

Fig. 7(d). Daily Concentration in Air of I-131

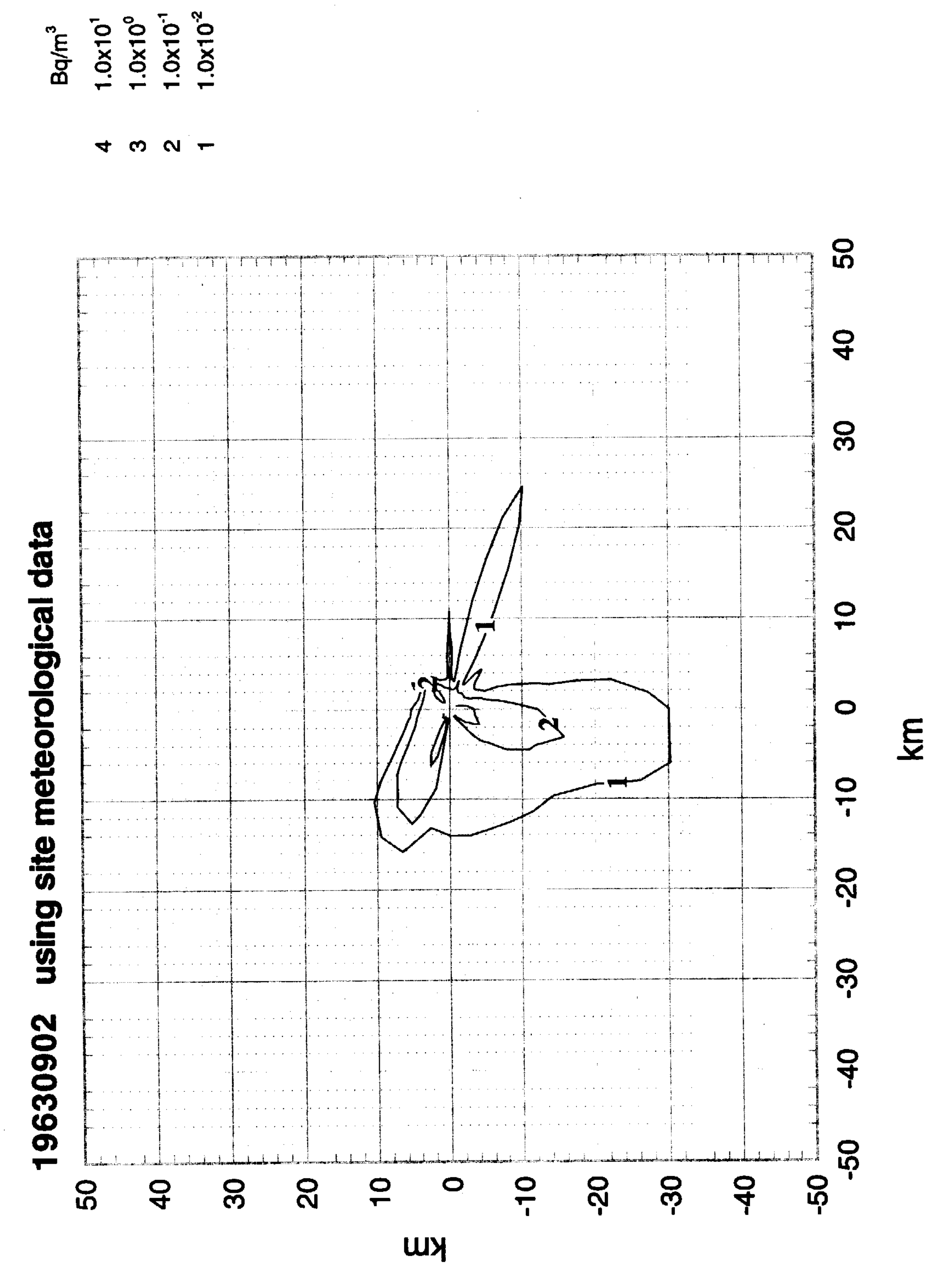

Fig. 8(a). Daily Concentration in Air of I-131

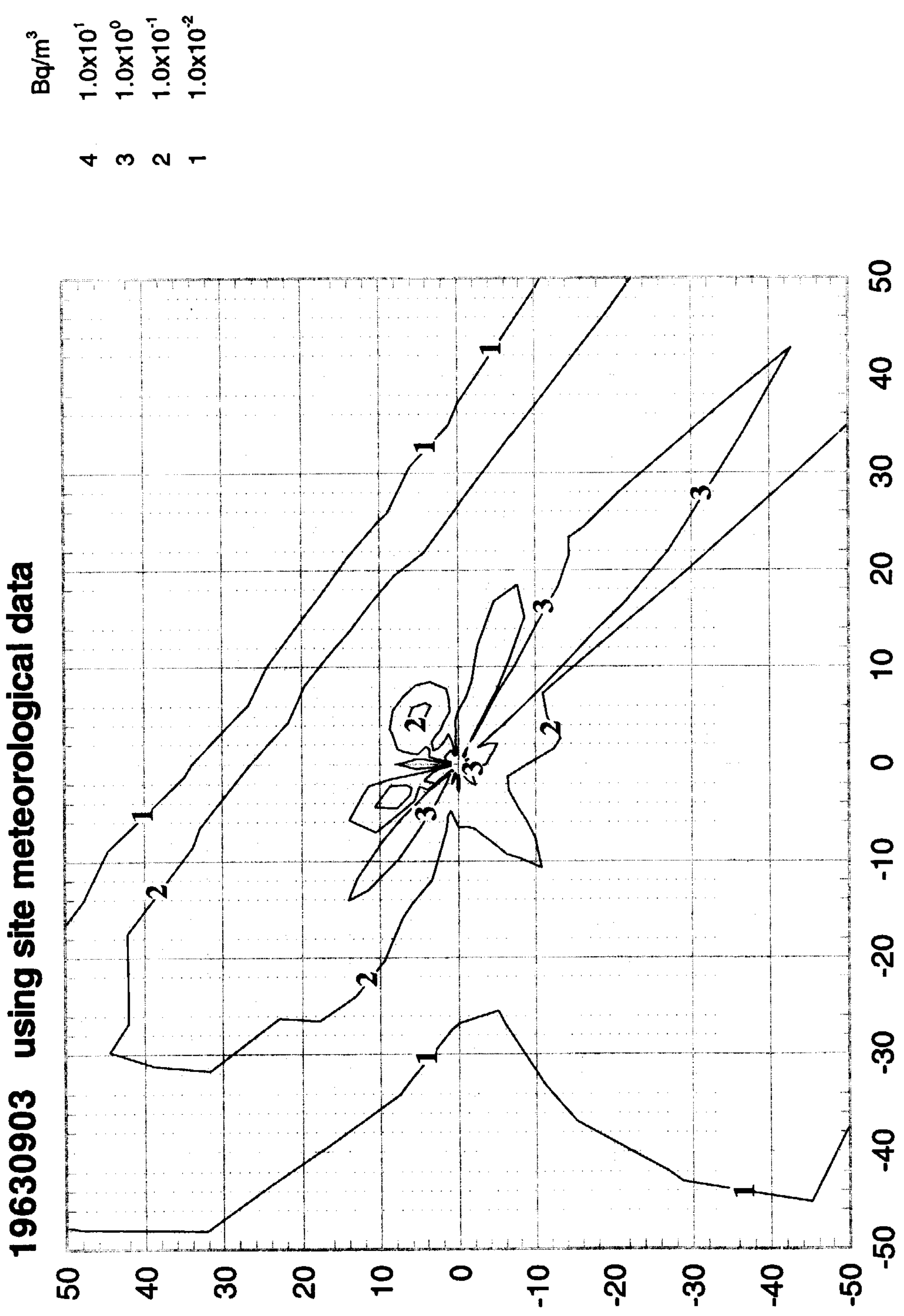

Fig. 8(b). Daily Concentration in Air of I-131

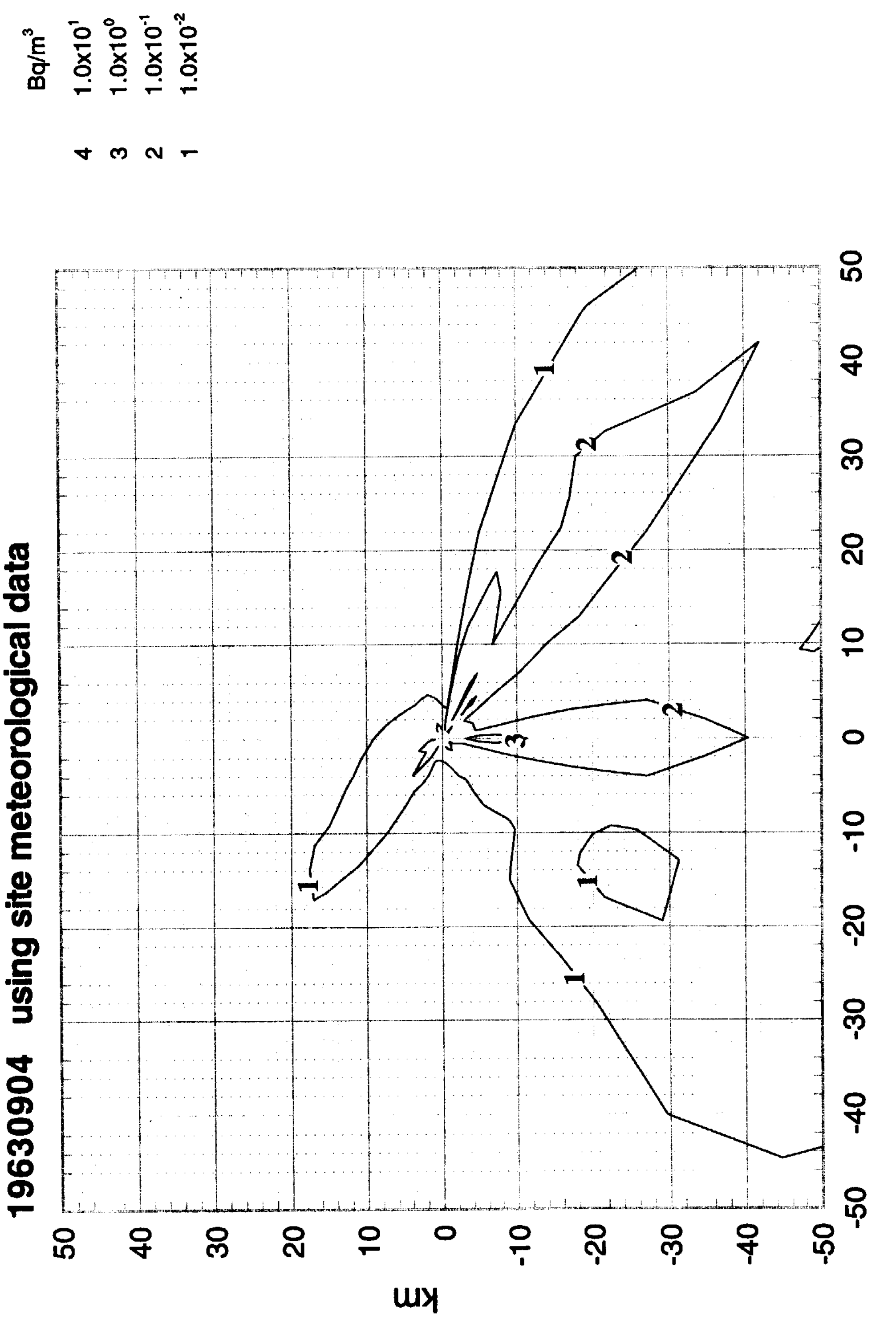

Fig. 8(c). Daily Concentration in Air of I-131

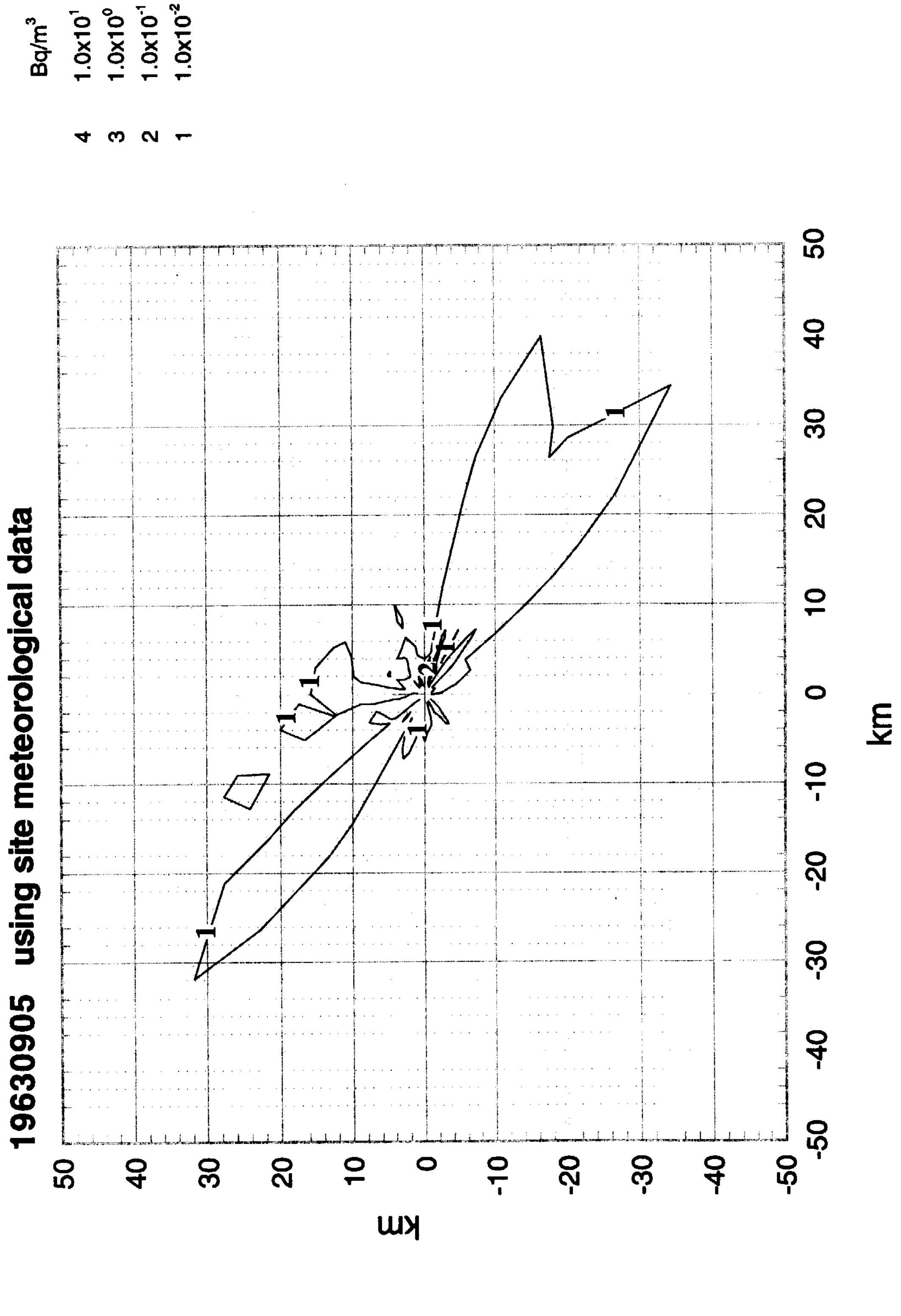

Fig. 8(d). Daily Concentration in Air of I-131

APPENDIX I

Description of Hanford Test Scenario
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B I O M A S S

DESCRIPTION OF THE HANFORD TEST SCENARIO

October 1996

INTERNATIONAL ATOMIC ENERGY AGENCY

International Programme on

BIOsphere Modelling and ASSessment methods

PREFACE

The Hanford Environmental Dose Reconstruction (HEDR) Project was prompted by mounting concern about possible health effects to the public from more than 40 years of nuclear operations at the Hanford Site. The primary objective of the HEDR Project was to estimate the radiation dose (with descriptions of the uncertainties inherent in such estimates) that individuals could have received as a result of emissions since 1944 from the U.S. Department of Energy's (DOE) Hanford Site near Richland, Washington. An independent Technical Steering Panel (TSP) directed the work on the project which was conducted by Battelle Pacific Northwest Laboratories (BNW) under contract with the Centers for Disease Control and Prevention.

This report provides input to modelers outside of the HEDR for the purpose of model validation. This report was originally prepared in cooperation with the International Atomic Energy Agency Co-ordinated Research Programme on Validation of Models for the Transfer of Radionuclidesin Terrestrial, Urban, and Aquatic Environments (VAMP), and continued use in the International Programme on Biosphere Modeling and Assessment Methods (BIOMASS). Modelers may use the information provided in the model description as the basis for model validation and intercomparison. The scenario described herein is structured such that modelers may begin the calculation with atmospheric source term information, with measured air concentrations, or with measured deposition on vegetation.

CONTENTS

PART 1

SCENARIO DESCRIPTION

1.0 INTRODUCTION

The following set of data and information has been collected to assist the validation of radiological assessment models. The test scenario is an inadvertent acute release of ^{131}I to the environment from the Hanford Purex Chemical Separations Plant stack that occurred on September 2-5, 1963. Monitoring data were collected in nine counties in the northwestern United States over the two-month period following this release.

The primary purposes of this model test are:

- to compare the release dispersion patterns in the Hanford environment that are predicted by the models with measured deposition;
- to compare predictions of ^{131}I body content and concentrations in environmental materials with observed values in the Hanford region;
- to compare and analyze the radiation doses from ^{131}I that are predicted by the models in the Hanford environment;
- to compare predictions of the total dose to specified individuals in a dose reconstruction.

The pathways contributing to dose are primarily through the air and terrestrial environments.

2.0 INPUT INFORMATION

An acute, inadvertent release of ^{131}I from the 60-meter stack of a nuclear chemical separations plant (centrally-located on the 1450 square-kilometer Hanford Site) occurred beginning 2 September 1963. This release resulted from the accidental charging of short-aged fuel elements into a dissolver of the Purex separation plant. Plant operations were shut down as soon as the abnormal release was detected. Steps were immediately taken to retain as much of the ^{131}I as possible within the plant. Laboratory analyses of stack effluent samples were made. These are provided as a possible starting point for calculations. The routine program of environmental surveillance was augmented with additional sampling. Measurements of wind velocity and temperature are made routinely at the site meteorology tower. Similar data from additional weather stations within a few hundred kilometers are also provided for those who may wish to use them in dispersion modeling.

No significant rainfall occurred in the region during the next few weeks. No protective measures were taken following the release. No atmospheric nuclear test explosions occurred in the several month period prior to this event. Routine atmospheric releases of ^{131}I prior to and following this event were on the order of 4 X 10^9 Bq/month (0.1 Ci/month), or less.

2.1 Iodine Chemical Form

The iodine released was essentially 100% molecular (I_2). It is believed that the iodine quickly partitioned into particulate, reactiv gaseous, and organic phases. Equilibrium partitioning between these phases is assumed to be approximately 25% particulate (5-25%), 40% reactive gas (20-60%, and the rest organic (Ramsdell et al. 1994).

2.2 Site Description

The Hanford Site is located in a rural, semiarid region of southeastern Washington State and occupies an area of about 1450 square kilometers. The Site lies about 320 km northeast of Portland, Oregon, 270 km southeast of Seattle, Washington, and 200 km southwest of Spokane, Washington. The semiarid land on which the Hanford Site is located has a sparse covering of desert shrubs and drought-resistant grasses. The most broadly distributed type of vegetation on the Site is the sagebrush/cheatgrass/bluegrass community. Most abundant of the mammals is the Great Basin pocket mouse. Of the big-game animals, the mule deer is most widely found, while the cottontail rabbit is the most abundant small-game animal. Coyotes are also plentiful. The bald eagle is a regular winter visitor to the area along the Columbia River.

The terrain of the central and eastern parts of the Hanford Site is relatively flat. The northern and western parts of the Site have moderate to steep topographic ridges composed of basalt and sediments. The elevations of the alluvial plain that covers much of the Site vary from 105 m (345 ft) above mean sea level in the southeast corner to 245 m (803 ft) in the northwest. The central plateau of the Site varies in elevation from 190 to 245 m (623 to 803 ft). The highest point is on Rattlesnake Mountain (1093 m or 3585 ft) at the southwestern border of the Site.

The Columbia River, which originates in the mountains of eastern British Columbia, Canada, flows through the northern edge of the Hanford Site and forms part of the northern edge of the Hanford Site and forms part of the Site's eastern boundary. Land surrounding the Hanford Site is used primarily for agriculture and livestock grazing. Agricultural lands are found north and east of the Columbia River and south of the Yakima River. These areas contain orchards, vineyards, and fields of alfalfa, wheat, and vegetables. The Hanford Site north of the Columbia River contains both a state wildlife management area and a federal wildlife refuge. The northeast slope of the Rattlesnake Hills along the southwestern boundary of the Site is designated as the Arid Lands Ecology Reserve and is used for ecological research.

The population in the area surrounding the Site is rural, with the exception of the area near the southeast boundary where the cities of Richland, Pasco, and Kennewick are located. No people live within the boundaries of the Hanford Site; most Site workers live in the three cities. Smaller communities in the vicinity are Benton City, West Richland, Mesa, and Othello. All together about 80,000 people lived in the vicinity of the Site.

The prevailing regional winds are from the northwest, with occasional cold-air drainage into valleys and strong crosswinds. The region is a typical desert basin, where frequent strong temperature inversions occur at night and break during the day, resulting in unstable and turbulent wind conditions.

2.3 Metorological Data

Tabular data of meteorological observations taken at the Hanford Meteorological Station (HMS) is provided in Section 2. This, and additional data from other nearby stations, is available in similar format in electronic form. A description of the available data is provided in Section 2.

All meteorological data are hourly observations. The observations were taken at the start of each hour and represent the conditions at that time. Wind speeds and directions, temperatures, and other data recorded represent the conditions at that time only, not an hourly average.

2.4 Measurements of Environmental ^{131}I

2.4.1 Vegetation Samples

Increased vegetation sampling was begun on 2 September and continued for the next week. Leafy sagebrush (*Artemisia tridentata*) (approximately 40% moisture) was collected whenever possible at on-site locations. A few samples consisted of leafy weeds, cheat grass (*bromus tectorum*), and in one case, bare sage stems (≤ 20% moisture) where a fire had previously destroyed the normal vegetation growth. Off-site vegetation samples consisted of pasture grass samples (generally about 80% moisture from irrigated areas, and much less from unirrigated areas) from local dairy farms and native vegetation (leafy weeds: up to 40% moisture) along highways and at the permanent atmospheric monitoring stations. Sampling of grass and milk was extended up to 100 kilometers southeast of the release point. The maximum off-site vegetation contamination of 13 pCi/g was measured on a sample of green hay from a farm 32 kilometers SSE of the release point where no cattle were being grazed. Maximum on-site vegetation contamination was found within 3 kilometers of the stack.

The values provided in the table are those historically recorded (with the units updated to modern S.I. usage). The measurements were made and a counting room background was subtracted before the results were recorded. In some instances, this results in a negative value being recorded. This indicates that the value was below the detection level of the instrumentation at the time. That lower limit is not known.

2.4.2 Air Samples

Twenty-two permanent atmospheric monitoring stations were maintained in the Hanford environs. Equipment installed in these stations included an "HV-70" brand filter and a caustic scrubber in series. These permanent air sampling stations were supplemented by several temporary caustic scrubber and charcoal cartridge samplers during September 1963. The concentrations provided in the table are daily values obtained by averaging the result (dividing) evenly over the varying sampling periods, with no decay correction.

The particulate filter was about 99.8% efficient for 3 micrometer size particles, and the caustic solution was reported to capture "most" of the elemental iodine, but would have been inefficient with organic forms.

Air sample measurements are provided in the table in Section 2; the table notation requires some explanation. The locations are provided in notations such as 100 BSE or 200 EWC. These notations refer to positions at the Hanford Site operating areas, in these examples, 100 B Area and 200 E Area. These operating areas are shown on the map in Section 2. The additional designation refers to locations along the outer fence of these areas. The notation 100 BSE means that the sampler was located at the eastern end of the southern fence of the 100 B Area. The notation 200 EWC indicates the sampler was located at the center of teh western fence of the 200 E Area. For areas without this type of notation, the sampler can be considered to be near the center of the designated area. Detailed latitude and longitude descriptors of all sample locations are also provided in Section 2.

2.4.3 Milk Samples

Routine milk collection in 1963 included daily to weekly samples from seven local dairy farms, two milk shed composites twice per month, and three commercial brands of milk twice per month. Spot sampling at several other dairy farms brought the total number of farms where milk and grass were sampled up to fifteen during the month of September 1963.

Darigold creamery processes milk from the east of the Hanford Site; the Twin City Dairy processes milk from both the east and the south of the Hanford Site. The general area of each creamery's collection is represented on the map in Section 2; Darigold by the area roughly bounded by Ringold, Eltopia, Pasco, and Riverview, and Twin City by the same area plus the area south of the Yakima River between Kiona and Kennewick in a band no more than 5 kiometers wide.

3.0 ASSESSMENT TASKS

3.1 General

The following subsections contain a description of the calculational endpoints suggested in this scenario. The quantities to be predicted are separated into two groups. The first group are quantities for which measurements exist and against which model predictions can be tested. The second group contains quantities which can only be predicted but not tested (such as radiation dose). The latter are included because they are the most common and useful endpoints in radiological assessments. For all quantities, a 90% confidence level (5% and 95%, respectively, lower and upper bound estimates) should be given to quantify the expected uncertainty in the result. It is anticipated that these values will be "subjective" confidence intervals given the nature of the data provided for this scenario.

For the quantities requested in Sections 3.2 and 3.3, you are required to estimate the arithmetic mean x for the time-periods specified, and a confidence interval thereof.

3.2 Calculations for Model Testing

3.2.1 Total Deposition

Estimate the ^{131}I deposition (Bq) at the following locations: Farm A, Farm B, Mesa, Ringold, and Pasco.

3.2.2 ^{131}I Concentrations in Media

Estimate the integrated contamination of specified media from the region for the period of September 1963. The concentrations should be given for products prior to preparation for human consumption, integrated over this time period at the following locations: Farm A, Farm B, Mesa, Ringold, and Pasco.

Milk. Estimate the integrated ^{131}I concentrations in milk (Bq d L^{-1}) for the month of September 1963, at the following locations: Farm A, Farm B, Mesa, Ringold, and Pasco. Estimate the ^{131}I concentration of composite milk samples taken daily from the Twin City Dairy and the Darigold Dairy for September.

Vegetation. Estimate the average integrated ^{131}I concentrations in leafy sagebrush; pasture grass; and green alfalfa (Bq d kg^{-1} f.w.) for the month of September 1963 for the 5 locations.

3.2.3 Human Intake

Estimate the integrated ^{131}I intake (Bq) of test persons (woman, man, child) for the month of September 1963, from Darigold and Carnation creameries.

Estimate the October 19, 1963 thyroid burden for a four-year old boy and his 8-year old sister who were residents of a Farm B located 25 kilometers SSE of the point of release, where the maximum off-site exposure occurred. Milk was obtained from a single cow on the farm maintained for the sole use of the owner's family. Milk consumption estimated by the parents was 1 gallon/day (4 L/d) for the boy and one quart/day (1 L/d) for the girl.

3.3 Calculations for Comparison of Dose Predictions

In this part of the scenario, the "test persons" are adults 20 years old in 1963.

3.3.1 External Dose

Estimate the mean dose to the test persons at the locations Farm A, Farm B, Mesa, Ringold, and Pasco, from external exposure due to ^{131}I from the cloud released (mSv). Estimate the mean dose from the ^{131}I ground deposits in the periods September 2, 1963 to September 5, 1963; and September 2, 1963 to October 1, 1963 for the test persons.

3.3.2 Inhalation Dose

Estimate the mean dose to the test persons at the 5 locations from inhalation from the ^{131}I cloud (mSv).

3.3.3 Ingestion Dose

Estimate the mean dose to the test persons from ingestion (mSv) for the period between September 2, 1963 to September 30, 1963 for the test persons.

3.3.4 Total Dose

Estimate the mean dose to the test persons from all pathways (mSv) for the periods September 2, 1963 to September 5, 1963, and September 2, 1963 to October 1, 1963, for the test persons.

3.3.5 Dispersion Contours (Optional)

Estimate the atmospheric transport within 40 km (25 miles) of the Purex Plant. Derive the estimated maximum concentrations of ^{131}I dispersed in air, deposited on vegetation, and measured in farm milk over the test area. Sketch contours for each on the map provided of the test area using the contour values given below.

Contour Values

Air: 0.01 - 0.1; 0.1-1; 1-10 $Bq\text{-}m^{-3}$ at 6 pm on each day from September 2 through September 6. (Air measurements are based on 24-hour samples.)

Vegetation: 0.01- 0.1; 0.1-1; 1-10 Bq/kg at 6 pm on each day from September 2 through September 6

Farm Milk: 0.1-1; 1-10; 10-20 Bq/L at 6 pm on each day from September 2 through September 6

3.3 Format of the Results

A set of forms and maps has been prepared for the predictions (see attachment). It would be appreciated if predictions could be submitted on these forms and maps, to enable an easy comparison with observations and other model results and also, if possible, on a diskette.

Send your results to:

Mr. C. Torres
BIOMASS Secretariat
International Atomic Energy Agency
Division of Nuclear Fuel Cycle and Waste Management
P.O. Box 100
A-1400 VIENNA
Austria

PART 2

POTENTIALLY USEFUL INFORMATION

DATA TABLES

HOURLY SOURCE TERM DATA

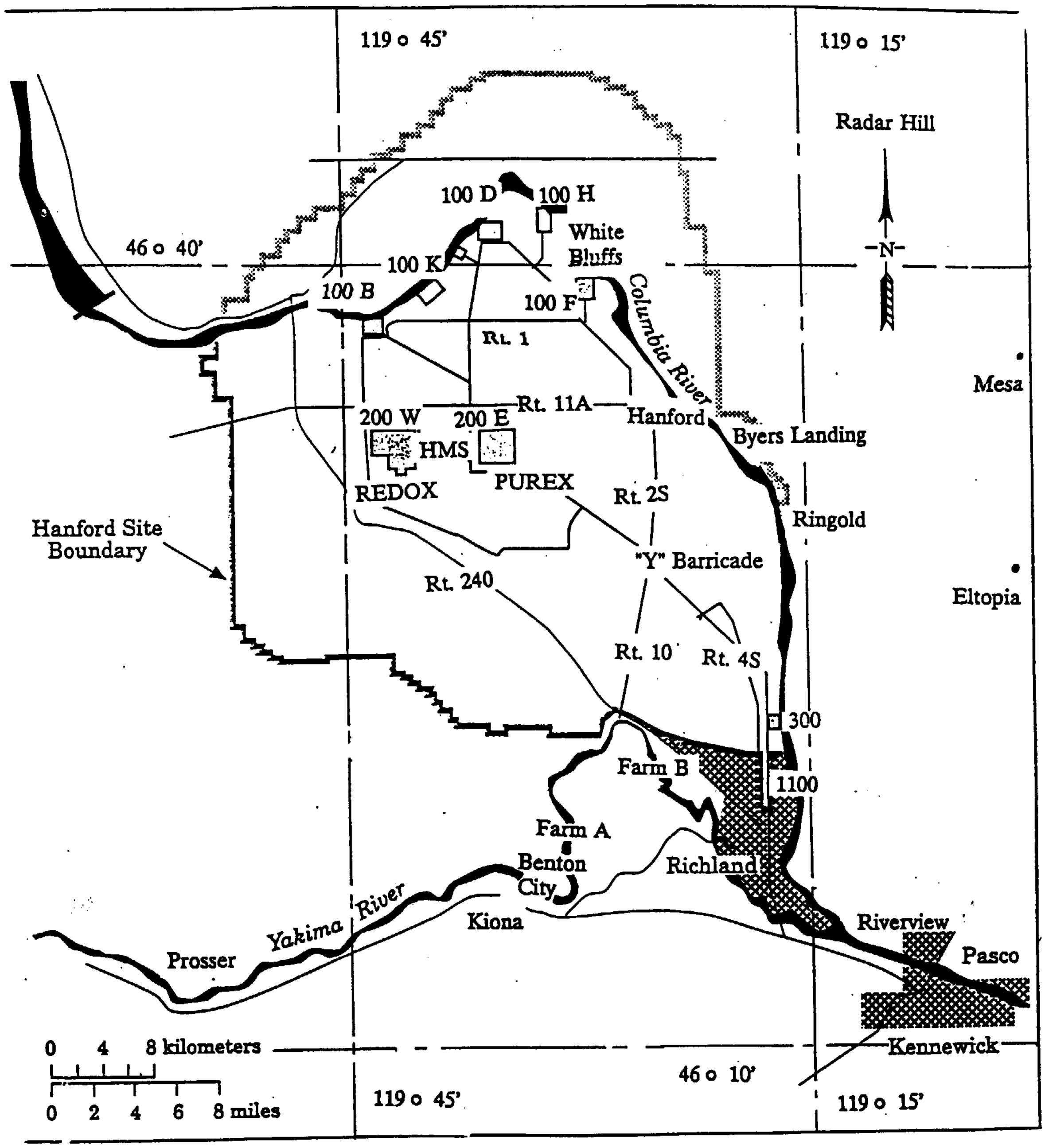
DATE	TIME	^{131}I ACTIVITY RELEASED (Bq)	(Ci)
September 2	12:25 - 16:25	2.04×10^{11}	5.5
September 2	16:25 - 23:30	6.84×10^{11}	18.5
September 2-3	23:30 - 09:10	8.25×10^{11}	22.3
September 3	09:10 - 11:55	1.44×10^{11}	3.9
September 3	11:55 - 15:05	8.51×10^{10}	2.3
September 3	15:10 - 23:30	1.96×10^{11}	5.3
September 3	23:30 - 08:50	8.51×10^{10}	2.3
September 4	08:50 - 15:00	4.81×10^{10}	1.3
September 4-5	15:00 - 09:10	4.07×10^{10}	1.1
September 5	09:10 - 14:45	7.77×10^{9}	0.21
September 5-6	14:45 - 00:30	5.92×10^{9}	0.16
September 6	00:30 - 09:00	6.66×10^{9}	0.18
September 6	09:00 - 14:25	3.52×10^{9}	0.095
September 6-7	14:25 - 09:00	8.51×10^{9}	0.23
September 7	09:00 - 15:20	4.07×10^{9}	0.11
September 7-8	15:20 - 14:00	1.37×10^{10}	0.37
September 8-9	14:00 - 09:00	1.07×10^{10}	0.29
Sept. 9 - 10	09:00 - 09:15	1.33×10^{10}	0.36
Sept. 10 - 11	09:15 - 09:00	1.30×10^{10}	0.35
to Sept. 30		2.59×10^{11}	7 ± 2
TOTAL		2.33×10^{12}	72 ± 2

1) Hourly data from handwritten record by Soldat

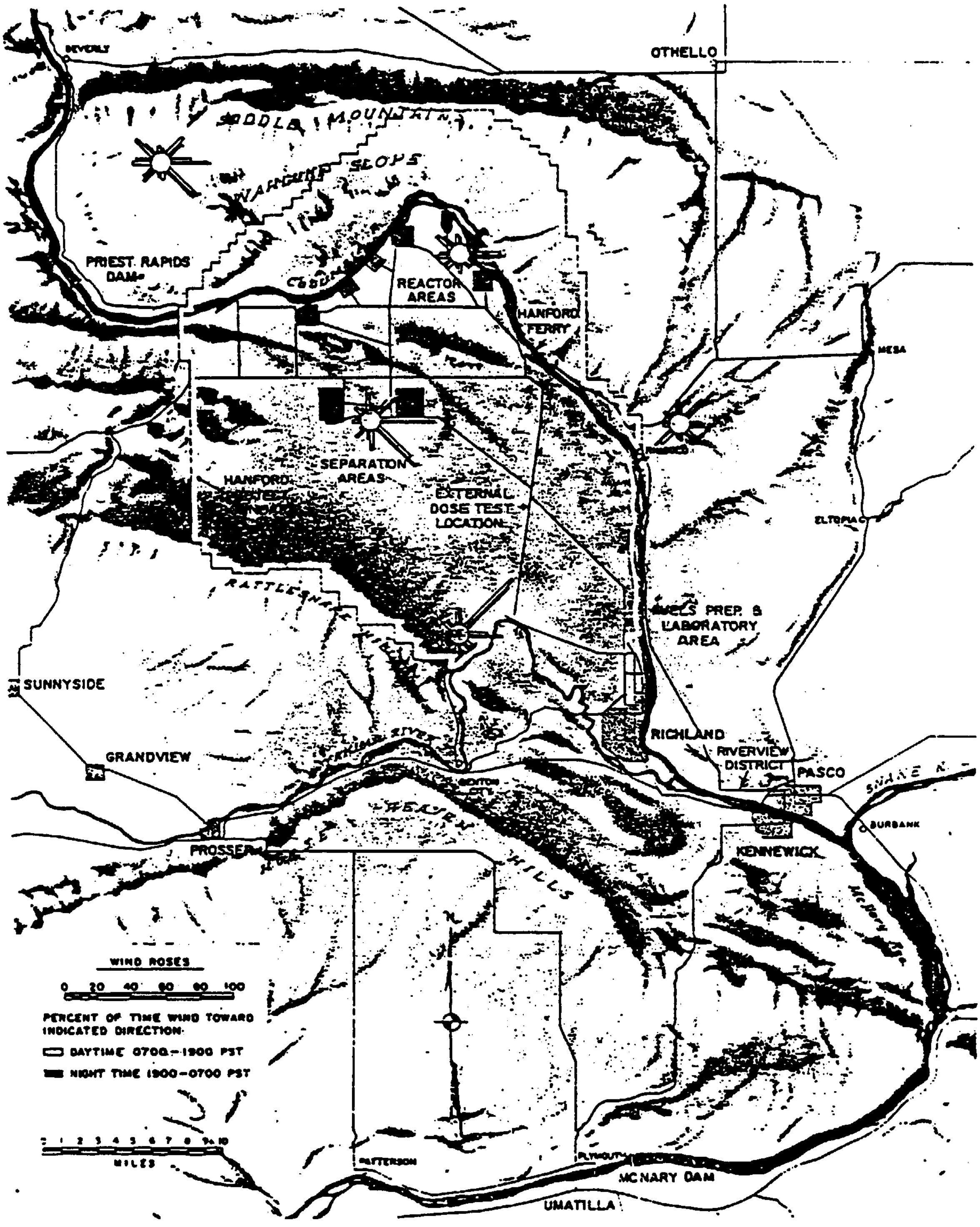
2) Monthly total (72 Ci) from HW-76525 9, page 3, calculated as monthly average of 2.4 Ci/day times 30 days. Note also that this reference says daily average 12 months prior to this event was 1.3×10^{10} Bq/d (0.36 Ci/d) (essentially same as that seen following return to routine operations in the latter part of the month).

MAPS AND LOCATIONS OF MEASUREMENTS

(NORTH LATITUDE AND WEST LONGITUDE)


119 o 45'
119 o 15'
Radar Hill
N
100 D
100 H
White
Bluffs
46 o 40'
100 K
100 B
100 F
Columbia River
Rt. 1
Mesa
200 W
200 E
Rt. 11A
Hanford
Byers Landing
HMS
PUREX
REDOX
Rt. 2S
Ringold
Hanford Site
Boundary
"Y" Barricade
Eltopia
Rt. 240
Rt. 10
Rt. 4S
300
Farm B
1100
Farm A
Benton
City
Richland
Yakima River
Kiona
Riverview
Prosser
Pasco
0 4 8 kilometers
Kennewick
46 o 10'
0 2 4 6 8 miles
119 o 45'
119 o 15'

S8402063.62



Features of Hanford Project and Vicinity

LOCATIONS	North Latitude Deg	Min	Sec	West Longitude Deg	Min	Sec
ROUTE 2N, MILE 3	46	36	55	119	25	16
ROUTE 2N, MILE 5	46	38	7	119	27	3
ROUTE 2N, MILE 7	46	39	30	119	28	34
ROUTE 2N, MILE 9	46	40	39	119	30	28
ROUTE 2S, MILE 1	46	34	10	119	22	46
ROUTE 2S, MILE 3	46	32	24	119	22	45
ROUTE 2S, MILE 5	46	30	37	119	23	3
ROUTE 4S, MILE 13	46	28	11	119	22	44
ROUTE 4S, MILE 15	46	26	59	119	20	56
ROUTE 4S, MILE 17	46	25	45	119	19	9
ROUTE 4S, MILE 19	46	24	31	119	17	25
ROUTE 4S, MILE 21	46	22	49	119	16	58
Y BARRICADE	46	28	56	119	23	30
200E - GATE HOUSE	46	32	42	119	32	12
ERC GATE (ERC INTERSECTION)	46	22	14	119	26	39
ERC GATE + 1 MILE	46	22	55	119	26	3
ERC GATE + 2 MILES (TO ROUTE 10 + 4S)	46	23	3	119	24	45
ERC GATE + 3 MILES	46	23	56	119	24	32
ERC GATE + 4 MILES (TO RT10 +4S)	46	24	50	119	24	22
ERC GATE + 5 MILES	46	25	44	119	24	9
ERC GATE + 6 MILES (TO RT10 +4S)	46	26	38	119	23	58
ERC GATE + 7 MILES	46	27	32	119	23	48
ERC GATE + 8 MILES (TO RT 10 +4S)	46	28	27	119	23	38
ERC GATE + 9 MILES	46	29	21	119	23	24
ERC GATE + 10 MILES	46	30	14	119	23	7
ROUTE 10 + ROUTE 4S INTERSECTION	46	28	40	119	23	30
ROUTE 11A + ROUTE 3 INTERSECTION	46	34	48	119	36	17
ROUTE 11A + ROUTE 4S INTERSECTION	46	34	48	119	33	12
ROUTE 11A + ROUTE 6 INTERSECTION	46	34	47	119	39	43
ROUTE 11A , FROM ROUTE 3 TO ROUTE 6, MIL	46	34	49	119	36	53
ROUTE 11A , FROM ROUTE 3 TO ROUTE 6, MIL	46	34	49	119	37	29
ROUTE 11A, FROM ROUTE 3 TO ROUTE 6, MILE	46	34	49	119	38	6
ROUTE 11A, FROM ROUTE 3 TO ROUTE 6, MILE	46	34	48	119	38	42
ROUTE 11A, FROM ROUTE 4S TO ROUTE 6, MIL	46	34	49	119	33	49
ROUTE 11A, FROM ROUTE 4S TO ROUTE 6, MIL	46	34	49	119	34	24
ROUTE 11A, FROM ROUTE 4S TO ROUTE 6, MIL	46	34	49	119	35	0
ROUTE 4S, 3 MILES SOUTH OF Y BARRICADE	46	26	26	119	20	8
ROUTE 4S, 5 MILES SOUTH OF Y BARRICADE	46	25	11	119	18	22
ROUTE 4S, 7 MILES SOUTH OF Y BARRICADE	46	23	50	119	16	58
ROUTE 4S, 9 MILES SOUTH OF Y BARRICADE	46	22	1	119	16	58
ROUTE 4S, 11 MILES SOUTH OF Y BARRICADE	46	20	12	119	16	57
ROUTE 4S, 13 MILES SOUTH OF Y BARRICADE	46	18	20	119	17	10
ROUTE 4S, 15 MILES SOUTH OF Y BARRICADE	46	16	48	119	18	18
ROUTE 4S, 17 MILES SOUTH OF Y BARRICADE	46	15	33	119	16	46
ROUTE 4S, 19 MILES SOUTH OF Y BARRICADE	46	14	43	119	14	58
ROUTE 4S, 21 MILES SOUTH OF Y BARRICADE	46	13	55	119	12	53
200E - 1	46	33	32	119	31	13
200E - 4	46	34	9	119	30	50
200E -7	46	33	27	119	31	41
200 - 8	46	33	28	119	30	49
200 - 10	46	33	7	119	32	8
200 - 12	46	33	10	119	30	52
ROUTE 4S, MILE 1	46	33	53	119	33	14

ROUTE 4S, MILE 3	46	32	36	119	32	26
ROUTE 4S, MILE 4	46	32	36	119	31	14
ROUTE 4S, MILE 5	46	32	28	119	30	3
A ZONE	46	33	23	119	37	35
B ZONE	46	33	25	119	32	4
ATTERBURY	46	16	45	119	28	29
NEW PASCO BRIDGE TO PROSSER, MILE 2	46	13	30	119	9	59
NEW PASCO BRIDGE TO PROSSER, MILE 4	46	13	15	119	12	16
NEW PASCO BRIDGE TO PROSSER, MILE 6	46	14	20	119	14	27
NEW PASCO BRIDGE TO PROSSER, MILE 8	46	14	50	119	16	43
NEW PASCO BRIDGE TO PROSSER, MILE 10	46	15	19	119	18	60
NEW PASCO BRIDGE TO PROSSER, MILE 12	46	15	41	119	21	17
NEW PASCO BRIDGE TO PROSSER, MILE 14	46	15	50	119	23	29
NEW PASCO BRIDGE TO PROSSER, MILE 16	46	15	37	119	25	46
NEW PASCO BRIDGE TO PROSSER, MILE 18	46	15	7	119	27	59
NEW PASCO BRIDGE TO PROSSER, MILE 20	46	15	13	119	30	17
NEW PASCO BRIDGE TO PROSSER, MILE 22	46	15	57	119	32	28
NEW PASCO BRIDGE TO PROSSER, MILE 24	46	15	47	119	34	30
NEW PASCO BRIDGE TO PROSSER, MILE 26	46	15	0	119	36	43
NEW PASCO BRIDGE TO PROSSER, MILE 28	46	14	9	119	38	47
NEW PASCO BRIDGE TO PROSSER, MILE 30	46	13	17	119	40	50
PROSSER, EAST OF CITY LIMITS	42	12	49	119	43	6
JOHNSON	46	17	13	119	33	11
BARKER	46	20	58	119	22	23
BUCKINGHAM	46	21	33	119	14	46
BLEAZARD	46	25	10	119	12	6
NEW MOON	46	33	55	119	6	45
TEDRO	46	15	9	119	10	51
RADAR HILL	46	43	13	119	10	27
RADAR HILL TO PASCO, MILE 2	46	41	25	119	10	25
RADAR HILL TO PASCO, MILE 4	46	39	36	119	10	24
RADAR HILL TO PASCO, MILE 6	46	37	48	119	10	25
RADAR HILL TO PASCO, MILE 8	46	36	9	119	10	26
RADAR HILL TO PASCO, MILE 10	46	34	54	119	11	27
RADAR HILL TO PASCO, MILE 12	46	33	28	119	12	57
RADAR HILL TO PASCO, MILE 14	46	31	60	119	14	6
RADAR HILL TO PASCO, MILE 18	46	29	17	119	12	14
RADAR HILL TO PASCO, MILE 20	46	27	53	119	11	41
RADAR HILL TO PASCO, MILE 22	46	26	3	119	11	42
RADAR HILL TO PASCO, MILE 24	46	24	10	119	11	43
RADAR HILL TO PASCO, MILE 26	46	22	20	119	11	47
RADAR HILL TO PASCO, MILE 28	46	20	25	119	11	48
RADAR HILL TO PASCO, MILE 30	46	18	46	119	11	16
RADAR HILL TO PASCO, MILE 32	46	17	3	119	11	17
RADAR HILL TO PASCO, MILE 34	46	15	17	119	10	42
RADAR HILL TO PASCO, MILE 36	46	14	22	119	9	27
RADAR HILL TO PASCO, MILE 38	46	14	21	119	7	5
KINNE	46	32	8	119	14	54
HARRIS	46	15	12	119	13	39
PUREX STACK	46	33	0	119	31	6
MET TOWER	46	33	47	119	35	55
100 BSE	46	37	56	119	38	7
100-F	46	38	59	119	26	42
100-K	46	38	41	119	35	44
100-D	46	41	8	119	31	32
100-HE	46	41	38	119	29	0
200 ESE	46	32	33	119	30	52

200 EWC	46	33	2	119	33	9
200 EEC	46	33	2	119	30	52
200E SEMI	46	33	24	119	31	35
REDOX	46	32	3	119	37	7
200 WEC	46	33	15	119	36	29
200 WWC	46	33	6	119	38	14
300-A	46	22	13	119	16	37
HANFORD	46	35	0	119	22	30
WHITE BLUFFS	46	39	42	119	28	30
BYERS LANDING	46	22	11	119	15	32
700-A	46	16	42	119	16	30
1100-A	46	19	21	119	17	0
BENTON CITY	46	18	0	119	30	0
PASCO	46	13	0	119	2	0
KENNEWICK	46	11	0	119	4	0

CONSUMPTION DATA

Means, Standard Deviations, and Number of Observations[3] for the Distributions of Average Daily Food Consumption for Green Leafy Vegetables and Fresh Milk by Age Group in Spring of 1965

Age Group	Green Leafy Vegetables (grams)	NOBS	Fresh Milk (grams)
Males			
<1	0 (0)	8	588 (478)
1-4	9 (16)	52	453 (250)
5-9	15 (22)	72	678 (314)
10-14	18 (29)	99	725 (388)
15-19	32 (39)	84	755 (564)
>20	47 (60)	534	377 (370)
Females			
<1	0 (0)	14	550 (498)
1-4	5 (13)	44	549 (273)
5-9	18 (20)	71	635 (301)
10-14	22 (32)	79	588 (328)
15-19	29 (44)	88	523 (403)
>20	50 (63)	608	260 (257)

[3]Standard Deviations in parentheses; NOBS = Number of Observations

METEOROLOGICAL DATA

The following additional information is available in electronic format:

Station Name	Latitude	Longitude	Meas. Ht.	Sfc Roughness
Hanford, WA	46.563	119.598	17.1	0.05
Walla Walla, WA	46.100	118.283	6.1	0.10
Baker, OR	44.833	117.817	6.1	0.20
Burns, OR	43.583	119.050	20.7	0.10
Dallesport, WA	45.617	121.150	6.1	0.20
Lewiston, ID	46.383	117.017	12.2	0.20
Moses Lake, WA	47.183	119.333	3.7	0.05
Pendleton, OR	45.683	118.850	6.1	0.10
Redmond, OR	44.267	121.150	6.1	0.10
Spokane, WA	47.667	117.333	12.2	0.20
Stampede Pass, WA	47.283	121.333	8.8	1.00
Yakima, WA	46.567	120.533	6.1	0.20

Notes:

1. All latitudes are north and longitudes are west.
2. Wind measurement height is in meters
3. Surface roughness (z0) is in meters
4. Release point (PUREX stack) 46.549N, 119.517W
5. Release height 60.5 m
6. Stack radius 1.067 m
7. Stack flow 56.63 m^3/s
8. Effluent temperature ~25 C
9. Meteorological data format (1x,i2,i3,i2,1x,2i2,1x,i3,1x,12(2i2,2i1))
10. The first 3 fields contain the last 2 digits of the year, the day of the year (1-365), and the hour of the observation (0-23). The next 2 fields contain the wind direction (16 pt compass) and wind speed (miles per hour) measured at Hanford at the release height. The next field is the ambient air temperature at the release height in tenths of a degree F (650 = 65.0). Then come 12 fields containing surface level wind, stability, and precipitation data. The data in the 2i2,2i1 groups are, in order, wind direction, wind speed, Pasquill-Gifford-Turner stability class (1-7) in place of (A-G)...1=A, and precipitation class. Precipitation classes are 0 = none, 1 = light liquid precip (rain or drizzle), 2 = moderate liquid precip, 3 = heavy liquid precip, 4 = light frozen precip (snow), 5 = moderate frozen precip, 6 = heavy precip, and 8 and 9 are missing data. We use the US National Weather Service definitions of light, moderate, and heavy to go to precipitation rates. All wind directions are given in a 16 pt compass with 0 or 16 used for north, 4 for east, etc. Calms and variable are indicated by 17 and 18, and 88 and 99 indicate missing data. Wind speeds for all stations except Hanford are in knots (nautical miles per hour). Hanford winds are in miles per hour. The order of the stations in the record is the same as in the list above.

METEOROLOGICAL DATA - SURFACE OBSERVATIONS MADE AT HMS

DAY/HOUR	SEA LEVEL PRESSURE (MBS)	DEW POINT (°F)	WIND DIRECTION	WIND SPEED (MPH)	PRESSURE (INCHES)	DRY BULB (°F)	WET BULB (°F)	RELATIVE HUMIDITY (%)	SOLRAD (LANGLEY'S)
Sept 2, 1963									
1am	134	47	WNW	9	29.17	64	55	54	0
2am	136	46	WSW	11	29.17	64	54	51	0
3am	142	46	WSW	10	29.19	61	53	57	0
4am	146	46	W	8	29.20	61	53	58	0
5am	149	49	WNW	10	29.21	63	55	60	3
6am	156	48	WNW	6	29.23	63	55	59	24
7am	160	48	W	5	29.24	63	55	52	50
8am	163	50	NW	7	29.25	71	59	47	76
9am	165	50	NE	7	29.25	74	60	43	97
10am	167	49	E	3	29.26	76	60	39	104
11am	163	49	NNE	6	29.25	78	61	36	126
12pm	160	48	NNW	8	29.24	81	61	32	123
1pm	156	47	NNE	3	29.23	82	61	29	112
2pm	153	47	NE	6	29.22	83	62	29	96
3pm	149	47	SE	2	29.21	83	62	28	67
4pm	145	46	S	1	29.20	83	61	27	46
5pm	145	46	NNW	1	29.20	83	61	27	20
6pm	145	46	ESE	7	29.20	81	61	29	2
7pm	147	46	SE	3	29.20	76	59	34	0
8pm	155	45	ESE	10	29.22	73	57	37	0
9pm	157	44	NW	9	29.23	70	56	40	0
10pm	164	46	NW	7	29.25	68	56	45	0
11pm	164	46	W	9	29.25	65	54	50	0
12am	166	47	WNW	8	29.26	64	55	54	0

METEOROLOGICAL DATA - SURFACE OBSERVATIONS MADE AT HMS

DAY/HOUR	SEA LEVEL PRESSURE (MBS)	DEW POINT (°F)	WIND DIRECTION	WIND SPEED (MPH)	PRESSURE (INCHES)	DRY BULB (°F)	WET BULB (°F)	RELATIVE HUMIDITY (%)	SOLRAD (LANGLEY'S)
Sept 3, 1963									
1am	166	48	WNW	7	29.26	64	55	56	0
2am	170	48	NW	7	29.27	61	54	61	0
3am	173	44	SSW	2	29.28	58	51	59	0
4am	177	42	SSE	3	29.28	56	49	60	0
5am	180	41	SSW	5	29.29	55	48	59	4
6am	187	43	SSW	5	29.31	59	51	56	24
7am	188	49	NW	4	29.32	65	56	57	50
8am	187	50	NW	6	29.32	69	58	51	73
9am	190	50	NNE	1	29.33	73	59	45	92
10am	190	50	NNW	4	29.32	76	60	40	108
11am	186	50	NNW	5	29.31	79	62	36	116
12pm	179	47	SSE	2	29.29	82	61	29	114
1pm	176	47	ENE	6	29.28	83	61	28	106
2pm	169	45	N	4	29.26	86	62	24	92
3pm	161	43	E	5	29.24	87	62	22	72
4pm	152	44	NNE	4	29.22	87	62	22	47
5pm	148	42	SE	4	29.21	87	61	21	20
6pm	147	41	NNE	3	29.20	84	60	23	2
7pm	144	40	NNW	4	29.20	78	57	26	0
8pm	144	40	NW	8	29.20	74	56	30	0
9pm	147	39	NW	6	29.20	69	53	33	0
10pm	145	39	W	6	29.20	69	53	33	0
11pm	148	39	WSW	9	29.20	69	53	33	0
12am	145	39	WNW	8	29.20	66	52	36	0

METEOROLOGICAL DATA - SURFACE OBSERVATIONS MADE AT HMS

DAY/HOUR	SEA LEVEL PRESSURE (MBS)	DEW POINT (°F)	WIND DIRECTION	WIND SPEED (MPH)	PRESSURE (INCHES)	DRY BULB (°F)	WET BULB (°F)	RELATIVE HUMIDITY (%)	SOLRAD (LANGLEY'S)
Sept 4, 1963									
1am	145	40	W	8	29.20	67	53	37	0
2am	144	39	W	8	29.19	66	52	37	0
3am	141	40	W	8	29.19	66	52	38	0
4am	136	40	WNW	10	29.18	67	53	37	0
5am	135	39	W	9	29.17	66	52	37	3
6am	137	41	NW	3	29.18	64	52	43	24
7am	141	44	NW	11	29.18	68	55	41	50
8am	141	44	WNW	4	29.18	74	57	34	72
9am	141	45	NW	10	29.18	79	59	30	92
10am	135	42	NNW	7	29.17	82	61	29	108
11am	128	47	N	6	29.15	84	62	27	114
12pm	122	47	NNW	5	29.13	86	62	25	114
1pm	110	44	NW	2	29.10	89	63	21	106
2pm	102	46	E	2	29.08	93	65	20	90
3pm	94	45	E	0	29.06	94	65	19	67
4pm	88	45	ESE	2	29.04	93	64	19	42
5pm	84	45	SSE	5	29.02	93	64	19	16
6pm	83	44	ESE	4	29.02	89	63	21	1
7pm	84	43	SE	2	29.02	81	59	26	0
8pm	86	43	SSE	10	29.03	80	59	27	0
9pm	90	41	NW	7	29.04	73	56	31	0
10pm	92	44	WNW	7	29.05	76	58	33	0
11pm	91	51	WNW	8	29.05	76	61	42	0
12am	93	53	WNW	15	29.05	77	62	43	0

METEOROLOGICAL DATA - SURFACE OBSERVATIONS MADE AT HMS

DAY/HOUR	SEA LEVEL PRESSURE (MBS)	DEW POINT (°F)	WIND DIRECTION	WIND SPEED (MPH)	PRESSURE (INCHES)	DRY BULB (°F)	WET BULB (°F)	RELATIVE HUMIDITY (%)	SOLRAD (LANGLEY'S)
Sept 5, 1963									
1am	95	53	WNW	13	29.06	76	62	46	0
2am	98	53	WNW	16	29.07	75	62	46	0
3am	105	53	NW	6	29.09	71	61	52	0
4am	104	54	WNW	11	29.08	72	61	53	0
5am	105	53	W	9	29.09	69	59	56	4
6am	108	53	W	6	29.09	70	60	56	21
7am	110	54	NW	7	29.10	75	62	48	47
8am	114	54	NW	5	29.10	78	63	42	74
9am	114	53	W	0	29.10	82	63	37	94
10am	108	52	WSW	1	29.09	84	64	33	109
11am	98	50	WSW	4	29.07	88	65	28	114
12pm	97	49	SSW	4	29.06	90	64	24	114
1pm	91	47	W	5	29.05	93	65	21	104
2pm	85	50	ESE	4	29.03	95	67	22	90
3pm	77	49	ENE	3	29.01	95	67	21	68
4pm	74	48	NE	6	29.00	95	66	20	42
5pm	69	48	SE	6	28.98	93	66	22	16
6pm	69	45	SE	5	28.98	90	63	21	2
7pm	74	44	SE	8	28.99	84	61	25	0
8pm	84	47	WNW	16	29.03	82	61	29	0
9pm	88	48	NW	18	29.04	80	61	32	0
10pm	93	49	NW	14	29.05	78	61	36	0
11pm	98	47	NW	6	29.07	75	59	36	0
12am	102	46	NW	11	29.08	74	58	38	0

METEOROLOGICAL DATA - HMS TOWER OBSERVATIONS
TEMPERATURE AND WIND DATA

DATE/TIME	SUBSURFACE (IN)			TEMPERATURES (°F) AT TOWER HEIGHT							WIND SPEED (MPH) AT TOWER HEIGHT						WIND DIRECTION AT TOWER HEIGHT (10s of degrees)		
	-0.5	-15	-36	3′	50′	100′	200′	250′	300′	400′	7′	50′	100′	200′	300′	400′	50′	200′	400′
Sept 2,1963																			
1am	69.5	-	-	65.0	66.1	65.9	66.6	66.5	66.3	66.0	7	11	13	16	17	19	29	29	29
2am	68.6	-	-	66.3	66.7	66.5	66.8	66.8	66.7	66.6	9	13	15	19	21	24	27	29	29
3am	68.0	-	-	60.5	62.0	63.8	66.5	66.7	66.6	66.2	5	10	12	15	15	16	25	27	27
4am	66.9	-	-	62.6	63.5	64.0	65.3	65.2	65.0	64.8	5	9	12	13	13	15	27	27	27
5am	66.0	80.4	77.0	62.9	64.3	64.4	64.6	64.5	64.2	63.9	6	9	11	13	15	17	27	29	29
6am	65.8	-	-	61.5	63.5	63.9	64.5	64.2	64.0	63.9	4	8	10	14	14	16	27	29	29
7am	65.8	-	-	62.7	63.5	64.0	65.0	65.0	64.5	64.5	2	3	5	8	7	8	27	29	29
8am	70.0	-	-	68.4	68.0	66.9	66.5	66.2	65.9	65.9	5	6	6	7	7	8	29	32	29
9am	78.8	-	-	73.0	71.0	69.5	69.3	69.2	68.9	68.2	6	6	7	8	8	8	34	34	34
10am	88.0	-	-	74.0	73.0	71.2	71.8	70.6	70.6	70.7	4	5	6	6	6	6	34	36	34
11am	93.0	80.0	77.2	78.1	75.2	74.1	73.9	72.9	72.1	72.4	4	4	4	4	3	3	37	37	37
12pm	100.0	-	-	78.2	77.1	76.5	76.2	75.5	75.8	76.1	4	4	4	4	4	3	37	37	37
1pm	106.4	-	-	80.7	79.0	78.1	77.6	77.1	77.3	77.4	6	7	7	7	6	6	37	36	36
2pm	110.0	-	-	83.0	80.4	78.9	78.5	78.6	78.4	78.5	5	5	6	5	5	4	36	36	34
3pm	111.4	-	-	83.0	82.0	80.5	80.5	79.9	80.2	80.1	3	3	3	3	3	3	36	2	2
4pm	108.8	-	-	83.9	83.0	81.4	80.6	80.4	80.3	80.0	2	2	2	3	3	3	2	2	37
5pm	103.8	79.5	77.5	83.7	82.7	82.2	81.5	81.1	81.0	81.1	2	2	2	2	2	2	37	23	37
6pm	99.9	-	-	82.8	81.6	81.3	80.7	80.5	80.3	80.1	5	5	6	7	7	7	11	11	9
7pm	95.5	-	-	78.4	79.1	78.8	78.8	78.3	78.2	77.9	6	6	7	7	8	9	11	14	11
8pm	85.0	-	-	73.9	75.2	76.5	77.1	76.8	76.7	76.5	5	6	8	10	11	12	14	14	14
9pm	80.0	-	-	70.7	74.4	76.5	76.5	76.2	76.1	76.0	4	8	10	12	12	14	16	18	16
10pm	78.1	-	-	68.6	70.9	71.2	72.0	72.0	72.0	73.1	3	7	10	15	16	15	32	32	32
11pm	74.0	80.0	77.2	64.2	69.4	69.8	70.7	71.5	77.1	72.4	2	7	10	16	16	15	29	32	32
12am	71.9	-	-	65.0	68.0	68.6	69.7	69.8	70.0	70.5	3	7	11	16	16	20	29	32	32

METEOROLOGICAL DATA - HMS TOWER OBSERVATIONS
TEMPERATURE AND WIND DATA

DATE/TIME	SUBSURFACE (IN)			TEMPERATURES (°F) AT TOWER HEIGHT							WIND SPEED (MPH) AT TOWER HEIGHT						WIND DIRECTION AT TOWER HEIGHT (10s of degrees)		
	-0.5	-15	-36	3′	50′	100′	200′	250′	300′	400′	7′	50′	100′	200′	300′	400′	50′	200′	400′
Sept 3,1963																			
1am	70.0	-	-	63.0	65.9	66.4	68.0	68.4	69.8	70.5	2	6	10	15	18	17	29	32	32
2am	68.6	-	-	61.8	65.1	65.3	66.7	67.0	67.7	69.0	2	7	10	16	17	17	32	32	32
3am	67.7	-	-	60.3	65.0	65.2	65.8	65.7	65.9	66.9	1	4	7	10	12	14	29	32	32
4am	66.0	-	-	55.2	62.4	63.5	64.3	64.3	64.6	64.9	2	3	2	6	9	12	20	29	29
5am	64.2	80.0	77.1	54.3	63.7	64.0	64.6	64.3	64.3	64.3	1	1	1	2	4	6	20	29	29
6am	62.8	-	-	54.8	61.6	61.7	63.1	63.3	63.1	63.5	1	4	3	3	5	5	20	29	29
7am	63.0	-	-	61.0	62.3	62.5	63.5	63.9	64.0	64.1	1	3	4	5	6	7	27	27	29
8am	68.8	-	-	66.0	65.7	64.9	64.5	64.0	64.2	64.2	5	5	5	5	5	6	32	29	29
9am	77.0	-	-	70.3	67.8	67.2	67.5	67.5	67.1	66.3	3	3	3	3	3	3	34	34	34
10am	88.0	-	-	74.8	71.8	72.0	71.9	71.1	70.8	70.3	2	2	2	2	2	2	34	34	36
11am	92.8	79.8	77.0	78.1	76.2	74.9	75.1	75.0	75.1	75.1	3	3	3	3	2	2	36	36	2
12pm	101.9	-	-	80.8	79.0	77.9	77.6	76.9	76.8	77.1	4	4	4	4	4	4	5	5	5
1pm	107.0	-	-	84.0	82.0	80.3	80.1	79.5	79.2	79.1	4	4	4	5	5	5	5	5	5
2pm	110.5	-	-	86.1	84.0	82.3	81.6	81.4	81.0	81.0	5	5	5	6	6	6	2	5	5
3pm	111.2	-	-	86.7	86.3	85.0	84.0	83.4	83.9	84.0	4	4	4	5	5	5	11	11	7
4pm	110.0	-	-	86.6	86.1	84.6	84.4	84.4	84.5	84.6	3	4	4	4	4	4	2	2	7
5pm	106.2	79.0	77.2	87.2	86.8	85.7	85.4	84.3	84.7	84.9	3	3	3	3	4	4	7	9	9
6pm	100.5	-	-	86.0	86.4	85.1	84.9	84.4	84.6	84.4	1	2	2	3	3	3	32	36	2
7pm	92.5	-	-	80.9	84.1	83.5	83.6	83.2	83.0	82.7	0	2	3	3	3	3	36	36	2
8pm	86.0	-	-	74.7	81.6	81.7	82.0	81.8	81.7	81.4	2	6	7	8	7	7	32	36	36
9pm	80.5	-	-	71.6	80.2	80.5	81.3	80.9	80.9	80.4	2	8	7	7	6	6	32	36	36
10pm	77.0	-	-	65.2	75.7	76.5	78.9	79.5	79.7	79.5	2	6	8	12	9	8	27	32	34
11pm	74.2	80.0	77.2	68.8	75.0	75.5	76.8	77.5	78.2	79.0	3	7	8	11	11	10	27	29	32
12am	72.6	-	-	68.0	73.4	76.5	76.5	76.3	77.0	78.8	3	8	9	12	12	12	27	32	32

METEOROLOGICAL DATA - HMS TOWER OBSERVATIONS
TEMPERATURE AND WIND DATA

DATE/TIME	SUBSURFACE (IN)			TEMPERATURES (°F) AT TOWER HEIGHT							WIND SPEED (MPH) AT TOWER HEIGHT						WIND DIRECTION AT TOWER HEIGHT (10s of degrees)		
	-0.5	-15	-36	3′	50′	100′	200′	250′	300′	400′	7′	50′	100′	200′	300′	400′	50′	200′	400′
Sept 4,1963																			
1am	70.3	-	-	67.2	71.7	72.2	75.0	77.0	77.8	78.0	2	7	9	15	13	12	27	32	34
2am	69.6	-	-	67.4	72.2	72.6	73.8	74.9	76.4	76.8	3	8	10	17	15	13	27	32	32
3am	68.6	-	-	66.3	70.0	72.1	76.4	76.5	76.8	76.7	3	9	12	17	14	12	29	32	34
4am	68.0	-	-	66.3	70.0	70.6	72.8	74.6	75.4	76.0	3	8	10	17	15	13	27	29	32
5am	67.6	80.1	77.3	65.4	68.2	69.0	71.4	73.8	74.2	74.6	4	9	11	18	17	15	29	29	32
6am	66.8	-	-	65.4	68.0	68.5	69.5	69.5	69.8	71.1	2	7	8	13	16	19	29	32	32
7am	66.6	-	-	65.4	65.9	66.2	66.0	66.1	66.3	68.2	3	5	6	10	12	17	32	32	32
8am	70.1	-	-	70.5	70.4	68.9	68.9	69.4	69.8	69.5	5	6	6	7	6	6	32	34	34
9am	79.0	-	-	76.6	76.0	73.4	73.2	73.4	73.1	72.5	7	8	8	9	9	8	32	32	32
10am	86.0	-	-	81.0	78.9	77.2	77.1	76.8	76.4	76.1	6	8	8	9	9	9	32	32	32
11am	93.6	79.8	77.6	83.1	81.1	80.0	79.4	78.9	78.8	78.7	3	4	4	5	5	5	34	34	34
12pm	102.1	-	-	85.3	83.3	82.6	82.5	81.9	82.0	82.0	3	3	3	3	3	3	2	36	36
1pm	110.0	-	-	90.0	87.7	86.2	86.6	85.7	85.8	85.8	3	3	3	3	3	3	5	5	2
2pm	114.0	-	-	90.9	90.1	88.7	88.9	88.4	88.5	88.6	3	3	3	3	3	2	23	25	27
3pm	115.8	-	-	92.0	92.1	90.9	90.7	89.5	89.4	89.9	3	3	3	4	3	3	16	16	16
4pm	114.2	-	-	94.3	93.7	92.3	91.8	91.1	91.6	92.1	3	3	3	4	3	3	14	14	14
5pm	110.0	79.0	77.0	93.0	93.2	91.7	92.2	91.4	91.3	91.6	5	5	5	6	6	6	14	14	14
6pm	103.8	-	-	91.6	92.3	91.3	91.2	90.7	90.5	90.4	5	5	6	6	6	6	14	14	14
7pm	95.9	-	-	85.4	88.6	88.2	88.3	88.0	87.9	87.5	3	7	7	7	7	7	11	14	14
8pm	89.0	-	-	80.4	86.1	87.4	87.5	87.3	87.5	87.5	4	9	9	9	7	6	14	14	14
9pm	84.3	-	-	75.1	82.0	84.1	85.7	85.5	85.7	86.5	2	6	7	8	8	8	20	18	16
10pm	80.3	-	-	75.8	82.1	83.0	84.0	83.6	84.1	84.7	2	7	9	12	13	13	29	32	32
11pm	78.5	80.0	78.5	77.4	79.8	80.5	82.2	82.3	82.3	82.3	4	10	12	16	18	20	29	29	29
12am	77.2	-	-	75.8	78.7	78.7	78.8	78.8	78.9	79.1	5	10	12	15	17	21	29	29	29

METEOROLOGICAL DATA - HMS TOWER OBSERVATIONS
TEMPERATURE AND WIND DATA

DATE/TIME	SUBSURFACE (IN)			TEMPERATURES (°F) AT TOWER HEIGHT							WIND SPEED (MPH) AT TOWER HEIGHT						WIND DIRECTION AT TOWER HEIGHT (10s of degrees)		
	-0.5	-15	-36	3'	50'	100'	200'	250'	300'	400'	7'	50'	100'	200'	300'	400'	50'	200'	400'
Sept 5,1963																			
1am	76.1	-	-	76.4	77.2	77.1	78.0	78.0	78.3	79.6	10	15	18	23	25	27	29	32	29
2am	75.6	-	-	75.3	76.0	76.0	76.8	76.7	76.9	77.3	11	17	18	24	25	27	32	32	32
3am	75.2	-	-	73.5	74.5	74.5	74.9	74.9	74.6	75.3	6	10	12	18	20	21	29	32	32
4am	74.0	-	-	72.5	74.1	74.2	74.4	74.1	74.0	73.9	5	10	12	15	16	18	32	32	29
5am	72.3	80.4	77.0	70.1	73.6	73.6	74.4	74.9	75.1	75.1	4	10	13	15	16	18	29	29	29
6am	71.0	-	-	69.3	71.0	71.2	73.4	73.2	73.5	73.8	4	9	11	17	18	19	27	29	29
7am	71.0	-	-	72.8	73.2	72.2	72.8	72.9	72.7	72.7	4	7	8	11	12	14	29	32	29
8am	75.5	-	-	76.5	75.8	74.6	74.6	74.8	74.3	73.3	4	6	7	8	8	8	32	32	32
9am	84.0	-	-	80.4	79.1	77.3	77.1	76.9	76.8	76.2	3	4	4	5	4	4	32	34	32
10am	93.0	-	-	83.0	82.0	80.6	80.2	79.8	79.4	79.1	1	1	1	2	2	2	25	34	34
11am	98.1	80.2	76.8	87.6	84.6	83.3	83.1	82.8	82.6	82.6	2	2	2	2	2	2	25	25	27
12pm	107.0	-	-	89.3	87.1	86.1	85.9	85.6	85.6	85.0	3	3	4	4	4	4	25	25	25
1pm	113.0	-	-	92.9	90.1	88.9	88.0	87.5	87.8	88.1	4	4	4	5	5	5	20	20	20
2pm	116.5	-	-	93.5	90.7	89.7	89.4	88.5	88.2	88.6	6	6	6	6	6	6	11	11	11
3pm	116.5	-	-	95.0	93.2	91.9	90.5	90.3	90.3	90.6	4	5	5	5	5	5	9	9	9
4pm	114.7	-	-	94.6	93.6	92.1	91.2	91.0	91.3	91.2	4	5	5	5	5	5	5	5	7
5pm	110.0	79.9	76.8	93.6	93.6	92.6	92.6	91.7	91.8	92.1	5	5	5	5	5	5	11	11	11
6pm	104.0	-	-	92.1	92.4	91.6	91.5	91.1	90.9	90.9	5	8	8	8	8	8	14	14	14
7pm	96.0	-	-	84.1	88.0	88.0	88.3	88.7	88.5	88.4	4	9	9	9	9	9	14	14	14
8pm	90.0	-	-	85.1	87.2	86.6	86.3	85.8	85.8	85.7	5	10	11	13	14	15	32	32	32
9pm	86.2	-	-	81.0	81.8	81.5	82.3	82.5	83.1	83.7	11	15	18	23	25	24	32	32	32
10pm	83.8	-	-	79.1	79.6	79.3	79.8	79.3	79.6	80.3	10	15	17	21	24	25	32	32	32
11pm	81.2	80.9	77.0	76.6	77.8	77.9	78.8	78.4	78.7	79.0	6	10	12	16	20	24	29	29	29
12am	78.2	-	-	73.6	76.8	76.9	77.5	77.6	77.9	78.0	3	9	10	13	16	20	32	32	32

AGRICULTURAL DATA

The following information is taken from "1963 United States Census of Agriculture," Volume 1 Part 46 - Washington, U.S. Department of Commerce, Bureau of the Census. The information is not specific to eastern Washington State. It is included here to provide the modeler with a general idea of the nature of agricultural practices at the time of the release.

TABLE 1

LETTUCE, COMMERCIAL CROP: ACREAGE, PRODUCTION - 1963

SEASON AND STATE:	Early Fall - Washington	
ACREAGE:	1,000 acres	400 ha
PRODUCTION:	165,000 CWT	7,500 tonnes

Table 2

HAY, ALL: ACREAGE, YIELD, PRODUCTION - 1963

STATE:	Washington	
AREA HARVESTED:	854,000 acres	346,000 ha
PRODUCTION:	1,976,000 tons	1,796,000 tonnes

Table 3

HAY - ALFALFA AND ALFALFA MIXTURES: CLOVER, TIMOTHY, AND MIXTURES OF CLOVER AND GRASSES; ACREAGE AND PRODUCTION - 1963

STATE: Washington

ALFALFA AND ALFALFA MIXTURES:

·	AREA HARVESTED	444,000 acres	180,000 ha
·	PRODUCTION	1,243,000 tons	1,130,000 tonnes

CLOVER, TIMOTHY, AND MIXTURES OF CLOVER AND GRASSES:

·	AREA HARVESTED	238,000 acres	96,000 ha
·	PRODUCTION	476,000 tons	433,000 tonnes

WILD HAY:

·	AREA HARVESTED	43,000 acres	17,400 ha
·	PRODUCTION	54,000 tons	49,000 tonnes

TABLE 4

HAY, ALL: PRODUCTION AND FARM DISPOSITION - 1963

PRODUCTION: 1,976,000 tons 1,800,000 tonnes

FARM DISPOSITION:

·	KEPT ON FARMS	1,304,000 tons	1,185,000 tonnes
·	SOLD	672,000 tons	615,000 tonnes

TABLE 5

FEED CONSUMED BY LIVESTOCK AND POULTRY: FEED, INCLUDING PASTURE, (EXPRESSED IN FEED UNIT)[4] CONSUMED PER HEAD OR PER UNIT OF PRODUCTION, BY DIFFERENT CLASSES - 1950 - 1962

YEAR BEGINNING OCTOBER 1, 1962

DAIRY CATTLE:

MILK COWS PER HEAD	7,405
MILK COWS PER 100 POUNDS MILK PRODUCED	110
OTHER DAIRY CATTLE, PER HEAD	4,474

TABLE 7

MILK COWS RATIONS: CONCENTRATES AND ROUGHAGE FED PER COW AND DAIRY PASTURE - 1963

STATE: Washington

GRAIN AND OTHER CONCENTRATES FED DURING CALENDAR YEAR:

PER COW	2,490 lb	1130 kg
PER 100 POUNDS (45 kg) OF MILK PRODUCED	28 lb	12.7 kg

ROUGHAGE FED DURING WINTER FEEDING PERIOD BEGINNING IN OCTOBER[5]:

HAY, PER COW	2.7 tons	2.45 tonnes
ALL ROUGHAGE, PER COW, HAY EQUIVALENT[6]	3.6 tons	3.26 tonnes

CONDITION OF DAIRY PASTURE FEED PERCENT OF NORMAL[7]: 89%

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[4]A feed unit is the equivalent of pound of corn in feeding value.

[5]Average for the October-May feeding period as reported by dairy correspondents.

[6]In computing hay equivalents, 3 tons of silage are considered equal to 1 ton of hay.

[7]Seasonal average condition for April 1-Oct. 1 period.

TABLE 8

MILK COW RATIONS: INDIVIDUAL FEEDS AS PERCENTAGE OF TOTAL CONCENTRATE RATIONS FEED TO MILK COWS - 1963

STATE:	Washington
PERCENT OF CORN:	3
PERCENT OF OATS:	3
PERCENT OF BARLEY:	4
PERCENT OF COMMERCIAL MIXED FEEDS:	79
PERCENT OF MISCELLANEOUS OTHER:	11

TABLE 9

MILK, MILKFAT, AND BUTTER PRODUCTION ON FARMS: NUMBER OF PRODUCING COWS, YIELD PER COW, AND TOTAL QUANTITY PRODUCED

STATE:	Washington	
NUMBER OF MILK COWS ON FARMS[8]:	222,000	
PRODUCTION PER MILK COW[9]:		
· MILK	8,960 lb	4060 kg
· MILKFAT	349 lb	158 kg
PERCENTAGE OF FAT IN MILK:		3.90 %
TOTAL PRODUCTION ON FARMS[2]:		
· MILK	994,000 tons	900,000 tonnes
· MILK FAT	39,000 tons	35,000 tonnes
BUTTER CHURNED ON FARMS:	400,000 lb	180,000 kg

[8]Estimated average number during year, heifers not freshened excluded.

[9]Excludes milk sucked by calves.

TABLE 10

MILK: QUANTITIES USED AND MARKETED BY FARMERS - 1963

STATE:	Washington	
MILK USED ON FARMS WHERE PRODUCED:		
FED TO CALVES[10]	24,500 tons	22,000 tonnes
CONSUMED AS FLUID MILK OR CREAM	28,500 tons	26,000 tonnes
USED FOR FARM CHURNED BUTTER	4,500 tons	4,100 tonnes
TOTAL UTILIZED ON FARMS	57,500 tons	52,000 tonnes
MILK MARKETED BY FARMERS:		
DELIVERED TO PLANTS AND DEALERS		
WHOLE MILK	905,000 tons	822,000 tonnes
FARM SKIMMED CREAM	15,000 tons	13,600 tonnes
RETAILED BY FARMERS AS MILK AND CREAM[11]	17,000 tons	15,500 tonnes
COMBINED MILK AND CREAM MARKETINGS	937,000 tons	852,000 tonnes

[10]Excludes milk sucked by calves.

[11]Sales by producer-distributors and other farmers on own routes or at farm.

TABLE 11

FARM DAIRY PRODUCTS: QUANTITY SOLD, AND FARM USE - 1963

STATE:	Washington	
DELIVERIES TO PLANTS, DEALERS, ETC. AT WHOLESALE:		
WHOLE MILK SOLD	905,000 tons	822,000 tonnes
FARM SEPARATED MILKFAT CREAM SOLD	630 tons	573 tonnes
MILK AND CREAM RETAILED BY FARMERS:		
SOLD, MILK EQUIVALENT	16,000,000 quarts	15,000,000 liters

TABLE 12

DAIRY PRODUCTS: ANNUAL PER CAPITA CIVILIAN CONSUMPTION, UNITED STATES - 1963

BUTTER[12]:		
PER CAPITA	6.7 lb	3.0 kg
CHEESE[13]:		
PER CAPITA	9.3 lb	4.2 kg
CONDENSED AND EVAPORATED MILK[14]:		
PER CAPITA	11.7 lb	5.3 kg
ICE CREAM (PRODUCT WEIGHT):		
PER CAPITA	18.1 lb	8.2 kg
DRY WHOLE MILK:		
PER CAPITA	0.19 lb	86 grams
NONFAT DRY MILK (HUMAN FOOD):		
PER CAPITA	5.6 lb	2.5 kg

[12] Includes both farm and factory-made butter.

[13] Includes all kinds of cheese except cottage, pot, and bakers' cheese, and full-skim American.

[14] The evaporated milk is unskimmed, unsweetened, case goods. The condensed milk is unsweetened (plain condensed) unskimmed, bulk goods, and sweetened condensed milk is unskimmed, case, and bulk goods.

TABLE 13

SPECIFIC MILK COW FEEDING REGIMES DEVELOPED FROM PRECEEDING DATA

(Beck et al. 1992. PNL-7227 HEDR Hanford Environmental Dose Reconstruction Project)

Early Autumn Season

Private Milk Cows

Pasture grass; dry wt.	9 kg/day
Grain supplement	1 kg/day

Commercial Dairy Cattle

Pasture grass; dry wt.	8.5 kg/day
Grain supplement	1.5 kg/day
Alfalfa hay	1.0 kg/day

PART 3

CONTEMPORANEOUS MONITORING DATA

FARM	COLLECTION SITE	COUNTY	DATE	VEGETATION TYPE	I-131 pCi/g	I-131 Bq/Kg
	"ROUTE 2N, MILE 3"		9/2/63	LEAFY SAGE	0.666	24.64
	"ROUTE 2N, MILE 5"		9/2/63	BARE SAGE STEMS	-0.792	-29.3
	"ROUTE 2N, MILE 7"		9/2/63	BARE SAGE STEMS	-0.38	-14.06
	"ROUTE 2N, MILE 9"		9/2/63	LEAFY SAGE	-0.664	-24.57
	"ROUTE 2S, MILE 1"		9/2/63	LEAFY SAGE	0.218	8.07
	"ROUTE 2S, MILE 3"		9/2/63	LEAFY SAGE	2.29	84.73
	"ROUTE 2S, MILE 5"		9/2/63	LEAFY SAGE	-0.335	-12.4
	"ROUTE 4S, MILE 13"		9/2/63	BARE SAGE STEMS	0.251	9.29
	"ROUTE 4S, MILE 15"		9/2/63	LEAFY SAGE	-1.52	-56.24
	"ROUTE 4S, MILE 17"		9/2/63	LEAFY SAGE	-0.96	-35.52
	"ROUTE 4S, MILE 19"		9/2/63	LEAFY SAGE	-2.34	-86.58
	"ROUTE 4S, MILE 21"		9/2/63	LEAFY SAGE	1.49	55.13
	Y BARRICADE		9/2/63	LEAFY SAGE	-0.582	-21.53
	200E - GATE HOUSE		9/3/63	LEAFY SAGE	8.74	323.38
	"ERC INTERSECTION		9/3/63		5	185
	"ERC INTERSECTION TO ROUTE 10 + ROUTE 4S, MILE 2"		9/3/63		0.534	19.76
	"ERC INTERSECTION TO ROUTE 10 + ROUTE 4S, MILE 4"		9/3/63		5.83	215.71
	"ERC INTERSECTION TO ROUTE 10 + ROUTE 4S, MILE 6"		9/3/63		6	222
	"ERC INTERSECTION TO ROUTE 10 + ROUTE 4S, MILE 8"		9/3/63		1.15	42.55
	ROUTE 10 + ROUTE 4S INTERSECTION		9/3/63		0.917	33.93
	ROUTE 11A + ROUTE 3 INTERSECTION		9/3/63	DRY CHEAT GRASS	3.91	144.67
	ROUTE 11A + ROUTE 4S INTERSECTION		9/3/63	LEAFY SAGE	2.33	86.21
	ROUTE 11A + ROUTE 6 INTERSECTION		9/3/63	LEAFY SAGE	-0.064	-2.37
	"ROUTE 11A, FROM ROUTE 3 TO ROUTE 6, MILE 0.5"		9/3/63	HALF DRY GRASS	0.322	11.91
	"ROUTE 11A, FROM ROUTE 3 TO ROUTE 6, MILE 1"		9/3/63	DRY CHEAT GRASS	1.44	53.28
	"ROUTE 11A, FROM ROUTE 3 TO ROUTE 6, MILE 1.5"		9/3/63	DRY CHEAT GRASS	0.956	35.37
	"ROUTE 11A, FROM ROUTE 3 TO ROUTE 6, MILE 2"		9/3/63	DRY CHEAT GRASS	2.05	75.85
	"ROUTE 11A, FROM ROUTE 4S TO ROUTE 6, MILE 0.5"		9/3/63	LEAFY SAGE	3.66	135.42
	"ROUTE 11A, FROM ROUTE 4S TO ROUTE 6, MILE 1"		9/3/63	DRY CHEAT GRASS	14.3	529.1
	"ROUTE 11A, FROM ROUTE 4S TO ROUTE 6, MILE 1.5"		9/3/63	DRY CHEAT GRASS	5.3	196.1
	"ROUTE 4S, 3 MILES SOUTH OF Y BARRICADE"		9/3/63	LEAFY SAGE	7.72	285.64
	"ROUTE 4S, 5 MILES SOUTH OF Y BARRICADE"		9/3/63	LEAFY SAGE	91.3	3378.1
	"ROUTE 4S, 7 MILES SOUTH OF Y BARRICADE"		9/3/63	LEAFY SAGE	18.7	691.9
	"ROUTE 4S, 9 MILES SOUTH OF Y BARRICADE"		9/3/63	LEAFY SAGE	14	518
	"ROUTE 4S, 11 MILES SOUTH OF Y BARRICADE"		9/3/63	LEAFY SAGE	7.41	274.17
	"ROUTE 4S, 13 MILES SOUTH OF Y BARRICADE"		9/3/63	LEAFY SAGE	12	444

"ROUTE 4S, 15 MILES SOUTH OF Y BARRICADE"		9/3/63	LEAFY SAGE	5.64	208.68
"ROUTE 4S, 17 MILES SOUTH OF Y BARRICADE"		9/3/63	LEAFY SAGE	1.17	43.29
"ROUTE 4S, 19 MILES SOUTH OF Y BARRICADE"		9/3/63	LEAFY SAGE	0.765	28.31
"ROUTE 4S, 21 MILES SOUTH OF Y BARRICADE"		9/3/63	LEAFY SAGE	0.316	11.69
Y BARRICADE		9/3/63	LEAFY SAGE	13.9	514.3
100 B GATE		9/4/63	BARE SAGE STEMS	6.53	241.61
100 D GATE		9/4/63	LEAFY SAGE	0.094	3.48
100 F GATE		9/4/63	LEAFY SAGE	0.099	3.66
100 H GATE		9/4/63	BARE SAGE STEMS	0.375	13.88
100 K GATE		9/4/63	LEAFY SAGE	0.696	25.75
200E - 1		9/4/63	LEAFY SAGE	11.1	410.7
200E - 4		9/4/63	LEAFY SAGE	6.3	233.1
200E - 7		9/4/63	LEAFY SAGE	4.2	155.4
200E - 8		9/4/63	LEAFY SAGE	44	1628
200E - 10		9/4/63	LEAFY SAGE	22.4	828.8
200E - 12		9/4/63	LEAFY SAGE	125	4625
"ROUTE 4S, MILE 1"		9/4/63	LEAFY SAGE	19.5	721.5
"ROUTE 4S, MILE 3"		9/4/63	LEAFY SAGE	7.67	283.79
"ROUTE 4S, MILE 4"		9/4/63	LEAFY SAGE	246	9102
"ROUTE 4S, MILE 5"		9/4/63	LEAFY SAGE	63.7	2356.9
A ZONE		9/6/63		6.01	222.37
B ZONE		9/6/63		67.2	2486.4
614 BUILDING - BYERS		9/7/63	LEAFY WEEDS	0.809	29.93
A ZONE		9/13/63		3.29	121.73
B ZONE		9/13/63		87.2	3226.4
A ZONE		9/20/63		1.28	47.36
B ZONE		9/20/63		30.8	1139.6
A ZONE		9/27/63		1.36	50.32
B ZONE		9/27/63		10.2	377.4
FARM A BENTON CITY	BENTON	9/3/63	HALF DRY GRASS	1.04	38.48
"NEW PASCO BRIDGE TO PROSSER, MILE 2"	BENTON	9/3/63	DRY GRASS	-0.741	-27.42
"NEW PASCO BRIDGE TO PROSSER, MILE 4"	BENTON	9/3/63	DRY GRASS	0.376	13.91
"NEW PASCO BRIDGE TO PROSSER, MILE 6"	BENTON	9/3/63	DRY GRASS	3.08	113.96
"NEW PASCO BRIDGE TO PROSSER, MILE 8"	BENTON	9/3/63	LEAFY SAGE	2.49	92.13
"NEW PASCO BRIDGE TO PROSSER, MILE 10"	BENTON	9/3/63	LEAFY SAGE	2.15	79.55
"NEW PASCO BRIDGE TO PROSSER, MILE 12"	BENTON	9/3/63	GREEN HAY	13	481
"NEW PASCO BRIDGE TO PROSSER, MILE 14"	BENTON	9/3/63	LEAFY SAGE	4.06	150.22
"NEW PASCO BRIDGE TO PROSSER, MILE 16"	BENTON	9/3/63	LEAFY SAGE	1.97	72.89
"NEW PASCO BRIDGE TO PROSSER, MILE 18"	BENTON	9/3/63	HALF DRY GRASS	1.8	66.6
"NEW PASCO BRIDGE TO PROSSER, MILE 20"	BENTON	9/3/63	DRY GRASS	0.735	27.2

"NEW PASCO BRIDGE TO PROSSER, MILE 22"	BENTON	9/3/63	LEAFY SAGE	1.16	42.92
"NEW PASCO BRIDGE TO PROSSER, MILE 24"	BENTON	9/3/63	GREEN GRASS	0.649	24.01
"NEW PASCO BRIDGE TO PROSSER, MILE 26"	BENTON	9/3/63	GREEN GRASS	1.29	47.73
"NEW PASCO BRIDGE TO PROSSER, MILE 28"	BENTON	9/3/63	GREEN GRASS	0.37	13.69
"NEW PASCO BRIDGE TO PROSSER, MILE 30"	BENTON	9/3/63	GREEN GRASS	0.621	22.98
"PROSSER, EAST OF CITY LIMITS"	BENTON	9/3/63	GREEN GRASS	0.405	14.99
FARM A BENTON CITY	BENTON	9/4/63	PASTURE GRASS	1.53	56.61
FARM A BENTON CITY	BENTON	9/5/63	PASTURE GRASS	1.39	51.43
FARM A BENTON CITY	BENTON	9/6/63	PASTURE GRASS	1.78	65.86
FARM J	BENTON	9/7/63	PASTURE GRASS	1.6	59.2
FARM M	BENTON	9/7/63	PASTURE GRASS	1.36	50.32
614 BUILDING - BENTON CITY	BENTON	9/7/63	LEAFY WEEDS	1.53	56.61
614 BUILDING - KENNEWICK	BENTON	9/7/63	LEAFY WEEDS	0.598	22.13
FARM A BENTON CITY	BENTON	9/7/63	PASTURE GRASS	2.61	96.57
FARM A BENTON CITY	BENTON	9/8/63	PASTURE GRASS	1.04	38.48
FARM A BENTON CITY	BENTON	9/9/63	PASTURE GRASS	0.344	12.73
FARM A BENTON CITY	BENTON	9/10/63	PASTURE GRASS	0.387	14.32
FARM M	BENTON	9/11/63	PASTURE GRASS	0.054	2
FARM A BENTON CITY	BENTON	9/11/63	PASTURE GRASS	0.049	1.81
FARM A BENTON CITY	BENTON	9/12/63	PASTURE GRASS	0.376	13.91
FARM B TWIN BRIDGE	BENTON	9/12/63	PASTURE GRASS	0.938	34.71
FARM A BENTON CITY	BENTON	9/13/63	PASTURE GRASS	0.119	4.4
FARM B TWIN BRIDGE	BENTON	9/13/63	PASTURE GRASS	0.24	8.88
FARM B TWIN BRIDGE	BENTON	9/13/63	PASTURE GRASS	1.15	42.55
FARM A BENTON CITY	BENTON	9/14/63	PASTURE GRASS	0.201	7.44
FARM A BENTON CITY	BENTON	9/16/63	PASTURE GRASS	0.175	6.48
FARM B TWIN BRIDGE	BENTON	9/16/63	PASTURE GRASS	0.391	14.47
FARM A BENTON CITY	BENTON	9/17/63	PASTURE GRASS	0.371	13.73
FARM B TWIN BRIDGE	BENTON	9/17/63	PASTURE GRASS	0.327	12.1
FARM A BENTON CITY	BENTON	9/18/63	PASTURE GRASS	0.359	13.28
FARM B TWIN BRIDGE	BENTON	9/18/63	PASTURE GRASS	0.994	36.78
FARM A BENTON CITY	BENTON	9/19/63	PASTURE GRASS	0.368	13.62
FARM B TWIN BRIDGE	BENTON	9/19/63	PASTURE GRASS	0.356	13.17
FARM A BENTON CITY	BENTON	9/20/63	PASTURE GRASS	0.195	7.22
FARM B TWIN BRIDGE	BENTON	9/20/63	PASTURE GRASS	0.495	18.32
FARM A BENTON CITY	BENTON	9/23/63	WEEDS	0.223	8.25
FARM B TWIN BRIDGE	BENTON	9/23/63	PASTURE GRASS	0.552	20.42
FARM A BENTON CITY	BENTON	9/24/63	WEEDS	0.295	10.92
FARM B TWIN BRIDGE	BENTON	9/24/63	WEEDS	0.839	31.04
FARM A BENTON CITY	BENTON	9/25/63	PASTURE GRASS	0.612	22.64

FARM B	TWIN BRIDGE	BENTON	9/25/63	PASTURE GRASS	0.575	21.28
FARM A	BENTON CITY	BENTON	9/26/63	PASTURE GRASS	1.11	41.07
FARM B	TWIN BRIDGE	BENTON	9/26/63	PASTURE GRASS	1.02	37.74
FARM A	BENTON CITY	BENTON	9/27/63	PASTURE GRASS	0.311	11.51
FARM B	TWIN BRIDGE	BENTON	9/27/63	PASTURE GRASS	0.59	21.83
FARM A	BENTON CITY	BENTON	9/30/63	ALFALFA	0.236	8.73
FARM B	TWIN BRIDGE	BENTON	9/30/63	PASTURE GRASS	0.374	13.84
FARM G	BYERS LANDING	FRANKLIN	9/3/63	PASTURE GRASS	0.3	11.1
FARM Z	ELTOPIA	FRANKLIN	9/3/63	PASTURE GRASS	0.093	3.44
FARM N	MESA	FRANKLIN	9/3/63	PASTURE GRASS	0.264	9.77
FARM T	PASCO	FRANKLIN	9/3/63	PASTURE GRASS	0.468	17.32
FARM T	PASCO	FRANKLIN	9/3/63	PASTURE GRASS	0.616	22.79
PASCO		FRANKLIN	9/3/63	LEAFY SAGE	0.146	5.4
RADAR HILL		FRANKLIN	9/3/63	LEAFY SAGE	0.259	9.58
"RADAR HILL TO PASCO, MILE 2"		FRANKLIN	9/3/63	LEAFY SAGE	-0.076	-2.81
"RADAR HILL TO PASCO, MILE 4"		FRANKLIN	9/3/63	GREEN HAY	0.263	9.73
"RADAR HILL TO PASCO, MILE 6"		FRANKLIN	9/3/63	GREEN ALFALFA	0.264	9.77
"RADAR HILL TO PASCO, MILE 8"		FRANKLIN	9/3/63	GREEN GRASS	0.235	8.7
"RADAR HILL TO PASCO, MILE 10"		FRANKLIN	9/3/63	LEAFY SAGE	0.234	8.66
"RADAR HILL TO PASCO, MILE 12"		FRANKLIN	9/3/63	LEAFY SAGE	0.0676	2.5
"RADAR HILL TO PASCO, MILE 14"		FRANKLIN	9/3/63	HALF DRY GRASS	-0.465	-17.21
"RADAR HILL TO PASCO, MILE 18"		FRANKLIN	9/3/63	GREEN HAY	0.732	27.08
"RADAR HILL TO PASCO, MILE 20"		FRANKLIN	9/3/63	LEAFY SAGE	-0.161	-5.96
"RADAR HILL TO PASCO, MILE 22"		FRANKLIN	9/3/63	LEAFY SAGE	0.477	17.65
"RADAR HILL TO PASCO, MILE 24"		FRANKLIN	9/3/63	GREEN CLOVER	0.489	18.09
"RADAR HILL TO PASCO, MILE 26"		FRANKLIN	9/3/63	LEAFY SAGE	0.074	2.74
"RADAR HILL TO PASCO, MILE 28"		FRANKLIN	9/3/63	LEAFY SAGE	0.127	4.7
"RADAR HILL TO PASCO, MILE 30"		FRANKLIN	9/3/63	LEAFY SAGE	0.355	13.14
"RADAR HILL TO PASCO, MILE 32"		FRANKLIN	9/3/63	LEAFY SAGE	0.37	13.69
"RADAR HILL TO PASCO, MILE 34"		FRANKLIN	9/3/63	DRY RYE HEADS	-0.414	-15.32
"RADAR HILL TO PASCO, MILE 36"		FRANKLIN	9/3/63	LEAFY SAGE	0.152	5.62
"RADAR HILL TO PASCO, MILE 38"		FRANKLIN	9/3/63	LEAFY SAGE	-0.249	-9.21
FARM K	RINGOLD	FRANKLIN	9/3/63	PASTURE GRASS	1.25	46.25
FARM H	RIVERVIEW	FRANKLIN	9/3/63	PASTURE GRASS	0.495	18.32
FARM G	BYERS LANDING	FRANKLIN	9/4/63	PASTURE GRASS	0.18	6.66
FARM Z	ELTOPIA	FRANKLIN	9/4/63	PASTURE GRASS	0.174	6.44
FARM Z	ELTOPIA	FRANKLIN	9/4/63	HAY	-0.0104	-0.38
FARM T	PASCO	FRANKLIN	9/4/63	PASTURE GRASS	0.365	13.51
FARM K	RINGOLD	FRANKLIN	9/4/63	PASTURE GRASS	0.204	7.55
FARM N	MESA	FRANKLIN	9/5/63	PASTURE GRASS	0.245	9.07

FARM T PASCO	FRANKLIN	9/5/63	PASTURE GRASS	0.537	19.87
FARM K RINGOLD	FRANKLIN	9/5/63	PASTURE GRASS	0.504	18.65
FARM H RIVERVIEW	FRANKLIN	9/5/63	PASTURE GRASS	2.68	99.16
FARM T PASCO	FRANKLIN	9/6/63	PASTURE GRASS	0.278	10.29
FARM K RINGOLD	FRANKLIN	9/6/63	PASTURE GRASS	0.083	3.07
614 BUILDING - PASCO	FRANKLIN	9/7/63	LEAFY WEEDS	0.57	21.09
FARM T PASCO	FRANKLIN	9/7/63	PASTURE GRASS	0.323	11.95
FARM K RINGOLD	FRANKLIN	9/7/63	PASTURE GRASS	0.461	17.06
FARM T PASCO	FRANKLIN	9/8/63	PASTURE GRASS	0.61	22.57
FARM K RINGOLD	FRANKLIN	9/8/63	PASTURE GRASS	0.433	16.02
FARM T PASCO	FRANKLIN	9/9/63	PASTURE GRASS	0.184	6.81
FARM K RINGOLD	FRANKLIN	9/9/63	PASTURE GRASS	0.466	17.24
FARM H RIVERVIEW	FRANKLIN	9/9/63	PASTURE GRASS	0.792	29.3
FARM T PASCO	FRANKLIN	9/10/63	PASTURE GRASS	0.177	6.55
PASCO	FRANKLIN	9/10/63	CLOVER	0.579	21.42
FARM K RINGOLD	FRANKLIN	9/10/63	PASTURE GRASS	0.13	4.81
FARM G BYERS LANDING	FRANKLIN	9/11/63	PASTURE GRASS	0.261	9.66
FARM Z ELTOPIA	FRANKLIN	9/11/63	PASTURE GRASS	0.195	7.22
FARM N MESA	FRANKLIN	9/11/63	PASTURE GRASS	0.118	4.37
FARM T PASCO	FRANKLIN	9/11/63	PASTURE GRASS	0.11	4.07
FARM K RINGOLD	FRANKLIN	9/11/63	PASTURE GRASS	0.374	13.84
FARM T PASCO	FRANKLIN	9/12/63	PASTURE GRASS	0.327	12.1
FARM K RINGOLD	FRANKLIN	9/12/63	PASTURE GRASS	0.259	9.58
FARM T PASCO	FRANKLIN	9/13/63	PASTURE GRASS	0.0534	1.98
FARM K RINGOLD	FRANKLIN	9/13/63	PASTURE GRASS	0.0134	0.5
FARM T PASCO	FRANKLIN	9/14/63	PASTURE GRASS	0.129	4.77
FARM T PASCO	FRANKLIN	9/16/63	PASTURE GRASS	0.0935	3.46
FARM K RINGOLD	FRANKLIN	9/16/63	PASTURE GRASS	0.081	3
FARM G BYERS LANDING	FRANKLIN	9/17/63	PASTURE GRASS	0.251	9.29
FARM T PASCO	FRANKLIN	9/17/63	PASTURE GRASS	0.128	4.74
FARM T PASCO	FRANKLIN	9/18/63	PASTURE GRASS	0.225	8.33
FARM Z ELTOPIA	FRANKLIN	9/19/63	PASTURE GRASS	0.204	7.55
FARM N MESA	FRANKLIN	9/19/63	PASTURE GRASS	0.191	7.07
FARM T PASCO	FRANKLIN	9/19/63	PASTURE GRASS	0.297	10.99
FARM K RINGOLD	FRANKLIN	9/19/63	PASTURE GRASS	0.154	5.7
FARM H RIVERVIEW	FRANKLIN	9/19/63	PASTURE GRASS	0.902	33.37
FARM T PASCO	FRANKLIN	9/20/63	PASTURE GRASS	0.279	10.32
FARM K RINGOLD	FRANKLIN	9/20/63	PASTURE GRASS	0.103	3.81
FARM T PASCO	FRANKLIN	9/23/63	WEEDS & ALFALFA	-0.014	-0.52
FARM K RINGOLD	FRANKLIN	9/23/63	WEEDS	0.319	11.8

FARM T	PASCO	FRANKLIN		9/24/63	WEEDS	0.31	11.47
FARM K	RINGOLD	FRANKLIN		9/24/63	PASTURE GRASS	0.407	15.06
FARM G	BYERS LANDING		FRANKLIN	9/25/63	ALFALFA	0.185	6.85
FARM Z	ELTOPIA	FRANKLIN		9/25/63	ALFALFA	0.161	5.96
FARM N	MESA	FRANKLIN		9/25/63	ALFALFA	0.359	13.28
FARM T	PASCO	FRANKLIN		9/25/63	WEEDS	0.217	8.03
FARM K	RINGOLD	FRANKLIN		9/25/63	PASTURE GRASS	0.47	17.39
FARM H	RIVERVIEW		FRANKLIN	9/25/63	WEEDS	0.317	11.73
FARM T	PASCO	FRANKLIN		9/26/63	ALFALFA	0.095	3.52
FARM K	RINGOLD	FRANKLIN		9/26/63	PASTURE GRASS	0.178	6.59
FARM T	PASCO	FRANKLIN		9/27/63	PASTURE GRASS	0.101	3.74
FARM K	RINGOLD	FRANKLIN		9/27/63	PASTURE GRASS	0.315	11.66
FARM T	PASCO	FRANKLIN		9/30/63	PASTURE GRASS	0.203	7.51

FARM	COLLECTION SITE	COUNTY	DATE	I-131 pCi/L	I-131 Bq/L
FARM A	BENTON CITY	BENTON	9/4/63	64.8	2.40
FARM L	KIONA	BENTON	9/4/63	10.3	0.38
FARM A	BENTON CITY	BENTON	9/5/63	117	4.33
TWIN CITY	PROSSER-BENTON CITY	BENTON	9/5/63	3.1	0.11
FARM A	BENTON CITY	BENTON	9/6/63	113	4.18
FARM A	BENTON CITY	BENTON	9/7/63	96.7	3.58
FARM J		BENTON	9/7/63	91	3.37
FARM M		BENTON	9/7/63	56.6	2.09
TWIN CITY	PROSSER-BENTON CITY	BENTON	9/7/63	58.7	2.17
FARM A	BENTON CITY	BENTON	9/8/63	77.7	2.87
FARM L	KIONA	BENTON	9/8/63	<4.2	<0.16
FARM A	BENTON CITY	BENTON	9/9/63	69.4	2.57
FARM A	BENTON CITY	BENTON	9/10/63	33.8	1.25
FARM A	BENTON CITY	BENTON	9/11/63	29.4	1.09
FARM A	BENTON CITY	BENTON	9/12/63	22.9	0.85
FARM B	1 MILE NORTH OF TWIN BRIDGES	BENTON	9/12/63	136	5.03
FARM A	BENTON CITY	BENTON	9/13/63	19.6	0.73
FARM B	1 MILE NORTH OF TWIN BRIDGES	BENTON	9/13/63	119	4.40
FARM A	BENTON CITY	BENTON	9/14/63	16.1	0.60
FARM B	1 MILE NORTH OF TWIN BRIDGES	BENTON	9/14/63	95.1	3.52
FARM A	BENTON CITY	BENTON	9/16/63	24.5	0.91
FARM B	1 MILE NORTH OF TWIN BRIDGES	BENTON	9/16/63	48.4	1.79
FARM A	BENTON CITY	BENTON	9/17/63	22	0.81
FARM B	1 MILE NORTH OF TWIN BRIDGES	BENTON	9/17/63	65.2	2.41
TWIN CITY	PROSSER - BENTON CITY	BENTON	9/17/63	19.7	0.73
FARM A	BENTON CITY	BENTON	9/18/63	19.5	0.72
FARM B	1 MILE NORTH OF TWIN BRIDGES	BENTON	9/18/63	43.4	1.61
FARM A	BENTON CITY	BENTON	9/19/63	20.2	0.75
FARM B	1 MILE NORTH OF TWIN BRIDGES	BENTON	9/19/63	54.4	2.01
FARM A	BENTON CITY	BENTON	9/20/63	19.2	0.71
FARM B	1 MILE NORTH OF TWIN BRIDGES	BENTON	9/20/63	51.9	1.92
FARM A	BENTON CITY	BENTON	9/23/63	19.2	0.71
FARM B	1 MILE NORTH OF TWIN BRIDGES	BENTON	9/23/63	38.7	1.43
FARM A	BENTON CITY	BENTON	9/24/63	14.3	0.53
FARM B	1 MILE NORTH OF TWIN BRIDGES	BENTON	9/24/63	31.3	1.16
FARM A	BENTON CITY	BENTON	9/25/63	11.4	0.42
FARM B	1 MILE NORTH OF TWIN BRIDGES	BENTON	9/25/63	32.9	1.22
FARM A	BENTON CITY	BENTON	9/26/63	9.4	0.35
FARM B	1 MILE NORTH OF TWIN BRIDGES	BENTON	9/26/63	25.8	0.95
FARM A	BENTON CITY	BENTON	9/27/63	9.8	0.36
FARM B	1 MILE NORTH OF TWIN BRIDGES	BENTON	9/27/63	25.8	0.95
FARM A	BENTON CITY	BENTON	9/30/63	10.7	0.40
FARM B	1 MILE NORTH OF TWIN BRIDGES	BENTON	9/30/63	29.1	1.08
DARIGOLD		COMPOSITE	9/16/63	8	0.30
LUCERNE		COMPOSITE	9/16/63	<1.2	<0.04
TWIN CITY		COMPOSITE	9/16/63	12.3	0.46

DARIGOLD		COMPOSITE	9/26/63	1.9	0.07
LUCERNE		COMPOSITE	9/26/63	3.8	0.14
TWIN CITY		COMPOSITE	9/26/63	4.1	0.15
FARM T	PASCO	FRANKLIN	9/3/63	<2.0	<0.07
FARM Z	ELTOPIA	FRANKLIN	9/4/63	9.9	0.37
FARM G	BYERS LANDING	FRANKLIN	9/4/63	10.2	0.38
FARM K	RINGOLD	FRANKLIN	9/4/63	16.1	0.60
FARM T	PASCO	FRANKLIN	9/4/63	18.9	0.70
FARM H	RIVERVIEW	FRANKLIN	9/5/63	40	1.48
FARM K	RINGOLD	FRANKLIN	9/5/63	30.4	1.12
FARM N	MESA	FRANKLIN	9/5/63	3.6	0.13
FARM T	PASCO	FRANKLIN	9/5/63	22.8	0.84
TWIN CITY	COLUMBIA BASIN	FRANKLIN	9/5/63	4	0.15
FARM K	RINGOLD	FRANKLIN	9/6/63	36.1	1.34
FARM T	PASCO	FRANKLIN	9/6/63	17.2	0.64
FARM K	RINGOLD	FRANKLIN	9/7/63	32.9	1.22
FARM T	PASCO	FRANKLIN	9/7/63	14.4	0.53
FARM K	RINGOLD	FRANKLIN	9/8/63	27.5	1.02
FARM T	PASCO	FRANKLIN	9/8/63	17.3	0.64
TWIN CITY	COLUMBIA BASIN	FRANKLIN	9/8/63	18.1	0.67
FARM K	RINGOLD	FRANKLIN	9/9/63	89.2	3.30
FARM T	PASCO	FRANKLIN	9/9/63	37.1	1.37
FARM K	RINGOLD	FRANKLIN	9/10/63	23.2	0.86
FARM T	PASCO	FRANKLIN	9/10/63	20.8	0.77
FARM Z	ELTOPIA	FRANKLIN	9/11/63	10.1	0.37
FARM G	BYERS LANDING	FRANKLIN	9/11/63	28.6	1.06
FARM H	RIVERVIEW	FRANKLIN	9/11/63	37	1.37
FARM K	RINGOLD	FRANKLIN	9/11/63	14.9	0.55
FARM N	MESA	FRANKLIN	9/11/63	34.2	1.27
FARM T	PASCO	FRANKLIN	9/11/63	13.8	0.51
FARM K	RINGOLD	FRANKLIN	9/12/63	12.2	0.45
FARM T	PASCO	FRANKLIN	9/12/63	14.3	0.53
FARM K	RINGOLD	FRANKLIN	9/13/63	8.2	0.30
FARM T	PASCO	FRANKLIN	9/13/63	19.8	0.73
FARM T	PASCO	FRANKLIN	9/14/63	8.3	0.31
FARM K	RINGOLD	FRANKLIN	9/16/63	5.8	0.21
FARM T	PASCO	FRANKLIN	9/16/63	4.2	0.16
FARM G	BYERS LANDING	FRANKLIN	9/17/63	36.8	1.36
FARM K	RINGOLD	FRANKLIN	9/17/63	32.3	1.20
FARM T	PASCO	FRANKLIN	9/17/63	4.7	0.17
TWIN CITY	COLUMBIA BASIN	FRANKLIN	9/17/63	18.7	0.69
FARM K	RINGOLD	FRANKLIN	9/18/63	8.3	0.31
FARM T	PASCO	FRANKLIN	9/18/63	5.2	0.19
FARM Z	ELTOPIA	FRANKLIN	9/19/63	7.1	0.26
FARM H	RIVERVIEW	FRANKLIN	9/19/63	12.3	0.46
FARM K	RINGOLD	FRANKLIN	9/19/63	12.3	0.46
FARM N	MESA	FRANKLIN	9/19/63	19	0.70
FARM T	PASCO	FRANKLIN	9/19/63	7	0.26
FARM K	RINGOLD	FRANKLIN	9/20/63	31	1.15

FARM T	PASCO	FRANKLIN	9/20/63	6.2	0.23
FARM K	RINGOLD	FRANKLIN	9/23/63	11.4	0.42
FARM T	PASCO	FRANKLIN	9/23/63	3	0.11
FARM K	RINGOLD	FRANKLIN	9/24/63	14.2	0.53
FARM T	PASCO	FRANKLIN	9/24/63	3.8	0.14
FARM Z	ELTOPIA	FRANKLIN	9/25/63	8.4	0.31
FARM G	BYERS LANDING	FRANKLIN	9/25/63	12.3	0.46
FARM H	RIVERVIEW	FRANKLIN	9/25/63	7.4	0.27
FARM K	RINGOLD	FRANKLIN	9/25/63	8.7	0.32
FARM N	MESA	FRANKLIN	9/25/63	17.3	0.64
FARM T	PASCO	FRANKLIN	9/25/63	5.4	0.20
FARM K	RINGOLD	FRANKLIN	9/26/63	14.2	0.53
FARM T	PASCO	FRANKLIN	9/26/63	8	0.30
FARM K	RINGOLD	FRANKLIN	9/27/63	10.6	0.39
FARM T	PASCO	FRANKLIN	9/27/63	5.5	0.20
FARM K	RINGOLD	FRANKLIN	9/30/63	4.8	0.18
FARM T	PASCO	FRANKLIN	9/30/63	5.2	0.19

HUMAN IODINE-131 THYROID BURDEN MEASUREMENTS

Barker farm, 19 October 1963	
4-year-old boy	73 pCi (2.7 Bq)
8-year-old girl	Below detection limit of 30 pCi (1 Bq)

APPENDIX II

Comparisons between predicted and observed time-dependent air concentrations of ^{131}I at several stations

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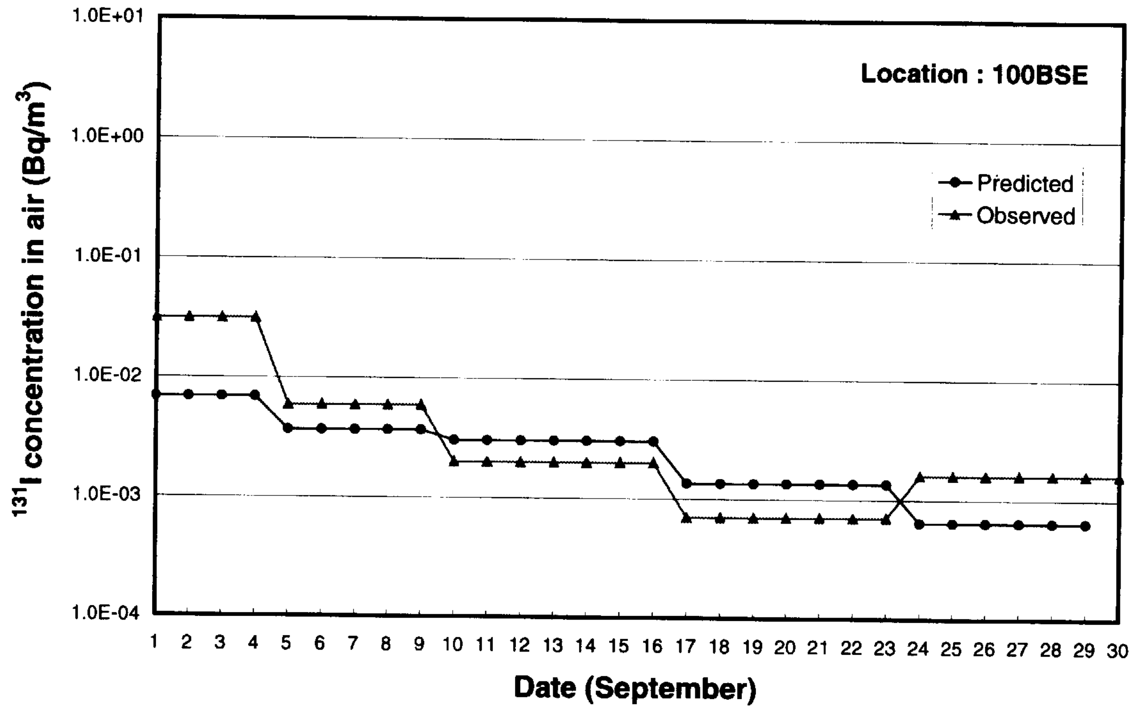

Fig.II-1 Comparison of predicted and observed data of ^{131}I concentration in air for 100BSE

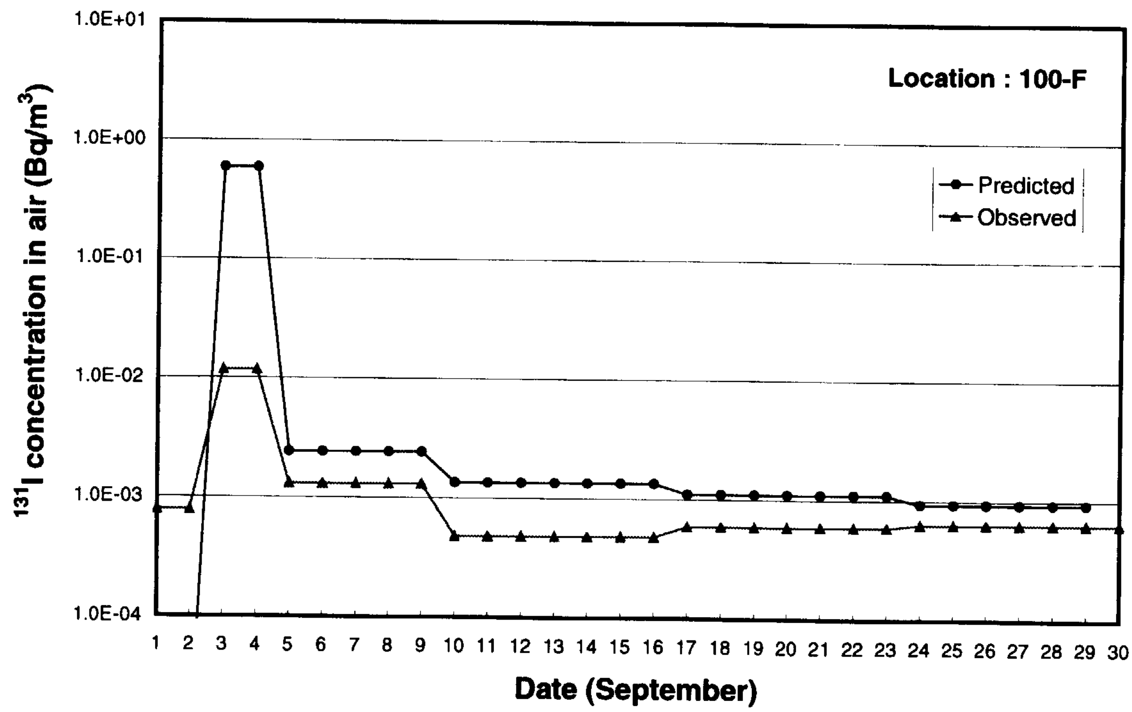

Fig.II-2 Comparison of predicted and observed data of ^{131}I concentration in air for 100-F

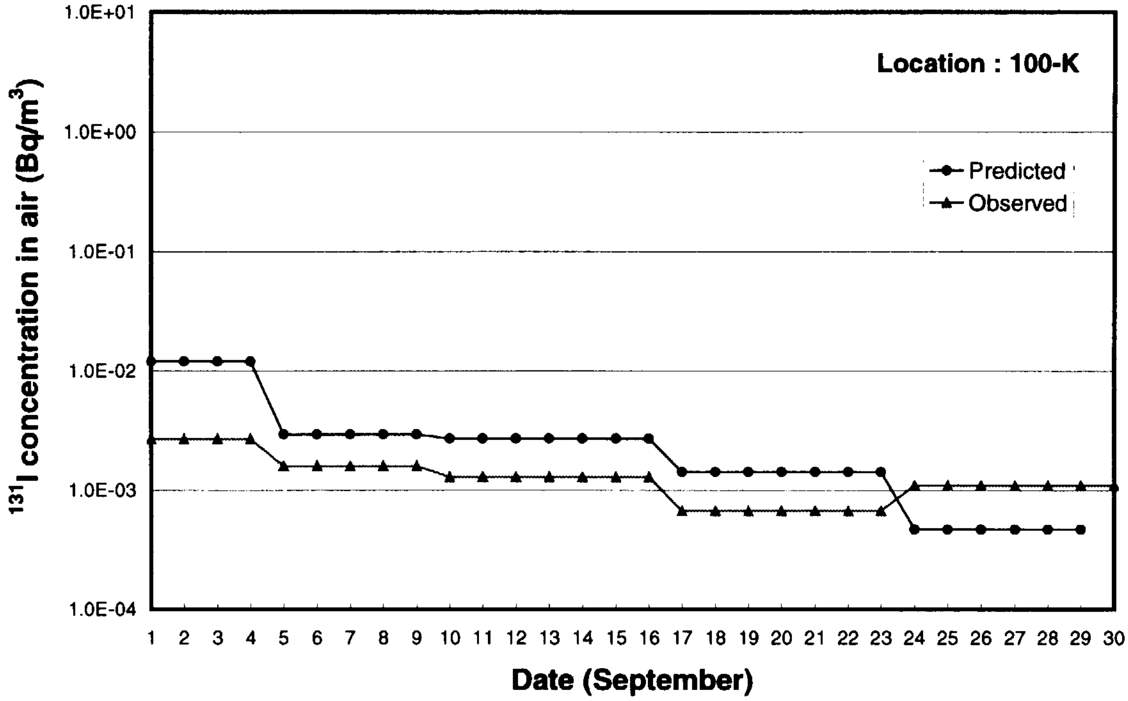

Fig.II-3 Comparison of predicted and observed data of ^{131}I concentration in air for 100-K

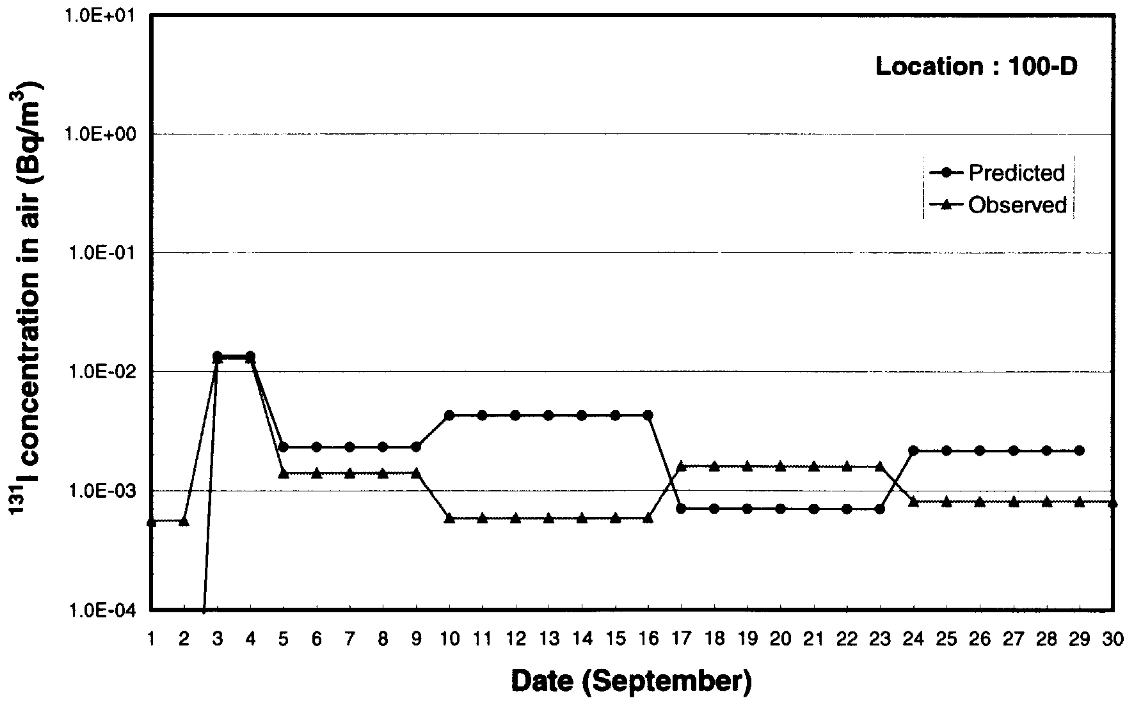

Fig.II-4 Comparison of predicted and observed data of ^{131}I concentration in air for 100-D

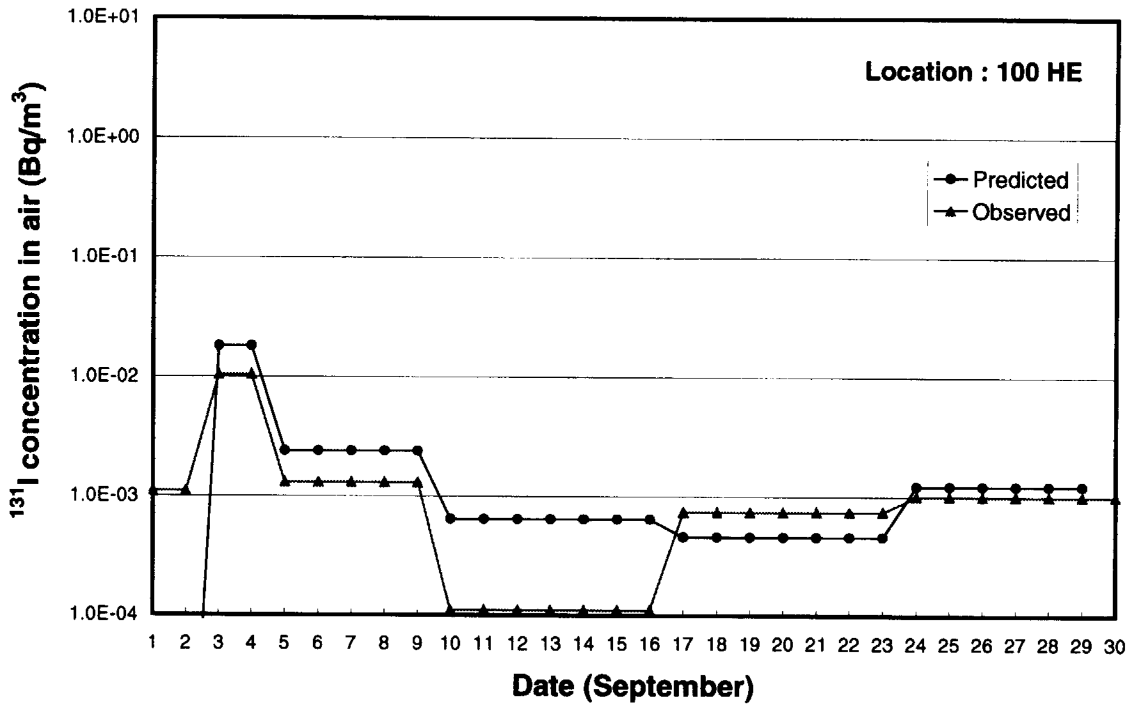

Fig.II-5 Comparison of predicted and observed data of ^{131}I concentration in air for 100 HE

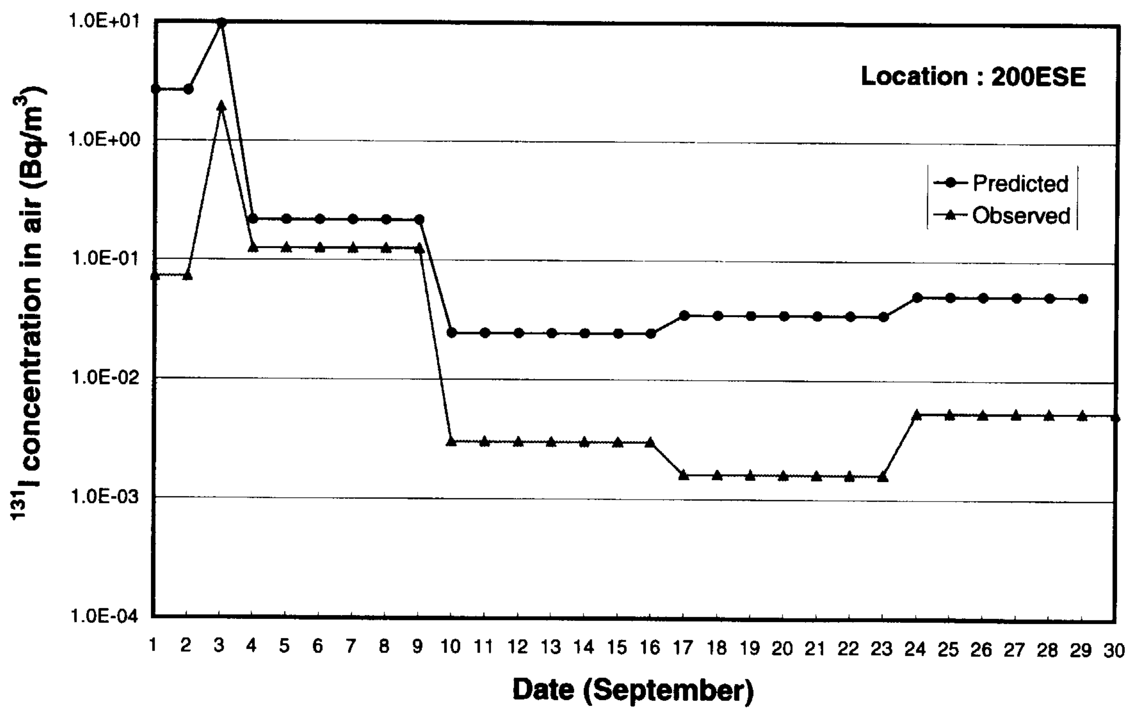

Fig.II-6 Comparison of predicted and observed data of ^{131}I concentration in air for 200ESE

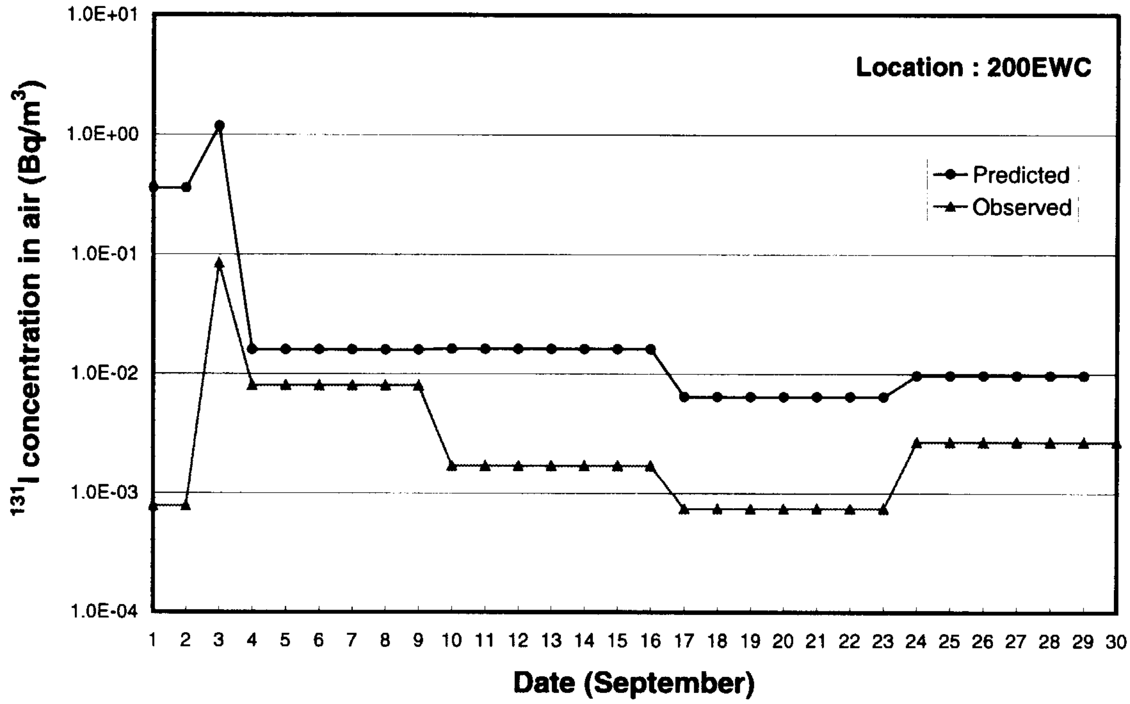

Fig.II-7 Comparison of predicted and observed data of ^{131}I concentration in air for 200EWC

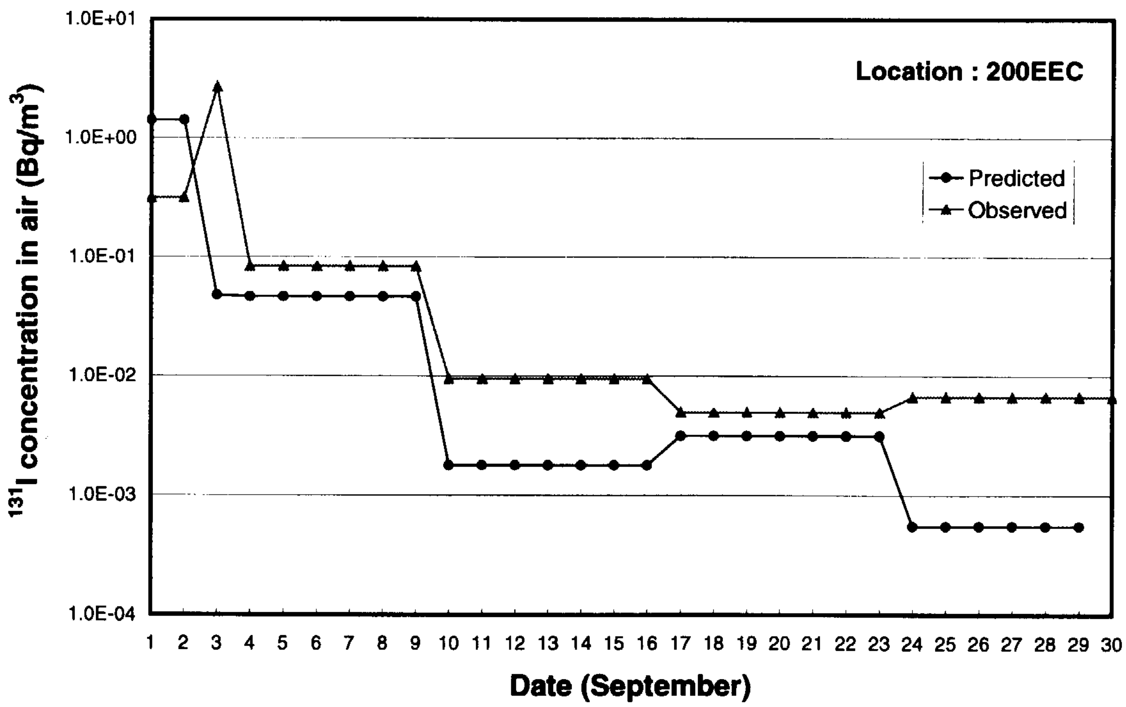

Fig.II-8 Comparison of predicted and observed data of ^{131}I concentration in air for 200EEC

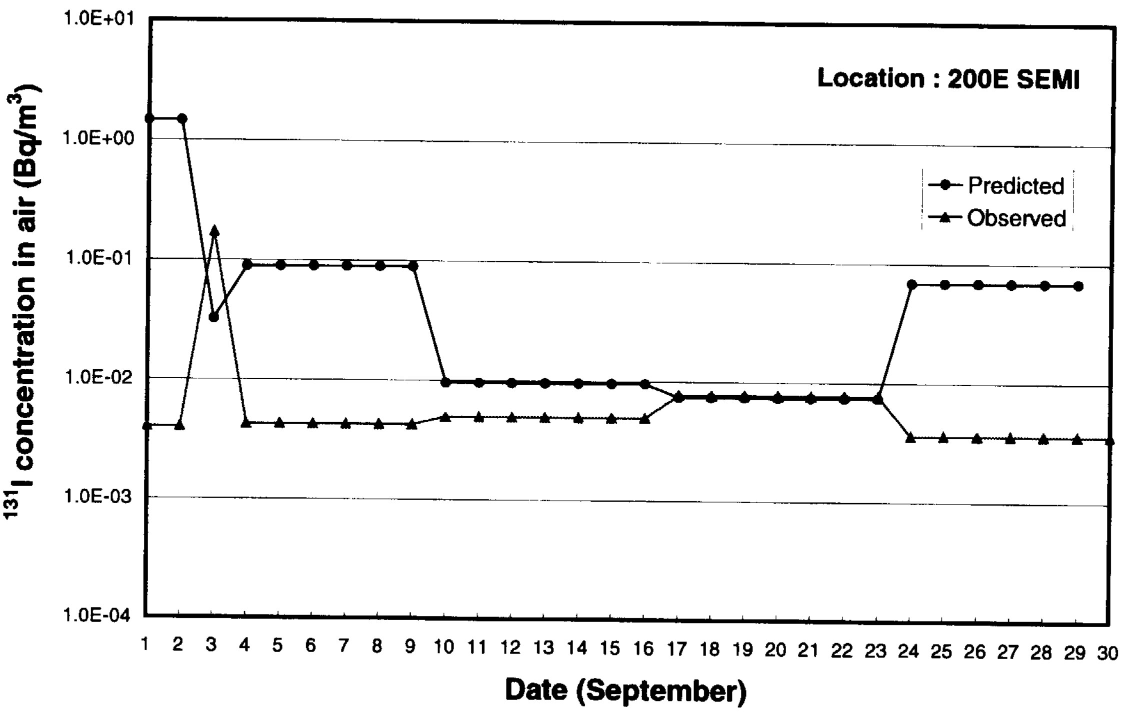

Fig.II-9 Comparison of predicted and observed data of ^{131}I concentration in air for 200E SEMI

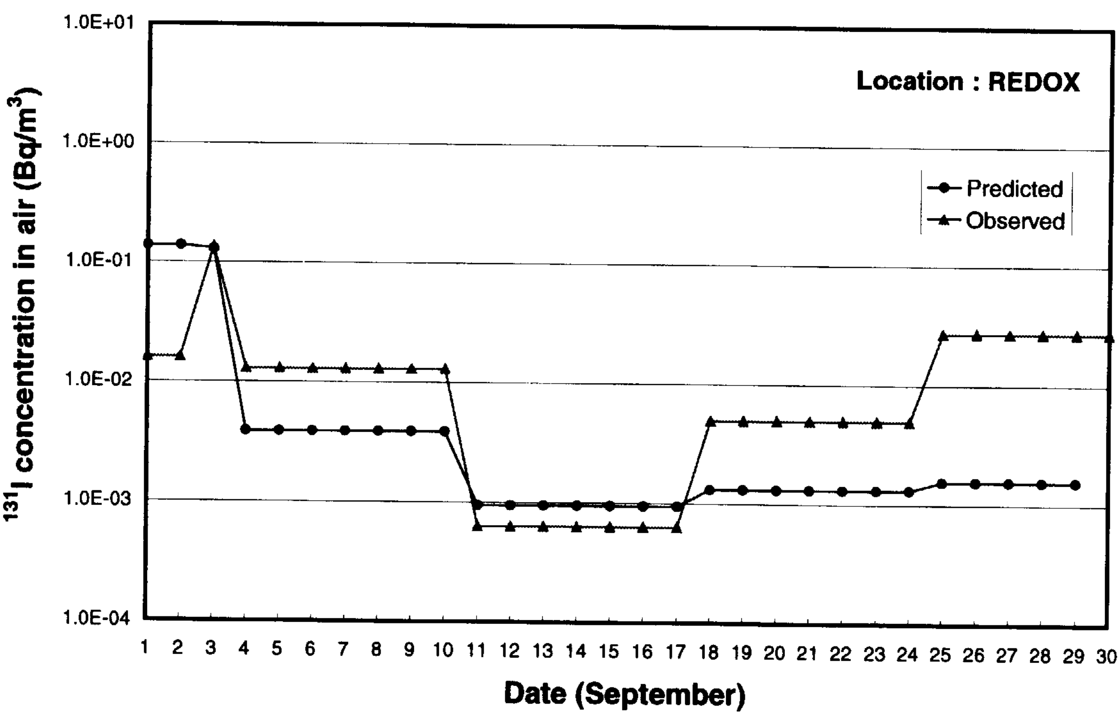

Fig.II-10 Comparison of predicted and observed data of ^{131}I concentration in air for REDOX

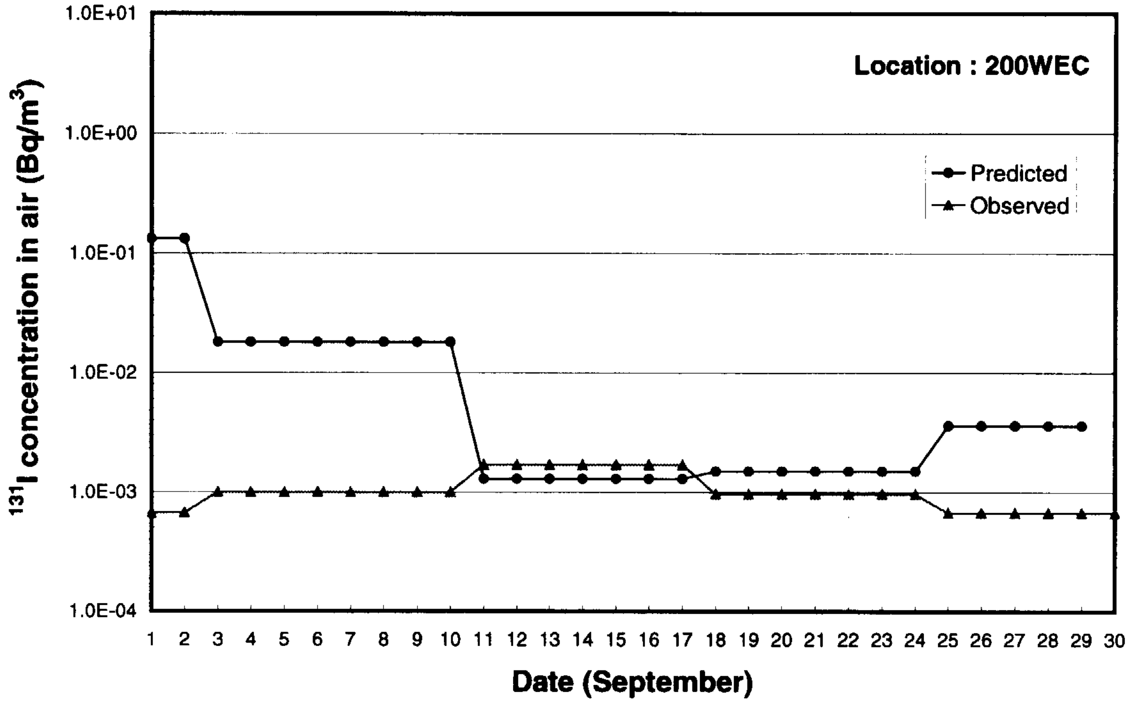

Fig.II-11 Comparison of predicted and observed data of ^{131}I concentration in air for 200WEC

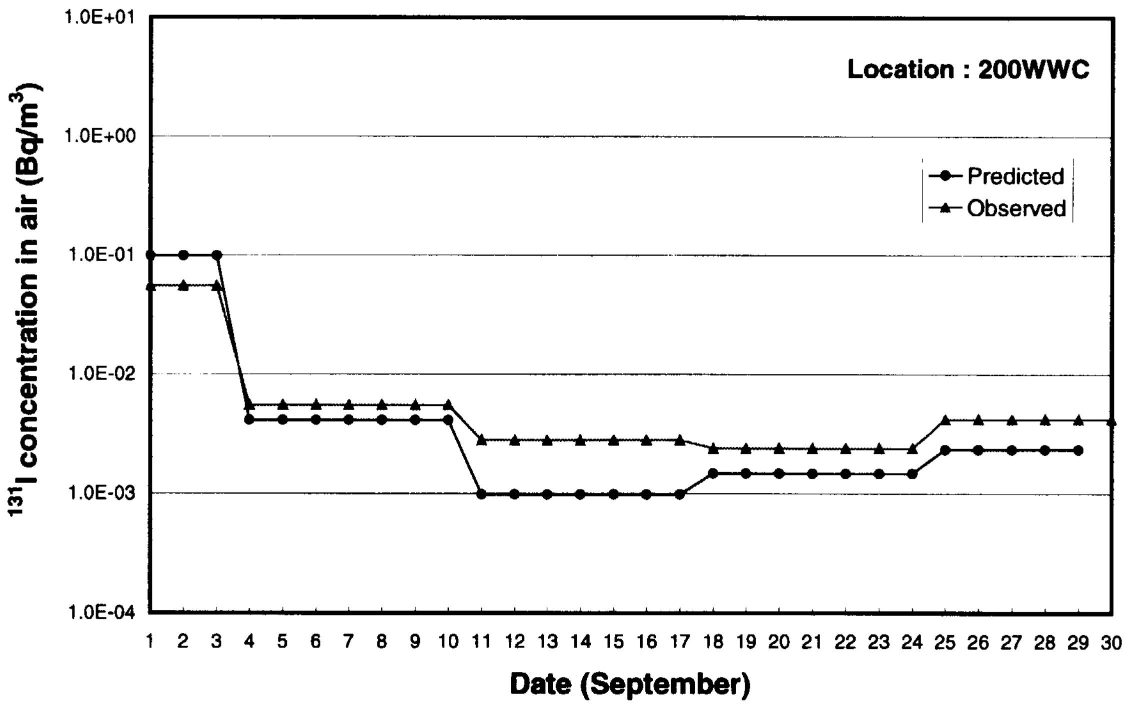

Fig.II-12 Comparison of predicted and observed data of ^{131}I concentration in air for 200WWC

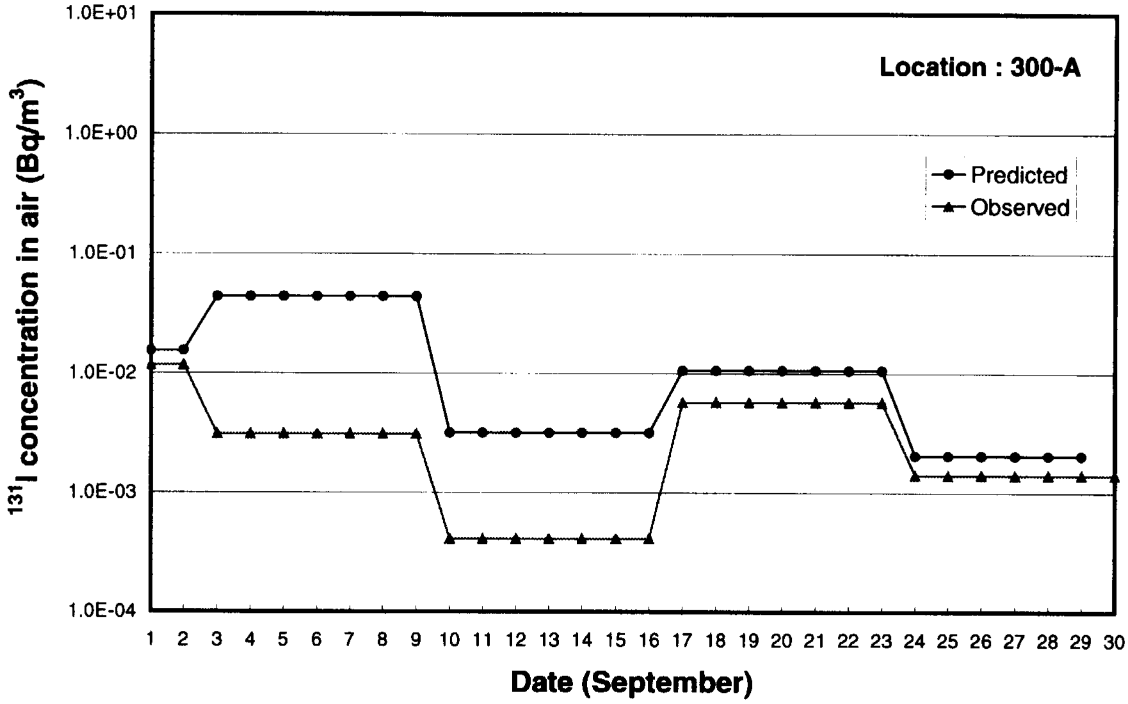

Fig.II-13 Comparison of predicted and observed data of ^{131}I concentration in air for 300-A

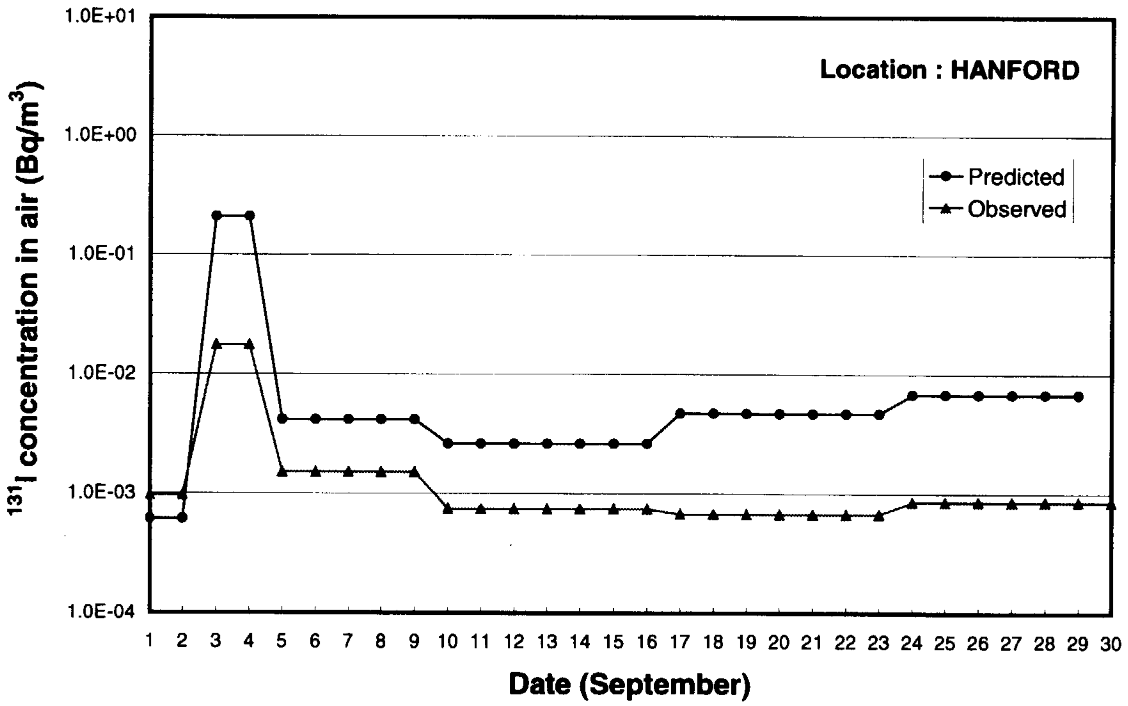

Fig.II-14 Comparison of predicted and observed data of ^{131}I concentration in air for HANFORD

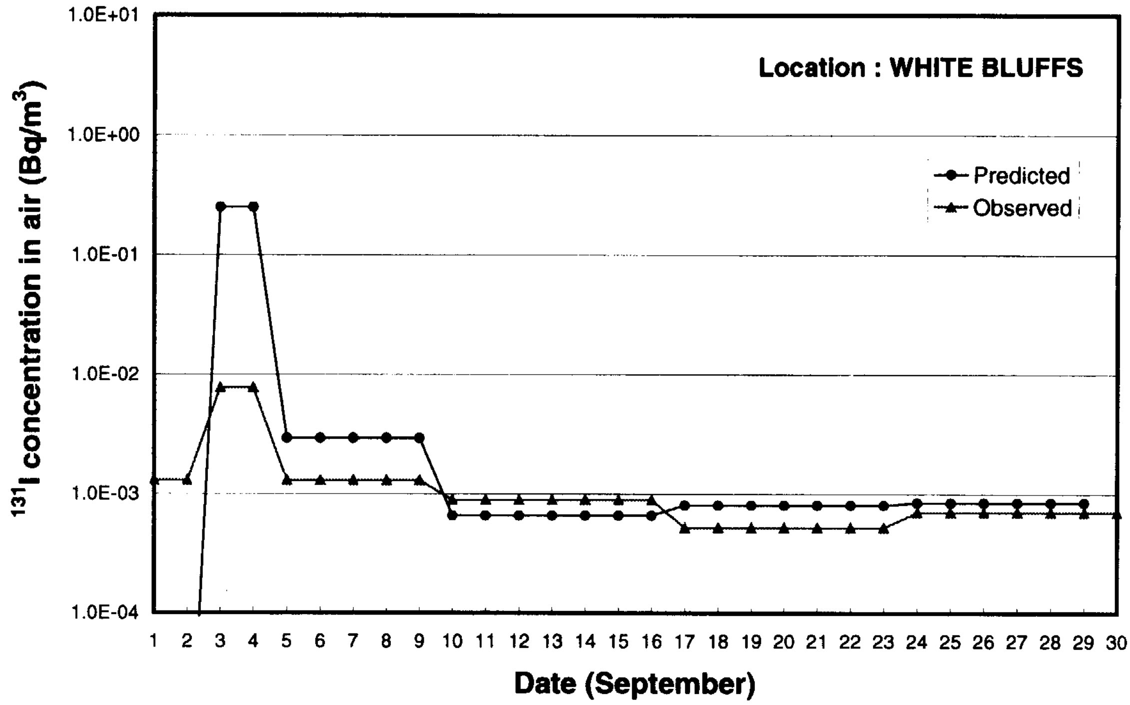

Fig.II-15 Comparison of predicted and observed data of ^{131}I concentration in air for WHITE BLUFFS

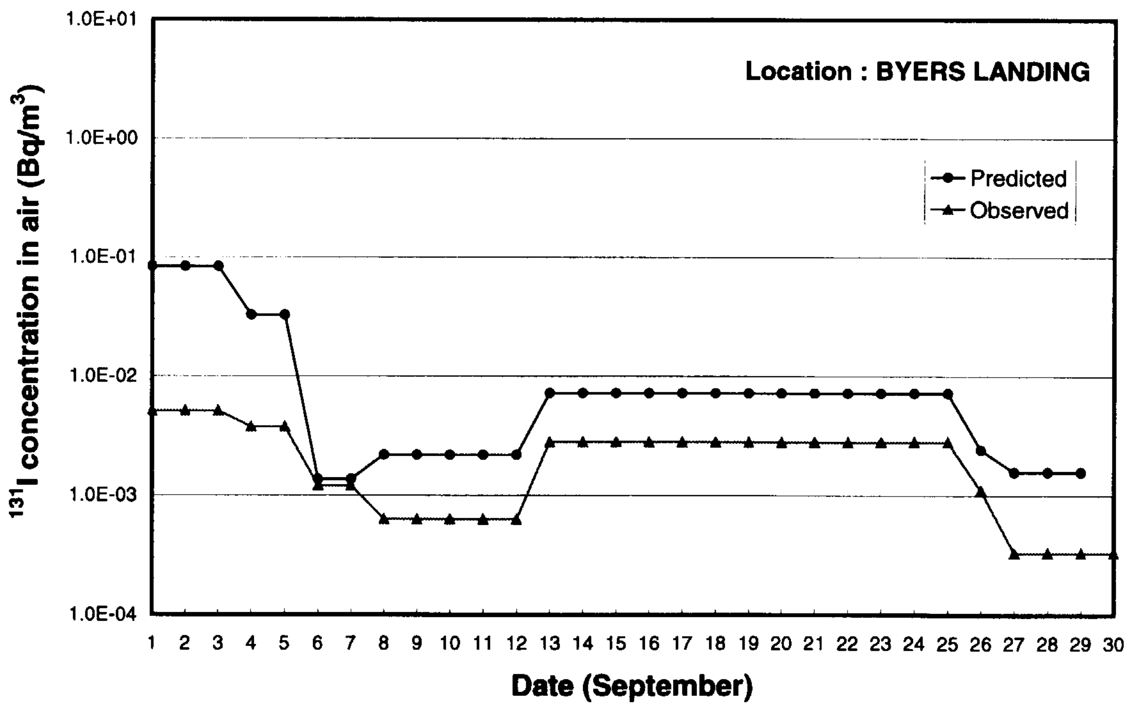

Fig.II-16 Comparison of predicted and observed data of ^{131}I concentration in air for BYERS LANDING

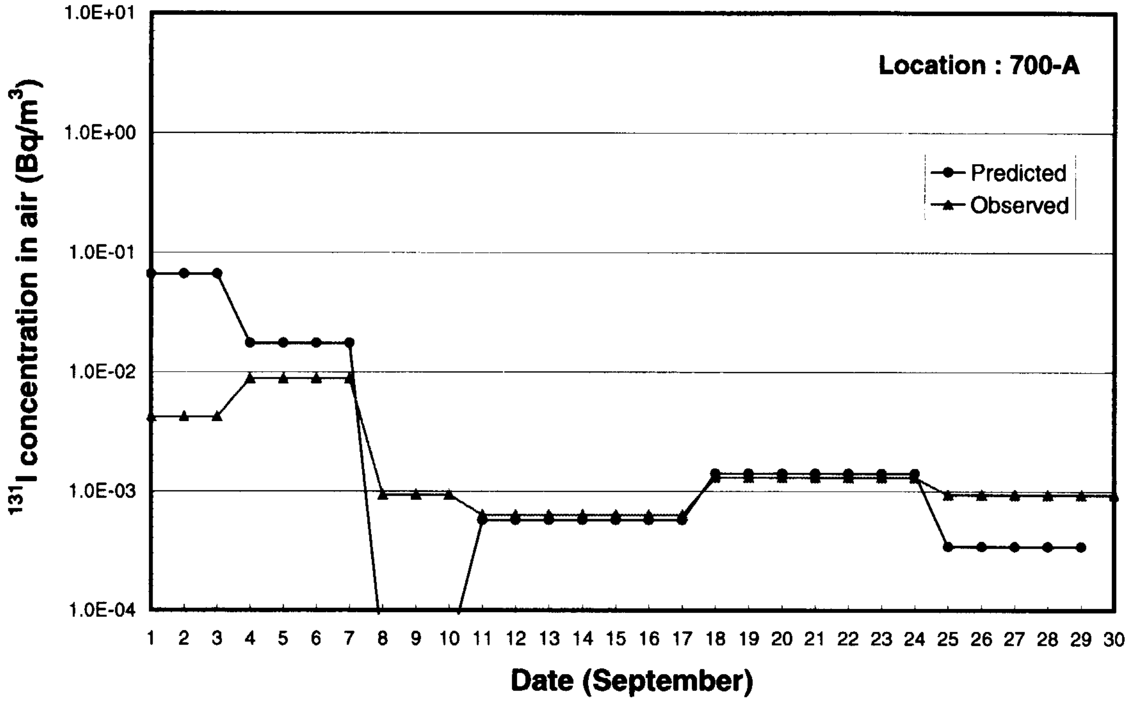

Fig.II-17 Comparison of predicted and observed data of ^{131}I concentration in air for 700-A

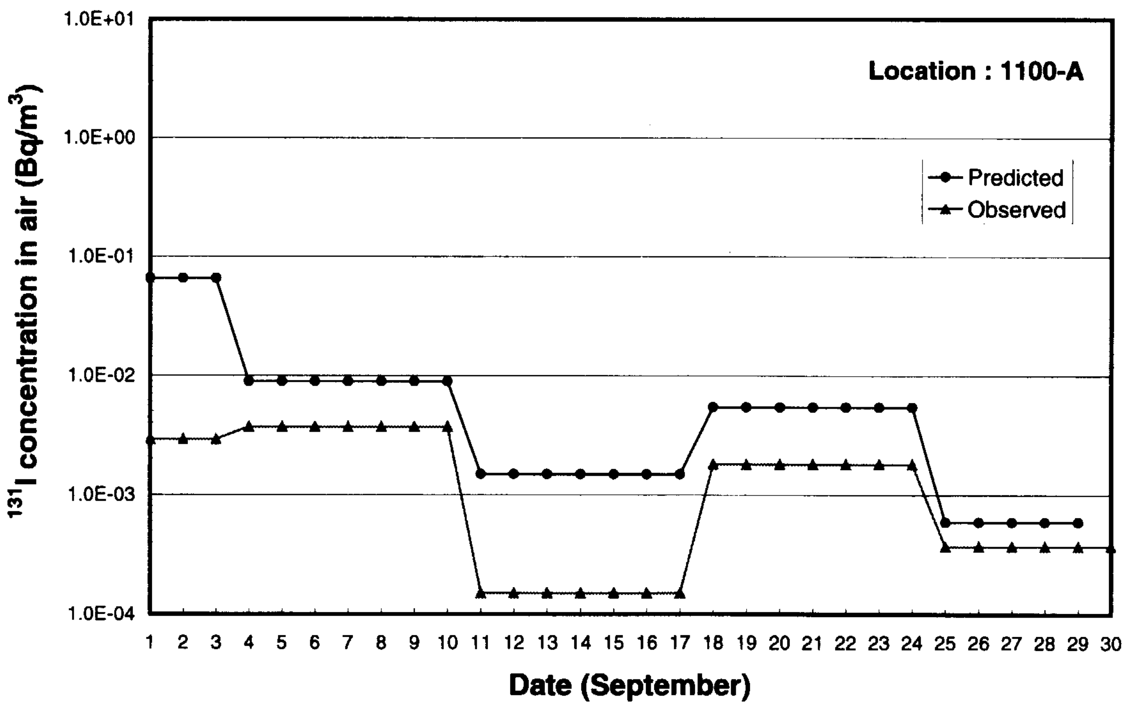

Fig.II-18 Comparison of predicted and observed data of ^{131}I concentration in air for 1100-A

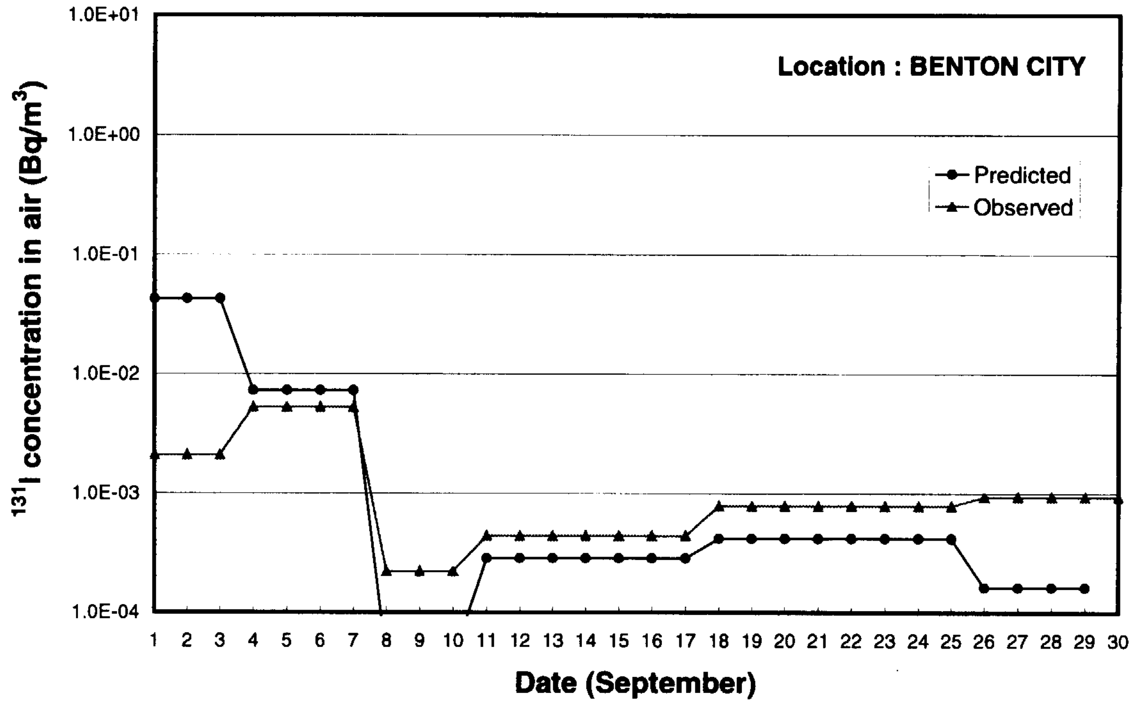

Fig.II-19 Comparison of predicted and observed data of ^{131}I concentration in air for BENTON CITY

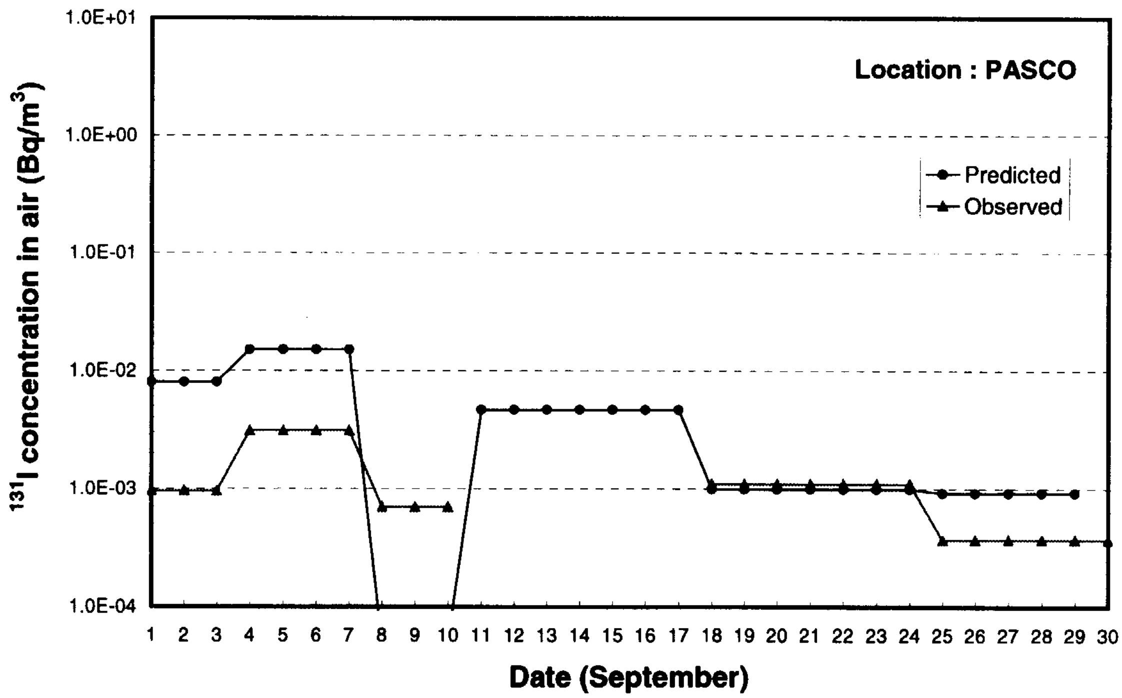

Fig.II-20 Comparison of predicted and observed data of ^{131}I concentration in air for PASCO

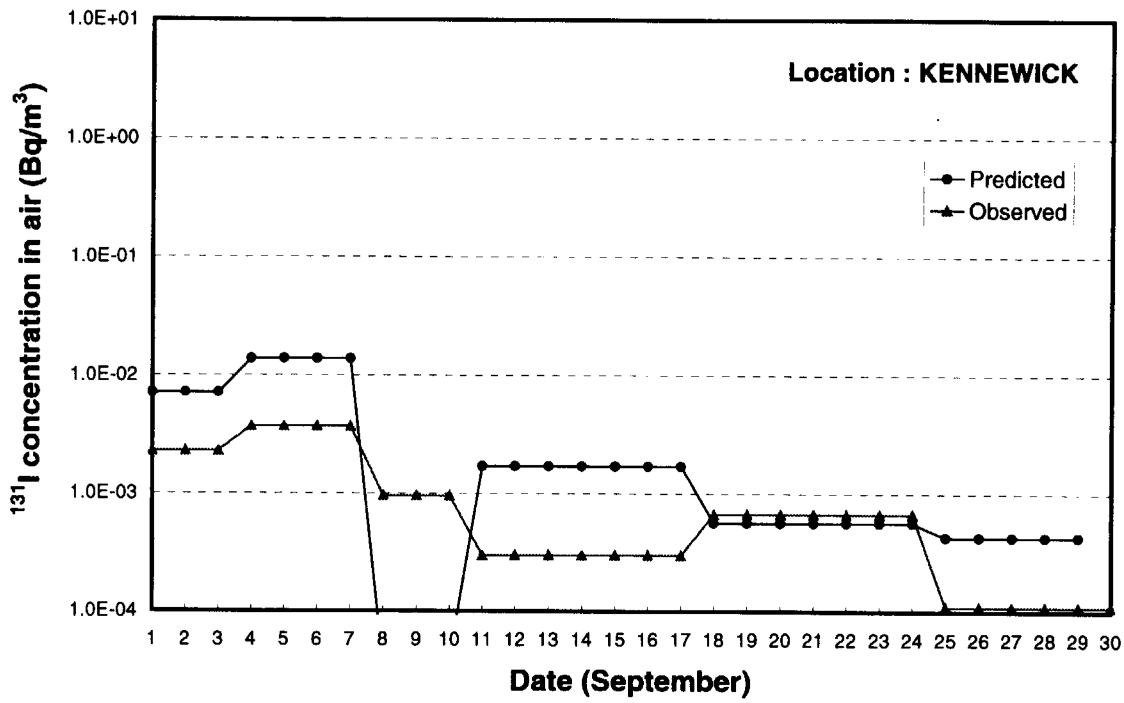

Fig.II-21 Comparison of predicted and observed data of ^{131}I concentration in air for KENNEWICK

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国際単位系(SI)と換算表

表1　SI基本単位および補助単位

量	名　称	記　号
長　さ	メートル	m
質　量	キログラム	kg
時　間	秒	s
電　流	アンペア	A
熱力学温度	ケルビン	K
物質量	モル	mol
光　度	カンデラ	cd
平面角	ラジアン	rad
立体角	ステラジアン	sr

表3　固有の名称をもつSI組立単位

量	名　称	記号	他のSI単位による表現
周波数	ヘルツ	Hz	s^{-1}
力	ニュートン	N	$m \cdot kg/s^2$
圧力，応力	パスカル	Pa	N/m^2
エネルギー，仕事，熱量	ジュール	J	N·m
工率，放射束	ワット	W	J/s
電気量，電荷	クーロン	C	A·s
電位，電圧，起電力	ボルト	V	W/A
静電容量	ファラド	F	C/V
電気抵抗	オーム	Ω	V/A
コンダクタンス	ジーメンス	S	A/V
磁束	ウェーバ	Wb	V·s
磁束密度	テスラ	T	Wb/m^2
インダクタンス	ヘンリー	H	Wb/A
セルシウス温度	セルシウス度	℃	
光束	ルーメン	lm	cd·sr
照度	ルクス	lx	lm/m^2
放射能	ベクレル	Bq	s^{-1}
吸収線量	グレイ	Gy	J/kg
線量当量	シーベルト	Sv	J/kg

表2　SIと併用される単位

名　称	記　号
分，時，日	min, h, d
度，分，秒	°, ′, ″
リットル	l, L
トン	t
電子ボルト	eV
原子質量単位	u

$1\ eV = 1.60218 \times 10^{-19}\ J$

$1\ u = 1.66054 \times 10^{-27}\ kg$

表4　SIと共に暫定的に維持される単位

名　称	記　号
オングストローム	Å
バーン	b
バール	bar
ガル	Gal
キュリー	Ci
レントゲン	R
ラド	rad
レム	rem

$1\ Å = 0.1\ nm = 10^{-10}\ m$

$1\ b = 100\ fm^2 = 10^{-28}\ m^2$

$1\ bar = 0.1\ MPa = 10^5\ Pa$

$1\ Gal = 1\ cm/s^2 = 10^{-2}\ m/s^2$

$1\ Ci = 3.7 \times 10^{10}\ Bq$

$1\ R = 2.58 \times 10^{-4}\ C/kg$

$1\ rad = 1\ cGy = 10^{-2}\ Gy$

$1\ rem = 1\ cSv = 10^{-2}\ Sv$

表5　SI接頭語

倍数	接頭語	記　号
10^{18}	エクサ	E
10^{15}	ペタ	P
10^{12}	テラ	T
10^{9}	ギガ	G
10^{6}	メガ	M
10^{3}	キロ	k
10^{2}	ヘクト	h
10^{1}	デカ	da
10^{-1}	デシ	d
10^{-2}	センチ	c
10^{-3}	ミリ	m
10^{-6}	マイクロ	μ
10^{-9}	ナノ	n
10^{-12}	ピコ	p
10^{-15}	フェムト	f
10^{-18}	アト	a

(注)

1. 表1－5は「国際単位系」第5版，国際度量衡局 1985年刊行による。ただし，1 eV および 1 u の値はCODATAの1986年推奨値によった。
2. 表4には海里，ノット，アール，ヘクタールも含まれているが日常の単位なのでここでは省略した。
3. barは，JISでは流体の圧力を表わす場合に限り表2のカテゴリーに分類されている。
4. EC閣僚理事会指令ではbar，barnおよび「血圧の単位」mmHgを表2のカテゴリーに入れている。

換　算　表

力	$N(=10^5 dyn)$	kgf	lbf
	1	0.101972	0.224809
	9.80665	1	2.20462
	4.44822	0.453592	1

粘　度　$1\ Pa \cdot s(N \cdot s/m^2) = 10\ P$(ポアズ)$(g/(cm \cdot s))$

動粘度　$1\ m^2/s = 10^4 St$(ストークス)(cm^2/s)

圧力	MPa(=10 bar)	kgf/cm^2	atm	mmHg(Torr)	lbf/in^2(psi)
	1	10.1972	9.86923	7.50062×10^3	145.038
	0.0980665	1	0.967841	735.559	14.2233
	0.101325	1.03323	1	760	14.6959
	1.33322×10^{-4}	1.35951×10^{-3}	1.31579×10^{-3}	1	1.93368×10^{-2}
	6.89476×10^{-3}	7.03070×10^{-2}	6.80460×10^{-2}	51.7149	1

エネルギー・仕事・熱量	$J(=10^7 erg)$	kgf・m	kW・h	cal(計量法)	Btu	ft・lbf	eV
	1	0.101972	2.77778×10^{-7}	0.238889	9.47813×10^{-4}	0.737562	6.24150×10^{18}
	9.80665	1	2.72407×10^{-6}	2.34270	9.29487×10^{-3}	7.23301	6.12082×10^{19}
	3.6×10^6	3.67098×10^5	1	8.59999×10^5	3412.13	2.65522×10^6	2.24694×10^{25}
	4.18605	0.426858	1.16279×10^{-6}	1	3.96759×10^{-3}	3.08747	2.61272×10^{19}
	1055.06	107.586	2.93072×10^{-4}	252.042	1	778.172	6.58515×10^{21}
	1.35582	0.138255	3.76616×10^{-7}	0.323890	1.28506×10^{-3}	1	8.46233×10^{18}
	1.60218×10^{-19}	1.63377×10^{-20}	4.45050×10^{-26}	3.82743×10^{-20}	1.51857×10^{-22}	1.18171×10^{-19}	1

1 cal ＝ 4.18605 J(計量法)

＝ 4.184 J　(熱化学)

＝ 4.1855 J　(15 ℃)

＝ 4.1868 J(国際蒸気表)

仕事率　1 PS(仏馬力)

＝ 75 kgf·m/s

＝ 735.499 W

放射能	Bq	Ci
	1	2.70270×10^{-11}
	3.7×10^{10}	1

吸収線量	Gy	rad
	1	100
	0.01	1

照射線量	C/kg	R
	1	3876
	2.58×10^{-4}	1

線量当量	Sv	rem
	1	100
	0.01	1

(86年12月26日現在)

OSCAAR Calculations for the Hanford Dose Reconstruction Scenario of BIOMASS Theme 2