VERMONT YANKEE NUCLEAR POWER CORPORATION

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REPLY TO
ENGINEERING OFFICE
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August 30, 1995
BVY 95 - 97

United States Nuclear Regulatory Commission
Washington, DC 20555

ATTN: Document Control Desk

References: (1) License No. DPR-28 (Docket No. 50-271)
(2) Letter from R. W. Capstick, Vermont Yankee, to USNRC, "Request to Routinely Dispose of Slightly Contaminated waste in Accordance with 10CFR20.302(a)", BVY 89-59, June 18, 1989.
(3) Letter from M. B. Fairtile, USNRC, to L.A.Tremblay, Vermont Yankee, "Approval Under 10 CFR 20.302(a) of Procedures for Disposal of Slightly Contaminated Septic Waste On Site at Vermont Yankee (TAC No. 73776)", dated August 30, 1989.

Subject: Request to Amend Previous Approval Granted Under 10 CFR 20.302(a) for Disposal of Contaminated Septic Waste

In accordance with the criteria of the Code of Federal Regulations, Title 10, Section 20.2002 (previously cited 10CFR20.302(a)), enclosed please find the subject application to amend the previously granted approval (Reference 3) to dispose of slightly contaminated septic waste on site at Vermont Yankee by expanding the allowable waste stream to include slightly contaminated Cooling Tower silt material.

This application specifically requests approval to dispose of Cooling Tower silt deposits, contaminated at minimal levels, which have been or might be generated through the end of station operations at the Vermont Yankee Nuclear Power Plant. The proposed silt disposal method is the same as the septic waste disposal method requested in Reference 2 and approved in Reference 3. The disposal method utilizes on site land spreading in the same designated areas used for septic waste. Disposal of this waste in the manner proposed, rather than holding it for future disposal at a 10CFR Part 61 licensed facility when access to one becomes available, will save substantial costs and valuable disposal site space for waste of higher radioactivity levels.

A radiological assessment and proposed operational controls based on continued on site disposal of accumulated river silt removed from the basins of the plant's mechanical draft cooling towers is contained in Enclosure A. The assessment demonstrates that the dose impact expected from the disposal of silt removed from the cooling towers during normal maintenance will not exceed the dose limits already imposed for septic waste disposal. The combined radiological impact for all on site disposal operations shall be limited to a total body or organ dose of a maximally exposed member of the public of less than one mrem/year during the period of active Vermont Yankee control of the site, or less than five mrem/year to an inadvertent intruder after termination of active site control. Enclosure B contains a copy of the original assessment and disposal procedures for

A009

septic waste (References 2 and 3) for your use and reference in evaluating the proposed amendment.

Upon receipt of your approval, Enclosure A will be incorporated into the Vermont Yankee ODCM.

We trust that the information contained in the submittal is sufficient, however, should you have any questions or require further information concerning this matter, please contact this office.

Sincerely,

VERMONT YANKEE NUCLEAR POWER CORPORATION

James J. Duffy
James J. Duffy
Licensing Engineer

Enclosures A & B

c: USNRC Region I Administrator (Letter and Enclosure A)
USNRC Resident Inspector - VYNPS (Letter and Enclosure A)
USNRC Project Manager - VYNPS (Letter and Enclosure A)

ENCLOSURE A

VERMONT YANKEE NUCLEAR POWER PLANT

ASSESSMENT OF ROUTINE DISPOSAL OF COOLING TOWER SILT IN AREAS ON SITE PREVIOUSLY DESIGNATED FOR SEPTIC WASTE DISPOSAL

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VERMONT YANKEE NUCLEAR POWER PLANT

Assessment of Routine Disposal of Cooling Tower Silt In Areas On Site Previously Designated for Septic Waste Disposal

1.0 INTRODUCTION:

Vermont Yankee Nuclear Power Corporation (Vermont Yankee) requested from the NRC in 1989 permission to routinely dispose of slightly contaminated septic waste in designated on site areas in accordance with 10CFR20.302(a). The NRC responded to this request on August 30, 1989 by granting approval of the proposed procedures for on site disposal of septic waste concluding that the commitments as documented in our request were acceptable, provided that our request and analysis be permanently incorporated into the plant's Offsite Dose Calculation Manual (ODCM). Revision 9 to the ODCM (Appendix B) incorporated the assessment and approval of the methods utilized for on site dispose of slightly contaminated sewage sludge.

In addition to the previously identified solids content of septic waste as a source of environmental low level radioactive contaminated material, cooling tower silt deposits resulting from the settling of solids from river water passing through the mechanical draft cooling tower system have been identified to also contain low levels of plant specific radionuclides. Periodic removal of the silt from the cooling tower basins is a necessary maintenance practice to insure operability of the cooling system. However, due to the presence of by-product materials in the silt, proper disposal requirements must be applied to insure that the potential radiological impact is within acceptable limits.

This assessment of silt disposal expands the original septic waste disposal assessment to include earthen type materials (cooling tower silt deposits) while maintaining the original radiological assessment modeling and dose limit criteria that have been approved for septic waste spreading on site. This assessment demonstrates that cooling tower silt can be disposed of in the same manner, and under the same dose limit criteria as previously approved for septic waste in Appendix B to the Vermont Yankee ODCM. Implementation of the following commitments as an amendment to the original 10 CFR

Part 20.302(a) approval for septic waste shall be incorporated into the Vermont Yankee ODCM upon approval by the NRC.

2.0 WASTE STREAM DESCRIPTION:

The waste involved in this assessment is residual solids (silt) collected in the basins of the plant's mechanical draft cooling tower system. " · silt consists of organic and inorganic sediments and earthen type materials that have settled from the cooling water flow taken from the Connecticut River as it passes through the towers. As a result of de-sludging of the tower basins in 1993, an estimated 14,000 cubic feet of silt was accumulated on site. Clean-out operations will also occur periodically to ensure continued system operability. Sample analysis performed to the plant's environmental lower limits of detection requirements, as contained in Technical Specification Table 4.9.3., has identified Cobalt-60 and Cesium-137 in low concentrations as being present in silt collected in 1993.

The cooling towers are located at the southern end of the plant facility complex, but are not directly connected to any system in the plant that contains radioactivity. The postulated mechanism of how plant-related radionuclides have been introduced into the cooling system silt assumes that past routine effluents discharged from nearby plant gaseous release points were entrained in the large mechanically induced air flow that is pulled through the towers as a heat exchange medium. The cooling water flow provides a scrubbing action as it is breaks up into fine water droplets due to the splash pans of the towers. This scrubbing action washes any airborne particulates out of the air. Over long periods of operation, any radioactivity removed from the air flow could buildup to measurable levels in silt that settles out in the basins at the bottom of the towers.

Table 1 lists the analyses of twenty-one samples collected from the silt pile removed from the cooling tower basins. Radioactivity measurements, averaged over all the samples, indicate that the silt material can be characterized as containing approximately 50 pCi/kg (dry wt.) of Cobalt-60, and 198 pCi/kg (dry wt.) Cesium-137. Eight of the samples indicated no positive Cobalt-60 above a minimum detectable level achieved for the analysis.

Table 1

Cooling Tower Silt Radioactivity
(1993 samples*)

Sample #	Co-60 (pCi/kg dry)	Cs-137 (pCi/kg dry)
G12759	53	144
G12758	72	172
G12757	<14	201
G12756	<17	245
G12755	73	206
G12754	<16	165
G12753	<27	240
G12752	79	181
G12751	<29	180
G12750	35	107
G12749	59	171
G12748	<19	205
G12747	<38	209
G12746	< 7	218
G12745	50	241
G12744	40	220
G12743	68	264
G12742	45	195
G12724	71	115
G12723	104	264
G13940	126	218
Average:	50	198
Max.	126	264
Min.	< 7	107
Standard deviation:	30	42

* Average wet to dry sample weight ratio equal to 1.6. Dry weight silt density equal to 1.3 gm/cc.

For the purpose of estimating the total activity in the silt pile, the less than values in Table 1 are included as positives in the calculation of the average radioactivity concentration.

Cobalt-60, due to its relatively short half life, is typically associated with plant operations when measured in the near environment. However, Cesium-137 when measured in the environment may have a background component that is not related to power plant operations. Past weapons testing fallout has imposed a man made background level of Cesium-137 in New England soils and sediments that can vary over several hundred pCi/kg. The plant's Environmental Monitoring Program has shown that Connecticut River sediment in the vicinity of Vermont Yankee averages about 123 pCi/kg (dry wt.) of Cesium-137 (Table 2), with no plant related detectable level of Cobalt-60. The value of 123 pCi/kg may represent an estimate of the background level of Cesium-137 in sediment that would be subject to entrainment in cooling water flow that enters the plant. In comparing the measured levels of Cesium-137 on Table 1 with the past river sediment level, the average concentration in the cooling tower silt is higher than that of the river sediment data, but does fall within the observed range of recorded sediment Cs-137. The river sediment Cesium-137 concentration averages about 62% of the concentration value detected in the tower silt. For purposes of this assessment of plant related dose impact from the on site disposal of silt material, it is conservatively assumed that all detectable Cs-137 in cooling tower silt is directly related to plant operations. No background component is subtracted from the measured values for this case study since only a single sampling location (down stream) is included in the Environmental Monitoring Program which may not fully describe the true background levels in the region.

The total radioactivity for the current 14,000 cubic feet of silt collected on site can be estimated by multiplying this volume by its "as is" density of 2.1 gm/cc (i.e. 1.3 gm/cc dry weight density x 1.6 wet/dry weight ratio), and then conservatively assume that the measured average dry weight radioactivity concentrations for Cobalt and Cesium would be the same as in the collected silt. Multiplying the average Cobalt-60 and Cesium-137 concentration in silt by the mass of the collected material produces estimates (Table 3) of total radioactivity that was removed from the cooling tower basin in September, 1993.

Table 2

Cesium-137 in
Connecticut River Sediments*

Date	Cs-137 (pCi/kg dry)
05/24/94	61
10/13/93	85
06/02/93	60
10/15/92	137
05/20/92	176
10/24/91	178
05/16/91	230
10/25/90	84
05/16/90	62
10/04/89	<174
05/26/89	179
10/12/88	115
05/12/88	62
Average:	123
Max.	230
Min.	60
Standard deviation:	56

* Samples collected as part of the Vermont Yankee Radiological Environmental Monitoring Program (REMP) for river sediment sample location SE-11.

Table 3

Estimated Total Radioactive Material for 1993 Tower Clean-out

	Volume of Silt (ft3)	Mass (kg)	Average Concentration (pCi/kg)	Total Act. (as of 11/93) (uCi)	Decayed Act. (as of 6/95) (uCi)
Co-60	14,000	8.32E+5	50	42	34
C -137	14,000	8.32E+5	198	165	159

In addition to 14,000 cubic feet of silt already accumulated, it is anticipated that periodic maintenance work in cleaning out the cooling tower basins will generate approximately 4,000 cubic feet of new silt material over each successive 18 month operating cycle. Assuming the same level of plant-related radioactivity concentration that was originally observed, the additional amounts of radioactivity that will require on site disposal following each refueling cycle can also be estimated. Table 4 lists an estimate of the total radioactivity that might be present at each 18 month clean-out cycle.

Table 4

Estimated Total Radioactive Material for Each 18 Month Maintenance Cycle

	Volume of Silt (ft3)	Mass (kg)	Average Concentration (pCi/kg)	Total Activity (uCi)
Co-60	4,000	2.38E+5	50	12
Cs-137	4,000	2.38E+5	198	47

3.0 DISPOSAL METHOD:

The method of silt disposal shall utilize a technique of land spreading in a manner consistent with the current commitments for the on site disposal of septic waste as approved by the NRC and implemented as Appendix B of the Vermont Yankee ODCM (Reference 1). The same land areas designated and approved for septic waste disposal shall be used for the placement of silt removed from the cooling tower basins. Determination of the radiclogical dose impact shall also be made based on the same models and pathway assumptions as indicated in Appendix B of the ODCM.

3.1 Silt Disposal Procedure Requirements:

Gamma isotopic analysis of silt samples shall be made prior to each disposal by obtaining representative composite samples in sufficient numbers to characterize the material removed from the cooling tower basins. Each gamma isotopic analysis shall be required to achieve the environmental lower limits of detection as indicated for sediment on Table 4.9.3 of the Vermont Yankee Technical Specifications.

The estimation of total radioactivity to be disposed of shall be made based on the average of all composite sample analyses. The estimation of total radioactivity and projected dose impact shall be made prior to placing the collected silt on the designated disposal plots. The dose impact from each disposal operation shall be included with all past septic waste and silt spreading operations to ensure that the appropriate dose limits are not exceeded on any waste disposal area for the combination of all past operations.

The established dose criteria requires that all applications of earthen type materials within the approved designated disposal areas shall be limited to ensure that dose to a maximally exposed individual (during the Vermont Yankee control period) be maintained less than 1 mrem/year to the whole body and any organ, and the dose to an inadvertent intruder following termination of site control be maintained less than 5 mrem/year to the whole body and any organ.

The limits on concentrations of radionuclides as addressed in Appendix B to the ODCM for septic waste (i.e. each tank of septic sludge to be disposed are limited to a combined MPC ratio of less than 0.1) were included to ensure proper control was in-place to address the situation of small quantities of relatively high concentration material. This limitation does not directly apply to silt deposits since the slit is handled as dewatered sediments as opposed to liquid slurries of septic waste.

For dry earthen type material such as silt, a specific radionuclide concentration limit shall be applied in place of the of the septic waste liquid MPC ratio. No soil associated with a sample analysis that identifies a plant related radionuclide in excess of the concentration limits of Table 5 will be permitted regardless of the total pathway dose assessment determined for the quantity material under consideration. For the case where more than one radionuclide is detected, the sum of the ratio rule will be applied. The measured concentration of each radionuclide divided by its limiting concentration value shall be added with the sum of all fractions equal to or less than 1. This limiting condition will prevent small volumes of relatively high specific radioactivity from being spread on the disposal plots, and therefore reduce the potential for creating unexpected hot spots of concentrated material.

Table 5 lists, by radionuclide, soil concentration values that would generate an annual external effective dose equivalent of 25 mrem/year if it were assumed that an individual continuously stood on an infinite plane of soil contaminated to a depth of 15 cm. The assumptions of an infinite plane and continuous occupancy are conservative for situations where the amount of contaminated soil identified would not provide for a 15 cm soil depth over an extended surface area, and where disposal site access is limited. Twenty-five mrem/year was selected as a reference value based on the fact that it was a suitable fraction of the NRC annual dose limit (100 mrem/year per 10 CFR Part 20.1301) applied to members of the public from all station sources. The 25 mrem/year also equals the EPA dose limit from 40 CFR Part 190 which would apply to real members of the public offsite, and allow for credit to be taken in accounting for actual usage patterns such as occupancy time. The external dose factors provided on Table 5 were derived from Table E-2 of NUREG/CR-5512 (Reference 3).

Table 5

Dry Soil Maximum Concentration Values

Radionuclide	Soil Concentration pCi/kg (equal to 25 mrem/yr)
Cr-51	1.51E+05
Mn-54	5.50E+03
Fe-59	3.83E+03
Co-58	4.70E+03
CO-60	1.82E+03
Zn-65	7.85E+03
Zr-95	6.18E+03
Ag-110m	1.66E+03
Sb-124	2.51E+03
Cs-134	2.95E+03
Cs-137	8.13E+03
Ce-141	7.85E+04
Ce-144	8.75E+04

Assumptions include infinite planar distribution, uniform depth distribution to 15 cm, soil density at 1.625E+06 gm/m3, external direct dose pathway only with a 100% occupancy factor.

3.2 Administrative Procedure Requirements:

Dry silt material shall be dispersed using typical agricultural dry bulk surface spreading practices only in approved disposal areas on site.

Complete records of each disposal will be maintained. These records will include the concentration of radionuclides detected in the silt, an estimate of the total volume of silt disposed of, the total radioactivity in each disposal operation as well as the total accumulated on each disposal plot at the time of the spreading, the plot on which the silt was applied, and the results of any dose calculations or maximum allowable accumulated activity determinations required to demonstrate that the dose limits imposed on these land spreading operations have not been exceeded. The determination of the total radioactivity and dose calculations shall also include all past septic waste and silt disposal operations that placed low level radioactive material on the designated disposal plots.

The periodic disposal of silt on each of the approved land spreading areas will be limited to within the same established dose and radioactivity criteria that have been approved for septic waste disposal.

Concentration limits that are applied to the disposal of earthen type materials (dry soil) shall restrict the placement of small volumes of material that have relatively high concentrations of radioactivity such that direct exposure could not exceed a small proportion (25%) of the annual dose limits to members of the public that is contained in 10 CFR Part 20.1301.

Any farmer leasing land used for the disposal of silt deposits will be notified of the applicable restrictions placed on the site due to the land spreading of low level contaminated material. These restrictions are the same as detailed for septic waste spreading as given in Reference 1.

4.0 EVALUATION OF ENVIRONMENTAL IMPACTS:

4.1 Site Characteristics

The designated disposal sites consist of two fields located on the Vermont Yankee Nuclear Power Plant site. Both fields are on the plant property within the site boundary security fence. Site A contains an approximate ten-acre parcel of land centered approximately 2,000 feet northwest of the Reactor Building. Site B consist of approximately two acres and is centered approximately 1,500 feet south of the Reactor Building. These are the same land parcels approved by the NRC for the land disposal of septic waste, and are described in detail in Reference 1 along with the boundary restrictions for the placement of contaminated material.

Radiological assessments of septic waste disposal have determined that a single two-acre plot would be sufficient for the routine disposal of that waste stream over a 20 year period without exceeding the dose criteria to a maximum exposed individual or inadvertent intruder. As a result, the ten-acre field to the northwest can be divided into five disposal plots, with the two-acre site at the south end of the plant site providing a sixth plot. It is therefore concluded that there is sufficient space within the already approved disposal plots to accommodate additional material from the cooling tower basins along with the septic waste without the likelihood of exceeding the approved dose limit criteria.

Since the residual organic and inorganic solids associated with river sediment (silt) are similar to the sand and residual organic material remaining after decomposition of septic waste that is removed form the plant's septic tanks, the conclusions of no significant environmental (non-radiological) impact associated with the disposal of septic waste are not changed by the addition of another earthen type material, namely silt.

4.2 Radiological Impact:

The amount of cooling tower silt, in combination with any septic waste disposals, will be procedurally controlled to insure doses are maintained within the prior approved limits (Reference 1). These limits are based on past NRC proposed guidance (described in AIF/NESP-037, August 1986). The dose criteria require that the maximally exposed member of the general public receive a dose less than 1 mrem/year to the whole body or any organ due to the disposed material, and less than 5 mrem/year to the whole body or any organ of an inadvertent intruder.

To assess the doses received by the maximally exposed individual and inadvertent intruder resulting from silt spreading, the same pathway modeling, assumptions, and dose calculation methods as approved for septic disposal are used. These dose models implement the methodologies and dose conversion factors as provided in Regulatory Guide 1.109 (Reference 2).

Six potential pathways have been identified and include:

(a) Standing on contaminated ground,
(b) Inhalation of resuspended radioactivity,
(c) Ingestion of leafy vegetables,
(d) Ingestion of stored vegetables,
(f) Ingestion of meat, and
(g) Ingestion of cow's milk

Based on the septic waste evaluations, the liquid pathway was determined to be insignificant.

Both the maximum individual and inadvertent intruder are assumed to exposed to these pathways with difference between them related to occupancy time. The basic assumptions used in the radiological analyses include:

(a) Exposure to ground contamination and resuspended radioactivity is for a period of 104 hours per year during the Vermont Yankee active control of the disposal sites, and continuous thereafter. The 104 hour interval is representative of a farmer's time spend on a plot of land (4 hours per week for 6 months).

(b) For the purpose of projecting and illustrating the magnitude of dose impacts over the remaining life of the plant, it is assumed that the current concentration levels of activity detected in silt remain constant. Table 1 indicates the measured radioactivity levels for Cobalt-60 and Cesium-137 first noted in silt material.

(c) The maximum radiation source corresponds to the accumulation of radioactive material on a single plot (two acre) within the approved disposal sites over a period of 13 operating cycles. This extends over the next 18 years until after the operating license expires in 2012. The initial application (referenced to June, 1995) consists of 14,000 cubic feet of silt collected in 1993 along with the first periodic clean out of the tower basins that adds an additional 4,000 cubic feet. All subsequent applications of 4,000 cubic feet occur at 18 month intervals.

(d) For the analysis of the radiological impact during the Vermont Yankee active control of the disposal sites, no plowing is assumed to take place and all dispersed radioactive material remains on the surface, forming a source of unshielded direct radiation.

(e) No radioactive material is dispersed directly on crops for human or animal consumption. Crop contamination is only through root up-take.

(f) The deposition on crops of suspended radioactivity is insignificantly small.

(g) Pathway data and usage factors used in the analysis are the same as those used in the plant's ODCM assessment of off-site radiological impact from routine releases, with the exception that the fraction of stored vegetables grown on the contaminated land was conservatively increased from 0.76 to 1.0 (at present no vegetable crops for human consumption are grown on any of the approved disposal plots).

(h) It is conservatively assumed that Vermont Yankee relinquishes control of the disposal sites after the operating license expires in 2012. (i.e., the source term accumulated on a single 2 acre disposal plot applies also for the inadvertent intruder).

(i) For the analysis of the impact after Vermont Yankee control of the site is relinquished, the radioactive material is plowed under and forms a uniform mix with the top six inches of soil; but nonetheless, undergoes resuspension in air at the same rate as the unplowed surface contamination. For direct ground plane exposure the self shielding due to the six inch plow layer reduces the surface dose rate by about a factor of four.

The dose models and methods used to generate deposition values and accumulated activity over the operating life of the plant are documents in Attachment 2 to Reference 1. Based on the measured concentrations and silt volumes noted in Section 2.0 above, the total radioactivity that remains on the disposal plots after the operating license expires is estimated on Table 6.

Table 6

Projected Radioactivity Buildup Due To Silt Spreading

Nuclide	Contribution from initial 14,000 ft3 (uCi)	Accumulation from 13 cycles at 4,000 ft3/ea. (uCi)	Total Remaining in year 2013 (uCi)
Cobalt-60	3.2	61.9	65.1
Cesium-137	104.9	500.5	605.4

The calculated potential radiation exposure following the spreading of all silt material anticipated to be generated through the remainder of the operating license on a single two acre plot is provides on Table 7.

Table 7

Dose Impact Due to Continued Spreading to End of License

Disposal Site Access	Radiation Exposure	Individual/Organ
Controlled by VYNPS	0.228 mrem/yr	adult/whole body
(max. exposed individual)	0.820 mrem/yr max.	child/bone
Uncontrolled by VYNPS	1.46 mrem/yr	adult/whole body
(inadvertent intruder after license termination)	2.41 mrem/yr max.	child/bone

The individual pathway contributions to the total dose due to continued silt spreading are shown on Table 8:

Table 8

Pathway-Dependent Critical Organ Doses

Pathway	Maximally exposed Individual/Organ (Child/Bone) (mrem/year)	Inadvertent Intruder Critical Individual/Organ (Child/Bone) (mrem/year)
Ground Irradiation	0.0474	0.957
Inhalation	0.00814	0.685
Stored Vegetables	0.528	0.528
Leafy Vegetables	0.0265	0.0265
Milk Ingestion	0.201	0.201
Meat Ingestion	0.00833	0.00833
Total:	0.82	2.41

In addition, the isotopic breakdown of the critical organ doses listed above (Table 8) for the two detected radionuclides is seen to be:

Table 9

Isotopic Breakdown of Maximum Radiation Exposures

Description	Isotope	Radioactivity (uCi/2 acres)	Dose (mrem/yr)	Percent of total
During control of disposal sites	Cs-137	605.4	0.805	98.2
	Co-60	65.1	0.0144	1.8
Max. organ: child/bone			0.82	
Termination of disposal site	Cs-137	605.4	2.12	88.0
	Co-60	65.1	0.29	12.0
Max. organ: child/bone			2.41	

For comparison to the total dose calculated assuming the continued disposal of silt removed from the tower basins through the end of the operating license, the dose from just the original 14,000 cubic feet collected is shown on Table 10.

Table 10

Dose Impact Due to Single (14,000ft3) Silt Spreading

Disposal Site Access	Radiation Exposure	Individual/Organ
Controlled by VYNPS (max. exposed individual in 1995)	0.064 mrem/yr 0.219 mrem/yr max.	adult/whole body child/bone
Uncontrolled by VYNPS (inadvertent intruder after license termination)	0.224 mrem/yr 0.393 mrem/yr max.	adult/whole body child/bone

Table 10 shows that the application of the silt material initially collected (14,000 cubic feet) accounts for about 27 percent of the maximum individual organ dose during the control period as compared to the scenario of continued periodic silt spreading over the balance of the operating license. This illustrates that dose impacts from the material currently collected are well below the acceptance criteria of limiting the dose from any two acre plot to no more than 1 mrem/year during the control period, and 5 mrem/year after termination of the license, and is expected to remain below the acceptance criteria throughout plant life. If unexpected buildup of radioactivity in future silt clean out operations were to occur, the option for use of alternate disposal plots remains available to ensure that the impact from any single two acre plot stays within the acceptance criteria.

Also of interest are derived dose conversion factors which provide a means of ensuring that septic and silt disposal operations remain within the prescribed radiological guidelines noted above. The critical organ (worst case), and whole body dose factors for all pathways on a per acre bases are given on Table 11 for periods during Vermont Yankee control of the disposal site, and on Table 12 for post control periods associated with the inadvertent intruder scenario. The dose conversion factors have been expanded to include other potential radionuclide beyond the original five that were addressed in Reference 1. This provides a means to assess other nuclides if future disposal operations identify additional radionuclides not previously observed. The development of these additional nuclide dose conversion factors utilize the same modeling and pathway assumptions as used to derive the factors for the original five radionuclide identified in septic waste. The models for these site and pathway specific dose factors are those in Regulatory Guide 1.109 (Reference 2), and are described in detail in Attachment II to Reference 1.

Table 11

All-Pathway Critical Organ / Whole Body Dose Conversion Factors
During Vermont Yankee Control of Disposal Sites

Nuclide	Individual/Organ	Critical Organ Dose Factor (mrem/yr per uCi/acre)	Whole Body Dose Factor (mrem/yr per uCi/acre)
Cr-51	Teen/Lung	1.14E-05	5.76E-06
Mn-54	Adult/GI-LLI	3.75E-04	1.93E-04
Fe-55	Child/Bone	6.45E-06	1.06E-06
Fe-59	Teen/Lung	4.61E-04	2.13E-04
Co-58	Teen/lung	3.27E-04	2.01E-04
Co-60	Teen/Lung	7.17E-04	5.31E-04
Zn-65	Child/Liver	1.64E-02	1.03E-02
Zr-95	Teen/lung	4.47E-04	1.34E-04
Ag110m	Teen/GI-LLI	1.32E-02	5.24E-04
Sb-124	Teen/Lung	8.34E-04	3.54E-04
Cs-134	Child/Liver	3.18E-03	1.28E-03
Cs-137	Child/Bone	2.66E-03	7.02E-04
Ce-141	Teen/Lung	1.54E-04	1.50E-05
Ce-144	Teen/Lung	6.00E-04	2.44E-05

Table 12

<u>All-Pathway Critical Organ / Whole Body Dose Conversion Factors</u>
<u>Post Vermont Yankee Control of Disposal Sites</u>
<u>(Inadvertent Intruder)</u>

Nuclide	Individual/Organ	Critical Organ Dose Factor (mrem/yr per uCi/acre)	Whole Body Dose Factor (mrem/yr per uCi/acre)
Cr-51	Teen/Lung	5.89E-04	1.19E-04
Mn-54	Teen/Lung	1.02E-02	3.12E-03
Fe-55	Teen/Lung	3.50E-04	2.27E-05
Fe-59	Teen/Lung	2.55E-02	4.43E-03
Co-58	Teen/lung	1.59E-02	3.72E-03
Co-60	Teen/Lung	3.19E-02	9.09E-03
Zn-65	Child/Liver	1.89E-02	1.25E-02
Zr-95	Teen/lung	2.93E-02	2.99E-03
Ag110m	Teen/Lung	3.59E-02	9.53E-03
Sb-124	Teen/Lung	4.73E-02	7.04E-03
Cs-134	Child/Liver	1.21E-02	9.36E-03
Cs-137	Child/Bone	6.98E-03	3.85E-03
Ce-141	Teen/Lung	1.21E-02	3.44E-04
Ce-144	Teen/Lung	5.00E-02	1.52E-03

5.0 RADIATION PROTECTION:

The disposal operation of silt material from the cooling tower basins will follow the applicable Vermont Yankee procedures to maintain doses as low as reasonable achievable and within the specific dose criteria as previously approved for septic waste disposal (Reference 1).

6.0 CONCLUSIONS:

Silt collected from the cooling tower basins is an earthen type material that is similar in characteristics to septic waste residual solids with respect to the radiological pathway behavior and modeling, and can be disposed through on site land spreading on the same disposal plots as previously evaluated and approved for septic waste disposal. The radiological assessment of low level contaminated silt shows that the projected dose from the on site periodic spreading of this material will have no significant dose impact to members of the public and can be maintained below the approved dose limitations already in-place for septic waste.

7.0 <u>REFERENCES:</u>

(1) Vermont Yankee ODCM, Appendix B; "Approval of Criteria for Disposal of Slightly Contaminated Septic Waste On-Site at Vermont Yankee". (Included NRC approval letter dated August 30, 1989, VY request for approval date June 28, 1989 with Attachments I and II)

(2) USNRC Regulatory Guide 1.109, Rev. 1; "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I", date October 1977.

(3) NUREG/CR-5512, Vol. 1, "Residual Radioactive Contamination From Decommissioning", Final Report, date October, 1992.

file: vsilt.mss

ENCLOSURE B

Approval Under 10 CFR 20.302(a) of Procedures for the
Disposal of Slightly Contaminated Septic Waste On Site at Vermont Yankee

ATTACHMENT 1

VERMONT YANKEE NUCLEAR POWER PLANT

APPLICATION FOR APPROVAL TO ROUTINELY DISPOSE OF
SEPTIC WASTE WITH MINIMAL LEVELS OF RADIOACTIVITY

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

August 30, 1989

RECEIVED
SEP - 7 1989
VERMONT YANKEE LICENSING

Docket No. 50-271

Mr. L. A. Tremblay
Licensing Engineering
Vermont Yankee Nuclear Power Corporation
Engineering Office
580 Main Street
Bolton, Massachusetts 01740-1398

Dear Mr. Tremblay:

SUBJECT: APPROVAL UNDER 10 CFR 20.302(a) OF PROCEDURES FOR DISPOSAL OF SLIGHTLY CONTAMINATED SEPTIC WASTE ON SITE AT VERMONT YANKEE (TAC NO. 73776)

REFERENCE: (a) June 28, 1989 letter from R. W. Capstick to US NRC Document Control Desk, including Attachment I and Attachment II.
(b) Final Environmental Statement related to the operation of Vermont Yankee Nuclear Power Station, dated July 1972.

In reference (a) Vermont Yankee Nuclear Power Corporation (Vermont Yankee, or the licensee) submitted an application for disposal of licensed material on site. This disposal was not previously considered by the staff in the Vermont Yankee Final Environmental Statement (FES), reference (b). This extensive application, prepared in accordance with 10 CFR 20.302(a), contains a detailed description of the licensed material, thoroughly analyzes and evaluates the information pertinent to the effects on the environment of the proposed disposal of the licensed material, and commits the licensee to follow specific procedures to minimize the risk of unexpected or hazardous exposures. In the FES, the NRC staff considered the potential effects on the environment of licensed material from operation of the plant and, in the assessment of the total radiological impact of the Vermont Yankee Station concluded that: "...operation of the Station will contribute only an extremely small increment to the radiation dose that area residents receive from natural background. Since fluctuations of the background dose may be expected to exceed the increment contributed by the plant, the dose will be immeasurable in itself and will constitute no meaningful risk to be balanced against the benefits of the plant."

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Since the disposal proposed by the licensee involves licensed material containing less than 0.1 percent of the radioactive materials, primarily cobalt-60 and cesium-137, already considered acceptable in the FES, and involves exposure pathways much less significant than those considered in the FES, we consider the site-specific application (Reference (a)) for Vermont Yankee Nuclear Power Station to have insignificant radiological impact. We accept the commitments and evaluations of the licensee, documented in reference (a), as further assurance that the proposed disposal procedures will have a negligible effect c, the environment and the general population in comparison to normal background ra.liation.

LAI 855

In conclusion, we find the licensee's procedures with commitments as documented in reference (a) to be acceptable, provided that reference (a) is permanently incorporated into the licensee's Offsite Dose Calculation Manual (ODCM) as an Appendix, and future modifications of reference (a) be reported to NRC in accordance with licensee commitments regarding ODCM changes.

Pursuant to 10 CFR 51.22(c)(9), no environmental assessment is required. This completes our review under TAC No.73776.

Sincerely,

Morton B. Fairtile

Morton B. Fairtile, Project Manager
Project Directorate I-3
Division of Reactor Projects I/II
Office of Nuclear Reactor Regulation

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Adjudicatory File (2)
Atomic Safety and Licensing Board
Panel Docket
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(25)

VERMONT YANKEE
NUCLEAR POWER CORPORATION

Ferry Road, Brattleboro, VT 05301-7002

REPLY TO
ENGINEERING OFFICE
580 MAIN STREET
BOLTON, MA 01740
(508) 779-6711

June 28, 1989
BVY 89-59

United States Nuclear Regulatory Commission
Washington, DC 20555

Attention: Document Control Desk

Reference: License No. DPR-28 (Docket No. 50-271).

Subject: Request to Routinely Dispose of Slightly Contaminated Septic Waste in Accordance with 10CFR 20.302(a)

Dear Sir:

In accordance with the criteria of the Code of Federal Regulations, Title 10, Section 20.302(a) (10CFR20.302(a)), enclosed please find the subject application for the disposal of very low level radioactive waste materials. Vermont Yankee Nuclear Power Corporation (Vermont Yankee) hereby requests NRC approval of the proposed procedures for the disposal of slightly contaminated septic waste generated at the Vermont Yankee Nuclear Power Plant in Vernon, Vermont.

This application specifically requests approval to dispose of septic tank waste, contaminated at minimal levels, which have been or might be generated through the end of station operations at the Vermont Yankee Nuclear Power Plant. The proposed method of disposal is for the on-site land spreading in designated areas in compliance with State of Vermont health code requirements for septic waste. Disposal of this waste in the manner proposed, rather than at a 10CFR Part 61 licensed facility would save Vermont Yankee not only substantial cost, but also valuable disposal site space which would then be available for wastes of higher radioactivity levels. Disposal as radioactive waste would require treatment of the biological aspects of the septage and solidification to a stable waste form, thereby increasing the volume substantially.

A radiological assessment and proposed operational controls, based upon the continued on-site disposal of septic waste as presently contained in the plant's septic tanks, are detailed in Attachments 1 and 2. Based upon this analysis, Vermont Yankee requests approval to dispose of septic tank waste on-site by land spreading in such a manner that the radioactivity concentration limit in any batch of septage to be spread does not exceed one-tenth of the MPC values listed in 10CFR20, Appendix B, Table II; and the combined radiological impact for all disposal operations shall be limited to a total body or organ dose of a maximally exposed member of the public of less than one mrem/year (less than 5 mrem/year to an inadvertent intruder).

Due to our expected need to utilize the proposed methodology of land application of septic waste on-site during the spring of 1990, we request your review and approval of this proposed disposal method by the end of the first quarter of 1990.

We trust that the information contained in the submittal is sufficient; however, should you have any questions or require further information concerning this matter, please contact this office

Very truly yours,

VERMONT YANKEE NUCLEAR POWER CORPORATION

Robert W. Capstick, Jr.

Robert W. Capstick, Jr.
Licensing Engineer

MSS/emd

Enclosures

cc: USNRC - Region I
USNRC - Resident Inspector, VTNPS

ATTACHMENT 1

VERMONT YANKEE NUCLEAR POWER PLANT

Application for Approval to Routinely Dispose of Septic Waste With Minimal Levels of Radioactivity

1.0 INTRODUCTION

Vermont Yankee Nuclear Power Corporation (Vermont Yankee) requests approval, pursuant to 10CFR20.302(a), of a method proposed herein for the routine disposal of slightly contaminated septic tank waste. Vermont Yankee proposes to dispose of this waste by spreading it on designated areas within the plant's site boundary fence. This application addresses specific information requested in 10CFR20.302(a).

2.0 WASTE STREAM DESCRIPTION

The waste involved in this application consists of residual solids and water associated with the sewage collection system at Vermont Yankee. The plant's sewage systems are of the septic tank and disposal field type. The two systems servicing the majority of the plant's sanitary waste are identified as (1) main septic system and (2) the south sewage disposal system.

The main septic system (design flow capacity 4,950 gallons/day) consists of a wastewater lift station, septic tank, and dual alternating disposal fields located on the north side of the plant. This system services the main complex of buildings central to the plant and processes approximately 3,500 gallons of wastewater per day. The septic tank, shown in Figure (1), will typically contain 9,250 gallons of septage.

The south sewage disposal system is a newly-installed (January 1989) pressurized mound system, which is used in lieu of the construction office building (COB) holding tank that had previously serviced the lavatory facilities on the south end of the plant. The new system is composed of a septic tank (5,700 gallon capacity, see Figure 2), pumping station, and pressurized mound disposal field. When dosing the field, a force main pressurizes the disposal field's piping system with the septic tank effluent, which distributes throughout the field. The south sewage disposal system has the design flow capacity to process 4,607 gallons of wastewater per day. The system is typically loaded at approximately 2,500 gallons per day during normal plant operations. Figure (3) indicates diagramatically the flow of both potable and wastewater throughout Vermont Yankee.

Both the main septic system and the south sewage disposal system's septic tanks collect waste from the plant's lavatories, showers, kitchens, and janitorial facilities outside the Radiological Control Area (RCA). No radioactivity is intentionally discharged to either of the septic systems. However, plant investigations into the source of low levels of contamination found in septic waste have identified that very small quantities of radioactive materials, which are below detection limits for radioactivity releases from the RCA, are carried out of the control area on individuals and accumulate in the septic waste collection tanks by way of floor wash water, showers, and hand washing. As a means of minimizing the transport of radioactive materials into the septic collection tanks, the primary source of the radioactivity (i.e., floor wash water) is now poured through a filter bag to remove suspended solids and dirt before the water is released into a janitorial sink.

The majority of the radioactivity found in waste sludge has been associated with the main septic tank. Grab samples of sludge from the bottom of the COB and main septic tank were analyzed by gamma spectroscopy with the following results of plant-related radionuclides:

	Isotope	Activity Concentration ±1 Sigma (pCi/kg Wet)
COB Sludge (June 8, 1988)	Cs-137	10.3 ± 1.8
	Co-60	45.4 ± 3.1
Main Tank Sludge (June 8, 1988)	Mn-54	39.3 ± 4.3
	Co-60	853.0 ± 12.0
	Zn-65	52.7 ± 8.2
	Cs-134	13.0 ± 2.2
	Cs-137	120.7 ± 5.2

The principle radionuclide is Cobalt-60, which accounts for 79% of the plant related activity in the septage samples. In comparison to in-plant smear samples taken for 10CFR61 waste characterizations, the septage sample from the main tank correlates very close with the distribution of radionuclides identified in-plant as shown below:

Relative Isotopic Distributions

Isotope	In-Plant Smears	Main Tank Sludge
Mn-54	3.6%	3.6%
Co-60	81.5	79.1
Zn-65	3.8	4.9
Cs-134	0.4	1.2
Cs-137	10.3	11.2

Additional analyses of the main tank septage showed that the liquid portion of the collected sample did not contain any plant-related activation or fission products, and that essentially all of the activity in the waste was associated with the solid sludge fraction. The average density of the collected sludge was found to be approximately equal to that of water, with a wet to dry ratio of 25.4 to 1.

Both the liquid and solid fractions of the main tank septic waste were also analyzed for strontium with no detectable activity found. The liquid portion of the waste sample was also analyzed for tritium with no activity above the minimum detectable levels found. Appendix A to Attachment 2 contains the laboratory analysis reports of the samples taken from the COB and main septic tanks.

Prior to identification of the plant-related radioactivity in septage waste, the COB holding tank was being pumped on the average of twice per week, with the sludge and waste liquid transported off-site primarily to the Brattleboro, Vermont, sewage treatment facility. Waste from the main septic tank was being pumped and transported off-site for disposal on the average of twice per year.

With the replacement of the COB holding tank by the new south sewage disposal system, and the requested implementation of on-site land disposal of accumulated septic waste, the frequency of collection tank pump-outs with land application of the waste is expected to be once per year. With the past pump-out frequency of the main tank being every six months, the accumulation of sludge at the bottom of the tank was well below its design capacity. During the 1988 sample collections, it was estimated that the sludge thickness was less than 1 foot of its 6-foot depth. However, for conservatism in the radiological evaluations, it is assumed that the sludge layer in the main septic tank and south disposal tank occupies 30% of their combined design volume, and that the frequency of pump-outs is semiannual as opposed to the expected annual cycle. Also, as noted above from laboratory analyses of the sludge layer taken from the bottom of the main tank, the average density of the tank contents is approximately equal to that of water, with a wet-to-dry ratio of 25.4 to 1. Hence, the weight of solids (W_{sol}) being disposed of is estimated, for purposes of this bounding dose assessment, to be approximately:

$$W_{sol} = 14{,}950 \text{ [gal]} \times 3{,}785.4 \text{ [cc/gal]} \times 10^{-3} \text{ [kg/cc]}$$
$$\times\ 0.30 \text{ [solids fraction]} \times (1/25.4) \text{ [dry/wet ratio]}$$
$$\sim 700 \text{ [kg] per pump-out of both tanks}$$

or, 1,400 kg of dry solids per year.

3.0 DISPOSAL METHOD

Approval of this application will allow Vermont Yankee to dispose of septage by utilization of a technique of land spreading or surface injection in a manner consistent with all applicable state of Vermont health regulations regarding disposal of septic waste. Details of the chemical and biological controls necessary to satisfy state health code requirements are provided in Reference 5.

The septage will be spread or surface injected on land areas owned by Vermont Yankee and situated within the plant's site boundary. Transportation of the septage waste to the disposal areas will involve pumping from one of the septic waste collection tanks (i.e., main septic tank, COB holding tank, new replacement COB septic tank, or from any other on-site septic waste collection point) into an enclosed truck-mounted tank. The enclosed tank truck is used to prevent spillage while in transit to the disposal areas. The septage will be transported to one of the two disposal sites designated for land application for septage from Vermont Yankee, and applied at a fixed rate based on either limitations imposed by the state of Vermont for heavy metals or organic content of the waste, or on the radioactivity content such that projected maximum individual doses will not exceed established dose objectives.

3.1 Septic Waste Disposal Procedure

Gamma isotopic analysis of septic waste shall be made prior to each disposal by obtaining a representative sample from each tank prior to pump-out. At least two septic waste samples will be collected from each tank to be pumped by taking a volumetric column of sludge and waste water which allows for analysis of the solid's distribution and content from top to bottom of each tank. The weight percent of solid content of the collected waste will be determined and applied to the gamma isotopic analysis in order to estimate the total radioactivity content of each tank to be pumped and spread on designated disposal fields.

These gamma isotopic analyses of the representative samples will be performed at the environmental Technical Specification lower limit of detection (LLD) requirements for liquids (see Technical Specification Table 4.9.3) in order to document the estimation of radiological impact from septage disposal.

The radionuclide concentrations and total radioactivity identified in the septage will be compared to the concentration and total curie limits established herein prior to disposal. The methodology and limits associated with determining compliance with the disposal dose and activity criteria are described in Attachment 2. If the concentration and total activity limits are met, compliance with the dose assessment criteria will have been demonstrated since the radiological analysis (Section 4.5 and Attachment 2) was based on evaluating the exposure to a maximally exposed individual and inadvertent intruder after the accumulation of twenty years of periodic semiannual spreading of the septic waste on a single (2 acre) plot within one of the designated disposal areas. If the activity limit per disposal area is projected to be exceeded, the appropriate exposure pathways as described in Section 4.5 will be evaluated prior to each additional application, or a separate plot within the designated disposal area will be utilized.

Annually, for years in which disposal occurs, the potential dose impact from disposal operations conducted during the year, including the impact from previous years, will be performed and results reported in the plant's Semiannual Radioactive Effluent Release Report which is filed after January 1. All exposures will be assessed utilizing the methodology described in Attachment 2.

The established dose criteria requires that all applications of septage within the approved designated disposal areas shall be limited to ensure the dose to a maximally-exposed individual be maintained less than 1 mrem/year to the whole body and any organ, and the dose to the inadvertent intruder be maintained less than 5 mrem/year. The total activity based on the measured radionuclide distribution for any single disposal plot is not expected to exceed the following:

Isotope	Maximum Accumulated Radioactivity Allowed Per Acre Q_i^{lim} [μCi]
Mn-54	1.4
Co-60	120.0
Zn-65	1.4
Cs-134	0.7
Cs-137	46.5

If any of the above radionuclides are projected to exceed the indicated activity values, then dose calculations will be performed prior to spreading, in accordance with the methods detailed in Section 4.2.2 of Attachment 2, to make the determination that the dose limit criteria will not be exceeded.

The concentration of radionuclides in any tank of septic waste to be disposed of will also be limited to a combined Maximum Permissible Concentration of Water (MPC) (as listed in 10CFR, Part 20, Appendix B, Table II, Column 2) ratio of less than or equal to 0.1.

For radiological control, each application of septage will be applied on the designated land area by approved plant procedure which adheres to the following assumptions which were used in developing the dose impact:

- o During surface spreading or injection, the septage, and any precipitation falling onto or flowing onto the disposal field, shall not overflow the perimeter of the designated area.
- o Septage shall not be surface spread or injected into the top 6-inch soil layer within 300 feet from any drinking water well supply.
- o Septage shall not be surface spread closer than 300 feet from the nearest dwelling or public building (or within 100 feet if injected into the top 6-inch surface layer).
- o Septage shall not be surface spread closer than 50 feet (or within 25 feet if injected into the top 6-inch surface layer) from any roads or site boundary adjacent to land areas.
- o Septage shall not be surface spread within 100 feet (or within 50 feet if injected into the top 6-inch surface layer) of any surface water (rivers, streams, drainage ditches).
- o Low areas of the approved fields, subject to seasonally high groundwater levels, are excluded from the septage application.

In addition to the radiological controls to limit the total accumulation of radioactive materials released by septic waste spreading, state of Vermont health code requirements will be followed to ensure the protection of the public and environment from chemical and biological hazards. The application rate and acreage will be determined prior to each disposal operation. This will vary with the chemical composition of the septage, the percent solids, and the radioactive concentrations.

3.2 Administrative Procedures

Complete records of each disposal will be maintained. These records will include the concentration of radionuclides in the septage, the total volume of septic waste disposed, the total activity in each batch as well as total accumulated on the disposal plot at time of spreading, the plot on which the septage was applied, and the results of any dose calculations required.

The annual disposal of septage on each of the approved plot areas will be limited to within the established dose, activity, and concentration criteria noted above, in addition to limitations dictated by chemical and biological conditions. Dose guidelines, and concentration and activity limits, will be maintained within the appropriate values as detailed in Attachment 2.

Any farmer using land which has been used for the disposal of septic waste will be notified of any applicable restrictions placed on the site due to the land spreading or injection of waste.

4.0 EVALUATION OF ENVIRONMENTAL IMPACT

4.1 Site Characteristics

4.1.1 Site Topography

The proposed disposal sites consist of two fields located on the Vermont Yankee Nuclear Power Plant site, which is located on the west bank of the Connecticut River in southwestern Vermont at latitude 42 degrees, 47 minutes north and longitude 72 degrees 31 minutes west. Both fields are on plant property within the site boundary and surrounded by a chain link fence.

Site A contains an approximate eight-acre parcel of usable land centered approximately 2,200 feet northwest of the Reactor Building. Site B contains about two acres and is centered approximately 1,700 feet south of the Reactor Building. The usable acreage of both the north and south disposal fields is restricted to those areas which have no slopes greater than five percent to limit surface runoff. A radiological assessment based on the 1988 measured radioactivity concentrations in sludge has determined that a single two-acre plot would be sufficient for the routine disposal of septage for twenty years without exceeding the dose criteria to maximum exposed individual or inadvertent intruder. As a result, the eight-acre field to the northwest could be divided into four disposal plots, with the two-acre site at the south end of the plant site, providing a fifth plot. A portion of the United States Geological Survey topographic map (Brattleboro quadrangle), showing the plant site, is presented in the Final Safety Analysis Report (FSAR) as Figure 2.5-1. A plan map showing the plant site and the disposal sites is given on Figure 4.

The sites are located along a glacial terrace on the west side of the Connecticut River. This terrace extends about 3,000 feet west rising gently and then more abruptly to a higher terrace and then to dissected uplands. Distance to the east from the disposal sites to the river is at least 100 feet if septage is disposed of by surface spreading within the designated areas, or 50 feet if septage is injected directly into the soil.

Relief of the proposed disposal sites is low, with elevation ranging between 250 feet and 265 feet (msl). Mean water surface elevation of the adjacent river is about 220 feet.

The topographic character of the site and surrounding area is compatible with this use. The spreading of septage at these locations will have no effect on the topography of the area.

4.1.2 Site Geology

Profiles of site exploratory borings are shown in the FSAR in Figures 2.5-8 through 2.5-11. Current site characteristics as determined from a recent detailed site investigation can be found in Reference 5.

Composition of surfacial materials is compatible with the proposed use of the site for septic waste disposal.

4.2 Area Characteristics

4.2.1 Meteorology

The site area experiences a continental-type climate with some modification due to the marine climate which prevails at the Atlantic seacoast to the east. Annual precipitation averages 43 inches and is fairly evenly distributed in each month of the year.

Potential impacts on septic waste disposal include occasional harsh weather: ice storms, severe thunderstorms, heavy rains due to hurricanes, the possibility of a tornado, and annual snowfall of from 30 to 118 inches per year. In addition, frozen ground can occur for up to 4 months of the year.

Septage spreading will be managed by written procedure such that material which is spread or a mix of that material with precipitation will not overflow the perimeter of the disposal site.

Additional information on meteorology of the site can be found in Section 2.3 of the Final Safety Analysis Report.

4.2.2 Hydrology

Hydrology of the site and local area is tied closely to flow in the adjacent Connecticut River. River flow is controlled by a series of hydroelectric and flood-control dams including the Vernon Dam which is about 3,500 feet downstream of the site.

All local streams drain to the Connecticut River and the site is in the direct path of natural groundwater flow from the local watershed easterly toward the river. Site groundwater level is influenced by both precipitation and changes in the level of ponding of the Connecticut River behind the Vernon Dam due to natural flow or dam operation.

Flood flows on the Connecticut are controlled by numerous dams including five upstream of the site. Elevation of the 100-year flood is about 228 ft (msl); and, thus, well below the elevation of the proposed site which ranges from about 250 to 265 feet (msl). The 100-year flood level is based on information presented in References (1) and (2).

Septage disposal by means of land spreading on the proposed site will have no adverse impact on area hydrology.

Further information about site hydrology is in Section 2.4 of the FSAR.

4.3 Water Usage

4.3.1 Surface Water

The adjacent Connecticut River is used for hydroelectric power, for cooling water for the Vermont Yankee plant, as well as for a variety of recreational purposes such as fishing and boating. The Connecticut River is not used as a potable water supply within 50 miles downstream of the plant.

Locally, water from natural springs are used for domestic and farm purposes. FSAR Table 2.4.5 and Figure 2.4-2 show springs used within a 1-mile radius of the site. FSAR Table 2.4.4 and Figure 2.4-1 show water supplies with surface water sources which are within a ten-mile radius of the site.

There will be no impact on surface water usage or quality as a result of septage disposal due to the required separation distances between surface waters and the disposal plots.

4.3.2 Groundwater

Based on a review of groundwater measurements in various site borings presented in the FSAR and References 3 and 5, an upper estimate of groundwater levels at the plant is about 240 feet. Considering the proximity of the Connecticut River and Vernon Pond, with a mean water surface elevation of 220 feet, this estimate for the groundwater level appears to be reasonable. Given the topography of the proposed disposal sites, it is highly unlikely that the groundwater level will be within 3 feet of the disposal area surface elevation. Prior to each application of septic waste to a disposal plot, the groundwater level in nearby test wells will be determined and no application will be allowed if the groundwater level in the vicinity of the disposal plot is found to be less than 3 feet.

Groundwater provides potable water for public wells as shown in FSAR Table 2.4.5 and Figure 2.4-1. Groundwater flow in the vicinity of the proposed disposal sites is towards the Connecticut River. There are no drinking-water wells located between the site and the river. Therefore, it is highly unlikely that any drinking water wells could be affected by septage disposal. FSAR Figure 2.4-2 and Table 2.4-5 present information on private wells near the plant.

The Vermont Yankee on-site wells provide water for plant use. This supply is routinely monitored for radioactive contamination.

To quantify the impact of septage disposal on the Connecticut River, a conservative groundwater/radionuclide travel time analysis was performed. For an assumed average travel distance of 200 feet from the disposal site to the river, a groundwater travel time of 408 days was estimated from Darcy's Law. This estimate is based on a permeability for the glacial till of 10 gpd/ft^2, a hydraulic gradient of 0.11 ft/ft, and a soil porosity of 0.3. This analysis conservatively assumed that the septage placed on the ground was immediately available to the groundwater. In practice, a minimum of 3 feet separation between groundwater and the surface will be required at time of application of the septic waste.

Due to ionic adsorption of the radionuclides on solid particles in the groundwater flow regime, most radionuclides travel at only a small fraction of the groundwater velocity. For the radionuclides present in the sludge, retardation coefficients were developed from NUREG/CR-3130 (Reference 4). Retardation coefficients for Co-60, Cs-137, and Cs-134 were directly obtained from NUREG/CR-3130. The coefficients for Zn-65 and Mn-54 were conservatively estimated using NUREG/CR-3130 as a guide. The radionuclides, their half-lives, retardation coefficients, and their travel time to the river are summarized in Table 1.

TABLE 1

Radionuclide Travel Times

Radionuclide	Half Life	Retardation Coefficient	Travel Time to River
Co-60	5.3 years	860	961 years
Cs-137	30.2 years	173	193 years
Cs-134	2.1 years	173	193 years
Zn-65	244 days	3	1,224 days
Mn-54	312 days	3	1,224 days

The radiological impact on the river for the radionuclides reaching the river under this conservative analysis is discussed in Attachment 2. Water usage of the Connecticut River downstream from the disposal area is limited to drinking water for dairy cows, irrigation of vegetable crops, and irrigation of cow and cattle fodder.

Based on the assessments noted above, it is concluded that groundwater sources will not be adversely impacted as a result of septage disposal on the proposed site.

4.4 Land Use

Both the eight-acre and two-acre sites proposed for the disposal areas are currently part of the Vermont Yankee Nuclear Power Plant Site inside the plant's site boundary which is enclosed by a chain link fence. It is undeveloped except for transmission line structures which traverse a portion of the northern disposal area. Development potential is under the control of Vermont Yankee. At present, the eight-acre site on the north end of the plant property is used by a local farmer for the growing of feed hay for use with his dairy herd. No curtailment of this activity as a result of the low levels of radioactivity in septage will be necessary.

Utilization of the proposed sites for septic waste disposal will result in no impact on adjacent land or properties because of the separation of the disposal plots from off-site properties, the general movement of groundwater toward the river and away from adjacent land areas, and the very low levels of radioactive materials contained in the waste. Administrative controls on spreading and the monitoring of disposal area conditions will provide added assurance that this proposed practice will not impact adjacent properties.

4.5 Radiological Impact

In addition to state of Vermont limits imposed on septage spreading, based on nutrient and heavy metal content, the amount of septage applied on each of the proposed disposal plots will also be procedurally controlled to insure doses are maintained within the stated limits. These limits are based on NRC Nuclear Reactor Regulation (NRR) staff proposed guidance (described in AIF/NESP-037, August 1986). The proposed dose criteria require that the maximally exposed member of the general public receive a dose less than 1 mrem/year to the whole body or any organ due to the disposal material, and less than 5 mrem/year to an inadvertent intruder.

To assess the doses received by the maximally-exposed individual and the inadvertent intruder, six potential pathways have been identified. These include:

(a) Standing on contaminated ground,

(b) Inhalation of resuspended radioactivity,

(c) Ingestion of leafy vegetables,

(d) Ingestion of stored vegetables,

(f) Ingestion of meat, and

(g) Ingestion of milk.

The liquid pathway was also evaluated and determined to be insignificant. Both the maximum individual and inadvertent intruder are assumed to be exposed to these pathways with difference between the two related to the occupancy time. The basic assumptions used in the radiological analyses include:

(a) Exposure to the ground contamination and to resuspended radioactivity is for a period of 104 hours per year during Vermont Yankee active control of the disposal sites, and continuous thereafter. The 104-hour interval being representative of a farmer's time on a plot of land (4 hours per week for 6 months).

(b) The septic tanks are emptied every 6 months. (Expected practice is to pump septic tanks once per year.)

(c) The tank radioactivity remains constant at the currently determined level. To account for the uncertainty associated with the counting statistics, the measured activity concentrations listed in Section 2 were increased by 3 sigmas. That is, the activity concentrations employed in dose assessment and the total radioactivity content per pump-out (at 700 kg of solids per batch) are as follows:

Isotope	Upper-Bound Activity Concentration [pCi/kg dry]	Upper-Bound Activity Content [Ci/tankful]
Mn-54	1,348	9.436E-07
Co-60	23,060	1.614E-05
Zn-65	1,620	1.134E-06
Cs-134	322	2.254E-07
Cs-137	4,100	2.870E-06

(d) The radiation source corresponds to the accumulation of radioactive material on a single plot (two-acre) within the proposed disposal sites over a period of 20 years (40 applications at 6-month intervals). (In actuality, the proposed sites will accommodate more than one disposal plot, and, in practice, more than one plot will most probably be used with an application frequency of once per year.)

(e) For the analysis of the radiological impact during Vermont Yankee active control of the disposal sites, all dispersed radioactive material remains on the surface and forms a source of unshielded radiation. (In practice, the septic waste will be either surface spread or directly injected within the top 6 inches of the disposal plot, in which case, the radioactive material will be mixed with the soil. This, in effect, would reduce the ground plane source of exposure by a factor of about four due to self-shielding.)

(f) No radioactive material is dispersed directly on crops for human or animal consumption, crop contamination being only through root uptake.

(g) The deposition on crops of resuspended radioactivity is insignificantly small.

(h) Pathway data and usage factors used in the analysis are the same as those used in the plant's ODCM assessment of the off-site radiological impact from routine releases,with the exception that the fraction of stored vegetables grown on the disposal plots was conservatively increased from 0.76 to 1.0 (at present no vegetable crops for direct human consumption are grown on any of the proposed disposal plots).

(i) It is conservatively assumed that Vermont Yankee relinquishes control of the disposal sites after the fortieth pump-out (i.e., the above source term applies also for the inadvertent intruder).

(j) For the analysis of the impact after Vermont Yankee control of the sites is relinquished, the radioactive material is plowed under and forms a uniform mix with the top six inches of soil; but, nonetheless, undergoes resuspension at the same rate as surface contamination.

From radiological impact assessments associated with the disposal of septage on different plot sizes (Attachment 2), it was determined that a single two-acre plot within the disposal sites would accommodate the 1 mrem/year prescribed dose to the critical organ of the maximally exposed individual for a period of up to 20 years, as well as the 5 mrem/year prescribed dose to the inadvertent intruder after control is assumed to be relinquished. The calculated potential radiation exposures following the spreading of 40 combined (main septic system and south disposal system) tankfuls (at six-month intervals) on a single two-acre plot are as follows:

Control of Disposal Sites	Radiation Exposure	Individual/Organ
Controlled by VYNPS (Maximum Exposed Individual)	0.1 mrem/yr 0.2 mrem/yr Maximum	Child/Whole Body Child/Liver
Uncontrolled (Inadvertent Intruder)	1.3 mrem/yr 3.9 mrem/yr Maximum	Adult/Whole Body Teenager/Lung

The individual pathway contributions to the total dose at the end of the 20-year accumulation of waste deposited on a single two-acre plot are as listed below:

Pathway-Dependent Critical Organ Doses

Pathway	Maximally Exposed Individual/Organ (Child/Liver) (mrem/year)	Inadvertent Intruder Critical Individual/Organ (Teenager/Lung) (mrem/year)
Ground Irradiation	0.0576	1.16
Inhalation	0.00122	2.74
Stored Vegetables	0.0913	0.00601
Leafy Vegetable	0.00467	0.00040
Milk Ingestion	0.0421	0.00229
Meat Ingestion	0.00249	0.00012
TOTAL	0.1994	3.909

In addition, an isotopic breakdown of the critical organ dose results listed above is shown in the following table:

Isotopic Breakdown of Maximum Radiation Exposures

Description	Isotope	Radioactivity [μCi/2 Acres]	Exposure [mrem/yr]
During Vermont Yankee	Mn-54	2.831	0.000436
control of the	Co-60	235.3	0.0559
disposal sites.	Zn-65	2.801	0.0230
Maximally Exposed	Cs-134	1.457	0.00231
Individual/Organ:	Cs-137	92.59	0.118
Child/Liver			
	TOTAL		0.199
After Vermont Yankee	Mn-54	2.831	0.0144
control of sites is	Co-60	235.3	3.76
relinquished.	Zn-65	2.801	0.00983
Inadvertent Intruder	Cs-134	1.457	0.000505
Critical Individual/	Cs-137	92.59	0.1247
Organ: Teenager/Lung			
	TOTAL		3.91

Of interest are also derived dose conversion factors which provide a means of ensuring septage disposal operations within the prescribed radiological guidelines. The critical-organ (worst-case) all-pathway values per acre are as follows:

All-Pathway Critical-Organ Dose Conversion Factors
During Vermont Yankee Control of Disposal Sites

Isotope	Individual/Organ	Exposure [mrem/yr-μCi/acre]
Mn-54	Adult/GE-LLI	3.74E-4
Co-60	Teenager/Lung	7.14E-4
Zn-65	Child/Liver	1.64E-2
Cs-134	Child/Liver	3.18E-3
Cs-137	Child/Bone	2.66E-3

The calculational methodology and details of the radiological assessment and proposed operational controls on total activity and concentration of waste to be disposed are presented in Attachment 2.

5.0 RADIATION PROTECTION

The disposal operation will follow the applicable Vermont Yankee procedures to maintain doses as low as reasonably achievable and within the specified dose and release concentration criteria.

REFERENCES

1. Flood Insurance Study, Vernon, Vermont, Windham County, FEMA, Community No. 500137, July 25, 1980.

2. Flood Insurance Study, Town of Hinsdale, New Hampshire, Cheshire County, FEMA, Community No. 330022, October 15, 1980.

3. Vermont Yankee Well Development Evaluation by Wagner, Heindel, and Noyes, Inc. July 10, 1986.

4. NUREG/CR-3130, Influence of Leach Rate and Other Parameters on Groundwater Migration, by Dames & Moore, February 1983.

5. Vermont Yankee Nuclear Power Corporation On-Site Septage Disposal Plan, by Wagner, Heindel, and Noyes, Incorporated, June 1989.

FIGURE 1

MAIN SEPTIC TANK

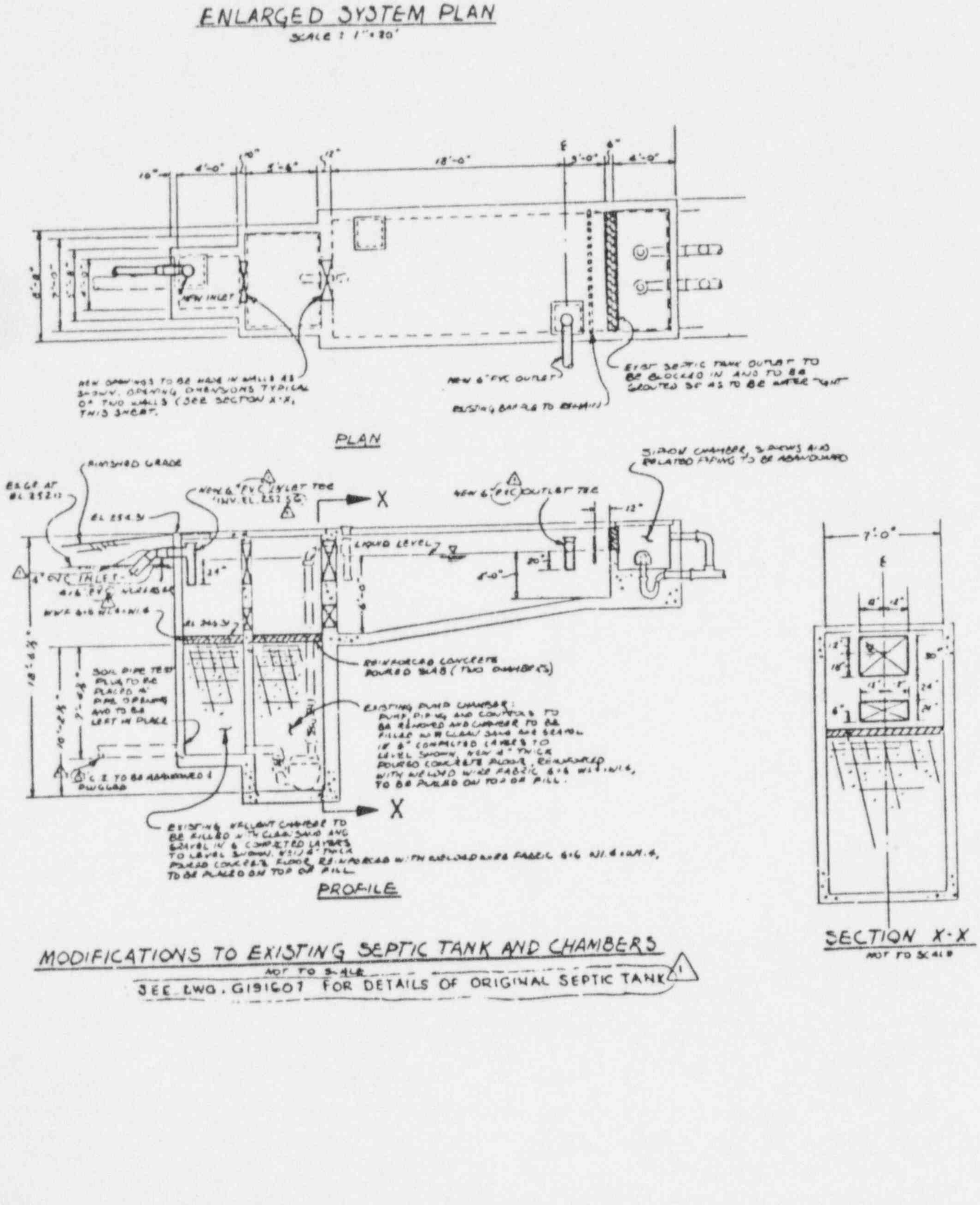
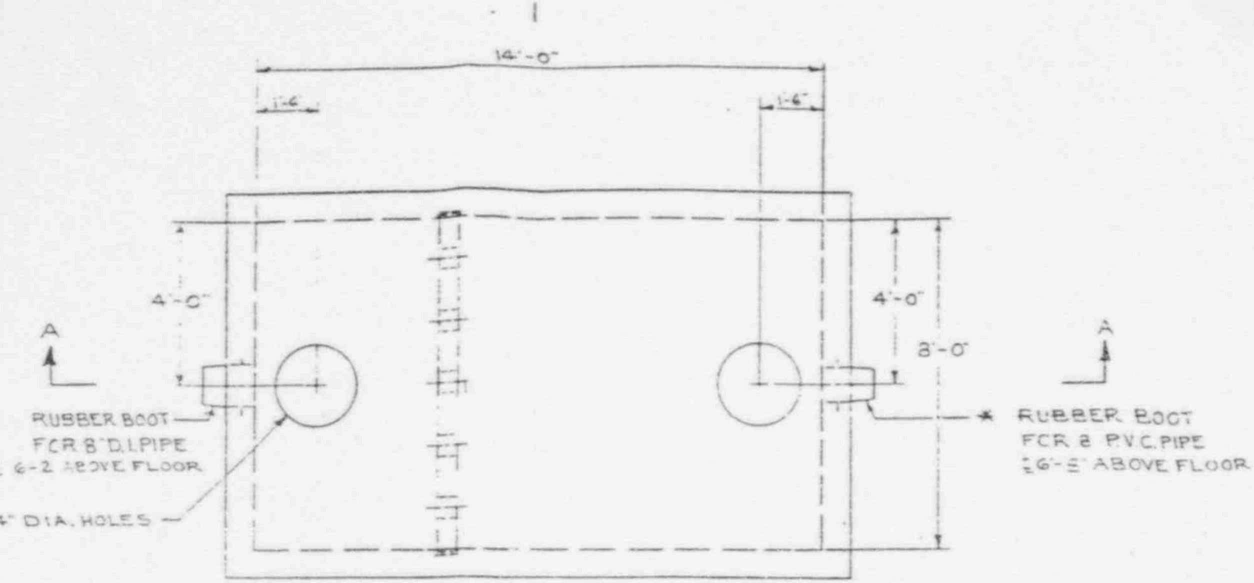
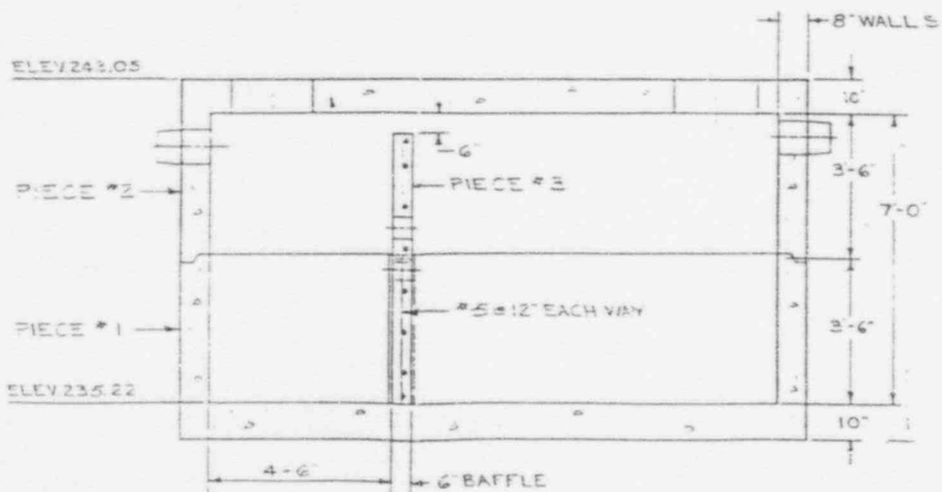


FIGURE 2

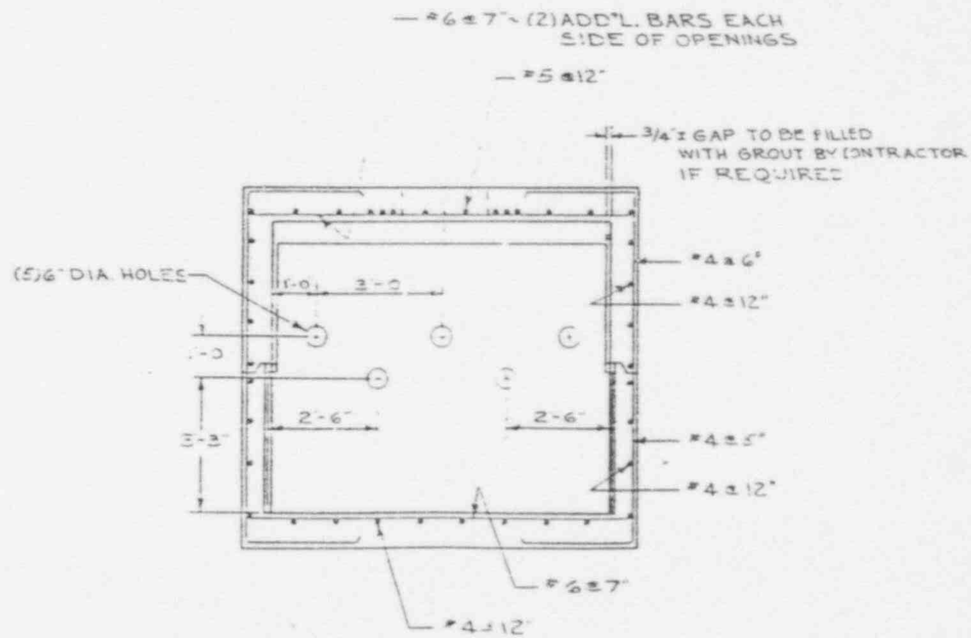
SOUTH DISPOSAL SYSTEM

SEPTIC TANK





SECTION A-A



SECTION B-B

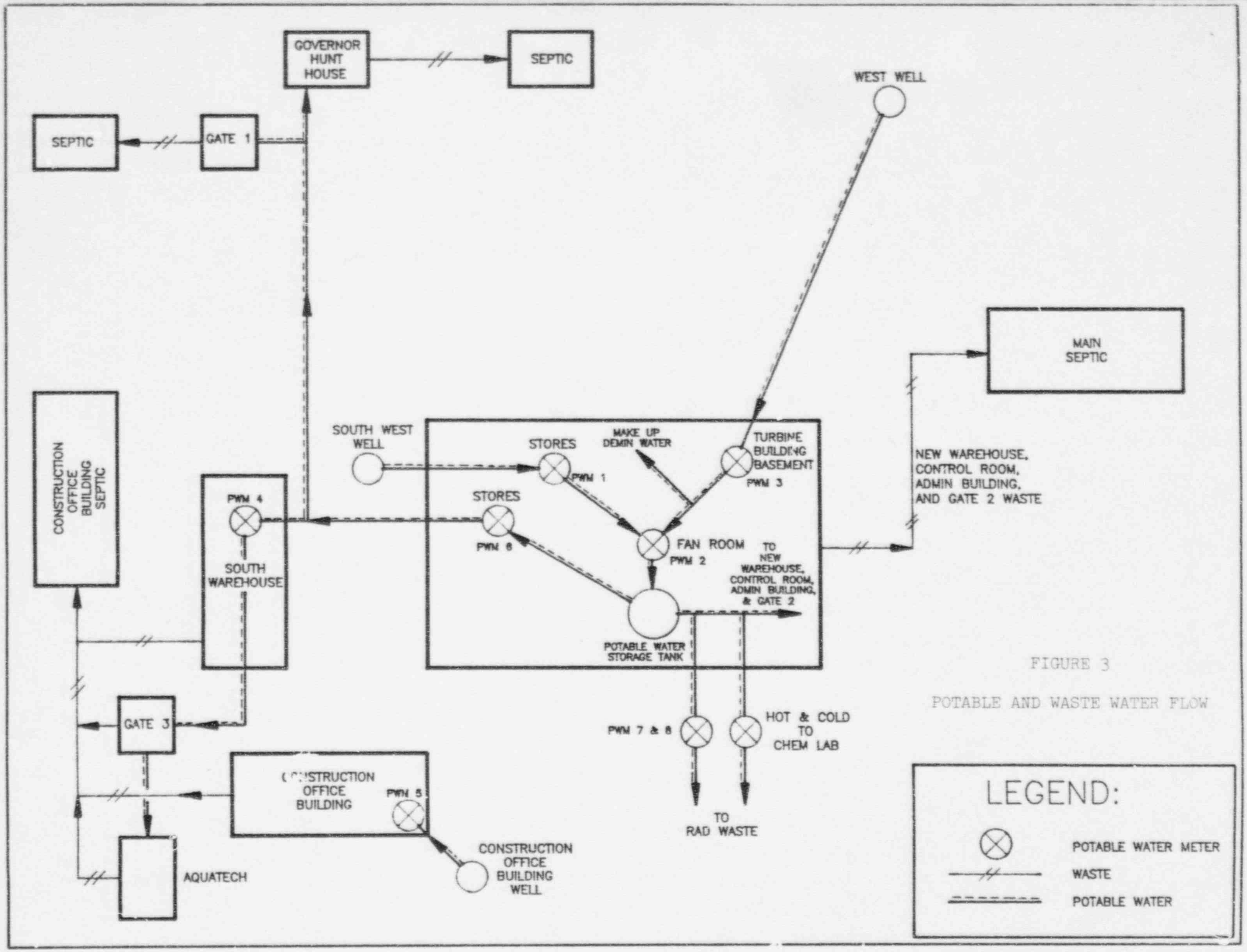


FIGURE 3

POTABLE AND WASTE WATER FLOW

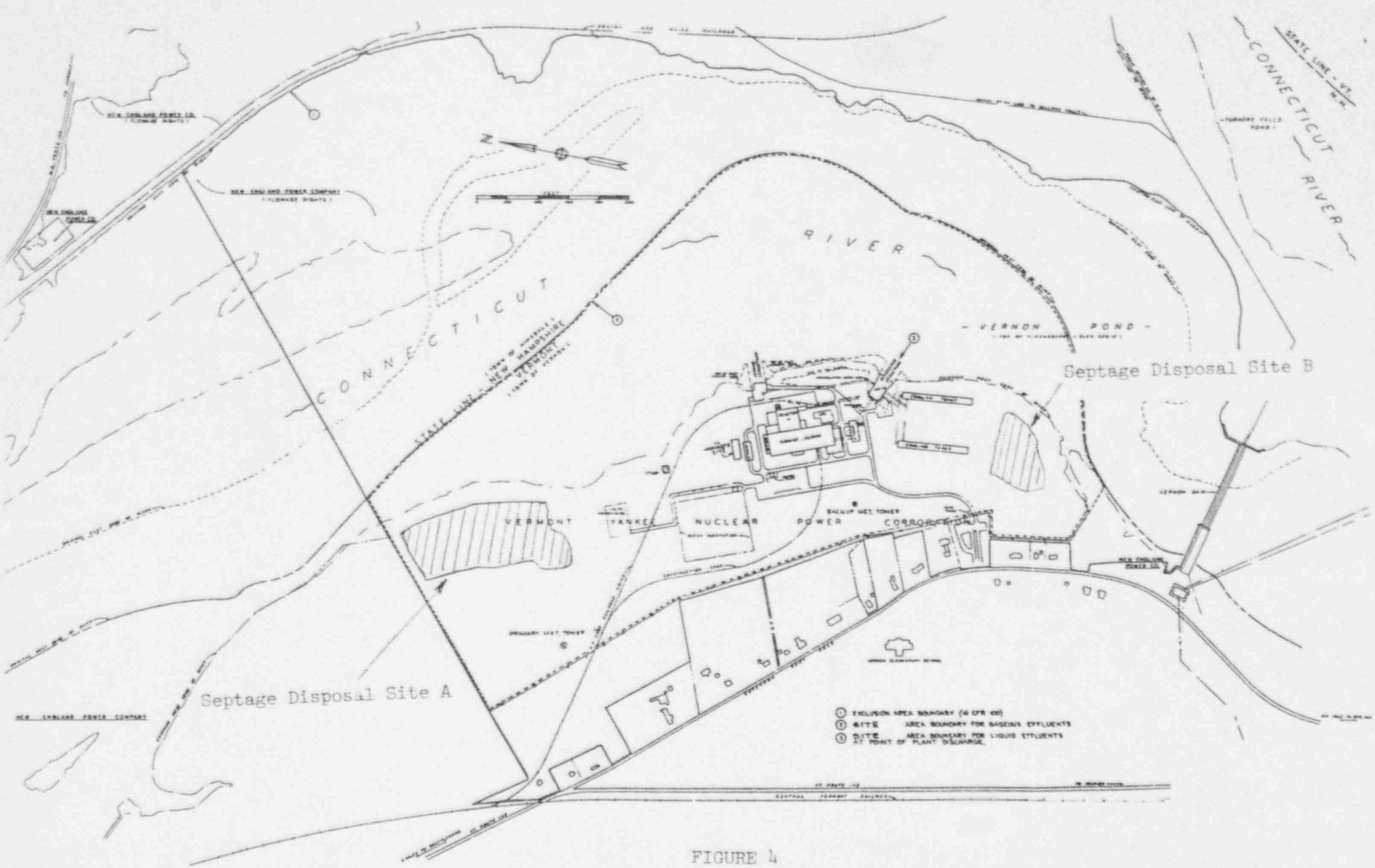


FIGURE 4

SEPTIC WASTE DISPOSAL AREAS

ATTACHMENT 2

VERMONT YANKEE NUCLEAR POWER PLANT

RADIOLOGICAL ASSESSMENT OF
ON-SITE DISPOSAL OF SEPTIC WASTE
and
PROPOSED PROCEDURAL CONTROLS TO ENSURE
COMPLIANCE WITH RADIOLOGICAL LIMITS

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ATTACHMENT 2

VERMONT YANKEE NUCLEAR POWER PLANT

Radiological Assessment of On-Site Disposal of Septic Waste and Proposed Procedural Controls to Ensure Compliance With Radiological Limits

1.0 INTRODUCTION

This calculation is in support of Vermont Yankee's application to the Nuclear Regulatory Commission for the on-site disposal of slightly radioactive septic waste in accordance with the provisions of 10CFR20.302 for very-low-level waste disposal. Specifically, the main purposes of the calculation were as follows:

(a) Determination of an optimal plot size for septage disposal (based on measured 1988 radioactivity concentrations in septic waste) which would accommodate both the radiological guidelines and the needed flexibilities for a smooth operation of the disposal program.

(b) Preparation of procedural controls to ensure compliance with the radiological guidelines.

Guidance for obtaining regulatory approval to dispose of very-low-level waste is presented in AIF/NESP-037 (Reference 6). According to this reference, the NRR staff personnel have proposed a number of draft dose guidelines regarding the impact of low-level waste disposal on the public health and safety for use in the preparation of 10CFR20.302(a) requests. Of these, the following two are pertinent to the present calculation:

(a) Doses to the total body and any body organ of a maximally exposed individual (a member of the general public or a worker who is not classified as a radiation worker) from the probable pathways of exposure to the disposed material should be less than 1 mrem/yr.

(b) Doses to the total body and any body organ of an inadvertent intruder, from the probable pathways of exposure, should be less than 5 mrem/yr.

In either case, consideration should be given to all possible exposure pathways, while allowing for land-usage restrictions which may be in effect. It is on these guidelines that the optimum disposal plot size was selected and the procedural controls prepared.

In addition to the dose guidelines listed above, the procedural controls recommended in this calculation also include MPC checks on the septage to be disposed. As stated in the above AIF report, the total activity concentration in the waste is expected to be below 50 pCi/gram (Reference (6), Page 4-1). This guideline is approximately equivalent to the MPC limits specified in 10CFR20, Appendix B, Table II, Column 2, for the release of radioactive material to unrestricted areas, and to also be approximately 50 times higher than the activities measured in the Vermont Yankee septic waste in 1988. A lower MPC ratio appears to be more appropriate for better control. As a result, and in addition to the prescribed dose limits, a combined MPC ratio of less than or equal to 0.1 was also included in the procedures to regulate the disposal of septic waste. With respect to the measured septage radioactivity, spectroscopic analyses of samples taken in 1988 from the Vermont Yankee main septic tank showed that the liquid portion of the collected samples did not contain any activation or fission products, and that the following plant-related radionuclides were found in the solids:

Isotope	Activity Concentration ±1 Sigma [pCi/kg dry]
Mn 54	1,126 ± 74
Co-60	22,400 ± 220
Zn-65	1,200 ± 140
Cs-134	166 ± 52
Cs-137	3,824 ± 92

2.0 SOURCE TERM AND OTHER BASIC DATA

2.1 Septic Tank Specifics

The effective capacity of the main septic tank, when filled to its maximum depth of 6 feet, is approximately 9,250 gallons. The south sewage disposal system is newly installed (January 1989) and replaces the construction office building (COB) holding tank that had previously serviced the lavatory facilities on the south end of the plant. This new system contains a 5,700 gallon septic tank. The total design capacity of both main system and new south system septic tanks is approximately 14,950 gallons.

Prior to 1988, the main tank was usually emptied every 6 months. Due to this high pump-out frequency, the accumulation of sludge at the bottom is well below the design capacity of the tank. During the 1988 sample collections, it was estimated that the sludge thickness was less than 1 foot. For conservatism in this radiological evaluation, it was assumed that the sludge occupies 30% of the design liquid volume of both the main septic tank and new south systems tank. Also, from laboratory analyses of the septic waste, the average density of the tank contents is approximately equal to that of water, and the wet to dry ratio of the sludge is 25.4 to 1. Hence, the weight of solids (W_{sol}) being disposed of is estimated for purposes of bounding dose analyses to be approximately:

$$W^{sol} = 14{,}950 \text{ gal} \times 3{,}785.4 \text{ cc/gal} \times 10^{-3} \text{ kg/cc}$$
$$\times\ 0.30 \text{ solids fraction} \times (1/25.4) \text{ dry/wet ratio}$$
$$\approx 700 \text{ kg}$$

2.2 Measured and Adjusted Septic Waste Radioactivities

Gamma spectroscopic analyses of septage samples from Vermont Yankee were carried out at the Yankee Environmental Laboratory in Westborough, Massachusetts (see Appendix A). For the main septic tank, no activation or fission products were found in the liquid portion of the collected samples. In the dry solids, on the other hand, the following man-made radionuclides were found to be statistically positive at the 99.9 percent confidence level:

Isotope	Activity Concentration ±1 Sigma (pCi/kg Dry)
Mn-547	1126 ± 74
Co-60	22400 ± 220
Zn-65	1200 ± 140
Cs-134	166 ± 52
Cs-137	3824 ± 92

To account for the uncertainty associated with the counting statistics, the measured activity concentrations listed above were increased by 3 sigmas. That is, the activity concentrations employed in this calculation, and the total radioactivity content per combined tankful of both south and main septic tanks) (at approximately 700 kg of solids per batch, from Section 2.1 of this calculation) are as follows:

Isotope	Upper-Bound Activity Concentration (pCi/kg dry)	Upper-Bound Activity Content (Ci/Batch)
Mn-54	1,348	9.436E-07
Co-60	23,060	1.614E-05
Zn-65	1,620	1.134E-06
Cs-134	322	2.254E-07
Cs-137	4,100	2.870E-06

2.3 Limiting Concentration Guidelines

The AIF Report (AIF/NESP-037) provided draft guidance on total activity concentration in waste stating that it is expected to be below 50 pCi/gram. As shown below, this guideline appears to be approximately equivalent to the MPC limits specified in 10CFR20, Appendix B, Table II, Column 2, for the release of radioactive material to unrestricted areas.

For the major radionuclides identified in the Vermont Yankee septic waste, the individual MPC limits are as follows:

Maximum Permissible Concentrations in Water

Isotope	Soluble (uCi/ml)	Insoluble uCi/ml)
Mn-54	1.0E-4	1.0E-4
Co-60	5.0E-5	3.0E-5
Zn-65	1.0E-4	2.0E-4
Cs-134	9.0E-6	4.0E-5
Cs-137	2.0E-5	4.0E-5

For a mix of radionuclides, 10CFR20 specifies that, in addition to the above individual limits, the following condition must also be met:

$$\Sigma\ (C_i/MPC_i) \leq 1.0$$

where: C_i is the measured concentration for Isotope i, and the summation is over all radionuclides in the mix.

As indicated in Section 2.2, the 1988 spectroscopic analyses of Vermont Yankee septage samples showed that there was no radioactivity in the septic water samples. That is, the limits which are currently applicable are those listed above for insoluble compounds. Using the activity data from Section 2.2, along with the main septic tank volume of 9,250 gallons, the current upper-bound activities and MPC ratios are approximately:

Isotope	Upper-Bound Activity Content (Ci/tankful)	Upper-Bound Activity Concentration (uCi/ml)	MPC Ratio
Mn-54	9.44E-07	2.67E-08	2.67E-04
Co-60	1.61E-05	4.57E-07	1.52E-02
Zn-65	1.13E-06	3.21E-08	1.60E-04
Cs-134	2.25E-07	6.38E-09	1.59E-04
Cs-137	2.87E-06	8.13E-08	2.03E-03
TOTAL	2.13E-05	6.03E-07	1.78E-02

It is seen that the overall MPC ratio is approximately 1.8 % of the regulatory limit, and that the total concentration is 1.2 % of the 50 pCi/g guideline. Thus, the sludge activity concentration can be at least 50 times higher without exceeding either limit. Obviously, if the MPC ratio of 1 or the 50 pCi/g guideline are not revised, the on-site disposal of septic waste will be regulated solely by the prescribed radiation exposure limits. For better control, therefore, it is hereby proposed that, in addition to the prescribed dose limits, a combined MPC ratio of less than or equal to 0.1 be also included in the procedures to regulate the disposal of septage. Refer to Section 4 for more details.

2.4 Disposal Sites

There are two sites on Vermont Yankee site property which are currently designated for on-site septic waste disposal, as follows:

(a) Site A, a 8-acre site approximately 2,200 feet northwest of the Reactor Building.

(b) Site B, a 2-acre site approximately 1,700 feet south of the Reactor Building.

Both sites are within the plant's site boundary and surrounded by a chain link fence, and under direct control of Vermont Yankee for all access.

2.5 Radioactivity at Disposal Plot After 20 Years

It is clear that, due to the longevity of the two primary isotopes identified in the sludge (Co-60 and Cs-137), the amount of radioactivity at the disposal plot will be increasing with each disposal application. However, since the content of radioactivity in septic waste is very low, and since it is neither practical nor necessary to carry out a new dose analysis prior to each disposal, the approach employed in this calculation was to assess the potential radiological impact at approximately the end of plant life. That is, the radiation source was assumed to correspond to the accumulation of radioactive material on a given plot within the proposed disposal sites over a period of 20 years (40 applications at an assumed 6-month interval).

Analytically, if Q_o is the amount of radioactivity per batch for a given isotope, then the total accumulated radioactivity Q_e at the disposal plot after 40 applications is given by:

$$Q_e = Q_o \; (1 + E + E^2 + E^3 + E^4 + \ldots. + E^{39}) \qquad (2.1)$$

$$= Q_o \; (1 - E^{39})/(1 - E) \qquad (2.2)$$

where: $E = \exp(-\lambda\Delta t)$ (2.3)

λ = is the decay constant for the selected isotope (1/year)

and

Δt = time interval between applications = 0.5 year

For the isotopes of interest, the results are as follows:

Isotope	Half Life	(1/yr)	Q_o (Ci/batch)	Q_e/Q_o	Q_e (Ci)
Mn-54	312.2 d	0.8109	9.436E-7	3.000	2.831E-06
Co-60	5.272 y	0.1315	1.614E-5	14.58	2.353E-04
Zn-65	243.8 d	1.038	1.134E-6	2.470	2.801E-06
Cs-134	2.065 y	0.3357	2.254E-7	6.464	1.457E-06
Cs-137	30.17 y	0.02297	2.870E-6	32.26	9.259E-05

2.6 Land-Spreading, Resuspension and Occupancy Factors

As pointed out above, even though the proposed sites can accommodate more than one disposal plot, only a single disposal plot will be assumed in assessing the potential radiological impact. If this plot has a surface area of N acres, then the surface area deposition S_e (Ci/m^2) following 40 disposal applications will be equal to:

$$S_e = Q_e \text{ (Ci)}/(N \text{ (acres)} \times 4046.9 \text{ (m}^2\text{/acre))} \tag{2.4}$$

The denominator of this equation is equivalent to the (D/Q) deposition factor normally employed in the impact assessment of deposited radionuclides. That is:

$$(D/Q) = 1/(N \text{ (acres)} \times 4046.9 \text{ (m}^2\text{/acre))}$$

$$= 2.471E\text{-}04/N \text{ (m}^{-2}\text{)} \tag{2.5}$$

Following the application of septage on the disposal plot, some of the radioactivity may become airborne as a result of resuspension effects. The model used to estimate the radionuclide concentration in air above the disposal plot was taken from WASH-1400, Appendix VI (Reference 7). According to that model, the relationship between the airborne concentration A_e (Ci/m^3) and the surface deposition is:

$$A_e = S_e \text{ (Ci/m}^2\text{)} \times K \text{ (1/m)} \tag{2.6}$$

where: K is the resuspension factor and is equal to 1.0E-05 (1/m) for semi-arid/grassland terrains (from Reference 1).

In actual practice, septage waste will be either surface spread at a controlled rate per acre, or directly injected into the top 6 inch surface soil layer, at a precalculated rate, in order to control the limiting factor. The assumptions made for analytical purposes are as follows:

(a) For the analysis of the radiological impact during Vermont Yankee active control of the disposal sites, no injection will be assumed to take place; all dispersed radioactive material will be assumed to remain on the surface and to form a source of unshielded radiation.

(b) For the analysis of the impact after Vermont Yankee control of the sites is assumed to be relinquished, the radioactive material will be assumed to be plowed under and to form a uniform mix with the top 6 inches of soil (to account for the shielding provided by the soil), but, nonetheless, to undergo resuspension at the same rate as surface contamination.

Analysis of preliminary results, based on the measured radioactivity concentration found in sludge during 1988, showed that a 2-acre disposal plot would meet the radiation criteria given in Section 2.3. This is the plot size, therefore, used in the final analyses.

As for the occupancy factors for direct exposure to the ground deposition and for immersion in the resuspended radioactivity, 104 hours were used for the radiological impact analysis during active Vermont Yankee control of the disposal sites, and continuous exposure was assumed thereafter. The 104-hour interval is expected to be an upper bound of a farmer's time spent on a plot of land, which is assumed to be 4 hours per week for 6 months while he plows, plants, and harvests his crop.

2.7 Site-Specific Pathway Data and Usage Factors

The following exposure pathways were addressed in this calculation for both the maximally exposed individual (i.e., during Vermont Yankee control of the disposal sites) and for the inadvertent intruder (i.e., after control is assumed to be relinquished):

(a) Standing on contaminated ground.
(b) Inhalation of resuspended radioactivity.
(c) Ingestion of leafy vegetables.
(d) Ingestion of stored vegetables.
(f) Ingestion of meat.
(g) Ingestion of milk.
(h) Liquid pathways.

Radiation exposures were computed for all pathways, with one exception. As shown in Section 2.8 below, the radiological impact from the liquid pathway was determined to be insignificant without the need of a detailed analysis. It should be noted that current agricultural activities permitted on the designated disposal sites are limited to the growing of feed crops (hay) for dairy animals. As such, the ingestion of leafy and stored vegetables are not existing exposure pathways, but have been included to demonstrate that these could al be accommodated within the proposed dose criteria for septic waste disposal.

Pathway data and usage factors as applicable to the area in the vicinity of the Vermont Yankee Nuclear Power Station are shown in the tables which follow. These are the same factors as used in the plant's ODCM assessment of the off-site radiological impact due to routine releases from the plant, with the following exceptions:

(a) The soil exposure time for spreading of the radioactivity content of the septage to cover each period of measured deposition was changed from a standard 15 years (given in Regulatory Guide 1.109) to 1 year.

(b) The fraction of stored vegetables grown on the contaminated land was conservatively increased from 0.76 to 1.0.

(c) The crop exposure time was changed from 2160 hours to 0 hours to reflect the condition that no radioactive material will be dispersed directly on crops for human or animal consumption, the deposition on crops of resuspended radioactivity being insignificantly small; that is, crop contamination is only through root uptake.

USAGE FACTORS

Individual	Vegetables (kg/yr)	Leafy Veg. (kg/yr)	Milk (l/yr)	Meat (kg/yr)	Inhalation (m^3/yr)
Adult	520	64	310	110	8,000
Teen	630	42	400	65	8,000
Child	520	26	330	41	3,700
Infant	---	---	330	---	1,400

VEGETABLE PATHWAY

	Stored Vegetables	Leafy Vegetables
Agricultural productivity (kg/m^2)	2.0	2.00
Soil surface density (kg/m^2)	240.0	240.0
Transport time to user (hours),	0.0	0.0
Soil exposure time (hours)	8,766.0	8,766.0
Crop exposure time to plume (hours)	.0	.0
Holdup after harvest (hours)	1,440.0	24.0
Fraction of stored vegetables grown in garden	1.0	
Fraction of leafy vegetables grown in garden		1.0

COW-MILK PATHWAY

	Pasture Feed	Stored Feed
Agricultural productivity (kg/m^2)	.7	2.0
Soil surface density (kg/m^2)	240.0	240.0
Transport time to user (hours)	48.0	48.0
Soil exposure time (hours)	8,766.0	8,766.0
Crop exposure time to plume (hours)	.0	.0
Holdup after harvest (hours)	.0	2,160.0
Animals daily feed (kg/day)	50.0	50.0
Fraction of year on pasture	.5	
Fraction pasture when on pasture	1.0	

MEAT PATHWAY

	Pasture Feed	Stored Feed
Agricultural productivity (kg/m^2)	.7	2.0
Soil surface density (kg/m^2)	240.0	240.0
Transport time to user (hours)	480.0	480.0
Soil exposure time (hours)	8,766.0	8,766.0
Crop exposure time to plume (hours)	.0	.0
Holdup after harvest (hours)	.0	2,160.0
Animals daily feed (kg/day)	50.0	50.0
Fraction of year on pasture	.5	
Fraction pasture when on pasture	1.0	

2.8 Liquid Pathways

There are three potential routes through which septic waste radioactivity may enter into the liquid pathway, as follows:

(a) Surface water runoff.

(b) Ground water pathway.

(c) Accidental releases into the Connecticut River.

Since there are no potable water wells between the disposal site and the river, it is evident that the only way for septic waste radioactivity to enter the liquid pathway is via the Connecticut River.

Even though surface water runoff may be a credible pathway into the river, the fraction of disposed radioactivity which may thus be transported to the river is very small for the following reasons:

(1) The selected disposal sites are set back from the river.

(2) Procedural controls will ensure that during surface spreading of all the septage and any precipitation falling onto or flowing onto the disposal plot will not overflow the perimeter of the disposal site.

(3) The disposal plots have slopes of 5% or less in order to limit surface runoff.

With respect to septage radionuclides reaching the Connecticut River via the ground-water pathway, the critical parameter is the total transport time from the field to the river. Should this transport time (which is element dependent) be large in comparison to the half-life of the radionuclide of interest, then decay in transit will remove the said radionuclide from the pathway. For the case on hand, the conservative travel times to go an average 200 feet to the river, and the fractions of land-spread radioactivity which are expected to reach the river are as follows:

Isotope	Half Life	Decay Constant (1/yr)	Travel Time to River (years) (Ground Water Path)	Fraction of Initial Activity Entering River
Mn-54	312.2 d	0.8109	3.35	6.61E-02
Co-60	5.272 y	0.1315	961.	0.0
Zn-65	243.8 d	1.038	3.35	3.09E-02
Cs-134	2.065 y	0.3357	193.	0.0
Cs-137	30.17 y	0.02297	193.	1.19E-02

Thus, only small fractions of Mn-54, Zn-65, and Cs-137 may make it to the river via the ground-water pathway; and, since the initial activities of these isotopes are relatively insignificant, it is clear that the ground-water pathway is not a credible one.

We proceed, then, with the analysis of an accidental release of the entire contents of a septic waste spreading truck directly into the Connecticut River. Following such an accident, the released radioactive material is expected to first mix with part of the water in Vernon Pond and to then gradually flow downstream of the Vernon Dam. The storage volume in Vernon Pond, excluding the volume below the crest, is approximately 6.0E+9 gallons (2.3E+13 cc). Since no use is made of the river between the plant and the Vernon dam, the only potential exposure pathway is downstream of the dam; and from Reference (2), the river flow through the dam is typically 10,000 cfs, and no less than 1,200 cfs during the dry season.

As a conservative condition, assume that the septic waste mixes with just one thousandth of the Vernon pond storage volume, i.e., with 2.3E+10 cc. This amount of water will pass through the dam in about 11 minutes if the river flow is 1,200 cfs, and in about 1.3 minutes if the flow is 10,000 cfs. Using the upper-bound activities given in Section 2.3, the expected concentrations in the pond, and the corresponding MPCs are as follows:

Isotope	Upper-Bound Activity Content (Ci/Batch)	Expected Concentration in Pond (uCi/ml)	MPC Ratio
Mn-54	9.44E-07	4.10E-11	4.10E-07
Co-60	1.61E-05	7.02E-10	2.34E-05
Zn-65	1.13E-06	4.93E-11	2.47E-07
Cs-134	2.25E-07	9.80E-12	2.45E-07
Cs-137	2.87E-06	1.25E-10	3.13E-06
TOTAL	2.13E-05	9.27E-10	2.74E-05

It is seen that the concentrations are negligibly small to pose any radiological concern.

In summary, as demonstrated above, the liquid pathway is not credible.

3.0 RADIOLOGICAL ASSESSMENT

The radiological impact associated with the on-site disposal of radioactive septage at Vermont Yankee was carried out using the dose assessment models in Regulatory Guide 1.109, and is consistent with the methodology employed by the Vermont Yankee ODCM. However, since the computer code used (ATMODOS; Reference (3)) is primarily for use with atmospheric releases, it was necessary to manipulate the input to obtain the desired results for direct deposition of radioactivity on soil due to land spreading of septic waste. In particular, special consideration was given to the following:

(a) The computation of an effective shielding factor to account for the effect provided by the soil after the waste is plowed under, or if it is directly injected into the top 6 inch surface layer.

(b) The definition of an annual activity release rate, which following a year's time of continuous release, would yield the ground deposition expected to prevail after 40 combined tank pump-outs, as calculated in Section 2.5.

(c) The definition of an effective atmospheric dispersion factor to represent the resuspended radioactivity.

(d) The proper representation of partial occupancy factors.

These are discussed in Sections 3.1 and 3.2 which follow.

The results of the radiological impact assessment are presented in Sections 3.3 and 3.4.

3.1 Dose Reduction as a Result of Plowing the Radioactive Material into the Soil

As pointed out in Section 2.6 of this calculation, the impact analysis after control of the disposal sites is relinquished, was based on the assumption that the radioactive material will be plowed to form a uniform mix with the top 6 inches of soil. To account for the gamma attenuation provided by the soil, it was necessary to carry out an appropriate shielding calculation. This was accomplished through use of the ALLEGRA and DIDOS-V computer codes (References 4 and 5). The ALLEGRA code was used to define the gamma spectrum (in MeV/sec) associated with the selected radionuclide mix. This spectrum was then entered into DIDOS-V to compute the radiation levels from the two following source/receptor geometries:

(a) A circular disk source with a radius of 150 m (represented by a cylindrical volume with a height equal to 0.001 m), the receptor location being along the disk axis, 1 m from the disk.

(b) A cylindrical volume source with a radius of 150 m and a height of 0.15 m, with the receptor located along the axis, 1 m above the source.

In the latter case, the source density was set equal to 1.6 g/cc; this is equivalent to the Reg. Guide 1.109 value of 240 kg/m^2 for the effective surface density of soil within a 15 cm plow layer. The source radii were assumed to be large so as to approximate semi-infinite conditions, thus, permitting a direct comparison of the DIDOS-V and ATMODOS results for the unplowed land. The source intensity (in $MeV/sec\text{-}m^3$, as required for input into DIDOS-V) was computed by distributing the radioactive material over a 2-acre surface, and within 0.001 m for the disk source and 0.15 m for the second case.

Copies of the ALLEGRA and DIDOS-V outputs appear in Appendix B, which should be referred to for more details. The DIDOS-V results are as follows:

Dose to air from the disk source = 1.085E-06 rad/hr
Dose to air from cylinder source = 2.629E-07 rad/hr
Overall soil shielding factor = 2.629E-07/1.085E-06 = 0.243

At this point, it is of interest to compare the DIDOS-V and ATMODOS exposure results from standing on contaminated ground. From the ATMODOS output in Appendix B (Section B.3.6), where the source term was the same as used in DIDOS-V, the skin dose due to exposure to contaminated ground for 104 hours is given as 6.78E-02 mrem. This is equivalent to a dose rate of 6.52E-4 mrem/hr, or (6.52E-4/1.11) = 5.87E-4 mrad/hr to air, 1.11 being the average ratio of tissue-to-air energy absorption coefficients (from Regulatory Guide 1.109). It is seen that ATMODOS underestimates the dose by a factor of 2, approximately; the reason for this is the slightly outdated set of dose conversion factors in the guide, as can be verified by inspecting the data in WASH-1400, for instance.

3.2 Data Manipulation for Use with ATMODOS

3.2.1 Radioactivity Release Rate

There are two parameters in the input to ATMODOS which affect the buildup of radioactivity at an off-site location, namely, the activity release rate and the accumulation period. To simulate this process, and to also account for the effect of the 40 applications described earlier, the accumulation period was set equal to 1 year, and the release rate was selected to be such that, at the end of one year, the total accumulated radioactivity at the disposal plot would be equal to the Q_e values given in Section 2.5. That is, if we define by Q_r the activity release rate (Ci/yr) which is required as input to ATMODOS, then the relationship between this parameter and Qe is as follows:

$$Q_e = Q_r \ (1 - E)/\lambda \qquad (3.1)$$

$$E = \exp(-\lambda \Delta t) \qquad (3.2)$$

λ = is the decay constant for the selected isotope (1/year) and

Δt = time interval between applications = 1 yr.

Using the information given for Q_e in Section 2.5, the desired values for Q_r are as follows:

Isotope	Q_e (Ci)	Q_r (Ci/yr)*	Ratio of $(Q_r \times 1\ \text{year})/Q_e$
Mn 54	2.831E-06	4.132E-06	1.460
Co 60	2.353E-04	2.511E-04	1.067
Zn 65	2.801E-06	4.502E-06	1.607
Cs 134	1.457E-06	1.715E-06	1.177
Cs 137	9.259E-05	9.366E-05	1.012

*For input to ATMODOS only.

3.2.2 Atmospheric Dispersion

What is of interest at this point is to provide a means of calculating the air immersion dose due to resuspension using the ATMODOS code (under the assumption that the resuspended material is due to an atmospheric release). To accomplish this, we proceed as follows. By definition, in the analysis of releases of gaseous effluents to the atmosphere, the airborne concentration at a receptor of interest is given by:

$$A_e = Q_r \text{ (Ci/yr)} \times (X/Q) \text{ (sec/m}^3\text{)}/3.1536E{+}7 \text{ (sec/yr)} \qquad (3.3)$$

Where: (X/Q) is the atmospheric dispersion factor.

Combining Equations (2.4), (2.6) and (3.3), it is seen that, for long-lived radionuclides (where the total accumulated radioactivity at the end of one year is numerically equal to the annual release rate, i.e. $Q_e = Q_r \times 1$ year), the airborne concentration at the disposal plot due to resuspension effects can be accommodated by the following atmospheric dispersion factor:

$$(X/Q) = K \text{ (1/m) } 3.1536E{+}7 \text{ (sec/yr)}/(N \text{ (acres)} \times 4046.9 \text{ (m}^2\text{/acre))}$$

$$= 7{,}792.6 \text{ (K/N) (sec/m}^3\text{)} \qquad (3.4)$$

With K = 1.0E-5 (1/m), and N = 2 acres, the last equation reduces to:

$$(X/Q) = 3.896E\text{-}02 \ (sec/m^3).$$

At this point it is important to note that this method of analysis is slightly conservative since the receptor is assumed to be immersed in a cloud of undecayed radioactivity. From the (Q_r/Q_e) ratios given in the last table in Section 3.2.1, it is seen that inhalation exposures will be overestimated by the following factors:

Isotope	Inhalation Exposure Overestimation Factor
Mn-54	1.460
Co-60	1.067
Zn-65	1.607
Cs-134	1.177
Cs-137	1.012

3.2.3 Occupancy Factors

As indicated in Section 2.6, the occupancy factor for exposure to ground deposition and for immersion in the resuspended radioactivity was set equal to 104 hours during control of the disposal sites, and was assumed to be continuous thereafter. Since occupancy factors cannot be entered directly into the ATMODOS code, the partial occupancy situation was accommodated as follows:

(1) The exposure to resuspended radioactivity was handled by multiplying the effective (X/Q), as given by Equation (3.4), by (104/8760), 8,760 being the number of hours in one year; this leads to a X/Q value of 4.626E-4 sec/m^3.

(2) The exposure to radioactivity deposited on the ground was handled by setting the shielding correction factor equal to the occupancy factor (i.e., equal to 104/8760 = 0.012).

It should be noted that the (X/Q) adjustment described above is appropriate in this case since radioactive material will not be dispersed on crops for human or animal consumption. The only pathway through which crop contamination can take place is through root uptake.

3.3 Land-Spreading Exposure Pathways

Three sets of ATMODOS computer runs were carried out, for the following:

(a) Assessment of the radiological impact during Vermont Yankee control of the disposal sites.

(b) Assessment of the radiological impact after control of the sites is assumed to be relinquished.

(c) Development of dose conversion factors providing a correlation between pathway exposures per soil activity for each isotope of interest.

The results for each case are presented in the subsections which follow. Briefly, note that they correspond to a disposal plot size of 2 acres, which was determined to be the appropriate size to meet both the radiation exposure criteria listed in Section 2.3, and the desired flexibilities listed in Section 2.4. The whole body and critical-organ radiation exposures (after 40 pump-outs on the same plot at a concentration level equivalent to the measured 1988 concentrations in septic waste) are as follows:

Control of Disposal Sites	Radiation Exposure	Individual/Organ
Controlled by VYNPS (Maximum Exposed Individual)	0.1 mrem/yr 0.2 mrem/yr Maximum	Child/Whole Body Child/Liver
Uncontrolled (Inadvertent Intruder)	1.3 mrem/yr 3.9 mrem/yr Maximum	Adult/Whole Body Teenager/Lung

The individual pathway contributions to the total dose are as follows:

Pathway-Dependent Critical Organ Doses

Pathway	Maximally Exposed Individual/Organ (Child/Liver) (mrem/year)	Inadvertent Intruder Critical Individual/Organ (Teenager/Lung) (mrem/year)
Ground Irradiation	0.0576	1.16
Inhalation	0.00122	2.74
Stored Vegetables	0.0913	0.00601
Leafy Vegetable	0.00467	0.00040
Milk Ingestion	0.0421	0.00229
Meat Ingestion	0.00249	0.00012
TOTAL	0.1994	3.909

In addition, an isotopic breakdown of the critical organ dose results listed above is shown in the following table:

Isotopic Breakdown of Maximum Radiation Exposures

Description	Isotope	Radioactivity (μCi/2 Acres)	(mrem/yr)
During Vermont Yankee control of the disposal sites. Maximally Exposed Individual/Organ: Child/Liver	Mn-54	2.831	0.000436
	Co-60	235.3	0.0559
	Zn-65	2.801	0.0230
	Cs-134	1.457	0.00231
	Cs-137	92.59	0.118
	TOTAL		0.199
After Vermont Yankee control of sites is relinquished. Inadvertent Intruder Critical Individual/Organ: Teenager/Lung	Mn-54	2.831	0.0144
	Co-60	235.3	3.76
	Zn-65	2.801	0.00983
	Cs-134	1.457	0.000505
	Cs-137	92.59	0.1247
	TOTAL		3.91

As for the dose conversion factors during active plant control of the disposal sites, the critical-organ all-pathway values for a 2-acre disposal plot are:

All-Pathway Worst-Case Dose Conversion Factors During Vermont Yankee Control of Disposal Sites

Isotope	Individual/Organ	Exposure (mrem/yr-μCi)
Mn-54	Adult/GE-LLI	1.87E-4
Co-60	Teenager/Lung	3.57E-4
Zn-65	Child/Liver	8.21E-3
Cs-134	Child/Liver	1.59E-3
Cs-137	Child/Bone	1.33E-3

In all cases, the exposure pathways are direct shine from shielded/unshielded ground deposition, inhalation of resuspended radioactivity, and ingestion of contaminated food (stored vegetables, leafy vegetables, milk and meat); exposure to the ground deposition and to resuspended radioactivity is for a period of 104 hours during control of the disposal sites, and continuous thereafter. Refer to Appendix B for copies of the ATMODOS outputs, and to the following list of assumptions employed in the calculations.

Briefly, the following basic assumptions were used in the calculational analyses:

(a) The septic tanks are emptied every 6 months (expected future practice is to pump tanks once per year).

(b) The tank radioactivity remains constant (at the main septic tank 1988 determined level plus 3 sigma).

(c) The radiation source corresponds to the accumulation of radioactive material on a single plot within the proposed disposal sites over a period of 20 years (40 applications at 6 month intervals). (In actuality, the proposed sites will accommodate more than one disposal plot, and, in practice, more than one plot will most probably be used.)

(d) For the analysis of the radiological impact during Vermont Yankee control of the disposal sites, no plowing or direct injection of septage takes place and all dispersed radioactive material remains on the surface and forms a source of unshielded radiation. (In practice, the waste will be either surface spread or directly injected into the top 6 inch layer of the disposed plot, in which case the radioactive material will be mixed with the soil. This in effect would reduce the ground plane source of exposure by a factor of about four due to self-shielding.)

(e) No radioactive material is dispersed directly on crops for human or animal consumption, crop contamination being only through root uptake.

(f) The deposition on crops of resuspended radioactivity is insignificantly small.

(g) Pathway data and usage factors used in the analysis are the same as those used in the plant's ODCM assessment of the off-site radiological impact from routine releases, with the exception that the fraction of stored vegetables grown on the disposal plots was conservatively increased from 0.76 to 1.0. (At present, no vegetable crops for direct human consumption are grown on any of the disposal sites.)

(h) It is assumed that Vermont Yankee relinquishes control of the disposal sites after the fortieth pump-out (i.e., the above source term applies also for the inadvertent intruder).

(i) For the analysis of the impact after Vermont Yankee control of the sites is relinquished, the radioactive material is plowed under and forms a uniform mix with the top 6 inches of soil, but, nonetheless, undergoes resuspension at the same rate as surface contamination.

(k) Exposure to the ground deposition and to resuspended radioactivity is for a period of 104 hours during Vermont Yankee control of the disposal sites, and continuous thereafter, the 104-hour interval being representative of a farmer's time on a plot of land (4 hours per week for 6 months).

3.3.1 Impact During Vermont Yankee Control of the Disposal Sites

The tables which follow present summaries of the ATMODOS results for the radiological impact during Vermont Yankee control of the disposal sites. The first table presents the results for the entire mix of radionuclides, and the second table shows the contributions by each isotope.

Total Accumulated Radioactivity on 2-Acre Plot
After 40 Disposal Applications

Isotope	Curies
Mn 54	2.831E-06
Co 60	2.353E-04
Zn 65	2.801E-06
Cs 134	1.457E-06
Cs 137	9.259E-05

Dose Delivered to Each Organ From all Radionuclides in the Mix
and From All Pathways Combined*
(Adult, Teenager, Child, and Infant)
(mrem/yr)

	Bone	Liver	Kidney	Lung	GI-LLI	Thyroid	Whole Body	Skin
A	9.20E-02	1.13E-01	7.92E-02	8.46E-02	9.66E-02	5.76E-02	9.42E-02	6.78E-02
T	1.13E-01	1.44E-01	9.08E-02	9.90E-02	9.65E-02	5.76E-02	9.41E-02	6.78E-02
C	1.86E-01	1.99E-01	1.10E-01	9.73E-02	8.22E-02	5.76E-02	9.94E-02	6.78E-02
I	1.14E-01	1.38E-01	8.36E-02	8.08E-02	7.59E-02	5.76E-02	7.19E-02	6.78E-02

*Each pathway includes unshielded exposure to ground contamination for 104 hours, with all radioactivity assumed to be on the surface of the ground; exposure to resuspended radioactivity is also for a period of 104 hours.

Isotope-Specific Contributions to the Dose Delivered to Each Organ From all Pathways Combined*
(Adult, Tee[illegible]r, Child, and Infant)
(mrem/yr)

	Bone	Liver	Kidney	Lung	GI-LLI	Thyroid	Whole Body	Skin
Source: Mn-54, 2.831E-06 Ci (2-acre plot)								
A	2.13E-04	3.18E-04	2.44E-04	2.98E-04	5.30E-04	2.13E-04	2.33E-04	2.50E-04
T	2.13E-04	3.66E-04	2.59E-04	3.34E-04	5.25E-04	2.13E-04	2.44E-04	2.50E-04
C	2.13E-04	4.36E-04	2.76E-04	3.09E-04	4.00E-04	2.13E-04	2.73E-04	2.50E-04
I	2.13E-04	2.18E-04	2.14E-04	2.74E-04	2.15E-04	2.13E-04	2.14E-04	2.50E-04
Source: Co-60, 2.353E-04 Ci (2-acre plot)								
A	5.20E-02	5.37E-02	5.20E-02	7.40E-02	8.32E-02	5.20E-02	5.56E-02	6.12E-02
T	5.20E-02	5.44E-02	5.20E-02	8.41E-02	8.30E-02	5.20E-02	5.73E-02	6.12E-02
C	5.20E-02	5.55E-02	5.20E-02	7.80E-02	7.16E-02	5.20E-02	6.24E-02	6.12E-02
I	5.20E-02	5.22E-02	5.20E-02	6.86E-02	5.26E-02	5.20E-02	5.25E-02	6.12E-02
Source: Zn-65, 2.801E-06 Ci (2-acre plot)								
A	3.43E-03	1.06E-02	7.13E-03	2.03E-04	6.72E-03	1.46E-04	4.87E-03	1.68E-04
T	4.61E-03	1.57E-02	1.01E-02	2.28E-04	6.72E-03	1.46E-04	7.38E-03	1.68E-04
C	8.72E-03	2.30E-02	1.45E-02	2.11E-04	4.16E-03	1.46E-04	1.44E-02	1.68E-04
I	6.18E-03	2.08E-02	1.02E-02	1.88E-04	1.76E-02	1.46E-04	9.69E-03	1.68E-04
Source: Cs-134, 1.457E-06 Ci (2-acre plot)								
A	5.89E-04	1.09E-03	5.06E-04	3.20E-04	2.42E-04	2.27E-04	9.31E-04	2.65E-04
T	7.92E-04	1.56E-03	6.50E-04	3.89E-04	2.44E-04	2.27E-04	8.44E-04	2.65E-04
C	1.50E-03	2.31E-03	8.74E-04	4.59E-04	2.38E-04	2.27E-04	6.67E-04	2.65E-04
I	7.74E-04	1.25E-03	4.89E-04	3.35E-04	2.30E-04	2.27E-04	3.30E-04	2.65E-04
Source: Cs-137, 9.259E-05 Ci (2-acre plot)								
A	3.57E-02	4.70E-02	1.93E-02	9.79E-03	5.86E-03	5.06E-03	3.25E-02	5.90E-03
T	5.52E-02	7.18E-02	2.78E-02	1.39E-02	6.00E-03	5.06E-03	2.83E-02	5.90E-03
C	1.23E-01	1.18E-01	4.19E-02	1.83E-02	5.76E-03	5.06E-03	2.18E-02	5.90E-03
I	5.50E-02	6.35E-02	2.07E-02	1.14E-02	5.24E-03	5.06E-03	9.20E-03	5.90E-03

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*Each pathway includes unshielded exposure to ground contamination for 104 hours, with all radioactivity assumed to be on the surface of the ground; exposure to resuspended radioactivity is also for a period of 104 hours.

3.3.2 Radiological Impact After Termination of Active Control of the Disposal Sites

The table which follows presents a summary of the ATMODOS results for the radiological impact after control of the disposal sites is assumed to be relinquished after 20 years of septic waste disposal. Tables showing the contributions by the variour isotopes were not prepared as they were determined to be of little significance.

Total Accumulated Radioactivity on 2-Acre Plot
After 40 Disposal Applications

Isotope	Curies
25 Mn-54	2.831E-06
27 Co-60	2.353E-04
30 Zn-65	2.801E-06
55 Cs-134	1.457E-06
55 Cs-137	9.259E-05

Dose Delivered to Each Organ From all Radionuclides in the Mix
and From all Pathways Combined*
(Adult, Teenager, Child, and Infant)
(mrem/yr)

	Bone	Liver	Kidney	Lung	GI-LLI	Thyroid	Whole Body	Skin
A	1.25E+00	1.29E+00	1.21E+00	3.04E+00	1.29E+00	1.16E+00	1.25E+00	1.37E+00
T	1.30E+00	1.35E+00	1.23E+00	3.91E+00	1.28E+00	1.16E+00	1.24E+00	1.37E+00
C	1.40E+00	1.41E+00	1.25E+00	3.39E+00	1.22E+00	1.16E+00	1.23E+00	1.37E+00
I	1.28E+00	1.32E+00	1.21E+00	2.58E+00	1.19E+00	1.16E+00	1.19E+00	1.37E+00

*Each pathway includes continuous exposure to ground contamination (uniformly distributed within a 6-inch layer of soil)

3.3.3 Isotopic Dose Conversion Factors

The table which follows presents isotope-dependent dose conversion factors for the various age groups and organs. They were computed using the ATMODOS computer code along with all the assumptions employed in the assessment of the radiological impact during Vermont Yankee control of the disposal sites. The source terms were defined using the adjustment ratio $(Q_r \times 1\ yr)/Q_e$ given in Section 3.2.1 to obtain an accumulated radioactivity of 1 uCi for each isotope of interest at the end of one year. These conversion factors form part of one of the procedural controls described in Section 4 for ensuring that the disposed contaminated septage does not lead to radiation exposures in excess of the specified limits.

Dose Conversion Factors

For Radioactive Material Spread over Two Acres

For all Pathways Combined*

(Adult, Teenager, Child, and Infant)

(mrem/yr-uCi)

	Bone	Liver	Kidney	Lung	GI-LLI	Thyroid	Whole Body	Skin
Source: Mn-54								
A	7.54E-05	1.12E-04	8.63E-05	1.05E-04	1.87E-04	7.54E-05	8.24E-05	8.84E-05
T	7.54E-05	1.29E-04	9.15E-05	1.18E-04	1.85E-04	7.54E-05	8.61E-05	8.84E-05
C	7.54E-05	1.54E-04	9.74E-05	1.09E-04	1.41E-04	7.54E-05	9.63E-05	8.84E-05
I	7.54E-05	7.71E-05	7.58E-05	9.68E-05	7.60E-05	7.54E-05	7.58E-05	8.84E-05
Source: Co-60								
A	2.21E-04	2.28E-04	2.21E-04	3.14E-04	3.54E-04	2.21E-04	2.36E-04	2.60E-04
T	2.21E-04	2.31E-04	2.21E-04	3.57E-04	3.53E-04	2.21E-04	2.43E-04	2.60E-04
C	2.21E-04	2.36E-04	2.21E-04	3.32E-04	3.04E-04	2.21E-04	2.65E-04	2.60E-04
I	2.21E-04	2.22E-04	2.21E-04	2.92E-04	2.24E-04	2.21E-04	2.23E-04	2.60E-04
Source: Zn-65								
A	1.22E-03	3.78E-03	2.55E-03	7.24E-05	2.40E-03	5.20E-05	1.74E-03	5.98E-05
T	1.65E-03	5.59E-03	3.60E-03	8.12E-05	2.40E-03	5.20E-05	2.64E-03	5.98E-05
C	3.11E-03	8.21E-03	5.19E-03	7.55E-05	1.48E-03	5.20E-05	5.12E-03	5.98E-05
I	2.21E-03	7.44E-03	3.63E-03	6.72E-05	6.29E-03	5.20E-05	3.46E-03	5.98E-05
Source: Cs-134								
A	4.04E-04	7.46E-04	3.47E-04	2.19E-04	1.66E-04	1.56E-04	6.39E-04	1.82E-04
T	5.44E-04	1.07E-03	4.46E-04	2.67E-04	1.67E-04	1.56E-04	5.79E-04	1.82E-04
C	1.03E-03	1.59E-03	6.00E-04	3.15E-04	1.64E-04	1.56E-04	4.58E-04	1.82E-04
I	5.31E-04	8.55E-04	3.36E-04	2.30E-04	1.58E-04	1.56E-04	2.26E-04	1.82E-04
Source: Cs-137								
A	3.86E-04	5.07E-04	2.09E-04	1.06E-04	6.33E-05	5.46E-05	3.52E-04	6.37E-05
T	5.97E-04	7.75E-04	3.00E-04	1.50E-04	6.48E-05	5.46E-05	3.06E-04	6.37E-05
C	1.33E-03	1.28E-03	4.53E-04	1.98E-04	6.23E-05	5.46E-05	2.35E-04	6.37E-05
I	5.94E-04	6.86E-04	2.24E-04	1.23E-04	5.66E-05	5.46E-05	9.94E-05	6.37E-05

*Each pathway includes unshielded exposure to ground contamination for 104 hours, with all radioactivity assumed to be on the surface of the ground; exposure to resuspended radioactivity is also for a period of 104 hours.

4.0 RECOMMENDED PROCEDURAL CONTROLS TO ENSURE COMPLIANCE WITH RADIOLOGICAL LIMITS

Once an on-site septage disposal permit has been secured, implementation of the disposal program must be accompanied with procedural controls to ensure that the applicable radiological limits are not violated. This section presents a list of proposed controls to this effect.

4.1 Total Radioactivity Dispersed per Disposal Plot

As pointed out in Section 2.5, since the content of radioactivity in septic waste is very low, and since it is neither practical nor necessary to carry out a new analysis prior to each disposal, assessment of the radiological impact was based on an assumed source corresponding to the expected accumulation of radioactive material on a given 2-acre dispos' plot over a period of 20 years (40 applications at 6-month intervals). As such, it will be necessary to keep accurate records of the time and location of septage disposal and of the ensuing buildup and decay of radioactivity on each disposal plot. The basic equation to be employed is as follows:

$$Q_i^{tot} = Q_i^{new} + Q_i^{old} \exp(-\lambda_i \Delta t) \qquad (4.1)$$

Where: Q_i^{tot} = total accumulated radioactivity at the selected 2-acre disposal plot after the current disposal (uCi).

Q_i^{new} = radioactivity added to the plot as a result of the current disposal (uCi).

Q_i^{old} = radioactivity accumulated at the selected disposal plot prior to the current disposal (uCi), as determined at the time of the previous disposal.

λ_i = radioactive decay constant (1/year).

Δt = time lapse since the previous disposal on the same disposal plot (years).

Q_i^{new} can be calculated using the following equation:

$$Q_i^{new} = 14{,}950 \text{ gallons} \times 3{,}785.4 \text{ cc/gallon} \times 1.0E\text{-}3 \text{ kg/cc}$$

$$\times \text{Fs (solids fraction)} \times C_i^{wet} \text{ (pCi/kg wet)}$$

$$\times 1.0E\text{-}6 \text{ (uCi/pCi)}$$

$$= 0.0566 \text{ Fs } C_i^{wet} \qquad (4.2)$$

Where: C_i^{wet} is the measured or estimated radionuclide concentration in the septic waste on a wet basis, and Fs is the fraction of solids in the septage per tankful. Fs was conservatively set equal to 0.3 in this calculation. 14,950 gallons equals the volume of both the main septic tank and the south disposal system collection tank.

4.2 Operational Limits

The disposal operating procedures to be established should address both the activity concentration and the potential radiation exposure. Should the activity concentration be in excess of the specified limit, then the sewage mix would not be suitable for on-site disposal and would have to be processed accordingly; this situation, however, is not likely to occur. On the other hand, approaching the exposure guideline is a possibility; but this can be easily accommodated by switching to a different plot within the disposal sites. The subsections which follow present pertinent information recommended for inclusion in the operating procedures.

4.2.1 Maximum Activity Concentrations

In line with the discussion presented in Section 2.3 of this calculation, the radionuclide concentrations in the septic waste must not exceed the following limits:

(a) One tenth of the MPC values listed in 10 CFR 20, Appendix B, Table II, Column 2.

(b) An overall MPC ratio of less than or equal to 0.1.

For the major radionuclides identified in the Vermont Yankee septic waste, the individual MPC limits are as follows:

Maximum Permissible Concentrations in Water
(10CFR20, Appendix B, Table II)

Isotope	Soluble (μCi/ml)	Insoluble (μCi/ml)
Mn 54	1.0E-4	1.0E-4
Co 60	5.0E-5	3.0E-5
Zn 65	1.0E-4	2.0E-4
Cs 134	9.0E-6	4.0E-5
Cs 137	2.0E-5	4.0E-5

For a mix of radionuclides in the sewage mix, the condition to be met is:

$$\Sigma \, (C_i/MPC_i) \leq 0.1$$

Where: C_i is the measured concentration for Isotope i, and the summation is over all radionuclides in the mix.

From the 1988 spectroscopic analysis of septic waste samples, all radioactivity is expected to be in insoluble form, and no radioactivity is expected in the liquid above the sludge. Should the situation change, use should be made of both the soluble and insoluble MPCs listed above, as appropriate.

4.2.2 Potential Radiation Exposures

As described in Section 2.3 of this calculation, the NRR draft guidelines for radiation exposure from all probable pathways due to the disposal of low-level waste are 1 mrem/yr to the total body and any body organ of a maximally exposed individual, and 5 mrem/yr to an inadvertent intruder. The maximally exposed individual is identified as a member of the general public or a worker who is not classified as a radiation worker.

Since the proposed septage disposal sites are within VYNPS property and under VYNPS control, occupancy of the disposal sites by an inadvertent intruder is only possible after plant decommissioning. That is, during the on-site septic waste disposal program, only the specified exposure guideline for the maximally exposed individual would be in effect.

To ensure proper operation of the on-site disposal program, a set of checkpoints was prepared as guidance. The action levels were based on the following results from Section 3:

Isotopic Breakdown of Maximum Radiation Exposures

Description	Isotope	Radioactivity (µCi/2 Acres)	Exposure (mrem/yr)
During Vermont Yankee control of the disposal sites. Maximally Exposed Individual/Organ: Child/Liver	Mn-54	2.831	0.000436
	Co-60	235.3	0.0559
	Zn-65	2.801	0.0230
	Cs-134	1.457	0.00231
	Cs-137	92.59	0.118
	TOTAL		0.199
After Vermont Yankee control of sites is relinquished. Inadvertent Intruder Critical Individual/ Organ: Teenager/Lung	Mn-54	2.831	0.0144
	Co-60	235.3	3.76
	Zn-65	2.801	0.00983
	Cs-134	1.457	0.000505
	Cs-137	92.59	0.1247
	TOTAL		3.91

It is seen that, whereas the exposure to the maximally exposed individual is approximately 20% of the 1 mrem/year guideline, the inadvertent intruder exposure is almost 80% of the 5 mrem/year limit. Thus, to ensure that both guidelines are met at all times, it is intended that the operational guideline for the maximally-exposed individual be set at 0.2 mrem/year. This is a conservative approach since the likelihood of intruder occupancy of the sites coinciding with the end of the on-site disposal program is nil; substantial decay of the radioactive material is expected by the time the sites are released to the general public. Of course, future reassessment of this operational guideline is not precluded. However, an operational limit close to the guideline is not recommended since it eliminates all flexibilities.

Based on the operational guideline of 0.2 mrem/yr to the maximally exposed individual, two checkpoints were prepared which would ensure that the radiation exposure limit will not be exceeded. They are as follows:

(a) Action Level 1 - Gross Radioactivity Limit

The up-to-date total radioactivity dispersed per disposal plot (Q_i^{tot}) is calculated for each isotope using Equation (4.1). If the condition:

$$Q_i^{tot} < Q_i^{lim}$$

is met for each isotope, where Q_i^{lim} represents the limiting values listed in the following table (from Section 3, rounded off to 2 significant figures), then disposal of the septic waste will not violate the exposure limit; otherwise, proceed to Action Level 2.

Isotope	Maximum Accumulated Radioactivity Allowed Per Acre Q_i^{lim} (uCi)
Mn-54	1.4
Co-60	120.0
Zn-65	1.4
Cs-134	0.7
Cs-137	46.5

(b) Action Level 2 - Radiation Exposure

If Action Level 1 fails, determine the potential radiation exposure using the equation:

$$\text{Dose (mrem/yr)} = \Sigma\ Q_i^{tot}\ DCF_i$$

Where: Q_i^{tot} is the up-to-date total radioactivity dispersed per disposal plot calculated for each isotope using Equation (4.1), DCF_i is the dose conversion factor for isotope i, and the summation is over all the radionuclides in the mix. The dose conversion factors are as follows:

Isotope	Individual/Organ	DCF_i (mrem/year-uCi/acre)
Mn-54	Adult/GI-LLI	3.74E-04
Co-60	Teenager/Lung	7.14E-04
Zn-65	Child/Liver	1.64E-02
Cs-134	Child/Liver	3.18E-03
Cs-137	Child/Bone	2.66E-03

The model overestimates the exposure by approximately 20% because the above DCF's correspond to the most restrictive exposure to any individual and any organ from all pathways, independently selected for each radionuclide. The exposure pathways are direct shine from unshielded ground deposition, inhalation of resuspended radioactivity, and ingestion of contaminated food (stored vegetables, leafy vegetables, milk and meat); exposure to the ground deposition and to resuspended radioactivity is for a period of 104 (hours/year).

If the calculated dose is in excess of 0.2 (mrem/yr), a different disposal plot would have to be selected.

5.0 REFERENCES

1. U.S. Nuclear Regulatory Commission, Reactor Safety Study, Appendix VI, Calculation of Reactor Accident Consequences, WASH-1400 (NUREG 75/014), October 1975.

2. Vermont Yankee Nuclear Power Station, FSAR, Section 2.4.4 Uses of River.

3. ATMODOS, A YAEC Computer Code for the Calculation of Off-Site Doses from Iodines and Particulates Discharged to the Atmosphere in line with the Models In Regulatory Guide 1.109

4. J. N. Hamawi, ALLEGRA - A Computer Code Making Use of the ORIGEN-2 Data Bases for the Analysis of Radioactive Decay Chains and the Computation of Gamma Spectra, ENTECH Engineering, Inc., Marlboro, MA, Technical Report P100-R15 (technical report in preparation).

5. J. N. Hamawi, /DIDOS-III - A Three-Dimensional Point-Kernel Shielding Code for Cylindrical Sources, ENTECH Engineering, Inc, Technical Report P100-R2, December 1982 (an upgraded version of the code, DIDOS-V, suitable for the analysis of infinitely large cylindrical sources, is currently in preparation).

6. Atomic Industrial Forum, National Environmental Studies Program, A Guide for Obtaining Regulatory Approval to Dispose of Very Low Level Wastes by Alternative Means, prepared by D. W. Chan, J. P. Davis & R. W. Wofford, General Physics Corporation, Columbia, Maryland, Technical Report No. AIF/NESP-037, August 1986.

APPENDIX A

LABORATORY ANALYSES OF SEPTIC WASTE

MAILED

JUN 09 [illegible]

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

Initial Analysis Report

Customer : Vermont Yankee Nuclear Power Corp.
YAEC ENVIRONMENTAL LAB
Attention: MS ELAINE KEEGAN
MR. [illegible] FLEMING

MR. STEPHEN SKIBNIOWSKY

Report Date: 06/09/88
Analysis Date: 6 /8 /88
Date Received: 6 /8 /88
Reference Date: 6 /8 /88

Sludge

Sample Amount: 1.01 Kg.

Elapsed Time : 0.65 days

Lab Sample No.: G72970
Sample Submission Code: VSL 02 2388
Other Analysis Requested: None
Comment: COB TANK BOTTOM

	NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram - WET]	MDC
	Np-239	8.24E-01	(-15 +- 11) E 0	35 E 0
	Co-57	9.98E-01	(5 +- 94) E-2	310 E-2
	Ce-144	9.98E-01	(-9 +- 73) E-1	240 E-1
	Ce-141	9.86E-01	(26 +- 17) E-1	55 E-1
	Mo-99	8.49E-01	(11 +- 20) E 0	65 E 0
	Se-75	9.96E-01	(-6 +- 15) E-1	49 E-1
	Cr-51	9.84E-01	(41 +- 93) E-1	310 E-1
	I -131	9.45E-01	(-15 +- 11) E-1	37 E-1
	Be-7	9.92E-01	(102 +- 94) E-1	310 E-1
	Ru-103	9.89E-01	(-11 +- 12) E-1	38 E-1
	I -133	5.95E-01	(22 +- 17) E-1	58 E-1
	Ba-140	9.65E-01	(-175 +- 68) E-1	230 E-1
	Cs-134	9.99E-01	(16 +- 16) E-1	53 E-1
	Ru-106	9.99E-01	(4 +- 13) E 0	43 E 0
*+	Cs-137	1.00E 00	(103 +- 18) E-1	54 E-1
	Ag-110M	9.98E-01	(-2 +- 19) E-1	64 E-1
	Zr-95	9.93E-01	(-19 +- 24) E-1	79 E-1
	Co-58	9.94E-01	(7 +- 13) E-1	42 E-1
	Mn-54	9.99E-01	(-7 +- 14) E-1	50 E-1
*+	AcTh228	1.00E 00	(287 +- 68) E-1	230 E-1
	TeI-132	8.70E-01	(117 +- 99) E-1	330 E-1
	Fe-59	9.90E-01	(-33 +- 27) E-1	91 E-1
	Zn-65	9.98E-01	(89 +- 36) E-1	120 E-1
*+	Co-60	1.00E 00	(454 +- 31) E-1	82 E-1
*+	K -40	1.00E 00	(87 +- 23) E 0	75 E 0
	Sb-124	9.92E-01	(-31 +- 31) E-1	100 E-1

Notes:
* Activity greater than 3*standard deviation
+ Peak is found

Approved by

D.E. McCurdy

D.E.McCurdy.

The quoted one-sigma uncertainty terms do not represent the propagation of all possible errors associated with the radioactive decay process (counting statistics). Estimates of the additional systematic and random uncertainties are the calibration curve, ± 5 percent, sample positioning (source to detector), ± 2 percent, sample non-homogeneity, ± 10 percent, and sample self-absorption, ± 10 percent.

MAILED

JUN 09 [illegible]

YAEC

ENVIRONMENTAL LAB

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

Initial Analysis Report

Customer: Vermont Yankee Nuclear Power Corp.
Attention: MS. ELAINE KEEGAN
MR. EDWARD CUMMING
MR. STEPHEN SKIBNIOWSKY

Report Date: 06/09/88
Analysis Date: 6 /8 /88
Date Received: 6 /8 /88
Reference Date: 6 /8 /88

Sludge

Sample Amount: 1.02 Kg.

Elapsed Time : 0.63 days

Lab Sample No.: G72971
Sample Submission Code: VSL 03 2388
Other Analysis Requested: None
Comment: COB TANK-LIQUID

	NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram-WET]	MDC
	Np-239	8.29E-01	(6 +- 10) E 0	34 E 0
	Co-57	9.98E-01	(65 +- 93) E-2	310 E-2
	Ce-144	9.98E-01	(20 +- 67) E-1	220 E-1
	Ce-141	9.87E-01	(0 +- 16) E-1	52 E-1
	Mo-99	8.54E-01	(-25 +- 19) E 0	63 E 0
	Se-75	9.96E-01	(4 +- 14) E-1	48 E-1
	Cr-51	9.84E-01	(81 +- 86) E-1	290 E-1
	I -131	9.47E-01	(8 +- 11) E-1	38 E-1
	Be-7	9.92E-01	(1 +- 10) E 0	35 E 0
	Ru-103	9.89E-01	(17 +- 12) E-1	41 E-1
	I -133	6.05E-01	(-1 +- 19) E-1	65 E-1
	Ba-140	9.66E-01	(33 +- 72) E-1	240 E-1
	Cs-134	9.99E-01	(-17 +- 14) E-1	48 E-1
	Ru-106	9.99E-01	(-1 +- 12) E 0	40 E 0
	Cs-137	1.00E 00	(-5 +- 13) E-1	44 E-1
	Ag-110M	9.98E-01	(-6 +- 16) E-1	54 E-1
	Zr-95	9.93E-01	(20 +- 22) E-1	75 E-1
	Co-58	9.94E-01	(13 +- 12) E-1	39 E-1
	Mn-54	9.99E-01	(11 +- 12) E-1	39 E-1
	AcTh228	1.00E 00	(-21 +- 66) E-1	260 E-1
	TeI-132	8.73E-01	(16 +- 91) E-1	300 E-1
	Fe-59	9.90E-01	(8 +- 28) E-1	93 E-1
	Zn-65	9.98E-01	(72 +- 34) E-1	110 E-1
	Co-60	1.00E 00	(-6 +- 18) E-1	76 E-1
+	K -40	1.00E 00	(55 +- 21) E 0	76 E 0
	Sb-124	9.93E-01	(6 +- 34) E-1	110 E-1

Notes:
+ Peak is found

Approved by

D.E.McCurdy

D.E.McCurdy.

The quoted one-sigma uncertainty terms do not represent the propagation of all possible errors associated with the radioactive decay process (counting statistics). Estimates of the additional systematic and random uncertainties are the calibration curve, ± 5 percent, sample positioning (source to detector), ± 3 percent, sample non-homogeneity, ± 10 percent, and sample self-absorption, ± 10 percent.

MAILED

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

Initial Analysis Report

Customer: Vermont Yankee Nuclear Power Corp.
Attention: MS. ELAINE KEEGAN
MR. EDWARD CUMMING
MR. STEPHEN SKIBNIOWSKY

Report Date: 06/09/88
Analysis Date: 6 /8 /88
Date Received: 6 /8 /88
Reference Date: 6 /8 /88

Sludge

Sample Amount: 0.99 Kg.

Elapsed Time : 0.59 days

Lab Sample No.: G72972
Sample Submission Code: VSL 04 2388
Other Analysis Requested: None
Comment: MAIN TANK BOTTOM

	NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram -WET]	MDC
	Np-239	8.40E-01	(2 +- 21) E 0	70 E 0
	Co-57	9.98E-01	(-10 +- 19) E-1	62 E-1
	Ce-144	9.99E-01	(11 +- 14) E 0	45 E 0
	Ce-141	9.87E-01	(-12 +- 32) E-1	110 E-1
	Mo-99	8.63E-01	(20 +- 38) E 0	120 E 0
	Se-75	9.97E-01	(34 +- 29) E-1	97 E-1
	Cr-51	9.85E-01	(-25 +- 18) E 0	61 E 0
	I -131	9.50E-01	(3 +- 23) E-1	78 E-1
	Be-7	9.92E-01	(-20 +- 19) E 0	65 E 0
	Ru-103	9.90E-01	(-10 +- 24) E-1	81 E-1
	I -133	6.26E-01	(-25 +- 37) E-1	120 E-1
	Ba-140	9.68E-01	(-23 +- 11) E 0	37 E 0
*+	Cs-134	9.99E-01	(130 +- 22) E-1	48 E-1
	Ru-106	9.99E-01	(-1 +- 28) E 0	93 E 0
*+	Cs-137	1.00E 00	(1207 +- 52) E-1	130 E-1
	Ag-110M	9.98E-01	(-8 +- 53) E-1	180 E-1
	Zr-95	9.94E-01	(-77 +- 59) E-1	200 E-1
	Co-58	9.94E-01	(-11 +- 34) E-1	110 E-1
*+	Mn-54	9.99E-01	(393 +- 43) E-1	120 E-1
*+	AcTh228	1.00E 00	(39 +- 11) E 0	32 E 0
	TeI-132	8.81E-01	(-7 +- 29) E 0	98 E 0
	Fe-59	9.91E-01	(68 +- 73) E-1	240 E-1
*+	Zn-65	9.98E-01	(527 +- 82) E-1	230 E-1
*+	Co-60	1.00E 00	(853 +- 12) E 0	14 E 0
*+	K -40	1.00E 00	(223 +- 35) E 0	110 E 0
	Sb-124	9.93E-01	(-12 +- 35) E-1	120 E-1

Notes:
* Activity greater than 3*standard deviation
+ Peak is found

Approved by

D.E.McCurdy

D.E.McCurdy.

The quoted one-sigma uncertainty terms do not represent the propagation of all possible errors associated with the radioactive decay process (counting statistics). Estimates of the additional systematic and random uncertainties are the calibration curve, ± 5 percent, sample positioning (source to detector), ± 3 percent, sample non-homogeneity, ± 10 percent, and sample self-absorption, ± 10 percent.

MAILED

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

Initial Analysis Report

Customer : Vermont Yankee Nuclear Power Corp.
Attention: MS. ELAINE KEEGAN
MR. EDWARD CUMMING
MR. STEPHEN SKIBNIOWSKY

Report Date: 06/20/88
Analysis Date: 6 /15/88
Date Received: 6 /14/88
Reference Date: 6 /8 /88

Septic-Solid

Sample Amount: 0.06 Kg.

Elapsed Time : 7.57 days

Lab Sample No.: G73075
Sample Submission Code: VSLs04 2388
Other Analysis Requested: None

Station No.: 04 Main Tank Bottom

	NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram	MDC]
	Np-239	1.07E-01	(55 +- 25) E 2	85 E 2
	Co-57	9.81E-01	(-9 +- 30) E 0	99 E 0
	Ce-144	9.82E-01	(3 +- 22) E 1	74 E 1
	Ce-141	8.51E-01	(137 +- 60) E 0	190 E 0
	Mo-99	1.51E-01	(-60 +- 29) E 2	97 E 2
	Se-75	9.57E-01	(85 +- 51) E 0	170 E 0
	Cr-51	8.27E-01	(14 +- 36) E 1	120 E 1
	I -131	5.21E-01	(-6 +- 74) E 0	250 E 0
	Be-7	9.06E-01	(12 +- 38) E 1	130 E 1
	Ru-103	8.75E-01	(-2 +- 46) E 0	150 E 0
x	I -133	2.49E-03	----	----
	Ba-140	6.64E-01	(-86 +- 40) E 0	130 E 0
*+	Cs-134	9.93E-01	(166 +- 52) E 0	150 E 0
	Ru-106	9.86E-01	(12 +- 49) E 1	160 E 1
*+	Cs-137	1.00E 00	(3824 +- 92) E 0	200 E 0
	Ag-110M	9.79E-01	(76 +- 96) E 0	320 E 0
	Zr-95	9.22E-01	(-2 +- 11) E 1	36 E 1
	Co-58	9.29E-01	(12 +- 60) E 0	200 E 0
*+	Mn-54	9.83E-01	(1126 +- 74) E 0	200 E 0
*+	AcTh228	1.00E 00	(76 +- 17) E 1	49 E 1
	TeI-132	1.99E-01	(-14 +- 22) E 2	75 E 2
	Fe-59	8.90E-01	(7 +- 14) E 1	48 E 1
*+	Zn-65	9.79E-01	(120 +- 14) E 1	40 E 1
*+	Co-60	9.97E-01	(2240 +- 22) E 1	23 E 1
*+	K -40	1.00E 00	(472 +- 53) E 1	160 E 1
	Sb-124	9.17E-01	(69 +- 61) E 0	200 E 0

Notes:
- * Activity greater than 3*standard deviation
- \+ Peak is found
- x Decay correction less than .01

Approved by

D.E. McCurdy

D.E.McCurdy.

The quoted one-sigma terms include only counting statistics and do not represent the propagation of all possible errors associated with the radioactive decay process. Estimates of the additional systematic and random uncertainties are: calibration curve, ± 5 percent, sample positioning, ± 2 percent, sample non-homogeneity, ± 10 percent, and sample self-absorption, ± 10 percent.

MAILED

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

Initial Analysis Report

Customer : Vermont Yankee Nuclear Power Corp.
Attention: MS. ELAINE KEEGAN
MR. EDWARD CUMMING
MR. STEPHEN SKIBNIOWSKY

Report Date: 06/20/88
Analysis Date: 6 /15/88
Date Received: 6 /14/88
Reference Date: 6 /8 /88

Septic-Liquid Portion

Sample Amount: 1.00 Kg.

Elapsed Time : 7.57 days

Lab Sample No.: G73074
Sample Submission Code: VSL104 2388
Other Analysis Requested: None

Station No.: 04 Main Tank Bottom

NUCLIDE	DECAY CORRECTION	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram	MDC]
Np-239	1.07E-01	(142 +- 88) E 0	290 E 0
Co-57	9.81E-01	(-16 +- 99) E-2	330 E-2
Ce-144	9.82E-01	(60 +- 73) E-1	240 E-1
Ce-141	8.51E-01	(15 +- 19) E-1	63 E-1
Mo-99	1.51E-01	(-123 +- 94) E 0	310 E 0
Se-75	9.57E-01	(-6 +- 15) E-1	50 E-1
Cr-51	8.27E-01	(3 +- 11) E 0	36 E 0
I -131	5.21E-01	(-6 +- 20) E-1	67 E-1
Be-7	9.06E-01	(37 +- 98) E-1	330 E-1
Ru-103	8.75E-01	(-5 +- 13) E-1	44 E-1
xI -133	2.48E-03	----	----
Ba-140	6.64E-01	(-23 +- 23) E-1	77 E-1
Cs-134	9.93E-01	(-9 +- 15) E-1	49 E-1
Ru-106	9.86E-01	(1 +- 12) E 0	41 E 0
Cs-137	1.00E 00	(21 +- 14) E-1	47 E-1
Ag-110M	9.79E-01	(-20 +- 18) E-1	59 E-1
Zr-95	9.22E-01	(29 +- 23) E-1	75 E-1
Co-58	9.29E-01	(20 +- 13) E-1	43 E-1
Mn-54	9.83E-01	(3 +- 13) E-1	42 E-1
AcTh228	1.00E 00	(28 +- 61) E-1	240 E-1
TeI-132	1.99E-01	(25 +- 37) E 0	120 E 0
Fe-59	8.90E-01	(-1 +- 25) E-1	82 E-1
Zn-65	9.79E-01	(31 +- 26) E-1	86 E-1
Co-60	9.97E-01	(-13 +- 22) E-1	86 E-1
+ K -40	1.00E 00	(34 +- 21) E 0	75 E 0
Sb-124	9.16E-01	(68 +- 30) E-1	100 E-1

Notes:
+ Peak is found
x Decay correction less than .01

Approved by

D.E.McCurdy.

The quoted one-sigma terms include only counting statistics and do not represent the propagation of all possible errors associated with the radioactive decay process. Estimates of the additional systematic and random uncertainties are: calibration curve, ± 5 percent, and sample positioning, ± 2 percent.

MAILED

JUL 1 1 [illegible]

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

Initial Analysis Report

Customer : Vermont Yankee Nuclear Power Corp.
Attention: MS. ELAINE KEEGAN
MR. EDWARD CUMMING

Report Date: 07/11/88
Date Received: 6 /14/88

Septic-Solid

LAB. No. SAMPLE CODE	DATE of REFERENCE	DATE of ANALYSIS	VOLUME Kg	NUCLIDE	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / KG - DRY]	MDC
S73075	6 /8	7 /7	0.022	Sr-90	(-14 +- 37)E 0	40E 0
VSLs04 2388	Main Tank Bottom			Sr-89	(52 +- 46)E 0	62E 0

Notes:

.ne quoted one-sigma terms include only counting statistics and do not represent the propagation of all possible errors associated with the radioactive decay process. Estimates of the additional systematic and random uncertainties are: calibration curve, ± 5 percent, and sample positioning, ± 2 percent.

Approved by

D E McCurdy

D.E.McCurdy.

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

MAILED
JUL 11 [illegible]

Initial Analysis Report

Customer: Vermont Yankee Nuclear Power Corp.
Attention: MS. ELAINE KEEGAN
MR. EDWARD CUMMING
YAEC ENVIRONMENTAL LAB.

Report Date: 07/11/88
Date Received: 6 /14/88

Septic-Liquid Portion

LAB. No. SAMPLE CODE	DATE of REFERENCE	ANALYSIS	VOLUME Kg	NUCLIDE	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram]	MDC
S73074	6 /8	6 /19	1.002	Sr-90	(113 +- 98)E-2	200E-2
VSL104 2388	Main Tank Bottom			Sr-89	(-10 +- 11)E-1	22E-1

Notes:

Approved by

D E McCurdy

D.E.McCurdy.

The quoted one-sigma terms include only counting statistics and do not represent the propagation of all possible errors associated with the radioactive decay process. Estimates of the additional systematic and random uncertainties are: calibration curve, ± 5 percent, and sample positioning, ± 2 percent.

MAILED

JUL 11 [illegible]

YAEC

YANKEE ATOMIC ELECTRIC COMPANY
ENVIRONMENTAL LABORATORY

Initial Analysis Report

Customer: Vermont Yankee Nuclear Power Corp.
Attention: MS. ELAINE KEEGAN
MR. EDWARD CUMMING

Report Date: 07/11/88
Date Received: 6 /14/88

Septic-Liquid Portion

LAB. No. SAMPLE CODE	DATE of REFERENCE	ANALYSIS	VOLUME Kg	NUCLIDE	ACTIVITY CONC. +- 1 SIGMA [Pico Curie / Kilogram]	MDC
H73074	6 /8	6 /20	0.003	H-3	(26 +- 15)E 1	49E 1
VSL104 2388	Main Tank Bottom					

Notes:

The quoted one-sigma terms include only counting statistics and do not represent the propagation of all possible errors associated with the radioactive decay process. Estimates of the additional systematic and random uncertainties are: calibration curve, ± 5 percent, and sample positioning, ± 2 percent.

Approved by

D E McCurdy

D.E.McCurdy.

APPENDIX B

Computer Code Outputs

This section contains copies of the computer code outputs employed in the calculation, as follows:

B.1 ALLEGRA - Gamma Ray Spectra

B.2 DILOS-V - Dose Reduction as a Result of Plowing

B.3 ATMODOS - Radiological Impact During VY Control of the Disposal Site

B.3.1 Impact due to Mn-54 in the Septage

B.3.2 Impact due to Co-60 in the Septage

B.3.3 Impact due to Zn-65 in the Septage

B.3.4 Impact due to Cs-134 in the Septage

B.3.5 Impact due to Cs-137 in the Septage

B.3.6 Impact due to All Nuclides in the Septage

B.4 ATMODOS - Radiological Impact After Termination of Vermont Yankee Control of the Disposal Site (All Nuclides)

B.5 ATMODOS - Unplowed-Land Dose Conversion Factors for Radiological Impact Assessment

B.5.1 Impact due to 1 uCi of Mn-54

B.5.2 Impact due to 1 uCi of Co-60

B.5.3 Impact due to 1 uCi of Zn-65

B.5.4 Impact due to 1 uCi of Cs-134

B.5.5 Impact due to 1 uCi of Cs-137

B.1 ALLEGRA - Gamma Ray Spectra

```
ALLEGRA (RADIOACTIVITY & GAMMA SPECTRA - ORIGEN-2 DATA BASE - ENTECH ENGINEERING, INC.  -  MOD 01 06/22/88)    88/06/30. PAGE    1

                                    TAPE 4 INPUT DATA LISTING

CARD              1         2         3         4         5         6         7         8
SEQ.     12345678901234567890123456789012345678901234567890123456789012345678901234567890

  1      VY - DISPOSAL OF CONTAMINATED SEWAGE - FIELD ACTIVITY AFTER 40 TANK FUMPINGS
  2          0    1    1    1    1    1    6    0    2
  3          2    1    1    0    0
  4       1.0       1.0       0.0       0.0       1.0       0.0
  5      MN54      250540     2.831E-06
  6      CO60      270600     2.353E-04
  7      ZN65      300650     2.801E-06
  8      CS134     551340     1.457E-06
  9      CS137     551370     9.259E-05
 10      BA137M    561371     8.759E-05
```

VY - DISPOSAL OF CONTAMINATED SEWAGE - FIELD ACTIVITY AFTER 40 TANK PUMPINGS

USER-SPECIFIED PRINTOUT CONTROL FLAGS:

NUCLIDES IN LIBRARY	: KPRINT(1) =	0
DECAY DATA IN LIBRARY	: KPRINT(2) =	1
GAMMA SPECTRA IN LIBRARY	: KPRINT(3) =	1
CALCULATED ACTIVITIES	: KPRINT(4) =	1
ISOTOPE-SPECIFIC SPECTRA	: KPRINT(5) =	1
TOTAL GAMMA SPECTRA	: KPRINT(6) =	1
TAPE 11 CONTENTS	: KPRINT(7) =	6
TAPE 12 CONTENTS	: KPRINT(8) =	0
INTERMEDIATE DECAY RESULTS	: KPRINT(9) =	2

DATA LIBRARY SELECTION OPTION = 2
INPUT ACTIVITY UNIT CONTROL = 1
GAMMA SPECTRA CONTROL FLAG = 1

SOURCE VOLUME (CUBIC METERS) = 1.0000E+00
SOURCE INTENSITY INPUT MULTIPLIER = 1.0000E+00
MIN. ISOTOPIC ACTIVITY FOR INCLUSION IN THE OUTPUT TABLES = .0000E+00

TOTAL NUMBER OF NUCLIDES IN THE INPUT = 6

LIST OF INPUT NUCLIDES AND ACTIVITIES (CURIES):

250540 2.831E-06 270600 2.353E-04 300650 2.801E-06 551340 1.457E-06 551370 9.259E-05 561371 8.759E-05

THERE IS CS137 AND/OR BA137M IN THE INPUT.
CHECK IF BOTH NUCLIDES ARE IN THE INPUT AND THAT THE BA137M ACTIVITY IS 0.946 TIMES THAT OF CS137.

ALLEGRA (RADIOACTIVITY & GAMMA SPECTRA - ORIGEN-2 DATA BASE - ENTECH ENGINEERING, INC. - MOD 01 06/22/88) 88/06/30. PAGE 3

VY - DISPOSAL OF CONTAMINATED SEWAGE - FIELD ACTIVITY AFTER 40 TANK PUMPINGS

DECAY CONSTANTS (1/HR), BRANCHING FRACTIONS AND DAUGHTER PRODUCTS - TAPE 10 PREPARATION DATE: 88/06/22.

NUCLIDE	DECAY CONST	BETA-GRND	BETA-META	POSI-GRND	POSI-META	ISOMER.TR	ALPHA EM.	BETA+NTRN	SPONT.FIS
MN 54	9.24196E-05	.000E+00	.000E+00	1.000E+00 CR 54	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
CO 60	1.50050E-05	1.000E+00 NI 60	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
ZN 65	1.18430E-04	.000E+00	.000E+00	1.000E+00 CU 65	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
CS134	3.83484E-05	1.000E+00 BA134	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
CS137	2.63582E-06	5.400E-02 BA137	9.460E-01 BA137M	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
BA137M	1.62987E+01	.000E+00	.000E+00	.000E+00	.000E+00	1.000E+00 BA137	.000E+00	.000E+00	.000E+00

TOTAL NUMBER OF RADIONUCLIDES IN THE DATA LIBRARY = 1030

VY - DISPOSAL OF CONTAMINATED SEWAGE - FIELD ACTIVITY AFTER 40 TANK PUMP[illegible]S

PHOTON SPECTRA (PHOTONS/DIS AT GIVEN ENERGY) - TAPE 10 PREPARATION DATE: 88/06/22.

NUCLIDE	.0100 MEV	.0250 MEV	.0375 MEV	.0575 MEV	.0850 MEV	.1250 MEV	.2250 MEV	.3750 MEV	.5750 MEV
	.850 MEV	1.250 MEV	1.750 MEV	2.250 MEV	2.750 MEV	3.500 MEV	5.000 MEV	7.000 MEV	9.000 MEV
MN 54	1.380E-01	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
	9.820E-01	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
CO 60	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	7.030E-05	.000E+00
	7.390E-05	2.000E+00	.000E+00	1.060E-05	3.280E-08	.000E+00	.000E+00	.000E+00	.000E+00
ZN 65	3.160E-01	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	2.750E-05	2.590E-02
	2.720E-05	4.530E-01	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
CS134	3.970E-04	.000E+00	6.580E-03	.000E+00	.000E+00	.000E+00	2.270E-04	1.250E-04	1.270E+00
	8.820E-01	5.830E-02	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
CS137	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
BA137M	4.740E-03	.000E+00	6.510E-02	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	1.030E+00
	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00

TOTAL NUMBER OF GAMMA SPECTRA IN THE DATA LIBRARY = 435

VY - DISPOSAL OF CONTAMINATED SEWAGE - FIELD ACTIVITY AFTER 40 TANK PUMPINGS

DECAYED RADIOACTIVITY (CURIES) AS A FUNCTION OF DECAY TIME (HRS)

NUCLIDE	.0000E+00
MN 54	2.8310E-06
CO 60	2.3530E-04
ZN 65	2.8010E-06
CS134	1.4570E-06
CS137	9.2590E-05
BA137M	8.7590E-05

VY - DISPOSAL OF CONTAMINATED SEWAGE - FIELD ACTIVITY AFTER 40 TANK PUMPINGS

RADIOACTIVITY TOTALS (CURIES) AS A FUNCTION OF DECAY TIME (HRS)

	NUCLIDES WITH ACTIVITY > .000E+00 (USER-SPECIFIED LIMIT)					ALL NUCLIDES ENCOUNTERED IN THE ANALYSIS				
T(HRS)	NOB. GASES	HALOGENS	OTHER	TOTAL	GIVEN MIX	NOB. GASES	HALOGENS	OTHER	TOTAL	GIVEN MIX
.000E+00	.0000E+00	.0000E+00	4.2257E-04	4.2257E-04	4.2257E-04	.0000E+00	.0000E+00	4.2257E-04	4.2257E-04	4.2257E-04

NUCLIDE MIX CONSISTS OF .0 % NOBLE GASES, .0 % HALOGENS, AND 100.0 % OTHERS

UY - DISPOSAL OF CONTAMINATED SEWAGE - FIELD ACTIVITY AFTER 40 TANK PUMPINGS

18-GROUP GAMMA ENERGY RELEASE RATES (MEV/SEC) AT T - .000E+00 HOURS

NUCLIDE	ACTIVITY (CURIES)	.0100 MEV .225 MEV 2.250 MEV	.0250 MEV .375 MEV 2.750 MEV	.0375 MEV .575 MEV 3.500 MEV	.0575 MEV .850 MEV 5.000 MEV	.0850 MEV 1.250 MEV 7.000 MEV	.1250 MEV 1.750 MEV 9.000 MEV	TOTAL
MN 54	2.831E-06	1.446E+02	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	
		.000E+00	.000E+00	.000E+00	8.743E+04	.000E+00	.000E+00	
		.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	8.758E+04
CO 60	2.353E-04	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	
		.000E+00	2.295E+02	.000E+00	5.469E+02	2.177E+07	.000E+00	
		2.076E+02	7.853E-01	.000E+00	.000E+00	.000E+00	.000E+00	2.177E+07
ZN 65	2.801E-06	3.275E+02	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	
		.000E+00	1.069E+00	1.543E+03	2.396E+00	5.868E+04	.000E+00	
		.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	6.056E+04
CS134	1.457E-06	2.140E-01	.000E+00	1.330E+01	.000E+00	.000E+00	.000E+00	
		2.753E+00	2.527E+00	3.937E+04	4.042E+04	3.929E+03	.000E+00	
		.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	8.373E+04
CS137	9.259E-05	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	
		.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	
		.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00
BA137M	8.759E-05	1.536E+02	.000E+00	7.912E+03	.000E+00	.000E+00	.000E+00	
		.000E+00	.000E+00	1.919E+06	.000E+00	.000E+00	.000E+00	
		.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	.000E+00	27E+06

VY - DISPOSAL OF CONTAMINATED SEWAGE - FIELD ACTIVITY AFTER 40 TANK PUMPINGS

GAMMA ENERGY RELEASE RATES (MEV/SEC) - ALL NUCLIDES OTHER THAN NOBLE GASES AND HALOGENS - (0, 0, 100)

AS A FUNCTION OF DECAY TIME (HOURS) - ORIGEN-2 GAMMA ENERGY GROUPS

E (MEV)	.0000E+00
.0100	6.2587E+02
.0250	.0000E+00
.0375	7.9250E+03
.0575	.0000E+00
.0850	.0000E+00
.1250	.0000E+00
.2250	2.7534E+00
.3750	2.3311E+02
.5750	1.9603E+06
.8500	1.2840E+05
1.2500	2.1828E+07
1.7500	.0000E+00
2.2500	2.0764E+02
2.7500	7.8529E-01
3.5000	.0000E+00
5.0000	.0000E+00
7.0000	.0000E+00
9.0000	.0000E+00
TOTAL	2.3926E+07

VY - DISPOSAL OF CONTAMINATED SEWAGE - FIELD ACTIVITY AFTER 40 TANK PUMPINGS

GRAND TOTAL GAMMA ENERGY RELEASE RATES (MEV/SEC) - NOBLE GASES, HALOGENS AND OTHERS - (100,100,100)

AS A FUNCTION OF DECAY TIME (HOURS) - ORIGEN-2 GAMMA ENERGY GROUPS

E (MEV)	.0000E+00
.0100	6.2587E+02
.0250	.0000E+00
.0375	7.9250E+03
.0575	.0000E+00
.0850	.0000E+00
.1250	.0000E+00
.2250	2.7534E+00
.3750	2.3311E+02
.5750	1.9603E+06
.8500	1.2840E+05
1.2500	2.1828E+07
1.7500	.0000E+00
2.2500	2.0764E+02
2.7500	7.8529E-01
3.5000	.0000E+00
5.0000	.0000E+00
7.0000	.0000E+00
9.0000	.0000E+00
TOTAL	2.3926E+07

VY - DISPOSAL OF CONTAMINATED SEWAGE - FIELD ACTIVITY AFTER 40 TANK PUMPINGS

GAMMA ENERGY RELEASE RATES (MEV/SEC) - USER-SPECIFIED MIX - (NOB, HAL, OTHER) - (.0, .0,100.0)

AS A FUNCTION OF DECAY TIME (HOURS) - ORIGEN-2 GAMMA ENERGY GROUPS

E (MEV)	.0000E+00
.0100	6.2587E+02
.0250	.0000E+00
.0375	7.9250E+03
.0575	.0000E+00
.0850	.0000E+00
.1250	.0000E+00
.2250	2.7534E+00
.3750	2.3311E+02
.5750	1.9603E+06
.8500	1.2840E+05
1.2500	2.1828E+07
1.7500	.0000E+00
2.2500	2.0764E+02
2.7500	7.8529E-01
3.5000	.0000E+00
5.0000	.0000E+00
7.0000	.0000E+00
9.0000	.0000E+00
TOTAL	2.3926E+07

***** END OF ANALYSIS *****

B.2 DIDOS-V - Dose Reduction as a Result of Plowing

```
DIDOS-V (CYLINDRICAL RADIATION SOURCE DOSIMETRY)   - ENTECH ENGINEERING/YANKEE ATOMIC - (MOD 01 - 10/15/86 )  88/07/02. PAGE    1

                              INPUT DATA LISTING  -  TAPE  4

 CARD             1         2         3         4         5         6         7         8
 SEQ.    1234567890123456789012345678901234567890123456789012345678901234567890123456789 0

   1     VY - DISP. OF CONTAM. SEWAGE - ACTIV. FROM 40 PUMPOUTS/2 ACRES - UNPLOWED LAND
   2         1    0    6    1    2    1 0.0        0.1236    5.0       50.0
   3         1       0.0        150.0     0.001
   4         1       0.0        150.0     0.001
   5      1.001      -1.0
```

INPUT DATA LISTING - TAPE 11

```
CARD             1         2         3         4         5         6         7         8
SEQ.    12345678901234567890123456789012345678901234567890123456789012345678901234567890

  1     VY - DISPOSAL OF CONTAMINATED SEWAGE - FIELD EQUILIBRIUM ACTIVITY (MEV/SEC)
  2     TIME (HRS)          .000E+00
  3      3.750E-02 3.750E-01 5.750E-01 8.500E-01 1.250E+00 2.250E+00
  4      7.925E+03 2.331E+02 1.960E+06 1.284E+05 2.183E+07 2.076E+02
```

VY - DISP. OF CONTAM. SEWAGE - ACTIV. FROM 40 PUMPOUTS/2 ACRES - UNPLOWED LAND

RECEPTOR 1 TIME (HRS) - .00

** SOURCE DESCRIPTION

UPRIGHT CIRCULAR CYLINDER MATERIAL - AIR
RADIUS (METERS) - 1.500E+02 HEIGHT (METERS) - 1.000E-03
VOLUME (CUB.M.) - 7.069E+01 DENSITY (G/CC) - 1.293E-03
MINIMUM SOURCE INTENSITY FOR INDEPENDENT ANALYSIS - .000E+00
SOURCE INTENSITY INPUT MULTIPLIER - 1.236E-01
MAX ENERGY DIFF FOR INDEPENDENT ANALYSIS (PERCENT) - 5.000E+00

** CONTAINER	MATERIAL	DENSITY(G/CC)	RADIUS (M)	HEIGHT (M)	RAD. THICKNESS (M)
	NONE				

** SHIELD SLABS	MATERIAL	DENSITY(G/CC)	THICKNESS (M)	ANGLE (DEG)	DELTA
	AIR	1.293E-03			

** DOSE POINT DESCRIPTION RECEPTOR ON AXIS 2-DIMENSIONAL ANALYSIS

ELEVATION RELATIVE TO LOWER END OF SOURCE (METERS) - 1.001E+00

** RESULTS

GAMMA GROUP	ENERGY (MEV)	ADJ. INTENS (MEV/S-M3)	SOURCE ATT COEF (1/M)	CONTAINER MU*T RADIAL	CONTAINER MU*T AXIAL	SHIELD MU*T	OVERALL BUILDUP	INTGRL VAL WITH BLDUP	DOSE TO AIR (R/HR)
1	.038	9.795E+02	3.423E-02	.000	.000	.000	1.737E+00	2.443E-03	1.009E-09
2	.375	2.881E+01	1.266E-02	.000	.000	.000	1.330E+00	2.484E-03	1.211E-11
3	.575	2.423E+05	1.060E-02	.000	.000	.000	1.241E+00	2.408E-03	9.941E-08
4	.850	1.587E+04	8.687E-03	.000	.000	.000	1.183E+00	2.375E-03	6.232E-09
5	1.250	2.698E+06	7.355E-03	.000	.000	.000	1.139E+00	2.362E-03	9.783E-07
6	2.250	2.566E+01	5.398E-03	.000	.000	.000	1.092E+00	2.367E-03	8.052E-12
								TOTAL	1.085E-06

MAXIMUM PATH-LENGTH USED IN ANALYSIS (MFP) - 50.0

* * * * * * * * * * * END OF PROBLEM * * * * * * * * * * *

INPUT DATA LISTING - TAPE 4

```
CARD           1         2         3         4         5         6         7         8
SEQ.  12345678901234567890123456789012345678901234567890123456789012345678901234567890

  1   VY - DISP. OF CONTAM. SEWAGE - ACTIV. FROM 40 PUMPOUTS/2 ACRES - PLOWED LAND
  2        1    0    6    1    2    1 0.0       8.237E-04 3.0       50.0
  3        3       1.6       150.0      .15
  4        3       1.6       150.0      .15
  5     1.15      -1.0
```

```
                              INPUT DATA LISTING  -  TAPE 11

CARD             1         2         3         4         5         6         7         8
SEQ.    12345678901234567890123456789012345678901234567890123456789012345678901234567890

  1     VY - DISPOSAL OF CONTAMINATED SEWAGE - FIELD EQUILIBRIUM ACTIVITY (MEV/SEC)
  2     TIME (HRS)           .000E+00
  3      3.750E-02 3.750E-01 5.750E-01 8.500E-01 1.250E+00 2.250E+00
  4      7.925E+03 2.331E+02 1.960E+06 1.284E+05 2.183E+07 2.076E+02
```

VY - DISP. OF CONTAM. SEWAGE - ACTIV. FROM 40 PUMPOUTS/2 ACRES - PLOWED LAND

RECEPTOR 1 TIME (HRS) - .00

** SOURCE DESCRIPTION

UPRIGHT CIRCULAR CYLINDER		MATERIAL -	CONCRETE
RADIUS (METERS) -	1.500E+02	HEIGHT (METERS) -	1.500E-01
VOLUME (CUB.M.) -	1.060E+04	DENSITY (G/CC) -	1.600E+00
MINIMUM SOURCE INTENSITY FOR INDEPENDENT ANALYSIS -			.000E+00
SOURCE INTENSITY INPUT MULTIPLIER -			8.237E-04
MAX ENERGY DIFF FOR INDEPENDENT ANALYSIS (PERCENT) -			3.000E+00

** CONTAINER	MATERIAL	DENSITY(G/CC)	RADIUS (M)	HEIGHT (M)	RAD. THICKNESS (M)
	NONE				

** SHIELD SLABS	MATERIAL	DENSITY(G/CC)	THICKNESS (M)	ANGLE (DEG)	DELTA
	AIR	1.293E-03			

** DOSE POINT DESCRIPTION RECEPTOR ON AXIS 2-DIMENSIONAL ANALYSIS

ELEVATION RELATIVE TO LOWER END OF SOURCE (METERS) = 1.150E+00

** RESULTS

GAMMA GROUP	ENERGY (MEV)	ADJ. INTENS (MEV/S-M3)	SOURCE ATT COEF (1/M)	CONTAINER MU*T RADIAL	CONTAINER MU*T AXIAL	SHIELD MU*T	OVERALL BUILDUP	INTGRL VAL WITH BLDUP	DOSE TO AIR (R/HR)
1	.038	6.528E+00	1.114E+02	.000	.000	.000	1.571E+00	6.181E-03	1.701E-11
2	.375	1.920E-01	1.582E+01	.000	.000	.000	2.598E+00	7.577E-02	2.462E-12
3	.575	1.614E+03	1.321E+01	.000	.000	.000	2.274E+00	7.860E-02	2.162E-08
4	.850	1.058E+02	1.102E+01	.000	.000	.000	2.014E+00	8.198E-02	1.434E-09
5	1.250	1.798E+04	9.109E+00	.000	.000	.000	1.812E+00	8.689E-02	2.398E-07
6	2.250	1.710E-01	6.742E+00	.000	.000	.000	1.576E+00	9.613E-02	2.179E-12
								TOTAL	2.629E-07

MAXIMUM PATH-LENGTH USED IN ANALYSIS (MFP) = 50.0

* * * * * * * * * * END OF PROBLEM * * * * * * * * * *

B.3 ATMODOS - Radiological Impact During VY Control of the Disposal Site

Presented below is a partial listing of one of the ATMODOS Tape 5 inputs used in this portion of the calculation. It corresponds to the output in Sec. B.3.6 below. With the exception of the nuclide data library, a large portion of which was deleted due to space limitations, the listing is complete.

The Tape 5 listings corresponding to the outputs in Sec. B.3.1 through B.3.5 are similar, except that a single isotope was analyzed in each case. Also, the tables with the detailed pathway/isotope/organ exposures were excluded from the output.

```
1 1VYPI   VY STANDARD PROGRAM INFORMATION FILE
VY - SEWAGE CONTAM - SOLIDS 1% BY WT - 2 ACRES - SHIELD F = 0.012 - 104 HR OCCUP
1.  .200  44.56FRESH  .500YESNO NO 0..012 1.NO NO NO 0.1.00
--EOR--
--EOF--
0 2VYGASRLGAS STK            VY 87 1 1 0 87063023:
     MN54  4.132E-6 25 MN  54
     CO60  2.511E-4 27 CO  60
     ZN65  4.502E-6 30 ZN  65
     CS134 1.715E-6 55 CS 134
     CS137 9.366E-5 55 CS 137
--EOR--
--EOF--
1 5QUERY  PATHWAYS: SHORE(1,2,3),BND,ROAD,RES1,RAD,MEAT,GOAT,COW
SHORE1    YESYES
SHORE2    YESYES
SHORE3    YESYES
BOUND     YESYES
ROAD      YESYES
RES1      YESYESYESYES
RADIUS    YESYES
MEAT      YESYESYESYES        YESYESYES
GOAT      YESYESYESYES    YES    YESYES
COW       YESYESYESYESYES        YESYES
--EOR--
--EOF--
```

1 6VYUFMAXVY MAXIMUM INDIVIDUAL USAGE FACTORS FOR STANDARD PFORBLEMS

520.00	64.00	310.00	110.00	21.00	.00	.00	12.00	.00	8000.00
630.00	42.00	400.00	65.00	16.00	.00	.00	67.00	.00	8000.00
520.00	26.00	330.00	41.00	6.90	.00	.00	14.00	.00	3700.00
.00	.00	330.00	.00	.00	.00	.00	.00	.00	1400.00

--EOR--

--EOF--

1 7VYGSD VY MAX INDIVIDUAL GAS SITE DATA FILE FOR STANDARD PROBLEMS

2.00	2.00	.70	2.00	.70	2.00	.70	2.00
240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00
.00	.00	48.00	48.00	48.00	48.00	480.00	480.00
8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1440.00	24.00	.00	2160.00	.00	2160.00	.00	2160.00
.00	.00	50.00	50.00	6.00	6.00	50.00	50.00
.00	.00	.50	.00	.50	.00	.50	.00
.00	.00	1.00	.00	1.00	.00	1.00	.00
1.0	1.00	.00	.00	.00	.00	.00	.00
5.60	.00	.00	.00	.00	.00	.00	.00

--EOR--

--EOF--

```
1 8ISTPNBLNUCLIDE LIBRARY FOR ALL DOSE PROGRAMS
      89
  1  3 1.78E-090.00E+000.00E+00                                          SOLUBLE
 H 9.0E-01 9.0E-01 9.0E-01 9.0E-01 9.3E-01 9.3E-01 4.8E-00 1.0E-02 1.2E-02
0.      1.05E-071.05E-071.05E-071.05E-071.05E-071.05E-07
0.      1.58E-071.58E-071.58E-071.58E-071.58E-071.58E-07
0.      1.06E-071.06E-071.06E-071.06E-071.06E-071.06E-07
0.      1.59E-071.59E-071.59E-071.59E-071.59E-071.59E-07
0.      2.03E-072.03E-072.03E-072.03E-072.03E-072.03E-07
0.      3.04E-073.04E-073.04E-073.04E-073.04E-073.04E-07
0.      3.08E-073.08E-073.08E-073.08E-073.08E-073.08E-07
0.      4.62E-074.62E-074.62E-074.62E-074.62E-074.62E-07
  6 14 3.83E-12                                                          SOLUBLE
 C 4.6E+03 9.1E+03 4.6E+03 1.8E+03 1.4E+03 1.8E+03 5.5E+00 1.2E-02 3.1E-02
2.84E-065.68E-075.68E-075.68E-075.68E-075.68E-075.68E-07
2.27E-064.26E-074.26E-074.26E-074.26E-074.26E-074.26E-07
4.06E-068.12E-078.12E-078.12E-078.12E-078.12E-078.12E-07
3.25E-066.09E-076.09E-076.09E-076.09E-076.09E-076.09E-07
1.21E-052.42E-062.42E-062.42E-062.42E-062.42E-062.42E-06
9.70E-061.82E-061.82E-061.82E-061.82E-061.82E-061.82E-06
2.37E-055.06E-065.06E-065.06E-065.06E-065.06E-065.06E-06
1.89E-053.79E-063.79E-063.79E-063.79E-063.79E-063.79E-06
 11 24 1.28E-052.50E-08        2.90E-08                                  SOLUBLE
  .
  .
  .
  .
  ETC (FOR A TOTAL OF 89 NUCLIDES)

--EOR--
--EOF--
1 3VYXQF  VY X/QFILE - SPECIAL VALUES - SEWAGE CONTAM. PROBLEM - 2 ACRE PLOTS
 FLD     0  COW   MEAT         4.626E-04 4.626E-04 1.236E-04 4.626E-04
--EOR--
--EOF--
```

B.3.1 Impact due to Mn 54 in the Septage

PROGRAM ATHODOS
YANKEE ATOMIC ELECTRIC COMPANY
DEC, 1985 REV. 7

REGULATORY GUIDE 1.109, APPENDIX C
MODELS FOR CALCULATING DOSE VIA
ADDITIONAL PATHWAYS FROM RADIOIODINES
AND OTHER RADIONUCLIDES DISCHARGED
TO THE ATMOSPHERE NOV,1977 LIBRARY

SECTOR		~D
DISTANCE		0 (METERS)
X/Q	-	4.63E-04 (SEC/M-3)
X/Q DEPLETED	-	4.63E-04 (SEC/M-3)
DELTA	-	1.24E-04 (1/M-2)

VY - SEWAGE CONTAM - SOLIDS 1% BY WT - 2 ACRES - SHIELD F - 0.012 - 104 HR OCCUP

6 PATHWAYS CONSIDERED

GROUND PLANE	YES
INHALATION	YES
STORED VEGETABLES	YES
LEAFY VEGETABLES	YES
COW MILK	YES
GOAT MILK	NO
MEAT	YES

THE FOLLOWING 1 NUCLIDES WERE USED IN THIS CALCULATION

NUCLIDE	RELEASE CURIES
25 MN 54	4.13E-06

VARIABLE			VEGETABLES		COW MILK		GOAT MILK		MEAT	
			STORED	LEAFY	PASTURE	STORED	PASTURE	STORED	PASTURE	STORED
YV	AGRICULTURAL PRODUCTIVITY	(KG/M-2)	2.00	2.00	.70	2.00	.70	2.00	.70	2.00
P	SOIL SURFACE DENSITY	(KG/M-2)	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00
T	TRANSPORT TIME TO USER	(HRS)			48.00	48.00	48.00	48.00	480.00	480.00
TB	SOIL EXPOSURE TIME	(HRS)	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00
TE	CROP EXPOSURE TIME TO PLUME	(HRS)	.00	.00	.00	.00	.00	.00	.00	.00
TH	HOLDUP AFTER HARVEST	(HRS)	1440.00	24.00	.00	2160.00	.00	2160.00	.00	2160.00
DF	ANIMALS DAILY FEED	(KG/DAY)			50.00	50.00	6.00	6.00	50.00	50.00
FP	FRACTION OF YEAR ON PASTURE				.50		.50		.50	
FS	FRACTION PASTURE WHEN ON PASTURE				1.00		1.00		1.00	
FG	FRACTION OF STORED VEG GROWN IN GARDEN		1.00							
FL	FRACTION OF LEAFY VEG GROWN IN GARDEN			1.00						

FI FRACTION ELEMENTAL IODINE - .500
H ABSOLUTE HUMIDITY - 5.60 (GM/M-3)
FC FRACTIONAL EQUILIBRIUM RATIO FOR C-14 - 1.000

USAGE FACTORS

AGE	VEG (KG/YR)	LEAFY VEG (KG/YR)	MILK (LI/YR)	MEAT (KG/YR)	INHALATION (M-3/YR)
ADULT	520.00	64.00	310.00	110.00	8000.00
TEEN	630.00	42.00	400.00	65.00	8000.00
CHILD	520.00	26.00	330.00	41.00	3700.00
INFANT	.00	.00	330.00	.00	1400.00

DOSE DELIVERED TO EACH ORGAN
FROM ALL PATHWAYS COMBINED
(MREM)

BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
2.13E-04	3.18E-04	2.44E-04	2.98E-04	5.30E-04	2.13E-04	2.33E-04	2.50E-04
2.13E-04	3.66E-04	2.59E-04	3.34E-04	5.25E-04	2.13E-04	2.44E-04	2.50E-04
2.13E-04	4.36E-04	2.76E-04	3.09E-04	4.00E-04	2.13E-04	2.73E-04	2.50E-04
2.13E-04	2.18E-04	2.14E-04	2.74E-04	2.15E-04	2.13E-04	2.14E-04	2.50E-04

B.3.2 Impact due to Co 60 in the Septage

PROGRAM ATMODOS
YANKEE ATOMIC ELECTRIC COMPANY
DEC. 1985 REV. 7

REGULATORY GUIDE 1.109, APPENDIX C
MODELS FOR CALCULATING DOSE VIA
ADDITIONAL PATHWAYS FROM RADIOIODINES
AND OTHER RADIONUCLIDES DISCHARGED
TO THE ATMOSPHERE NOV.1977 LIBRARY

SECTOR		FLD
DISTANCE	-	0 (METERS)
X/Q	-	4.63E-04 (SEC/M-3)
X/Q DEPLETED	-	4.63E-04 (SEC/M-3)
DELTA	-	1.24E-04 (1/M-2)

VY - SEWAGE CONTAM - SOLIDS 1% BY WT - 2
ACRES - SHIELD F - 0.012 - 104 HR OCCUP

6 PATHWAYS CONSIDERED

GROUND PLANE	YES
INHALATION	YES
STORED VEGETABLES	YES
LEAFY VEGETABLES	YES
COW MILK	YES
GOAT MILK	NO
MEAT	YES

THE FOLLOWING 1 NUCLIDES WERE USED IN THIS CALCULATION

NUCLIDE	RELEASE CURIES
27 CO 60	2.31E-04

VARIABLE			VEGETABLES		COW MILK		GOAT MILK		MEAT	
			STORED	LEAFY	PASTURE	STORED	PASTURE	STORED	PASTURE	STORED
YV	AGRICULTURAL PRODUCTIVITY	(KG/M-2)	2.00	2.00	.70	2.00	.70	2.00	.70	2.00
P	SOIL SURFACE DENSITY	(KG/M-2)	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00
T	TRANSPORT TIME TO USER	(HRS)			48.00	48.00	48.00	48.00	480.00	480.00
TB	SOIL EXPOSURE TIME	(HRS)	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00
TE	CROP EXPOSURE TIME TO PLUME	(HRS)	.00	.00	.00	.00	.00	.00	.00	.00
TH	HOLDUP AFTER HARVEST	(HRS)	1440.00	24.00	.00	2160.00	.00	2160.00	.00	2160.00
QF	ANIMALS DAILY FEED	(KG/DAY)			50.00	50.00	6.00	6.00	50.00	50.00
FP	FRACTION OF YEAR ON PASTURE				.50		.50		.50	
FS	FRACTION PASTURE WHEN ON PASTURE				1.00		1.00		1.00	
FG	FRACTION OF STORED VEG GROWN IN GARDEN		1.00							
FL	FRACTION OF LEAFY VEG GROWN IN GARDEN			1.00						

FI FRACTION ELEMENTAL IODINE = .500
H ABSOLUTE HUMIDITY = 5.60 (GM/M-3)
FC FRACTIONAL EQUILIBRIUM RATIO FOR C-14 = 1.000

USAGE FACTORS

AGE	VEG (KG/YR)	LEAFY VEG (KG/YR)	MILK (LI/YR)	MEAT (KG/YR)	INHALATION (M-3/YR)
ADULT	520.00	64.00	310.00	110.00	8000.00
TEEN	630.00	42.00	400.00	65.00	8000.00
CHILD	520.00	26.00	330.00	41.00	3700.00
INFANT	.00	.00	330.00	.00	1400.00

DOSE DELIVERED TO EACH ORGAN
FROM ALL PATHWAYS COMBINED
(MREM)

BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
5.20E-02	5.37E-02	5.20E-02	7.40E-02	8.32E-02	5.20E-02	5.56E-02	6.12E-02
5.20E-02	5.44E-02	5.20E-02	8.41E-02	8.30E-02	5.20E-02	5.73E-02	6.12E-02
5.20E-02	5.55E-02	5.20E-02	7.80E-02	7.16E-02	5.20E-02	6.24E-02	6.12E-02
5.20E-02	5.22E-02	5.20E-02	6.86E-02	5.26E-02	5.20E-02	5.25E-02	6.12E-02

PROGRAM ATMODOS
YANKEE ATOMIC ELECTRIC COMPANY
DEC. 1985 REV. 7

REGULATORY GUIDE 1.109, APPENDIX C
MODELS FOR CALCULATING DOSE VIA
ADDITIONAL PATHWAYS FROM RADIOIODINES
AND OTHER RADIONUCLIDES DISCHARGED
TO THE ATMOSPHERE NOV.1977 LIBRARY

SECTOR FLD
DISTANCE = 0 (METERS)
X/Q = 4.63E-04 (SEC/M-3)
X/Q DEPLETED = 4.63E-04 (SEC/M-3)
DELTA = 1.24E-04 (1/M-2)

VY - SEWAGE CONTAM - SOLIDS 1% BY WT - 2
ACRES - SHIELD F - 0.012 - 104 HR OCCUP

6 PATHWAYS CONSIDERED

GROUND PLANE	YES
INHALATION	YES
STORED VEGETABLES	YES
LEAFY VEGETABLES	YES
COW MILK	YES
GOAT MILK	NO
MEAT	YES

THE FOLLOWING 1 NUCLIDES WERE USED IN THIS CALCULATION

NUCLIDE	RELEASE CURIES
30 ZN 65	4.50E-06

VARIABLE			VEGETABLES STORED	VEGETABLES LEAFY	COW MILK PASTURE	COW MILK STORED	GOAT MILK PASTURE	GOAT MILK STORED	MEAT PASTURE	MEAT STORED
YV	AGRICULTURAL PRODUCTIVITY	(KG/M-2)	2.00	2.00	.70	2.00	.70	2.00	.70	2.00
P	SOIL SURFACE DENSITY	(KG/M-2)	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00
T	TRANSPORT TIME TO USER	(HRS)			48.00	48.00	48.00	48.00	480.00	480.00
TB	SOIL EXPOSURE TIME	(HRS)	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00
TE	CROP EXPOSURE TIME TO PLUME	(HRS)	.00	.00	.00	.50	.00	.00	.00	.00
TH	HOLDUP AFTER HARVEST	(HRS)	1440.00	24.00	.00	2160.00	.00	2160.00	.00	2160.00
QF	ANIMALS DAILY FEED	(KG/DAY)			50.00	50.00	6.00	6.00	50.00	50.00
FP	FRACTION OF YEAR ON PASTURE				.50		.50		.50	
FS	FRACTION PASTURE WHEN ON PASTURE				1.00		1.00		1.00	
FG	FRACTION OF STORED VEG GROWN IN GARDEN		1.00							
FL	FRACTION OF LEAFY VEG GROWN IN GARDEN			1.00						

FI FRACTION ELEMENTAL IODINE = .500
H ABSOLUTE HUMIDITY = 5.60 (GM/M-3)
PC FRACTIONAL EQUILIBRIUM RATIO FOR C-14 = 1.000

USAGE FACTORS

AGE	VEG (KG/YR)	LEAFY VEG (KG/YR)	MILK (LI/YR)	MEAT (KG/YR)	INHALATION (M-3/YR)
ADULT	520.00	64.00	310.00	110.00	8000.00
TEEN	630.00	42.00	400.00	65.00	8000.00
CHILD	520.00	26.00	330.00	41.00	3700.00
INFANT	.00	.00	330.00	.00	1400.00

DOSE DELIVERED TO EACH ORGAN
FROM ALL PATHWAYS COMBINED

(MREM)

BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
3.43E-03	1.06E-02	7.13E-03	2.03E-04	6.72E-03	1.46E-04	4.87E-03	1.68E-04
4.61E-03	1.57E-02	1.01E-02	2.28E-04	6.72E-03	1.46E-04	7.38E-03	1.68E-04
8.72E-03	2.30E-02	1.45E-02	2.11E-04	4.16E-03	1.46E-04	1.44E-02	1.68E-04
6.18E-03	2.08E-02	1.02E-02	1.88E-04	1.76E-02	1.46E-04	9.69E-03	1.68E-04

PROGRAM ATMODOS
YANKEE ATOMIC ELECTRIC COMPANY
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REGULATORY GUIDE 1.109, APPENDIX C
MODELS FOR CALCULATING DOSE VIA
ADDITIONAL PATHWAYS FROM RADIOIODINES
AND OTHER RADIONUCLIDES DISCHARGED
TO THE ATMOSPHERE NOV,1977 LIBRARY

SECTOR		FLD
DISTANCE	=	0 (METERS)
X/Q	=	4.63E-04 (SEC/M-3)
X/Q DEPLETED	=	4.63E-04 (SEC/M-3)
DELTA	=	1.24E-04 (1/M-2)

VY - SEWAGE CONTAM - SOLIDS 1% BY WT - 2 ACRES - SHIELD F = 0.012 - 104 HR OCCUP

THE FOLLOWING 1 NUCLIDES WERE USED IN THIS CALCULATION

NUCLIDE	RELEASE CURIES
CS CS 134	1.72E-06

6 PATHWAYS CONSIDERED

GROUND PLANE	YES
INHALATION	YES
STORED VEGETABLES	YES
LEAFY VEGETABLES	YES
COW MILK	YES
GOAT MILK	NO
MEAT	YES

VARIABLE			VEGETABLES		COW MILK		GOAT MILK		MEAT	
			STORED	LEAFY	PASTURE	STORED	PASTURE	STORED	PASTURE	STORED
YV	AGRICULTURAL PRODUCTIVITY	(KG/M-2)	2.00	2.00	.70	2.00	.70	2.00	.70	2.00
P	SOIL SURFACE DENSITY	(KG/M-2)	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00
T	TRANSPORT TIME TO USER	(HRS)			48.00	48.00	48.00	48.00	480.00	480.00
TB	SOIL EXPOSURE TIME	(HRS)	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00
TE	CROP EXPOSURE TIME TO PLUME	(HRS)	.00	.00	.00	.00	.00	.00	.00	.00
TH	HOLDUP AFTER HARVEST	(HRS)	1440.00	24.00	.00	2160.00	.00	2160.00	.00	2160.00
QF	ANIMALS DAILY FEED	(KG/DAY)			50.00	50.00	6.00	6.00	50.00	50.00
FP	FRACTION OF YEAR ON PASTURE				.50		.50		.50	
FS	FRACTION PASTURE WHEN ON PASTURE				1.00		1.00		1.00	
FG	FRACTION OF STORED VEG GROWN IN GARDEN		1.00							
FL	FRACTION OF LEAFY VEG GROWN IN GARDEN			1.00						

FI FRACTION ELEMENTAL IODINE = .500
H ABSOLUTE HUMIDITY = 5.60 (GM/M-3)
PC FRACTIONAL EQUILIBRIUM RATIO FOR C-14 = 1.000

USAGE FACTORS

AGE	VEG (KG/YR)	LEAFY VEG (KG/YR)	MILK (LI/YR)	MEAT (KG/YR)	INHALATION (M-3/YR)
ADULT	520.00	64.00	310.00	110.00	8000.00
TEEN	630.00	42.00	400.00	65.00	8000.00
CHILD	520.00	26.00	330.00	41.00	3700.00
INFANT	.00	.00	330.00	.00	1400.00

DOSE DELIVERED TO EACH ORGAN
FROM ALL PATHWAYS COMBINED
(MREM)

AGE	BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
ADULT	5.89E-04	1.09E-03	5.06E-04	3.20E-04	2.42E-04	2.27E-04	9.31E-04	2.65E-04
TEEN	7.92E-04	1.56E-03	6.50E-04	3.89E-04	2.44E-04	2.27E-04	8.44E-04	2.65E-04
CHILD	1.50E-03	2.31E-03	8.74E-04	4.59E-04	2.38E-04	2.27E-04	6.67E-04	2.65E-04
INFANT	7.74E-04	1.25E-03	4.89E-04	3.35E-04	2.30E-04	2.27E-04	3.30E-04	2.65E-04

PROGRAM ATMODOS
YANKEE ATOMIC ELECTRIC COMPANY
DEC, 1985 REV. 7

REGULATORY GUIDE 1.109, APPENDIX C
MODELS FOR CALCULATING DOSE VIA
ADDITIONAL PATHWAYS FROM RADIOIODINES
AND OTHER RADIONUCLIDES DISCHARGED
TO THE ATMOSPHERE NOV,1977 LIBRARY

SECTOR		FLD
DISTANCE	=	0 (METERS)
X/Q	=	4.63E-04 (SEC/M-3)
X/Q DEPLETED	=	4.63E-04 (SEC/M-3)
DELTA	=	1.24E-04 (1/M-2)

VY - SEWAGE CONTAM - SOLIDS 1% BY WT - 2
ACRES - SHIELD F = 0.012 - 104 HR OCCUP

6 PATHWAYS CONSIDERED

GROUND PLANE	YES
INHALATION	YES
STORED VEGETABLES	YES
LEAFY VEGETABLES	YES
COW MILK	YES
GOAT MILK	NO
MEAT	YES

THE FOLLOWING 1 NUCLIDES WERE USED IN THIS CALCULATION

NUCLIDE	RELEASE CURIES
55 CS 137	9.37E-05

VARIABLE			VEGETABLES STORED	VEGETABLES LEAFY	COW MILK PASTURE	COW MILK STORED	GOAT MILK PASTURE	GOAT MILK STORED	MEAT PASTURE	MEAT STORED
YV	AGRICULTURAL PRODUCTIVITY	(KG/M-2)	2.00	2.00	.70	2.00	.70	2.00	.70	2.00
P	SOIL SURFACE DENSITY	(KG/M-2)	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00
T	TRANSPORT TIME TO USER	(HRS)			48.00	48.00	48.00	48.00	480.00	480.00
TP	SOIL EXPOSURE TIME	(HRS)	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00
TE	CROP EXPOSURE TIME TO PLUME	(HRS)	.00	.00	.00	.00	.00	.00	.00	.00
TH	HOLDUP AFTER HARVEST	(HRS)	1440.00	24.00	.00	2160.00	.00	2160.00	.00	2160.00
DF	ANIMALS DAILY FEED	(KG/DAY)			50.00	50.00	6.00	6.00	50.00	50.00
FP	FRACTION OF YEAR ON PASTURE				.50		.50		.50	
FS	FRACTION PASTURE WHEN ON PASTURE				1.00		1.00		1.00	
FG	FRACTION OF STORED VEG GROWN IN GARDEN		1.00							
FL	FRACTION OF LEAFY VEG GROWN IN GARDEN			1.00						

FI FRACTION ELEMENTAL IODINE = .500
H ABSOLUTE HUMIDITY = 5.60 (GM/M-3)
PC FRACTIONAL EQUILIBRIUM RATIO FOR C-14 = 1.000

USAGE FACTORS

AGE	VEG (KG/YR)	LEAFY VEG (KG/YR)	MILK (LI/YR)	MEAT (KG/YR)	INHALATION (M-3/YR)
ADULT	520.00	64.00	310.00	110.00	8000.00
TEEN	630.00	42.00	400.00	65.00	8000.00
CHILD	520.00	26.00	330.00	41.00	3700.00
INFANT	.00	.00	330.00	.00	1400.00

DOSE DELIVERED TO EACH ORGAN
FROM ALL PATHWAYS COMBINED
(MREM)

BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
3.57E-02	4.70E-02	1.93E-02	9.79E-03	5.86E-03	5.06E-03	3.25E-02	5.90E-03
5.52E-02	7.18E-02	2.78E-02	1.39E-02	6.00E-03	5.06E-03	2.83E-02	5.90E-03
1.23E-01	1.18E-01	4.19E-02	1.83E-02	5.76E-03	5.06E-03	2.18E-02	5.90E-03
5.50E-02	6.35E-02	2.07E-02	1.14E-02	5.24E-03	5.06E-03	9.20E-03	5.90E-03

PROGRAM ATMODOS
YANKEE ATOMIC ELECTRIC COMPANY
DEC. 1985 REV. 7

REGULATORY GUIDE 1.109, APPENDIX C
MODELS FOR CALCULATING DOSE VIA
ADDITIONAL PATHWAYS FROM RADIOIODINES
AND OTHER RADIONUCLIDES DISCHARGED
TO THE ATMOSPHERE NOV.1977 LIBRARY

SECTOR		FLD
DISTANCE	-	0 (METERS)
X/Q	-	4.63E-04 (SEC/M-3)
X/Q DEPLETED	-	4.63E-04 (SEC/M-3)
DELTA	-	1.24E-04 (1/M-2)

VY - SEWAGE CONTAM - SOLIDS 1% BY WT - 2
ACRES - SHIELD F - 0.012 - 104 HR OCCUP

6 PATHWAYS CONSIDERED

GROUND PLANE	YES
INHALATION	YES
STORED VEGETABLES	YES
LEAFY VEGETABLES	YES
COW MILK	YES
GOAT MILK	NO
MEAT	YES

THE FOLLOWING 5 NUCLIDES WERE USED IN THIS CALCULATION

NUCLIDE	RELEASE CURIES
25 MN 54	4.13E-06
27 CO 60	2.51E-04
30 ZN 65	4.50E-06
55 CS 134	1.72E-06
55 CS 137	9.37E-05

VARIABLE			VEGETABLES		COW MILK		GOAT MILK		MEAT	
			STORED	LEAFY	PASTURE	STORED	PASTURE	STORED	PASTURE	STORED
YV	AGRICULTURAL PRODUCTIVITY	(KG/M-2)	2.00	2.00	.70	2.00	.70	2.00	.70	2.00
P	SOIL SURFACE DENSITY	(KG/M-2)	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00
T	TRANSPORT TIME TO USER	(HRS)			48.00	48.00	48.00	48.00	480.00	480.00
TB	SOIL EXPOSURE TIME	(HRS)	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00
TE	CROP EXPOSURE TIME TO PLUME	(HRS)	.00	.00	.00	.00	.00	.00	.00	.00
TH	HOLDUP AFTER HARVEST	(HRS)	1440.00	24.00	.00	2160.00	.00	2160.00	.00	2160.00
QF	ANIMALS DAILY FEED	(KG/DAY)			50.00	50.00	6.00	6.00	50.00	50.00
FP	FRACTION OF YEAR ON PASTURE				.50		.50		.50	
FS	FRACTION PASTURE WHEN ON PASTURE				1.00		1.00		1.00	
FG	FRACTION OF STORED VEG GROWN IN GARDEN		1.00							
FL	FRACTION OF LEAFY VEG GROWN IN GARDEN			1.00						

FI FRACTION ELEMENTAL IODINE = .500
H ABSOLUTE HUMIDITY = 5.60 (GM/M-3)
FC FRACTIONAL EQUILIBRIUM RATIO FOR C-14 = 1.000

USAGE FACTORS

AGE	VEG (KG/YR)	LEAFY VEG (KG/YR)	MILK (LI/YR)	MEAT (KG/YR)	INHALATION (M-3/YR)
ADULT	520.00	64.00	310.00	110.00	8000.00
TEEN	630.00	42.00	400.00	65.00	8000.00
CHILD	520.00	26.00	330.00	41.00	3700.00
INFANT	.00	.00	330.00	.00	1400.00

DOSE DELIVERED TO EACH ORGAN
FROM ALL PATHWAYS COMBINED
(MREM)

BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
9.20E-02	1.13E-01	7.92E-02	8.46E-02	9.66E-02	5.76E-02	9.42E-02	6.78E-02
1.13E-01	1.44E-01	9.08E-02	9.90E-02	9.65E-02	5.76E-02	9.41E-02	6.78E-02
1.86E-01	1.99E-01	1.10E-01	9.73E-02	8.22E-02	5.76E-02	9.94E-02	6.78E-02
1.14E-01	1.38E-01	8.36E-02	8.08E-02	7.59E-02	5.76E-02	7.19E-02	6.78E-02

ADULT
DOSES RECEIVED FROM
VARIOUS PATHWAYS
(MREM)

FLD SECTOR AT, A DISTANCE OF 0 METERS

PATHWAY	BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
GROUND PLANE								
54 MN							2.13E-04	2.50E-04
60 CO							5.20E-02	6.12E-02
65 ZN							1.46E-04	1.68E-04
134 CS							2.27E-04	2.65E-04
137 CS							5.06E-03	5.90E-03
TOTAL FOR PATHWAY							5.76E-02	6.78E-02
INHALATION								
54 MN	.00E+00	2.40E-06	5.96E-07	8.48E-05	4.69E-06	.00E+00	3.81E-07	
60 CO	.00E+00	4.24E-05	.00E+00	2.20E-02	1.05E-03	.00E+00	5.45E-05	
65 ZN	2.14E-06	6.81E-06	4.55E-06	5.70E-05	3.53E-06	.00E+00	3.07E-06	
134 CS	9.38E-06	2.13E-05	7.22E-06	2.45E-06	2.62E-07	.00E+00	1.83E-05	
137 CS	6.57E-04	8.53E-04	3.05E-04	1.03E-04	1.15E-05	.00E+00	5.88E-04	
TOTAL FOR PATHWAY	6.69E-04	9.26E-04	3.18E-04	2.22E-02	1.07E-03	.00E+00	6.64E-04	
STORED VEGETABLES								
54 MN	.00E+00	8.80E-05	2.62E-05	.00E+00	2.70E-04	.00E+00	1.68E-05	
60 CO	.00E+00	1.24E-03	.00E+00	.00E+00	2.33E-02	.00E+00	2.74E-03	
65 ZN	1.23E-03	3.90E-03	2.61E-03	.00E+00	2.46E-03	.00E+00	1.76E-03	
134 CS	2.30E-04	5.46E-04	1.77E-04	5.87E-05	9.56E-06	.00E+00	4.47E-04	
137 CS	1.97E-02	2.69E-02	9.15E-03	3.04E-03	5.22E-04	.00E+00	1.76E-02	
TOTAL FOR PATHWAY	2.12E-02	3.27E-02	1.20E-02	3.10E-03	2.66E-02	.00E+00	2.26E-02	
LEAFY VEGETABLES								
54 MN	.00E+00	1.23E-05	3.67E-06	.00E+00	3.78E-05	.00E+00	2.36E-06	
60 CO	.00E+00	1.56E-04	.00E+00	.00E+00	2.93E-03	.00E+00	3.44E-04	
65 ZN	1.78E-04	5.67E-04	3.80E-04	.00E+00	3.57E-04	.00E+00	2.56E-04	
134 CS	2.98E-05	7.10E-05	2.30E-05	7.63E-06	1.24E-06	.00E+00	5.80E-05	
137 CS	2.43E-03	3.33E-03	1.13E-03	3.76E-04	6.44E-05	.00E+00	2.18E-03	
TOTAL FOR PATHWAY	2.64E-03	4.14E-03	1.54E-03	3.83E-04	3.39E-03	.00E+00	2.84E-03	

ADULT
DOSES RECEIVED FROM
VARIOUS PATHWAYS
(MREM)

FLD SECTOR AT A DISTANCE OF 0 METERS

PATHWAY	BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
COW MILK								
54 MN	.00E+00	6.78E-07	2.02E-07	.00E+00	2.08E-06	.00E+00	1.29E-07	
60 CO	.00E+00	3.72E-05	.00E+00	.00E+00	6.98E-04	.00E+00	5.20E-05	
65 ZN	1.49E-03	4.74E-03	3.17E-03	.00E+00	2.99E-03	.00E+00	2.14E-03	
134 CS	8.32E-05	1.98E-04	6.40E-05	2.13E-05	3.46E-06	.00E+00	1.62E-04	
137 CS	7.05E-03	9.65E-03	3.27E-03	1.09E-03	1.87E-04	.00E+00	6.32E-03	
TOTAL FOR PATHWAY	8.63E-03	1.46E-02	6.51E-03	1.11E-03	3.88E-03	.00E+00	8.70E-03	
MEAT								
54 MN	.00E+00	7.40E-07	2.20E-07	.00E+00	2.27E-06	.00E+00	1.41E-07	
60 CO	.00E+00	1.70E-04	.00E+00	.00E+00	3.20E-03	.00E+00	3.76E-04	
65 ZN	3.86E-04	1.23E-03	8.22E-04	.00E+00	7.75E-04	.00E+00	5.56E-04	
134 CS	9.67E-06	2.30E-05	7.45E-06	2.47E-06	4.03E-07	.00E+00	1.88E-05	
137 CS	8.33E-04	1.14E-03	3.87E-04	1.29E-04	2.21E-05	.00E+00	7.46E-04	
TOTAL FOR PATHWAY	1.23E-03	2.56E-03	1.22E-03	1.31E-04	4.00E-03	.00E+00	1.70E-03	
TOTAL ALL PATHS	3.43E-02	5.50E-02	2.15E-02	2.69E-02	3.89E-02	.00E+00	9.42E-02	6.78E-02
TOTAL ALL PATHS INCLUDING WHOLE BODY DOSE FROM GROUND PLANE EXPOSURE	9.20E-02	1.13E-01	7.92E-02	8.46E-02	9.66E-02	5.76E-02	9.42E-02	

TEEN
DOSES RECEIVED FROM
VARIOUS PATHWAYS
(MREM)

FLD SECTOR AT A DISTANCE OF 0 METERS

PATHWAY	BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
GROUND PLANE								
54 MN							2.13E-04	2.50E-04
60 CO							5.20E-02	6.12E-02
65 ZN							1.46E-04	1.68E-04
134 CS							2.27E-04	2.65E-04
137 CS							5.06E-03	5.90E-03
TOTAL FOR PATHWAY							5.76E-02	6.78E-02
INHALATION								
54 MN	.00E+00	3.10E-06	7.71E-07	1.20E-04	4.05E-06	.00E+00	5.09E-07	
60 CO	.00E+00	5.57E-05	.00E+00	3.21E-02	9.54E-04	.00E+00	7.31E-05	
65 ZN	2.55E-06	8.82E-06	5.70E-06	8.19E-05	3.08E-06	.00E+00	4.12E-06	
134 CS	1.26E-05	2.84E-05	9.44E-06	3.68E-06	2.45E-07	.00E+00	1.38E-05	
137 CS	9.21E-04	1.16E-03	4.18E-04	1.66E-04	1.16E-05	.00E+00	4.27E-04	
TOTAL FOR PATHWAY	9.36E-04	1.26E-03	4.33E-04	3.25E-02	9.73E-04	.00E+00	5.19E-04	
STORED VEGETABLES								
54 MN	.00E+00	1.38E-04	4.11E-05	.00E+00	2.82E-04	.00E+00	2.73E-05	
60 CO	.00E+00	1.97E-03	.00E+00	.00E+00	2.57E-02	.00E+00	4.45E-03	
65 ZN	1.77E-03	6.13E-03	3.93E-03	.00E+00	2.60E-03	.00E+00	2.86E-03	
134 CS	3.74E-04	8.81E-04	2.80E-04	1.07E-04	1.10E-05	.00E+00	4.09E-04	
137 CS	3.35E-02	4.46E-02	1.52E-02	5.90E-03	6.35E-04	.00E+00	1.55E-02	
TOTAL FOR PATHWAY	3.57E-02	5.37E-02	1.94E-02	6.01E-03	2.92E-02	.00E+00	2.33E-02	
LEAFY VEGETABLES								
54 MN	.00E+00	1.05E-05	3.12E-06	.00E+00	2.15E-05	.00E+00	2.07E-06	
60 CO	.00E+00	1.34E-04	.00E+00	.00E+00	1.75E-03	.00E+00	3.03E-04	
65 ZN	1.39E-04	4.84E-04	3.10E-04	.00E+00	2.05E-04	.00E+00	2.26E-04	
134 CS	2.63E-05	6.20E-05	1.97E-05	7.52E-06	7.71E-07	.00E+00	2.88E-05	
137 CS	2.24E-03	2.99E-03	1.02E-03	3.95E-04	4.25E-05	.00E+00	1.04E-03	
TOTAL FOR PATHWAY	2.41E-03	3.68E-03	1.35E-03	4.02E-04	2.02E-03	.00E+00	1.60E-03	

TEEN
DOSES RECEIVED FROM
VARIOUS PATHWAYS
(MREM)

FLD SECTOR AT A DISTANCE OF 0 METERS

PATHWAY	BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
COW MILK								
54 MN	.00E+00	1.13E-06	3.37E-07	.00E+00	2.32E-06	.00E+00	2.24E-07	
60 CO	.00E+00	6.30E-05	.00E+00	.00E+00	8.20E-04	.00E+00	1.42E-04	
65 ZN	2.29E-03	7.95E-03	5.09E-03	.00E+00	3.36E-03	.00E+00	3.71E-03	
134 CS	1.44E-04	3.40E-04	1.08E-04	4.12E-05	4.23E-06	.00E+00	1.58E-04	
137 CS	1.28E-02	1.70E-02	5.79E-03	2.25E-03	2.42E-04	.00E+00	5.93E-03	
TOTAL FOR PATHWAY	1.52E-02	2.54E-02	1.10E-02	2.29E-03	4.43E-03	.00E+00	9.93E-03	
MEAT								
54 MN	.00E+00	5.65E-07	1.68E-07	.00E+00	1.16E-06	.00E+00	1.12E-07	
60 CO	.00E+00	1.32E-04	.00E+00	.00E+00	1.72E-03	.00E+00	2.98E-04	
65 ZN	2.72E-04	9.44E-04	6.04E-04	.00E+00	4.[illegible]0E-04	.00E+00	4.40E-04	
134 CS	7.69E-06	1.81E-05	5.75E-06	2.20E-06	2.25E-07	.00E+00	8.40E-06	
137 CS	6.92E-04	9.20E-04	3.13E-04	1.22E-04	1.31E-05	.00E+00	3.21E-04	
TOTAL FOR PATHWAY	9.71E-04	2.01E-03	9.23E-04	1.24E-04	2.14E-03	.00E+00	1.07E-03	
TOTAL ALL PATHS	5.52E-02	8.61E-02	3.31E-02	4.13E-02	3.88E-02	.00E+00	9.41E-02	6.78E-02
TOTAL ALL PATHS INCLUDING WHOLE BODY DOSE FROM GROUND PLANE EXPOSURE	1.13E-01	1.44E-01	9.08E-02	9.90E-02	9.65E-02	5.76E-02	9.41E-02	

CHILD
DOSES RECEIVED FROM
VARIOUS PATHWAYS
(MREM)

FLD SECTOR AT A DISTANCE OF 0 METERS

PATHWAY	BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
GROUND PLANE								
54 MN							2.13E-04	2.50E-04
60 CO							5.20E-02	6.12E-02
65 ZN							1.46E-04	1.68E-04
134 CS							2.27E-04	2.65E-04
137 CS							5.06E-03	5.90E-03
TOTAL FOR PATHWAY							5.76E-02	6.78E-02
INHALATION								
54 MN	.00E+00	2.60E-06	6.08E-07	9.55E-05	1.39E-06	.00E+00	5.76E-07	
60 CO	.00E+00	4.84E-05	.00E+00	2.60E-02	3.54E-04	.00E+00	8.34E-05	
65 ZN	2.81E-06	7.47E-06	4.71E-06	6.57E-05	1.08E-06	.00E+00	4.64E-06	
134 CS	1.64E-05	2.55E-05	8.31E-06	3.04E-06	9.68E-08	.00E+00	5.63E-06	
137 CS	1.25E-03	1.13E-03	3.88E-04	1.43E-04	4.97E-06	.00E+00	1.76E-04	
TOTAL FOR PATHWAY	1.26E-03	1.22E-03	4.01E-04	2.63E-02	3.62E-04	.00E+00	2.71E-04	
STORED VEGETABLES								
54 MN	.00E+00	2.06E-04	5.78E-05	.00E+00	1.73E-04	.00E+00	5.49E-05	
60 CO	.00E+00	3.07E-03	.00E+00	.00E+00	1.70E-02	.00E+00	9.05E-03	
65 ZN	3.47E-03	9.24E-03	5.82E-03	.00E+00	1.62E-03	.00E+00	5.75E-03	
134 CS	8.63E-04	1.42E-03	4.39E-04	1.58E-04	7.64E-06	.00E+00	2.99E-04	
137 CS	8.08E-02	7.74E-02	2.52E-02	9.07E-03	4.84E-04	.00E+00	1.14E-02	
TOTAL FOR PATHWAY	8.52E-02	9.13E-02	3.15E-02	9.23E-03	1.93E-02	.00E+00	2.66E-02	
LEAFY VEGETABLES								
54 MN	.00E+00	1.17E-05	3.29E-06	.00E+00	9.86E-06	.00E+00	3.13E-06	
60 CO	.00E+00	1.57E-04	.00E+00	.00E+00	8.68E-04	.00E+00	4.62E-04	
65 ZN	2.05E-04	5.46E-04	3.44E-04	.00E+00	9.60E-05	.00E+00	3.40E-04	
134 CS	4.56E-05	7.48E-05	2.32E-05	8.32E-06	4.03E-07	.00E+00	1.58E-05	
137 CS	4.06E-03	3.88E-03	1.27E-03	4.55E-04	2.43E-05	.00E+00	5.73E-04	
TOTAL FOR PATHWAY	4.31E-03	4.67E-03	1.64E-03	4.64E-04	9.99E-04	.00E+00	1.39E-03	

CHILD
DOSES RECEIVED FROM
VARIOUS PATHWAYS
(MREM)

FLD SECTOR AT A DISTANCE OF 0 METERS

PATHWAY	BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
COW MILK								
54 MN	.00E+00	1.69E-06	4.74E-07	.00E+00	1.42E-06	.00E+00	4.50E-07	
60 CO	.00E+00	9.78E-05	.00E+00	.00E+00	5.42E-04	.00E+00	2.89E-04	
65 ZN	4.49E-03	1.20E-02	7.54E-03	.00E+00	2.10E-03	.00E+00	7.44E-03	
134 CS	3.33E-04	5.47E-04	1.69E-04	6.08E-05	2.95E-06	.00E+00	1.15E-04	
137 CS	3.08E-02	2.95E-02	9.61E-03	3.46E-03	1.85E-04	.00E+00	4.35E-03	
TOTAL FOR PATHWAY	3.56E-02	4.21E-02	1.73E-02	3.52E-03	2.83E-03	.00E+00	1.22E-02	
MEAT								
54 MN	.00E+00	6.46E-07	1.81E-07	.00E+00	5.42E-07	.00E+00	1.72E-07	
60 CO	.00E+00	1.57E-04	.00E+00	.00E+00	8.70E-04	.00E+00	4.63E-04	
65 ZN	4.08E-04	1.09E-03	6.84E-04	.00E+00	1.91E-04	.00E+00	6.76E-04	
134 CS	1.36E-05	2.23E-05	6.90E-06	2.48E-06	1.20E-07	.00E+00	4.70E-06	
137 CS	1.27E-03	1.22E-03	3.97E-04	1.43E-04	7.64E-06	.00E+00	1.80E-04	
TOTAL FOR PATHWAY	1.70E-03	2.49E-03	1.09E-03	1.45E-04	1.07E-03	.00E+00	1.32E-03	
TOTAL ALL PATHS	1.28E-01	1.42E-01	5.20E-02	3.97E-02	2.45E-02	.00E+00	9.94E-02	6.78E-02
TOTAL ALL PATHS INCLUDING WHOLE BODY DOSE FROM GROUND PLANE EXPOSURE	1.86E-01	1.99E-01	1.10E-01	9.73E-02	8.22E-02	5.76E-02	9.94E-02	

INFANT
DOSES RECEIVED FROM
VARIOUS PATHWAYS
(MREM)

FLD SECTOR AT A DISTANCE OF 0 METERS

PATHWAY	BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
GROUND PLANE								
54 MN							2.13E-04	2.50E-04
60 CO							5.20E-02	6.12E-02
65 ZN							1.46E-04	1.68E-04
134 CS							2.27E-04	2.65E-04
137 CS							5.06E-03	5.90E-03
TOTAL FOR PATHWAY							5.76E-02	6.78E-02
INHALATION								
54 MN	.00E+00	1.54E-06	3.02E-07	6.06E-05	4.28E-07	.00E+00	3.02E-07	
60 CO	.00E+00	2.95E-05	.00E+00	1.66E-02	1.18E-04	.00E+00	4.34E-05	
65 ZN	1.28E-06	4.13E-06	2.14E-06	4.27E-05	3.39E-06	.00E+00	2.05E-06	
134 CS	9.96E-06	1.77E-05	4.79E-06	2.00E-06	3.36E-08	.00E+00	1.87E-06	
137 CS	7.54E-04	8.40E-04	2.37E-04	9.79E-05	1.83E-06	.00E+00	6.25E-05	
TOTAL FOR PATHWAY	7.65E-04	8.93E-04	2.44E-04	1.68E-02	1.23E-04	.00E+00	1.10E-04	
STORED VEGETABLES								
54 MN	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
60 CO	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
65 ZN	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00[illegible]	.00E+00	
134 CS	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00[illegible]	.00E+00	
137 CS	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00[illegible]	.00E+00	
TOTAL FOR PATHWAY	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
LEAFY VEGETABLES								
54 MN	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
60 CO	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
65 ZN	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
134 CS	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
137 CS	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
TOTAL FOR PATHWAY	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	

INFANT
DOSES RECEIVED FROM
VARIOUS PATHWAYS
(MREM)

FLD SECTOR AT A DISTANCE OF 0 METERS

PATHWAY	BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
COW MILK								
54 MN	.00E+00	3.14E-06	6.97E-07	.00E+00	1.16E-06	.00E+00	7.13E-07	
60 CO	.00E+00	2.00E-04	.00E+00	.00E+00	4.75E-04	.00E+00	4.72E-04	
65 ZN	6.03E-03	2.07E-02	1.00E-02	.00E+00	1.75E-02	.00E+00	9.54E-03	
134 CS	5.37E-04	1.00E-03	2.58E-04	1.06E-04	2.72E-06	.00E+00	1.01E-04	
137 CS	4.92E-02	5.76E-02	1.54E-02	6.25E-03	1.80E-04	.00E+00	4.08E-03	
TOTAL FOR PATHWAY	5.57E-02	7.94E-02	2.57E-02	6.36E-03	1.81E-02	.00E+00	1.42E-02	
MEAT								
54 MN	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
60 CO	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
65 ZN	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
134 CS	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
137 CS	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
TOTAL FOR PATHWAY	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
TOTAL ALL PATHS	5.65E-02	8.03E-02	2.60E-02	2.32E-02	1.83E-02	.00E+00	7.19E-02	6.78E-02
TOTAL ALL PATHS INCLUDING WHOLE BODY DOSE FROM GROUND PLANE EXPOSURE	1.14E-01	1.38E-01	8.36E-02	8.08E-02	7.59E-02	5.76E-02	7.19E-02	

B.4 ATMODOS - Radiological Impact After Termination of VY Control of the Disposal Site (All Nuclides)

Presented below is a partial listing of the ATMODOS Tape 5 input used in this portion of the calculation. It corresponds to the output which follows. With the exception of the nuclide data library, a large portion of which was deleted due to space limitations, the listing is complete.

```
1 1VYPI   VY STANDARD PROGRAM INFORMATION FILE
VY - SEWAGE CONTAM - SOLIDS 1% BY WT - 2 ACRES - SHIELD F = 0.242 - CONT. OCCUP
1.  .200  44.56FRESH  .500YESNO NO 0..242 1.NO NO NO 0.1.00
--EOR--
--EOF--
0 2VYGASRLGAS STK              VY 87 1 1 0 87063023:
     MN54  4.132E-6 25 MN  54
     CO60  2.511E-4 27 CO  60
     ZN65  4.502E-6 30 ZN  65
     CS134 1.715E-6 55 CS 134
     CS137 9.366E-5 55 CS 137
--EOR--
--EOF--
1 5QUERY  PATHWAYS: SHORE(1,2,3),BND,ROAD,RES1,RAD,MEAT,GOAT,COW
SHORE1    YESYES
SHORE2    YESYES
SHORE3    YESYES
BOUND     YESYES
ROAD      YESYES
RES1      YESYESYESYES
RADIUS    YESYES
MEAT      YESYESYESYES        YESYESYES
GOAT      YESYESYESYES   YES   YESYES
COW       YESYESYESYESYES        YESYES
--EOR--
--EOF--
1 6VYUFMAXVY MAXIMUM INDIVIDUAL USAGE FACTORS FOR STANDARD PFORBLEMS
  520.00   64.00  310.00  110.00    21.00      .00      .00   12.00      .00 8000.00
  630.00   42.00  400.00   65.00    16.00      .00      .00   67.00      .00 8000.00
  520.00   26.00  330.00   41.00     6.90      .00      .00   14.00      .00 3700.00
     .00     .00  330.00     .00      .00      .00      .00     .00      .00 1400.00
--EOR--
--EOF--
```

```
1 7VYGSD  VY MAX INDIVIDUAL GAS SITE DATA FILE FOR STANDARD
                                                                    PROBLEMS
     2.00      2.00       .70      2.00       .70      2.00       .70      2.00
   240.00    240.00    240.00    240.00    240.00    240.00    240.00    240.00
      .00       .00     48.00     48.00     48.00     48.00    480.00    480.00
  8766.00   8766.00   8766.00   8766.00   8766.00   8766.00   8766.00   8766.00
      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
  1440.00     24.00       .00   2160.00       .00   2160.00       .00   2160.00
      .00       .00     50.00     50.00      6.00      6.00     50.00     50.00
      .00       .00       .50       .00       .50       .00       .50       .00
      .00       .00      1.00       .00      1.00       .00      1.00       .00
      1.0      1.00       .00       .00       .00       .00       .00       .00
     5.60       .00       .00       .00       .00       .00       .00       .00
--EOR--
--EOF--
1 8ISTPNBLNUCLIDE LIBRARY FOR ALL DOSE PROGRAMS
       89
   1  3 1.78E-090.00E+000.00E+00                                       SOLUBLE
 H 9.0E-01 9.0E-01 9.0E-01 9.0E-01 9.3E-01 9.3E-01 4.8E-00 1.0E-02 1.2E-02
0.       1.05E-071.05E-071.05E-071.05E-071.05E-071.05E-07
0.       1.58E-071.58E-071.58E-071.58E-071.58E-071.58E-07
0.       1.06E-071.06E-071.06E-071.06E-071.06E-071.06E-07
0.       1.59E-071.59E-071.59E-071.59E-071.59E-071.59E-07
0.       2.03E-072.03E-072.03E-072.03E-072.03E-072.03E-07
0.       3.04E-073.04E-073.04E-073.04E-073.04E-073.04E-07
0.       3.08E-073.08E-073.08E-073.08E-073.08E-073.08E-07
0.       4.62E-074.62E-074.62E-074.62E-074.62E-074.62E-07
   6 14 3.83E-12                                                       SOLUBLE
 C 4.6E+03 9.1E+03 4.6E+03 1.8E+03 1.4E+03 1.8E+03 5.5E+00 1.2E-02 3.1E-02
2.84E-065.68E-075.68E-075.68E-075.68E-075.68E-075.68E-07
2.27E-064.26E-074.26E-074.26E-074.26E-074.26E-074.26E-07
4.06E-068.12E-078.12E-078.12E-078.12E-078.12E-078.12E-07
3.25E-066.09E-076.09E-076.09E-076.09E-076.09E-076.09E-07
1.21E-052.42E-062.42E-062.42E-062.42E-062.42E-062.42E-06
9.70E-061.82E-061.82E-061.82E-061.82E-061.82E-061.82E-06
2.37E-055.06E-065.06E-065.06E-065.06E-065.06E-065.06E-06
1.89E-053.79E-063.79E-063.79E-063.79E-063.79E-063.79E-06
  11 24 1.28E-052.50E-08        2.90E-08                               SOLUBLE
   .
   .
   .
   .
   ETC (FOR A TOTAL OF 89 NUCLIDES)

 --EOR--
 --EOF--
 1 3VYXQF  VY X/QFILE - SPECIAL VALUES - SEWAGE CONTAM. PROBLEM - 2 ACRE PLOTS
  FLD     0  COW    MEAT          3.896E-02 3.896E-02 1.236E-04 3.896E-02
 --EOR--
 --EOF--
```

PROGRAM ATHODOS
YANKEE ATOMIC ELECTRIC COMPANY
DEC, 1985 REV. 7

REGULATORY GUIDE 1.109, APPENDIX C
MODELS FOR CALCULATING DOSE VIA
ADDITIONAL PATHWAYS FROM RADIOIODINES
AND OTHER RADIONUCLIDES DISCHARGED
TO THE ATMOSPHERE NOV,1977 LIBRARY

SECTOR		FLD	
DISTANCE	=	0	(METERS)
X/Q	=	3.90E-02	(SEC/M-3)
X/Q DEPLETED	=	3.90E-02	(SEC/M-3)
DELTA	=	1.24E-04	(1/M-2)

VY - SEWAGE CONTAM. - SOLIDS 1% BY WT -
2 ACRES - SHIELD F - 0.242 - CONT. OCCUP

6 PATHWAYS CONSIDERED

GROUND PLANE	YES
INHALATION	YES
STORED VEGETABLES	YES
LEAFY VEGETABLES	YES
COW MILK	YES
GOAT MILK	NO
MEAT	YES

THE FOLLOWING 5 NUCLIDES WERE USED IN THIS CALCULATION

NUCLIDE	RELEASE CURIES
25 MN 54	4.13E-06
27 CO 60	2.51E-04
30 ZN 65	4.50E-06
55 CS 134	1.72E-06
55 CS 137	9.37E-05

VARIABLE			VEGETABLES		COW MILK		GOAT MILK		MEAT	
			STORED	LEAFY	PASTURE	STORED	PASTURE	STORED	PASTURE	STORED
YV	AGRICULTURAL PRODUCTIVITY	(KG/M-2)	2.00	2.00	.70	2.00	.70	2.00	.70	2.00
P	SOIL SURFACE DENSITY	(KG/M-2)	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00
T	TRANSPORT TIME TO USER	(HRS)			48.00	48.00	48.00	48.00	480.00	480.00
TB	SOIL EXPOSURE TIME	(HRS)	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00
TE	CROP EXPOSURE TIME TO PLUME	(HRS)	.00	.00	.00	.00	.00	.00	.00	.00
TH	HOLDUP AFTER HARVEST	(HRS)	1440.00	24.00	.00	2160.00	.00	2160.00	.00	2160.00
QF	ANIMALS DAILY FEED	(KG/DAY)			50.00	50.00	6.00	6.00	50.00	50.00
FP	FRACTION OF YEAR ON PASTURE				.50		.50		.50	
FS	FRACTION PASTURE WHEN ON PASTURE				1.00		1.00		1.00	
FG	FRACTION OF STORED VEG GROWN IN GARDEN		1.00							
FL	FRACTION OF LEAFY VEG GROWN IN GARDEN			1.00						

FI FRACTION ELEMENTAL IODINE = .500
H ABSOLUTE HUMIDITY = 5.60 (GM/M-3)
FC FRACTIONAL EQUILIBRIUM RATIO FOR C-14 = 1.000

USAGE FACTORS

AGE	VEG (KG/YR)	LEAFY VEG (KG/YR)	MILK (LI/YR)	MEAT (KG/YR)	INHALATION (M-3/YR)
ADULT	520.00	64.00	310.00	110.00	8000.00
TEEN	630.00	42.00	400.00	65.00	8000.00
CHILD	520.00	26.00	330.00	41.00	3700.00
INFANT	.00	.00	330.00	.00	1400.00

DOSE DELIVERED TO EACH ORGAN
FROM ALL PATHWAYS COMBINED

(MREM)

BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
1.25E+00	1.29E+00	1.21E+00	3.04E+00	1.29E+00	1.16E+00	1.25E+00	1.37E+00
1.30E+00	1.35E+00	1.23E+00	3.91E+00	1.28E+00	1.16E+00	1.24E+00	1.37E+00
1.40E+00	1.41E+00	1.25E+00	3.39E+00	1.22E+00	1.16E+00	1.23E+00	1.37E+00
1.28E+00	1.32E+00	1.21E+00	2.58E+00	1.19E+00	1.16E+00	1.19E+00	1.37E+00

ADULT
DOSES RECEIVED FROM
VARIOUS PATHWAYS
(MREM)

FLD SECTOR AT A DISTANCE OF 0 METERS

PATHWAY	BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
GROUND PLANE								
54 MN							4.30E-03	5.05E-03
60 CO							1.05E+00	1.23E+00
65 ZN							2.94E-03	3.38E-03
134 CS							4.58E-03	5.34E-03
137 CS							1.02E-01	1.19E-01
TOTAL FOR PATHWAY							1.16E+00	1.37E+00
INHALATION								
54 MN	.00E+00	2.02E-04	5.02E-05	7.14E-03	3.95E-04	.00E+00	3.21E-05	
60 CO	.00E+00	3.57E-03	.00E+00	1.85E+00	8.83E-02	.00E+00	4.59E-03	
65 ZN	1.80E-04	5.74E-04	3.83E-04	4.80E-03	2.97E-04	.00E+00	2.59E-04	
134 CS	7.90E-04	1.80E-03	6.08E-04	2.07E-04	2.20E-05	.00E+00	1.54E-03	
137 CS	5.53E-02	7.18E-02	2.57E-02	8.70E-03	9.72E-04	.00E+00	4.95E-02	
TOTAL FOR PATHWAY	5.63E-02	7.80E-02	2.68E-02	1.87E+00	9.00E-02	.00E+00	5.59E-02	
STORED VEGETABLES								
54 MN	.00E+00	8.80E-05	2.62E-05	.00E+00	2.70E-04	.00E+00	1.68E-05	
60 CO	.00E+00	1.24E-03	.00E+00	.00E+00	2.33E-02	.00E+00	2.74E-03	
65 ZN	1.23E-03	3.90E-03	2.61E-03	.00E+00	2.46E-03	.00E+00	1.76E-03	
134 CS	2.30E-04	5.46E-04	1.77E-04	5.87E-05	9.56E-06	.00E+00	4.47E-04	
137 CS	1.97E-02	2.69E-02	9.15E-03	3.04E-03	5.22E-04	.00E+00	1.76E-02	
TOTAL FOR PATHWAY	2.12E-02	3.27E-02	1.20E-02	3.10E-03	2.66E-02	.00E+00	2.26E-02	
LEAFY VEGETABLES								
54 MN	.00E+00	1.23E-05	3.67E-06	.00E+00	3.78E-05	.00E+00	2.36E-06	
60 CO	.00E+00	1.56E-04	.00E+00	.00E+00	2.93E-03	.00E+00	3.44E-04	
65 ZN	1.78E-04	5.67E-04	3.80E-04	.00E+00	3.57E-04	.00E+00	2.56E-04	
134 CS	2.98E-05	7.10E-05	2.30E-05	7.63E-06	1.24E-06	.00E+00	5.80E-05	
137 CS	2.43E-03	3.33E-03	1.13E-03	3.76E-04	6.44E-05	.00E+00	2.18E-03	
TOTAL FOR PATHWAY	2.64E-03	4.14E-03	1.54E-03	3.83E-04	3.39E-03	.00E+00	2.84E-03	

ADULT
DOSES RECEIVED FROM
VARIOUS PATHWAYS
(MREM)

FLD SECTOR AT A DISTANCE OF 0 METERS

PATHWAY	BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
COW MILK								
54 MN	.00E+00	6.78E-07	2.02E-07	.00E+00	2.08E-06	.00E+00	1.29E-07	
60 CO	.00E+00	3.72E-05	.00E+00	.00E+00	6.98E-04	.00E+00	8.20E-05	
65 ZN	1.49E-03	4.74E-03	3.17E-03	.00E+00	2.99E-03	.00E+00	2.14E-03	
134 CS	8.32E-05	1.98E-04	6.40E-05	2.13E-05	3.46E-06	.00E+00	1.62E-04	
137 CS	7.05E-03	9.65E-03	3.27E-03	1.09E-03	1.87E-04	.00E+00	6.32E-03	
TOTAL FOR PATHWAY	8.63E-03	1.46E-02	6.51E-03	1.11E-03	3.88E-03	.00E+00	8.70E-03	
MEAT								
54 MN	.00E+00	7.40E-07	2.20E-07	.00E+00	2.27E-06	.00E+00	1.41E-07	
60 CO	.00E+00	1.70E-04	.00E+00	.00E+00	3.20E-03	.00E+00	3.76E-04	
65 ZN	3.86E-04	1.23E-03	8.22E-04	.00E+00	7.75E-04	.00E+00	5.56E-04	
134 CS	9.67E-06	2.30E-05	7.45E-06	2.47E-06	4.03E-07	.00E+00	1.88E-05	
137 CS	8.33E-04	1.14E-03	3.87E-04	1.29E-04	2.21E-05	.00E+00	7.46E-04	
TOTAL FOR PATHWAY	1.23E-03	2.56E-03	1.22E-03	1.31E-04	4.00E-03	.00E+00	1.70E-03	
TOTAL ALL PATHS	9.00E-02	1.32E-01	4.80E-02	1.88E+00	1.28E-01	.00E+00	1.25E+00	1.37E+00
TOTAL ALL PATHS INCLUDING WHOLE BODY DOSE FROM GROUND PLANE EXPOSURE	1.25E+00	1.29E+00	1.21E+00	3.04E+00	1.29E+00	1.16E+00	1.25E+00	

TEEN
DOSES RECEIVED FROM
VARIOUS PATHWAYS
(MREM)

FLD SECTOR AT A DISTANCE OF 0 METERS

PATHWAY	BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
GROUND PLANE								
54 MN							4.30E-03	5.05E-03
60 CO							1.05E+00	1.23E+00
65 ZN							2.94E-03	3.38E-03
134 CS							4.58E-03	5.34E-03
137 CS							1.02E-01	1.19E-01
TOTAL FOR PATHWAY							1.16E+00	1.37E+00
INHALATION								
54 MN	.00E+00	2.61E-04	6.49E-05	1.01E-02	3.41E-04	.00E+00	4.29E-05	
60 CO	.00E+00	4.69E-03	.00E+00	2.70E+00	8.04E-02	.00E+00	6.15E-03	
65 ZN	2.14E-04	7.43E-04	4.80E-04	6.89E-03	2.59E-04	.00E+00	3.47E-04	
134 CS	1.06E-03	2.39E-03	7.95E-04	3.10E-04	2.07E-05	.00E+00	1.16E-03	
137 CS	7.75E-02	9.81E-02	3.32E-02	1.40E-02	9.81E-04	.00E+00	3.60E-02	
TOTAL FOR PATHWAY	7.88E-02	1.06E-01	3.65E-02	2.74E+00	8.20E-02	.00E+00	4.37E-02	
STORED VEGETABLES								
54 MN	.00E+00	1.38E-04	4.11E-05	.00E+00	2.82E-04	.00E+00	2.73E-05	
60 CO	.00E+00	1.97E-03	.00E+00	.00E+00	2.57E-02	.00E+00	4.45E-03	
65 ZN	1.77E-03	6.13E-03	3.93E-03	.00E+00	2.60E-03	.00E+00	2.86E-03	
134 CS	3.74E-04	8.81E-04	2.80E-04	1.07E-04	1.10E-05	.00E+00	4.09E-04	
137 CS	3.35E-02	4.46E-02	1.52E-02	5.90E-03	6.35E-04	.00E+00	1.55E-02	
TOTAL FOR PATHWAY	3.57E-02	5.37E-02	1.94E-02	6.01E-03	2.92E-02	.00E+00	2.33E-02	
LEAFY VEGETABLES								
54 MN	.00E+00	1.05E-05	3.12E-06	.00E+00	2.15E-05	.00E+00	2.07E-06	
60 CO	.00E+00	1.34E-04	.00E+00	.00E+00	1.75E-03	.00E+00	3.03E-04	
65 ZN	1.39E-04	4.84E-04	3.10E-04	.00E+00	2.05E-04	.00E+00	2.26E-04	
134 CS	2.63E-05	6.20E-05	1.97E-05	7.52E-06	7.71E-07	.00E+00	2.88E-05	
137 CS	2.24E-03	2.99E-03	1.02E-03	3.95E-04	4.25E-05	.00E+00	1.04E-03	
TOTAL FOR PATHWAY	2.41E-03	3.68E-03	1.35E-03	4.02E-04	2.02E-03	.00E+00	1.60E-03	

TEEN
DOSES RECEIVED FROM
VARIOUS PATHWAYS
(MREM)

FLD SECTOR AT A DISTANCE OF 0 METERS

PATHWAY	BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
COW MILK								
54 MN	.00E+00	1.13E-06	3.37E-07	.00E+00	2.32E-06	.00E+00	2.24E-07	
60 CO	.00E+00	6.30E-05	.00E+00	.00E+00	8.20E-04	.00E+00	1.42E-04	
65 ZN	2.29E-03	7.95E-03	5.09E-03	.00E+00	3.36E-03	.00E+00	3.71E-03	
134 CS	1.44E-04	3.40E-04	1.08E-04	4.12E-05	4.23E-06	.00E+00	1.58E-04	
137 CS	1.28E-02	1.70E-02	5.79E-03	2.25E-03	2.42E-04	.00E+00	5.93E-03	
TOTAL FOR PATHWAY	1.52E-02	2.54E-02	1.10E-02	2.29E-03	4.43E-03	.00E+00	9.93E-03	
MEAT								
54 MN	.00E+00	5.65E-07	1.68E-07	.00E+00	1.16E-06	.00E+00	1.12E-07	
60 CO	.00E+00	1.32E-04	.00E+00	.00E+00	1.72E-03	.00E+00	2.98E-04	
65 ZN	2.72E-04	9.44E-04	6.04E-04	.00E+00	4.00E-04	.00E+00	4.40E-04	
134 CS	7.69E-06	1.81E-05	5.75E-06	2.20E-06	2.25E-07	.00E+00	8.40E-06	
137 CS	6.92E-04	9.20E-04	3.13E-04	1.22E-04	1.31E-05	.00E+00	3.21E-04	
TOTAL FOR PATHWAY	9.71E-04	2.01E-03	9.23E-04	1.24E-04	2.14E-03	.00E+00	1.07E-03	
TOTAL ALL PATHS	1.33E-01	1.91E-01	6.92E-02	2.74E+00	1.20E-01	.00E+00	1.24E+00	1.37E+00
TOTAL ALL PATHS INCLUDING WHOLE BODY DOSE FROM GROUND PLANE EXPOSURE	1.30E+00	1.33E+00	1.23E+00	3.91E+00	1.28E+00	1.16E+00	1.24E+00	

CHILD
DOSES RECEIVED FROM
VARIOUS PATHWAYS
(MREM)

FLD SECTOR AT A DISTANCE OF 0 METERS

PATHWAY	BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
GROUND PLANE								
54 MN							4.30E-03	5.03E-03
60 CO							1.05E+00	1.23E+00
65 ZN							2.94E-03	3.38E-03
134 CS							4.58E-03	5.34E-03
137 CS							1.02E-01	1.19E-01
TOTAL FOR PATHWAY							1.16E+00	1.37E+00
INHALATION								
54 MN	.00E+00	2.19E-04	5.12E-05	8.04E-03	1.17E-04	.00E+00	4.85E-05	
60 CO	.00E+00	4.07E-03	.00E+00	2.19E+00	2.98E-02	.00E+00	7.02E-03	
65 ZN	2.37E-04	6.30E-04	3.97E-04	5.53E-03	9.07E-05	.00E+00	3.71E-04	
134 CS	1.38E-03	2.15E-03	7.00E-04	2.56E-04	8.15E-06	.00E+00	4.76E-04	
137 CS	1.05E-01	9.54E-02	3.27E-02	1.20E-02	4.19E-04	.00E+00	1.49E-02	
TOTAL FOR PATHWAY	1.06E-01	1.03E-01	3.38E-02	2.22E+00	3.05E-02	.00E+00	2.28E-02	
STORED VEGETABLES								
54 MN	.00E+00	2.06E-04	5.78E-05	.00E+00	1.73E-04	.00E+00	5.49E-05	
60 CO	.00E+00	3.07E-03	.00E+00	.00E+00	1.70E-02	.00E+00	9.05E-03	
65 ZN	3.47E-03	9.24E-03	5.82E-03	.00E+00	1.62E-03	.00E+00	5.75E-03	
134 CS	8.63E-04	1.42E-03	4.39E-04	1.58E-04	7.64E-06	.00E+00	2.99E-04	
137 CS	8.08E-02	7.74E-02	2.52E-02	9.07E-03	4.84E-04	.00E+00	1.14E-02	
TOTAL FOR PATHWAY	8.52E-02	9.13E-02	3.15E-02	9.23E-03	1.93E-02	.00E+00	2.66E-02	
LEAFY VEGETABLES								
54 MN	.00E+00	1.17E-05	3.29E-06	.00E+00	9.86E-06	.00E+00	3.13E-06	
60 CO	.00E+00	1.57E-04	.00E+00	.00E+00	8.68E-04	.00E+00	4.62E-04	
65 ZN	2.05E-04	5.46E-04	3.44E-04	.00E+00	9.60E-05	.00E+00	3.40E-04	
134 CS	4.56E-05	7.48E-05	2.32E-05	8.32E-06	4.03E-07	.00E+00	1.58E-05	
137 CS	4.06E-03	3.88E-03	1.27E-03	4.55E-04	2.43E-05	.00E+00	5.73E-04	
TOTAL FOR PATHWAY	4.31E-03	4.67E-03	1.64E-03	4.64E-04	9.99E-04	.00E+00	1.39E-03	

CHILD
DOSES RECEIVED FROM
VARIOUS PATHWAYS
(MREM)

FLD SECTOR AT A DISTANCE OF 0 METERS

PATHWAY	BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
COW MILK								
54 MN	.00E+00	1.69E-06	4.74E-07	.00E+00	1.42E-06	.00E+00	4.50E-07	
60 CO	.00E+00	9.78E-05	.00E+00	.00E+00	5.42E-04	.00E+00	2.89E-04	
65 ZN	4.49E-03	1.20E-02	7.54E-03	.00E+00	2.10E-03	.00E+00	7.44E-03	
134 CS	3.33E-04	5.47E-04	1.69E-04	6.08E-05	2.95E-06	.00E+00	1.15E-04	
137 CS	3.08E-02	2.95E-02	9.61E-03	3.46E-03	1.85E-04	.00E+00	4.35E-03	
TOTAL FOR PATHWAY	3.56E-02	4.21E-02	1.73E-02	3.52E-03	2.83E-03	.00E+00	1.22E-02	
MEAT								
54 MN	.00E+00	6.46E-07	1.81E-07	.00E+00	5.42E-07	.00E+00	1.72E-07	
60 CO	.00E+00	1.57E-04	.00E+00	.00E+00	8.70E-04	.00E+00	4.63E-04	
65 ZN	4.08E-04	1.09E-03	6.84E-04	.00E+00	1.91E-04	.00E+00	6.76E-04	
134 CS	1.36E-05	2.23E-05	6.90E-06	2.48E-06	1.20E-07	.C3E+00	4.70E-06	
137 CS	1.27E-03	1.22E-03	3.97E-04	1.43E-04	7.64E-06	.00E+00	1.80E-04	
TOTAL FOR PATHWAY	1.70E-03	2.49E-03	1.09E-03	1.45E-04	1.07E-03	.00E+00	1.32E-03	
TOTAL ALL PATHS	2.33E-01	2.43E-01	8.54E-02	2.23E+00	5.46E-02	.00E+00	1.23E+00	1.37E+00
TOTAL ALL PATHS INCLUDING WHOLE BODY DOSE FROM GROUND PLANE EXPOSURE	1.40E+00	1.41E+00	1.25E+00	3.39E+00	1.22E+00	1.16E+00	1.23E+00	

INFANT
DOSES RECEIVED FROM
VARIOUS PATHWAYS
(MREM)

FLD SECTOR AT A DISTANCE OF 0 METERS

PATHWAY	BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
GROUND PLANE								
54 MN							4.30E-03	5.05E-03
60 CO							1.05E+00	1.23E+00
65 ZN							2.94E-03	3.38E-03
134 CS							4.58E-03	5.34E-03
137 CS							1.02E-01	1.19E-01
TOTAL FOR PATHWAY							1.16E+00	1.37E+00
INHALATION								
54 MN	.00E+00	1.29E-04	2.54E-05	5.10E-03	3.60E-03	.00E+00	2.54E-05	
60 CO	.00E+00	2.49E-03	.00E+00	1.40E+00	9.90E-03	.00E+00	3.63E-03	
65 ZN	1.07E-04	3.48E-04	1.81E-04	3.60E-03	2.86E-04	.00E+00	1.73E-04	
134 CS	8.39E-04	1.49E-03	4.03E-04	1.69E-04	2.83E-06	.00E+00	1.58E-04	
137 CS	6.35E-02	7.08E-02	1.99E-02	8.24E-03	1.54E-04	.00E+00	5.26E-03	
TOTAL FOR PATHWAY	6.44E-02	7.52E-02	2.05E-02	1.42E+00	1.04E-02	.00E+00	9.27E-03	
STORED VEGETABLES								
54 MN	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
60 CO	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
65 ZN	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
134 CS	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
137 CS	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
TOTAL FOR PATHWAY	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
LEAFY VEGETABLES								
54 MN	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
60 CO	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
65 ZN	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
134 CS	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
137 CS	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
TOTAL FOR PATHWAY	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	

INFANT
DOSES RECEIVED FROM
VARIOUS PATHWAYS
(MREM)

FLD SECTOR AT A DISTANCE OF 0 METERS

PATHWAY	BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
COW MILK								
54 MN	.00E+00	3.14E-06	6.97E-07	.00E+00	1.16E-06	.00E+00	7.13E-07	
60 CO	.00E+00	2.00E-04	.00E+00	.00E+00	4.75E-04	.00E+00	4.72E-04	
65 ZN	6.03E-03	2.07E-02	1.00E-02	.00E+00	1.75E-02	.00E+00	9.54E-03	
134 CS	5.37E-04	1.00E-03	2.58E-04	1.06E-04	2.72E-06	.00E+00	1.01E-04	
137 CS	4.92E-02	5.76E-02	1.54E-02	6.25E-03	1.80E-04	.00E+00	4.08E-03	
TOTAL FOR PATHWAY	5.57E-02	7.94E-02	2.57E-02	6.36E-03	1.81E-02	.00E+00	1.42E-02	
MEAT								
54 MN	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
60 CO	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
65 ZN	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
134 CS	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
137 CS	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
TOTAL FOR PATHWAY	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	.00E+00	
TOTAL ALL PATHS	1.20E-01	1.55E-01	4.63E-02	1.42E+00	2.85E-02	.00E+00	1.19E+00	1.37E+00
TOTAL ALL PATHS INCLUDING WHOLE BODY DOSE FROM GROUND PLANE EXPOSURE	1.28E+00	1.32E+00	1.21E+00	2.58E+00	1.19E+00	1.16E+00	1.19E+00	

B.5 ATMODOS - Unplowed-Land Dose Conversion Factors for Radiological Impact Assessment

The Tape 5 inputs to ATMODOS for these cases are identical to the one shown in Attachment B.3, the only exception being the isotopic intensities in File 2. In the current computer runs, each isotope was assumed to have an annual release rate which would yield an accumulated intensity of 1 μCi at the end of one year (uniformly spread over 2 acres of unplowed land).

PROGRAM ATHODOS
YANKEE ATOMIC ELECTRIC COMPANY
DEC, 1985 REV. 7

REGULATORY GUIDE 1.109, APPENDIX C
MODELS FOR CALCULATING DOSE VIA
ADDITIONAL PATHWAYS FROM RADIOIODINES
AND OTHER RADIONUCLIDES DISCHARGED
TO THE ATMOSPHERE NOV,1977 LIBRARY

SECTOR FLD
DISTANCE = 0 (METERS)
X/Q = 4.63E-04 (SEC/M-3)
X/Q DEPLETED = 4.63E-04 (SEC/M-3)
DELTA = 1.24E-04 (1/M-2)

VY - SEWAGE CONTAM - ASSUMED SRC - 2 ACR
ES - SHIELD F = 0.012 - 104 HR OCCUP.

THE FOLLOWING 1 NUCLIDES WERE USED IN THIS CALCULATION

NUCLIDE	RELEASE CURIES
25 MN 54	1.46E-06

6 PATHWAYS CONSIDERED

GROUND PLANE	YES
INHALATION	YES
STORED VEGETABLES	YES
LEAFY VEGETABLES	YES
COW MILK	YES
GOAT MILK	NO
MEAT	YES

VARIABLE			VEGETABLES		COW MILK		GOAT MILK		MEAT	
			STORED	LEAFY	PASTURE	STORED	PASTURE	STORED	PASTURE	STORED
YV	AGRICULTURAL PRODUCTIVITY	(KG/M-2)	2.00	2.00	.70	2.00	.70	2.00	.70	2.00
P	SOIL SURFACE DENSITY	(KG/M-2)	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00
T	TRANSPORT TIME TO USER	(HRS)			48.00	48.00	48.00	48.00	480.00	480.00
TB	SOIL EXPOSURE TIME	(HRS)	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00
TE	CROP EXPOSURE TIME TO PLUME	(HRS)	.00	.00	.00	.00	.00	.00	.00	.00
TH	HOLDUP AFTER HARVEST	(HRS)	1440.00	24.00	.00	2160.00	.00	2160.00	.00	2160.00
QF	ANIMALS DAILY FEED	(KG/DAY)			50.00	50.00	6.00	6.00	50.00	50.00
FP	FRACTION OF YEAR ON PASTURE				.50		.50		.50	
FS	FRACTION PASTURE WHEN ON PASTURE				1.00		1.00		1.00	
FG	FRACTION OF STORED VEG GROWN IN GARDEN		1.00							
FL	FRACTION OF LEAFY VEG GROWN IN GARDEN			1.00						

FI FRACTION ELEMENTAL IODINE = .500
H ABSOLUTE HUMIDITY = 5.60 (GM/M-3)
PC FRACTIONAL EQUILIBRIUM RATIO FOR C-14 = 1.000

USAGE FACTORS

AGE	VEG (KG/YR)	LEAFY VEG (KG/YR)	MILK (LI/YR)	MEAT (KG/YR)	INHALATION (M-3/YR)
ADULT	520.00	64.00	310.00	110.00	8000.00
TEEN	630.00	42.00	400.00	65.00	8000.00
CHILD	520.00	26.00	330.00	41.00	3700.00
INFANT	.00	.00	330.00	.00	1400.00

DOSE DELIVERED TO EACH ORGAN
FROM ALL PATHWAYS COMBINED
(MREM)

BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
7.54E-05	1.12E-04	8.63E-05	1.05E-04	1.87E-04	7.54E-05	8.24E-05	8.84E-05
7.54E-05	1.29E-04	9.15E-05	1.18E-04	1.85E-04	7.54E-05	8.61E-05	8.84E-05
7.54E-05	1.54E-04	9.74E-05	1.09E-04	1.41E-04	7.54E-05	9.63E-05	8.84E-05
7.54E-05	7.71E-05	7.58E-05	9.68E-05	7.60E-05	7.54E-05	7.58E-05	8.84E-05

PROGRAM ATHODOS
YANKEE ATOMIC ELECTRIC COMPANY
DEC, 1985 REV. 7

REGULATORY GUIDE 1.109, APPENDIX C
MODELS FOR CALCULATING DOSE VIA
ADDITIONAL PATHWAYS FROM RADIOIODINES
AND OTHER RADIONUCLIDES DISCHARGED
TO THE ATMOSPHERE NOV,1977 LIBRARY

SECTOR		FLD
DISTANCE	=	0 (METERS)
X/Q	=	4.63E-04 (SEC/M-3)
X/Q DEPLETED	=	4.63E-04 (SEC/M-3)
DELTA	=	1.24E-04 (1/M-2)

VY - SEWAGE CONTAM - ASSUMED SOURCE - 2
ACRES - SHIELD F = 0.012 - 104 HR OCCUP

6 PATHWAYS CONSIDERED

GROUND PLANE	YES
INHALATION	YES
STORED VEGETABLES	YES
LEAFY VEGETABLES	YES
COW MILK	YES
GOAT MILK	NO
MEAT	YES

THE FOLLOWING 1 NUCLIDES WERE USED IN THIS CALCULATION

NUCLIDE	RELEASE CURIES
27 CO 60	1.07E-06

VARIABLE			VEGETABLES		COW MILK		GOAT MILK		MEAT	
			STORED	LEAFY	PASTURE	STORED	PASTURE	STORED	PASTURE	STORED
YV	AGRICULTURAL PRODUCTIVITY	(KG/M-2)	2.00	2.00	.70	2.00	.70	2.00	.70	2.00
P	SOIL SURFACE DENSITY	(KG/M-2)	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00
T	TRANSPORT TIME TO USER	(HRS)			48.00	48.00	48.00	48.00	480.00	480.00
TB	SOIL EXPOSURE TIME	(HRS)	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00
TE	CROP EXPOSURE TIME TO PLUME	(HRS)	.00	.00	.00	.00	.00	.00	.00	.00
TH	HOLDUP AFTER HARVEST	(HRS)	1440.00	24.00	.00	2160.00	.00	2160.00	.00	2160.00
QF	ANIMALS DAILY FEED	(KG/DAY)			50.00	50.00	6.00	6.00	50.00	50.00
FP	FRACTION OF YEAR ON PASTURE				.50		.50		.50	
FS	FRACTION PASTURE WHEN ON PASTURE				1.00		1.00		1.00	
FG	FRACTION OF STORED VEG GROWN IN GARDEN		1.00							
FL	FRACTION OF LEAFY VEG GROWN IN GARDEN			1.00						

FI FRACTION ELEMENTAL IODINE = .500
H ABSOLUTE HUMIDITY = 5.60 (GM/M-3)
FC FRACTIONAL EQUILIBRIUM RATIO FOR C-14 = 1.000

USAGE FACTORS

AGE	VEG (KG/YR)	LEAFY VEG (KG/YR)	MILK (LI/YR)	MEAT (KG/YR)	INHALATION (M-3/YR)
ADULT	520.00	64.00	310.00	110.00	8000.00
TEEN	630.00	42.00	400.00	65.00	8000.00
CHILD	520.00	26.00	330.00	41.00	3700.00
INFANT	.00	.00	330.00	.00	1400.00

DOSE DELIVERED TO EACH ORGAN
FROM ALL PATHWAYS COMBINED
(MREM)

BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
2.21E-04	2.28E-04	2.21E-04	3.14E-04	3.54E-04	2.21E-04	2.36E-04	2.60E-04
2.21E-04	2.31E-04	2.21E-04	3.57E-04	3.53E-04	2.21E-04	2.43E-04	2.60E-04
2.21E-04	2.36E-04	2.21E-04	3.32E-04	3.04E-04	2.21E-04	2.65E-04	2.60E-04
2.21E-04	2.22E-04	2.21E-04	2.92E-04	2.24E-04	2.21E-04	2.23E-04	2.60E-04

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ADDITIONAL PATHWAYS FROM RADIOIODINES
AND OTHER RADIONUCLIDES DISCHARGED
TO THE ATMOSPHERE NOV.1977 LIBRARY

SECTOR		FLD
DISTANCE	=	0 (METERS)
X/Q	=	4.63E-04 (SEC/M-3)
X/Q DEPLETED	=	4.63E-04 (SEC/M-3)
DELTA	=	1.24E-04 (1/M-2)

VY - SEWAGE CONTAM - ASSUMED SOURCE - 2
ACRES - SHIELD F - 0.012 - 104 HR OCCUP

THE FOLLOWING 1 NUCLIDES WERE USED IN THIS CALCULATION

NUCLIDE	RELEASE CURIES
30 ZN 65	1.61E-06

6 PATHWAYS CONSIDERED

GROUND PLANE	YES
INHALATION	YES
STORED VEGETABLES	YES
LEAFY VEGETABLES	YES
COW MILK	YES
GOAT MILK	NO
MEAT	YES

VARIABLE			VEGETABLES STORED	VEGETABLES LEAFY	COW MILK PASTURE	COW MILK STORED	GOAT MILK PASTURE	GOAT MILK STORED	MEAT PASTURE	MEAT STORED
YV	AGRICULTURAL PRODUCTIVITY	(KG/M-2)	2.00	2.00	.70	2.00	.70	2.00	.70	2.00
P	SOIL SURFACE DENSITY	(KG/M-2)	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00
T	TRANSPORT TIME TO USER	(HRS)			48.00	48.00	48.00	48.00	480.00	480.00
TB	SOIL EXPOSURE TIME	(HRS)	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00
TE	CROP EXPOSURE TIME TO PLUME	(HRS)	.00	.00	.00	.00	.00	.00	.00	.00
TH	HOLDUP AFTER HARVEST	(HRS)	1440.00	24.00	.00	2160.00	.00	2160.00	.00	2160.00
QF	ANIMALS DAILY FEED	(KG/DAY)			50.00	50.00	6.00	6.00	50.00	50.00
FP	FRACTION OF YEAR ON PASTURE				.50		.50		.50	
FS	FRACTION PASTURE WHEN ON PASTURE				1.00		1.00		1.00	
FG	FRACTION OF STORED VEG GROWN IN GARDEN		1.00							
FL	FRACTION OF LEAFY VEG GROWN IN GARDEN			1.00						

FI FRACTION ELEMENTAL IODINE = .500
H ABSOLUTE HUMIDITY = 5.60 (GM/M-3)
FC FRACTIONAL EQUILIBRIUM RATIO FOR C-14 = 1.000

USAGE FACTORS

AGE	VEG (KG/YR)	LEAFY VEG (KG/YR)	MILK (LI/YR)	MEAT (KG/YR)	INHALATION (M-3/YR)
ADULT	520.00	64.00	310.00	110.00	8000.00
TEEN	630.00	42.00	400.00	65.00	8000.00
CHILD	520.00	26.00	330.00	41.00	3700.00
INFANT	.00	.00	330.00	.00	1400.00

DOSE DELIVERED TO EACH ORGAN
FROM ALL PATHWAYS COMBINED
(MREM)

BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
1.22E-03	3.78E-03	2.55E-03	7.24E-05	2.40E-03	5.20E-05	1.74E-03	5.98E-05
1.65E-03	5.59E-03	3.60E-03	8.12E-05	2.40E-03	5.20E-05	2.64E-03	5.98E-05
3.11E-03	8.21E-03	5.19E-03	7.55E-05	1.48E-03	5.20E-05	5.12E-03	5.98E-05
2.21E-03	7.44E-03	3.63E-03	6.72E-05	6.29E-03	5.20E-05	3.46E-03	5.98E-05

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AND OTHER RADIONUCLIDES DISCHARGED
TO THE ATMOSPHERE NOV.1977 LIBRARY

SECTOR FLD
DISTANCE - 0 (METERS)
X/Q - 4.63E-04 (SEC/M-3)
X/Q DEPLETED - 4.63E-04 (SEC/M-3)
DELTA - 1.24E-04 (1/M-2)

VY - SEWAGE CONTAM - ASSUMED SOURCE - 2
ACRES - SHIELD F - 0.012 - 104 HR OCCUP

THE FOLLOWING 1 NUCLIDES WERE USED IN THIS CALCULATION

NUCLIDE	RELEASE CURIES
55 CS 134	1.18E-06

6 PATHWAYS CONSIDERED

GROUND PLANE	YES
INHALATION	YES
STORED VEGETABLES	YES
LEAFY VEGETABLES	YES
COW MILK	YES
GOAT MILK	NO
MEAT	YES

VARIABLE			VEGETABLES		COW MILK		GOAT MILK		MEAT	
			STORED	LEAFY	PASTURE	STORED	PASTURE	STORED	PASTURE	STORED
YV	AGRICULTURAL PRODUCTIVITY	(KG/M-2)	2.00	2.00	.70	2.00	.70	2.00	.70	2.00
P	SOIL SURFACE DENSITY	(KG/M-2)	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00
T	TRANSPORT TIME TO USER	(HRS)			48.00	48.00	48.00	48.00	480.00	480.00
TB	SOIL EXPOSURE TIME	(HRS)	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00
TE	CROP EXPOSURE TIME TO PLUME	(HRS)	.00	.00	.00	.00	.00	.00	.00	.00
TH	HOLDUP AFTER HARVEST	(HRS)	1440.00	24.00	.00	2160.00	.00	2160.00	.00	2160.00
QF	ANIMALS DAILY FEED	(KG/DAY)			50.00	50.00	6.00	6.00	50.00	50.00
FP	FRACTION OF YEAR ON PASTURE				.50		.50		.50	
FS	FRACTION PASTURE WHEN ON PASTURE				1.00		1.00		1.00	
FG	FRACTION OF STORED VEG GROWN IN GARDEN		1.00							
FL	FRACTION OF LEAFY VEG GROWN IN GARDEN			1.00						

FI FRACTION ELEMENTAL IODINE = .500
H ABSOLUTE HUMIDITY = 5.60 (GM/M-3)
PC FRACTIONAL EQUILIBRIUM RATIO FOR C-14 = 1.000

USAGE FACTORS

AGE	VEG (KG/YR)	LEAFY VEG (KG/YR)	MILK (LI/YR)	MEAT (KG/YR)	INHALATION (M-3/YR)
ADULT	520.00	64.00	310.00	110.00	8000.00
TEEN	630.00	42.00	400.00	65.00	8000.00
CHILD	520.00	26.00	330.00	41.00	3700.00
INFANT	.00	.00	330.00	.00	1400.00

DOSE DELIVERED TO EACH ORGAN
FROM ALL PATHWAYS COMBINED
(MREM)

BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
4.04E-04	7.46E-04	3.47E-04	2.19E-04	1.66E-04	1.56E-04	6.39E-04	1.82E-04
5.44E-04	1.07E-03	4.46E-04	2.67E-04	1.67E-04	1.56E-04	5.79E-04	1.82E-04
1.03E-03	1.59E-03	6.00E-04	3.15E-04	1.64E-04	1.56E-04	4.58E-04	1.82E-04
5.31E-04	8.55E-04	3.36E-04	2.30E-04	1.58E-04	1.56E-04	2.26E-04	1.82E-04

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AND OTHER RADIONUCLIDES DISCHARGED
TO THE ATMOSPHERE NOV,1977 LIBRARY

SECTOR		FLD	
DISTANCE	=	0	(METERS)
X/Q	=	4.63E-04	(SEC/M-3)
X/Q DEPLETED	=	4.63E-04	(SEC/M-3)
DELTA	=	1.24E-04	(1/M-2)

VY - SEWAGE CONTAM - ASSUMED SOURCE - 2
ACRES - SHIELD F = 0.012 - 104 HR OCCUP

6 PATHWAYS CONSIDERED

GROUND PLANE	YES
INHALATION	YES
STORED VEGETABLES	YES
LEAFY VEGETABLES	YES
COW MILK	YES
GOAT MILK	NO
MEAT	YES

THE FOLLOWING 1 NUCLIDES WERE USED IN THIS CALCULATION

NUCLIDE	RELEASE CURIES
55 CS 137	1.01E-06

	VARIABLE		VEGETABLES STORED	VEGETABLES LEAFY	COW MILK PASTURE	COW MILK STORED	GOAT MILK PASTURE	GOAT MILK STORED	MEAT PASTURE	MEAT STORED
YV	AGRICULTURAL PRODUCTIVITY	(KG/M-2)	2.00	2.00	.70	2.00	.70	2.00	.70	2.00
P	SOIL SURFACE DENSITY	(KG/M-2)	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00
T	TRANSPORT TIME TO USER	(HRS)			48.00	48.00	48.00	48.00	480.00	480.00
TB	SOIL EXPOSURE TIME	(HRS)	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00
TE	CROP EXPOSURE TIME TO PLUME	(HRS)	.00	.00	.00	.00	.00	.00	.00	.00
TH	HOLDUP AFTER HARVEST	(HRS)	1440.00	24.00	.00	2160.00	.00	2160.00	.00	2160.00
QF	ANIMALS DAILY FEED	(KG/DAY)			50.00	50.00	6.00	6.00	50.00	50.00
FP	FRACTION OF YEAR ON PASTURE				.50		.50		.50	
FS	FRACTION PASTURE WHEN ON PASTURE				1.00		1.00		1.00	
FG	FRACTION OF STORED VEG GROWN IN GARDEN		1.00							
FL	FRACTION OF LEAFY VEG GROWN IN GARDEN			1.00						

FI FRACTION ELEMENTAL IODINE = .500
H ABSOLUTE HUMIDITY = 5.60 (GM/M-3)
PC FRACTIONAL EQUILIBRIUM RATIO FOR C-14 = 1.000

USAGE FACTORS

AGE	VEG (KG/YR)	LEAFY VEG (KG/YR)	MILK (LI/YR)	MEAT (KG/YR)	INHALATION (M-3/YR)
ADULT	520.00	64.00	310.00	110.00	8000.00
TEEN	630.00	42.00	400.00	65.00	8000.00
CHILD	520.00	26.00	330.00	41.00	3700.00
INFANT	.00	.00	330.00	.00	1400.00

DOSE DELIVERED TO EACH ORGAN
FROM ALL PATHWAYS COMBINED
(MREM)

BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
				6.33E-05	5.46E-05	3.52E-04	6.37E-05
3.86E-04	5.07E-04	2.09E-04	1.06E-04	6.48E-05	5.46E-05	3.06E-04	6.37E-05
5.97E-04	7.75E-04	3.00E-04	1.50E-04	6.23E-05	5.46E-05	2.35E-04	6.37E-05
1.33E-03	1.28E-03	4.53E-04	1.98E-04	5.66E-05	5.46E-05	9.94E-05	6.37E-05
5.94E-04	6.86E-04	2.24E-04	1.23E-04				

B.5.5 Impact due to 1 uCi of Cs 137

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ADDITIONAL PATHWAYS FROM RADIOIODINES
AND OTHER RADIONUCLIDES DISCHARGED
TO THE ATMOSPHERE NOV,1977 LIBRARY

SECTOR		FLD
DISTANCE	=	0 (METERS)
X/Q	=	4.63E-04 (SEC/M-3)
X/Q DEPLETED	=	4.63E-04 (SEC/M-3)
DELTA	=	1.24E-04 (1/M-2)

VY - SEWAGE CONTAM - ASSUMED SOURCE - 2
ACRES - SHIELD F = 0.012 - 104 HR OCCUP

THE FOLLOWING 1 NUCLIDES WERE USED IN THIS CALCULATION

NUCLIDE	RELEASE CURIES
55 CS 137	1.01E-06

6 PATHWAYS CONSIDERED

GROUND PLANE	YES
INHALATION	YES
STORED VEGETABLES	YES
LEAFY VEGETABLES	YES
COW MILK	YES
GOAT MILK	NO
MEAT	YES

VARIABLE			VEGETABLES		COW MILK		GOAT MILK		MEAT	
			STORED	LEAFY	PASTURE	STORED	PASTURE	STORED	PASTURE	STORED
YV	AGRICULTURAL PRODUCTIVITY	(KG/M-2)	2.00	2.00	.70	2.00	.70	2.00	.70	2.00
P	SOIL SURFACE DENSITY	(KG/M-2)	240.00	240.00	240.00	240.00	240.00	240.00	240.00	240.00
T	TRANSPORT TIME TO USER	(HRS)			48.00	48.00	48.00	48.00	480.00	480.00
TB	SOIL EXPOSURE TIME	(HRS)	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00	8766.00
TE	CROP EXPOSURE TIME TO PLUME	(HRS)	.00	.00	.00	.00	.00	.00	.00	.00
TH	HOLDUP AFTER HARVEST	(HRS)	1440.00	24.00	.00	2160.00	.00	2160.00	.00	2160.00
QF	ANIMALS DAILY FEED	(KG/DAY)			50.00	50.00	6.00	6.00	50.00	50.00
FP	FRACTION OF YEAR ON PASTURE				.50		.50		.50	
FS	FRACTION PASTURE WHEN ON PASTURE				1.00		1.00		1.00	
FG	FRACTION OF STORED VEG GROWN IN GARDEN		1.00							
FL	FRACTION OF LEAFY VEG GROWN IN GARDEN			1.00						

FI FRACTION ELEMENTAL IODINE = .500
H ABSOLUTE HUMIDITY = 5.60 (GM/M-3)
FC FRACTIONAL EQUILIBRIUM RATIO FOR C-14 = 1.000

USAGE FACTORS

AGE	VEG (KG/YR)	LEAFY VEG (KG/YR)	MILK (LI/YR)	MEAT (KG/YR)	INHALATION (M-3/YR)
ADULT	520.00	64.00	310.00	110.00	8000.00
TEEN	630.00	42.00	400.00	65.00	8000.00
CHILD	520.00	26.00	330.00	41.00	3700.00
INFANT	.00	.00	330.00	.00	1400.00

DOSE DELIVERED TO EACH ORGAN
FROM ALL PATHWAYS COMBINED
(MREM)

BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
3.86E-04	5.07E-04	2.09E-04	1.06E-04	6.33E-05	5.46E-05	3.52E-04	6.37E-05
5.97E-04	7.75E-04	3.00E-04	1.50E-04	6.48E-05	5.46E-05	3.06E-04	6.37E-05
1.33E-03	1.28E-03	4.53E-04	1.98E-04	6.23E-05	5.46E-05	2.35E-04	6.37E-05
5.94E-04	6.86E-04	2.24E-04	1.23E-04	5.66E-05	5.46E-05	9.94E-05	6.37E-05

TABLE 1
NON-SEQUENCED RECEPTOR LOCATIONS
BY AGE GROUP
DOSE DELIVERED TO EACH ORGAN FROM ALL PATHWAYS COMBINED
(EXTERNAL DIRECT DOSE ADDED TO ALL INTERNAL DOSES)
(MREM)

SECT	DIST. METERS	AGE GROUP	PATHWAY		BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	WHOLE BODY	SKIN
FLD	0	ADULT	COW	MEAT	3.86E-04	5.07E-04	2.09E-04	1.06E-04	6.33E-05	5.46E-05	3.52E-04	6.37E-05
FLD	0	TEEN	COW	MEAT	5.97E-04	7.75E-04	3.00E-04	1.50E-04	6.48E-05	5.46E-05	3.06E-04	6.37E-05
FLD	0	CHILD	COW	MEAT	1.33E-03	1.28E-03	4.53E-04	1.98E-04	6.23E-05	5.46E-05	2.35E-04	6.37E-05
FLD	0	INFANT	COW	MEAT	5.94E-04	6.86E-04	2.24E-04	1.23E-04	5.66E-05	5.46E-05	9.94E-05	6.37E-05

TABLE 2
SEQUENCED RECEPTOR LOCATIONS BY
DESCENDING WHOLE BODY DOSE
(EXTERNAL DIRECT DOSE ADDED TO ALL INTERNAL DOSES)
(MREM)

SECT	DIST. METERS	AGE GROUP	PATHWAY		BONE	LIVER	KIDNEY	LUNG	GI-LLI	THYROID	* WHOLE BODY	SKIN
FLD	0	CHILD	COW	MEAT	3.11E-03	8.21E-03	5.19E-03	7.55E-05	1.48E-03	5.20E-05	5.12E-03	5.98E-05
FLD	0	INFANT	COW	MEAT	2.21E-03	7.44E-03	3.63E-03	6.72E-05	6.29E-03	5.20E-05	3.46E-03	5.98E-05
FLD	0	TEEN	COW	MEAT	1.65E-03	5.59E-03	3.60E-03	8.12E-05	2.40E-03	5.20E-05	2.64E-03	5.98E-05
FLD	0	ADULT	COW	MEAT	1.22E-03	3.78E-03	2.55E-03	7.24E-05	2.40E-03	5.20E-05	1.74E-03	5.98E-05
FLD	0	ADULT	COW	MEAT	4.04E-04	7.46E-04	3.47E-04	2.19E-04	1.66E-04	1.56E-04	6.39E-04	1.82E-04
FLD	0	TEEN	COW	MEAT	5.44E-04	1.07E-03	4.46E-04	2.67E-04	1.67E-04	1.56E-04	5.79E-04	1.82E-04
FLD	0	CHILD	COW	MEAT	1.03E-03	1.59E-03	6.00E-04	3.15E-04	1.64E-04	1.56E-04	4.58E-04	1.82E-04
FLD	0	ADULT	COW	MEAT	3.86E-04	5.07E-04	2.09E-04	1.06E-04	6.33E-05	5.46E-05	3.52E-04	6.37E-05
FLD	0	TEEN	COW	MEAT	5.97E-04	7.75E-04	3.00E-04	1.50E-04	6.48E-05	5.46E-05	3.06E-04	6.37E-05
FLD	0	CHILD	COW	MEAT	2.21E-04	2.36E-04	2.21E-04	3.32E-04	3.04E-04	2.21E-04	2.65E-04	2.60E-04
FLD	0	TEEN	COW	MEAT	2.21E-04	2.31E-04	2.21E-04	3.37E-04	3.53E-04	2.21E-04	2.43E-04	2.60E-04
FLD	0	ADULT	COW	MEAT	2.21E-04	2.28E-04	2.21E-04	3.14E-04	3.54E-04	2.21E-04	2.36E-04	2.60E-04
FLD	0	CHILD	COW	MEAT	1.33E-03	1.28E-03	4.53E-04	1.98E-04	6.23E-05	5.46E-05	2.35E-04	6.37E-05
FLD	0	INFANT	COW	MEAT	5.31E-04	8.55E-04	3.36E-04	2.30E-04	1.58E-04	1.56E-04	2.26E-04	1.82E-04
FLD	0	INFANT	COW	MEAT	2.21E-04	2.23E-04	2.21E-04	2.92E-04	2.24E-04	2.21E-04	2.23E-04	2.60E-04
FLD	0	INFANT	COW	MEAT	5.94E-04	6.86E-04	2.24E-04	1.23E-04	5.56E-05	5.46E-05	9.94E-05	6.37E-05
FLD	0	CHILD	COW	MEAT	7.54E-05	1.54E-04	9.74E-05	1.09E-04	1.41E-04	7.54E-05	9.63E-05	8.84E-05
FLD	0	TEEN	COW	MEAT	7.54E-05	1.29E-04	9.15E-05	1.18E-04	1.85E-04	7.54E-05	8.61E-05	8.84E-05
FLD	0	ADULT	COW	MEAT	7.54E-05	1.12E-04	8.63E-05	1.05E-04	1.87E-04	7.54E-05	8.24E-05	8.84E-05
FLD	0	INFANT	COW	MEAT	7.54E-05	7.71E-05	7.58E-05	9.68E-05	7.60E-05	7.54E-05	7.58E-05	8.84E-05

TABLE 3
SEQUENCED RECEPTOR LOCATIONS BY
DESCENDING THYROID DOSE
(EXTERNAL DIRECT DOSE ADDED TO ALL INTERNAL DOSES)
(MREM)

SECT	DIST. METERS	AGE GROUP	PATHWAY		BONE	LIVER	KIDNEY	LUNG	GI-LLI	* THYROID	WHOLE BODY	SKIN
FLD	0	INFANT	COW	MEAT	2.21E-04	2.22E-04	2.21E-04	2.92E-04	2.24E-04	2.21E-04	2.23E-04	2.60E-04
FLD	0	CHILD	COW	MEAT	2.21E-04	2.36E-04	2.21E-04	3.32E-04	3.04E-04	2.21E-04	2.65E-04	2.60E-04
FLD	0	TEEN	COW	MEAT	2.21E-04	2.31E-04	2.21E-04	3.57E-04	3.53E-04	2.21E-04	2.43E-04	2.60E-04
FLD	0	ADULT	COW	MEAT	2.21E-04	2.28E-04	2.21E-04	3.14E-04	3.54E-04	2.21E-04	2.36E-04	2.60E-04
FLD	0	INFANT	COW	MEAT	5.31E-04	8.55E-04	3.36E-04	2.30E-04	1.58E-04	1.56E-04	2.26E-04	1.82E-04
FLD	0	CHILD	COW	MEAT	1.03E-03	1.59E-03	6.00E-04	3.15E-04	1.64E-04	1.56E-04	4.58E-04	1.82E-04
FLD	0	TEEN	COW	MEAT	5.44E-04	1.07E-03	4.46E-04	2.67E-04	1.67E-04	1.56E-04	5.79E-04	1.82E-04
FLD	0	ADULT	COW	MEAT	4.04E-04	7.46E-04	3.47E-04	2.19E-04	1.66E-04	1.56E-04	6.39E-04	1.82E-04
FLD	0	INFANT	COW	MEAT	7.54E-05	7.71E-05	7.58E-05	9.68E-05	7.60E-05	7.54E-05	7.58E-05	8.84E-05
FLD	0	CHILD	COW	MEAT	7.54E-05	1.54E-04	9.74E-05	1.09E-04	1.41E-04	7.54E-05	9.63E-05	8.84E-05
FLD	0	TEEN	COW	MEAT	7.54E-05	1.29E-04	9.15E-05	1.18E-04	1.85E-04	7.54E-05	8.61E-05	8.84E-05
FLD	0	ADULT	COW	MEAT	7.54E-05	1.12E-04	8.63E-05	1.05E-04	1.87E-04	7.54E-05	8.24E-05	8.84E-05
FLD	0	TEEN	COW	MEAT	5.97E-04	7.75E-04	3.00E-04	1.50E-04	6.48E-05	5.46E-05	3.06E-04	6.37E-05
FLD	0	ADULT	COW	MEAT	3.86E-04	5.07E-04	2.09E-04	1.06E-04	6.33E-05	5.46E-05	3.52E-04	6.37E-05
FLD	0	INFANT	COW	MEAT	5.94E-04	6.86E-04	2.24E-04	1.23E-04	5.66E-05	5.46E-05	9.94E-05	6.37E-05
FLD	0	CHILD	COW	MEAT	1.33E-03	1.28E-03	4.53E-04	1.98E-04	6.23E-05	5.46E-05	2.35E-04	6.37E-05
FLD	0	INFANT	COW	MEAT	2.21E-03	7.44E-03	3.63E-03	6.72E-05	6.29E-03	5.20E-05	3.46E-03	5.98E-05
FLD	0	CHILD	COW	MEAT	3.11E-03	8.21E-03	5.19E-03	7.55E-05	1.48E-03	5.20E-05	5.12E-03	5.98E-05
FLD	0	TEEN	COW	MEAT	1.65E-03	5.59E-03	3.60E-03	8.12E-05	2.40E-03	5.20E-05	2.64E-03	5.98E-05
FLD	0	ADULT	COW	MEAT	1.22E-03	3.78E-03	2.55E-03	7.24E-05	2.40E-03	5.20E-05	1.74E-03	5.98E-05

TAPLE 4
SEQUENCED RECEPTOR LOCATION BY
DESCENDING ORGAN DOSE

DOSE DELIVERED TO EACH ORGAN FROM ALL PATHWAYS COMBINED
(MREM)

SECTOR	DISTANCE METERS	AGE GROUP	PATHWAY	DOSE	ORGAN
FLD	0	CHILD	COW MEAT	8.21E-03	LIVER
FLD	0	CHILD	COW MEAT	8.21E-03	LIVER
FLD	0	CHILD	COW MEAT	8.21E-03	LIVER
FLD	0	INFANT	COW MEAT	7.44E-03	LIVER
FLD	0	INFANT	COW MEAT	7.44E-03	LIVER
FLD	0	INFANT	COW MEAT	7.44E-03	LIVER
FLD	0	INFANT	COW MEAT	6.29E-03	GI-LLI
FLD	0	INFANT	COW MEAT	6.29E-03	GI-LLI
FLD	0	INFANT	COW MEAT	6.29E-03	GI-LLI
FLD	0	TEEN	COW MEAT	5.59E-03	LIVER
FLD	0	TEEN	COW MEAT	5.59E-03	LIVER
FLD	0	TEEN	COW MEAT	5.59E-03	LIVER
FLD	0	CHILD	COW MEAT	5.19E-03	KIDNEY
FLD	0	CHILD	COW MEAT	5.19E-03	KIDNEY
FLD	0	CHILD	COW MEAT	5.19E-03	KIDNEY
FLD	0	CHILD	COW MEAT	5.12E-03	WHBODY
FLD	0	CHILD	COW MEAT	5.12E-03	WHBODY
FLD	0	CHILD	COW MEAT	5.12E-03	WHBODY
FLD	0	ADULT	COW MEAT	3.78E-03	LIVER
FLD	0	ADULT	COW MEAT	3.78E-03	LIVER
FLD	0	ADULT	COW MEAT	3.78E-03	LIVER
FLD	0	INFANT	COW MEAT	3.63E-03	KIDNEY
FLD	0	INFANT	COW MEAT	3.63E-03	KIDNEY
FLD	0	INFANT	COW MEAT	3.63E-03	KIDNEY
FLD	0	TEEN	COW MEAT	3.60E-03	KIDNEY
FLD	0	TEEN	COW MEAT	3.60E-03	KIDNEY
FLD	0	TEEN	COW MEAT	3.60E-03	KIDNEY
FLD	0	INFANT	COW MEAT	3.46E-03	WHBODY
FLD	0	INFANT	COW MEAT	3.46E-03	WHBODY
FLD	0	INFANT	COW MEAT	3.46E-03	WHBODY
FLD	0	CHILD	COW MEAT	3.11E-03	BONE
FLD	0	CHILD	COW MEAT	3.11E-03	BONE
FLD	0	CHILD	COW MEAT	3.11E-03	BONE
FLD	0	TEEN	COW MEAT	2.64E-03	WHBODY
FLD	0	TEEN	COW MEAT	2.64E-03	WHBODY
FLD	0	TEEN	COW MEAT	2.64E-03	WHBODY
FLD	0	ADULT	COW MEAT	2.55E-03	KIDNEY
FLD	0	ADULT	COW MEAT	2.55E-03	KIDNEY
FLD	0	ADULT	COW MEAT	2.55E-03	KIDNEY
FLD	0	ADULT	COW MEAT	2.40E-03	GI-LLI
FLD	0	TEEN	COW MEAT	2.40E-03	GI-LLI
FLD	0	ADULT	COW MEAT	2.40E-03	GI-LLI
FLD	0	TEEN	COW MEAT	2.40E-03	GI-LLI
FLD	0	ADULT	COW MEAT	2.40E-03	GI-LLI
FLD	0	TEEN	COW MEAT	2.40E-03	GI-LLI
FLD	0	INFANT	COW MEAT	2.21E-03	BONE
FLD	0	INFANT	COW MEAT	2.21E-03	BONE
FLD	0	INFANT	COW MEAT	2.21E-03	BONE
FLD	0	ADULT	COW MEAT	1.74E-03	WHBODY
FLD	0	ADULT	COW MEAT	1.74E-03	WHBODY

THE FOLLOWING FILES WERE USED IN THIS RUN

1	1	VYPI	VY STANDARD PROGRAM INFORMATION FILE
0	2	VYGASRL	GAS STK VY 87 1 1 0 87063023!
1	5	QUERY	PATHWAYS: SHORE(1,2,3),BHD,ROAD,RES1,RAD,HEAT,GOAT,COW
1	6	VYUFMAX	VY MAXIMUM INDIVIDUAL USAGE FACTORS FOR STANDARD PROBLEMS
1	7	VYGSD	VY MAX INDIVIDUAL GAS SITE DATA FILE FOR STANDARD PROBLEMS
1	8	ISTPNRL	NUCLIDE LIBRARY FOR ALL DOSE PROGRAMS
1	3	VYXQF	VY X/QFILE - SPECIAL VALUES - SEWAGE CONTAM. PROBLEM - 2 ACR