OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
ANALYSIS/MODEL COVER SHEET
Complete Only Applicable Items

1. QA: QA
Page: 1 of: 39

2. [√] Analysis [ ] Engineering
[√] Performance Assessment
[ ] Scientific

3. [ ] Model [ ] Conceptual Model Documentation
[ ] Model Documentation
[ ] Model Validation Documentation

4. Title:
Environmental Transport Parameters Analysis

5. Document Identifier (including Rev. No. and Change No., if applicable):
ANL-MGR-MD-000007 / Rev. 00

6. Total Attachments:
2

7. Attachment Numbers - No. of Pages in Each:
I - 1, and II - 13.

	Printed Name	Signature	Date
8. Originator	De (Wesley) Wu	D. Wu	9/21/99
9. Checker	Kaylie Rasmuson, Keith Kersch	Kaylie Rasmuson Keith M Kersch	9/21/99 9/21/99
10. Lead/Supervisor	John F. Schmitt	John F Schmitt	9/21/99
11. Responsible Manager	Larry D. Croft	Larry D. Croft	9/21/99

12. Remarks:

AP-3.10Q.3 Rev. 06/30/1999

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
ANALYSIS/MODEL REVISION RECORD

Complete Only Applicable Items

2. Analysis or Model Title:
Environmental Transport Parameters Analysis

3. Document Identifier (including Rev. No. and Change No., if applicable):

ANL-MGR-MD-000007 / Rev. 00

4. Revision/Change No.	5. Description of Revision/Change
Rev.00	Initial issue.

AP-3.10Q.4 Rev. 06/30/1999

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
TECHNICAL CHANGE REQUEST

QA: 3
Page 1 of: ~~3~~ DW 11/5/99

Section 1 - Change Description

1. TCR NO.: T1999-0061

1a. INTERIM TCR NO.: *(expedited changes only)* N/A

2. PRIORITY: ☑ Routine ☐ Expedited

3. Q: ☑ Q ☐ Non-Q

4. DOCUMENT ACTION: ☑ Initial Issue ☐ Revision ☐ Change ☐ Editorial

5. TCR TITLE:
Environmental Transport Parameter Analysis

6. ORIGINATOR:

Name	*Signature*	*Date*	*Phone*	*Bldg./Room*
De (Wesley) Wu	[signature]	7/16/99	295-5032	Sum 2/227K

7. DOCUMENTS REQUIRED TO IMPLEMENT CHANGE:

Document No. ANL-MGR-MD-000007 Rev./ICN 0/0

Title Environmental Transport Parameter Analysis

☐ Continuation Page

8. TCR JUSTIFICATION:
The subject analysis develops environmental transport parameters that are required/used by the computer code GENII-S to calculate radionuclide-specific biosphere dose conversion factors (BDCFs). These conversion factors will be used to calculate potential radiation doses to a hypothetical human receptor as a part of Performance Assessment for the Site Recommendation.

☐ Continuation Page

9. TCR DESCRIPTION: *(Include sketch(es) as necessary)*
The analysis develops environmental transport parameters for calculation of BDCFs using GENII-S code. AMR, which is prepared according to AP-3.10 procedure documents the process of selection, calculation and justification of environmental transport parameters.

☐ Continuation Page

10. ATTACHMENTS:
None

☐ Continuation Page

11. RELATED CAUSE DOCUMENT(S): (TCR, CAR, NCR, DR, ETC.)
None

12. CAUSE CODE(s)
1. 25
2.
3.
4.

13. IMPACT IF CHANGE IS NOT MADE:
Biosphere Dose Conversion Factors calculation in support of the TSPA for the Site Recommendation can not be calculated in support of the TSPA for the Site Recommendation..

☐ Continuation Page

14. RESPONSIBLE SUPERVISOR:

Name	*Signature*	*Date/Time*	*Phone*	*Bldg./Room*
John F. Schmitt	[signature]	7/16/99 7:55 AM	295-4249	Sum 2/221

Section 2 - Disposition of Expedited Changes

	Name	*Signature*	*Date*	
15. SME:				*Concur?* ☐ Yes ☐ No
16. OQA REPRESENTATIVE:				*Concur?* ☐ Yes ☐ No
17. RESPONSIBLE MANAGER:				*Interim Approval?* ☐ Yes ☐ No

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
TECHNICAL CHANGE REQUEST

QA: 3

18. TCR NO.:	19. INTERIM TCR NO.: *(expedited changes only)*	20. ACCEPTED BY CCB SECRETARY:
T1999-0061	N/A	1. Initials ____ Date/Time ____ DW 11/5/99 2. Initials Y Date/Time 11-4-9

Section 3 - Impact Analysis

21. DISPOSITION AUTHORITY: ☐ RM ☐ OM ☑ CCB

22. AUTHORIZATION TO CONTINUE: ☑ Yes ☐ No
Name: RG VAWTER — Signature: [signature] — Date: 7-21-99

23. CCB REQUIRED REVIEW LIST CHANGE: ☐ Yes ☐ No

24. TECHNICAL IMPACT(S): ☐ N/A

	Yes	No
1. Design	☐	☒
2. QA	☒	☐
3. Safety/Health	☐	☒
4. OMT	☐	☒
5. Interface	☐	☒
6. Regulatory/Environmental	☐	☒
7. Construction	☐	☒
8. Waste Isolation	☐	☒
9. Scientific Investigation	☐	☒
10. Specialty Engineering	☐	☒
11. Affected Technical Documents	☐	☒
12. Performance Assessment	☒	☐
13. Other	☐	☒

☐ Continuation Page ____

25 COST IMPACT(S): ☐ N/A

	Yes	No	Increase	Decrease	Amount
1. TPC	☐	☒	☐	☐	$
2. TSLCC	☐	☒	☐	☐	$
3. Budget Baseline	☐	☒	☐	☐	$

☐ Continuation Page ____

26. SCHEDULE IMPACT SCOPE:
☐ Level 0 ☐ Level 1 ☐ Level 2 ☐ Level 3 ☒ N/A
☐ Delay ☐ Improve ____ Days
☐ Continuation Page ____

27. OTHER IMPACTS: ☐ N/A

	Yes	No
1. Institutional	☐	☒
2. Contractual	☐	☒
3. Programmatic	☐	☒
4. Work Scope	☐	☒

28. OTHER IMPACTED DOCUMENTS: *(enter document no. & title)*
N/A

☐ Continuation Page ____

Section 4 - Disposition

29.

FUNCTION	RECOMMENDED? Yes	No	N/A	PRINT NAME/INITIAL/DATE
N/A				

30. DISPOSITION:
☑ Approve ☐ Approve with Conditions ☐ Disapprove ☐ Endorse ☐ Defer

*** After Making Disposition, Please Return TCR Package to the CCB Secretary ***

31. COMMENTS/IMPLEMENTING ACTIONS/RATIONALE FOR DISPOSITION OTHER THAN APPROVE:
N/A

☐ Continuation Page ____

32. ACTION ITEMS: ☐ Yes ☑ No ☐ N/A

	Name	Signature	Date
33. RESPONSIBLE MANAGER:	N/A		
34. RESPONSIBLE OPERATIONS MANAGER:	N/A		
35. CCB CHAIRPERSON:	Jean Younker	[signature]	11-4-99

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
TECHNICAL CHANGE REQUEST
CONTINUATION PAGE

1. TCR NO.: T1999-0061	

2. BLOCK NUMER	3. CONTINUATION INFORMATION
7	RIB 00064, Environmental Transport Parameter Values For Dose Assessment

Preliminary Impact Analysis

Potential Impact on Design, Site Characterization, and Performance Assessment

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TCR Title: Environmental Transport Parameter Analysis

TCR Number: T1999-0061

Responsible Manager: John F. Schmitt (295-4249)

The parameter values to be developed in this Analysis and Model Report (AMR) are required input to the GENII-S computer code used to calculate Biosphere Dose Conversion Factors (BCDFs) for specific radionuclides. BCDFs will be used as input to the Repository Integrated Performance computer model to calculate an estimate of annual radiation dose to a human receptor (i.e., critical group). Radiation dose estimates are required under the proposed Title 10 Code of Federal Regulations Part 63, Section 115. These estimates are an essential part of the Total System Performance Assessment for Site Recommendation (TSPA-SR). Therefore these parameter values are considered to be critical, and the impact on performance assessment is considered to be major.

The acquired and developed data associated with this AMR do not have a direct impact on either design or site characterization. Depending on the TSPA-SR biosphere dose estimates (that use these data), certain design aspects may be influenced. However, the potential impact of these data on design is considered to be low.

Potential impacts on internal and external interfaces are expected to be minimal. Developed data from this analysis are an internal organizational data feed that has been coordinated and planned through the project planning system. There are no direct external impacts on any organizations. Therefore, there are no impacts on any Interface Control Documents.

TCR No. T1999-0061

DETAILED IMPACT ANALYSIS for

Analysis Model Report: (ANL-MGR-MD-000007 Rev.00)
Environmental Transport Parameters Analysis, and

Reference Inference Base (RlB) Data Item: (RlB 00064)
Environmental Transport Parameter Values for Dose Assessment

Subject Matter Expert: ______________ Date: 10 - 26 - 99
Jeff Tappen

SUMMARY OF TECHNICAL BASELINE CHANGE

The Analysis Model Report (AMR) and Reference Inference Base (RIB) Data Item will document the selection or estimation of the best value for environmental transport parameters that are used in the computer code GENII-S (Leigh et al. 1993) to estimate potential radiation exposure. GENlI-S is being used to estimate radionuclide-specific biosphere dose conversion factors (BDCFs). The CRWMS-M&O Performance Assessment Organization will use the BDCFs to calculate potential radiation doses to a hypothetical human receptor group to assess post-closure performance for the Site Recommendation.

TECHNICAL IMPACT(S)

Only one technical impact was identified. This AMR and RlB Data Item provide values and justification for model inputs for calculating biosphere dose conversion factors. Therefore it contains information needed to complete the biosphere dose calculations in TSPA-SR and would have an impact on the Performance Assessment Organization if not issued.

Alternatives to the preparation of the AMR and RIB Data Item were not considered as this was the process selected and approved by M&O management.

This is the initial issue of these documents, therefore, review of previously approved changes was not applicable.

Technical Impact Evaluation and Justification:

1) **Design -**The AMR and RIB Data Item do not specify any information used in design or that could impact design. Therefore they have no impact.

2) **QA** – The AMR and RIB Data Item will have no impact on QA procedures. Implementation of the AMR and RIB Data Item will not require new QA procedures or surveillances.

3) **Safety/Health** – The AMR and RIB Data Item have no impact on safety and health concerns. Both documents specify and justify data values for model input parameters.

4) **Operations, Maintenance and Testing** – Implementation of the either the AMR or RIB Data Item will not affect any operations, maintenance, or testing procedure

5) **Interface** – The parameter values selected and justified in the AMR and RIB Data Item are an internal organizational data feed that will be accomplished through the Technical Database Management System (TDMS) and the RIB Data Item. Therefore there are no impacts on any Interface Control Documents.

6) **Regulatory/Environmental** – Although the parameter values developed in the AMR and RIB Data Item will support the evaluation of compliance with the radiation dose standard for the repository, the parameter values have no direct effect on either licensing strategy or environmental requirements.

7) **Construction** – Information developed and presented in either the AMR or RIB Data Item is not related to construction, and therefore neither document has an impact.

8) **Waste Isolation** – There is no impact on waste isolation. The AMR and RIB Data Item are not related to either natural or engineered barriers for isolating radioactive waste.

9) **Scientific Investigation** – The information developed in either the AMR or RIB Data Item will not impact any ongoing scientific investigations. Neither document contains data or information that would impact any scientific assumptions.

10) **Specialty Engineering** – The AMR and RIB Data Item are not related to any specialty engineering.

11) **Affected Technical Documents** – This is the initial issuance of this document. It does not impact any existing documents.

12) **Performance Assessment** – The data values selected or developed in this analysis are required to calculate biological dose conversion factors for specific radionuclides. The BDCFs are a direct data input into TSPA-SR. Therefore, the AMR and RIB Data Item does impact Performance Assessment.

13) **Other** - There are no other considerations related to technical impacts.

COST IMPACT(S)

Approval and issuance of this AMR and RIB Data Item will not impact Total Project Cost, Total System Life Cycle Cost, or baseline budget as evaluated against criteria in Attachment 6 in AP-3.4Q.

Cost Impact Evaluation:

1) **Total Project Cost (TPC)** – Implementation of the AMR and RIB Data Item does not impact TPC. It does not exceed Level 3-approval authority.

2) **TSLCC** – Issuance of the AMR and RIB Data Item will not impact Total System Life Cycle Cost.

3) **Budget Baseline** – The implementation will not impact the budget baseline. Implementation of the AMR and RIB Data Item is within the scope and planned cost in the Multi-Year Plan.

SCHEDULE IMPACT(S)

The data developed in the AMR and RIB Data Item feeds FY99 Activities SSPMR275 and SSPMR355. This information is needed to meet downstream deliverables, including the Level 3, Process Model Report for Biosphere Dose Conversion Factors. Implementation of the AMR and associated RIB Data Item will make data available for Activity SSPMR275 and SSPMR355. These activities will be completed within the schedule in the current FY99 & FY00 work plans. Therefore, there are no anticipated impacts on schedules.

OTHER IMPACT(S)

There are no other impacts expected from the implementation of the AMR and RIB Data Item.

1) **Institutional** – Because the AMR and RIB Data Item specify parameter values for model inputs, there are no impacts upon applicable agreements, laws, codes, and standards.

2) **Contractual** – The AMR and RIB Data Item do not impact the M&O contract.

3) **Programmatic** – There are no impacts on management plans within the Office of Civilian Radioactive Waste Management Program from the AMR and RIB Data Item.

4) **Work Scope** – No impact on the baseline work scope. Work associated with the AMR and RIB Data Item is covered by the FY99 Work Plan and the planned FY00 work scope.

CONTENTS

TABLES

Page

FIGURE

1. PURPOSE

This analysis and model report (AMR), *Environmental Transport Parameters Analysis*, is part of the efforts for the Biosphere Process Model Report, which supports the Site Recommendation Report, and the License Application. This AMR was developed under its document plan, TDP-MGR-MD-000005 (CRMWS M&O, 1999a).

The purpose of this AMR is to develop or select values for environmental transport parameters, a group of input data used by GENII-S, a computer code for statistical and deterministic simulations of radiation doses to humans from radionuclides in the environment. GENII-S is qualified software under the procedure of Yucca Mountain Project (YMP) for the calculation of the biosphere dose conversion factors (BDCFs) (Liu 1998). The BDCFs will be used for the proposed repository radiation dose assessment.

The scope of the analysis includes consideration of the following ten categories of environmental transport parameters: absolute humidity, deposition velocity, resuspension factor, crop biomass, basic soil parameters, soil ingestion rate, weathering half-life, translocation factor, animal feed and water consumption rates, and dry/wet ratio. Parameter descriptions are given in Section 4.1.

Two sets of values for each parameter are to be selected and justified. One set is for a reasonable and conservative estimate (the reasonable case), and the other set is for high bounding values (the bounding case). Reasonable is defined as being reasonably expected to occur based on the environmental conditions of Amargosa Valley, Nevada. Conservative is defined as a value that would result in a higher BDCF, when this parameter value could be selected. A high bounding value is defined as a value based on extreme environmental conditions that would result in the highest radiation exposure.

The approach for this AMR was as follows:
1. Perform a scientific literature search to evaluate the adequacy of the existing GENII-S parameters for the postclosure scenario of the proposed repository.
2. Identify potential parametric values that are relevant to the postclosure scenario, and compare them with GENII-S default values.
3. Select, justify and document the parameter values selected for use in the BDCFs calculation.
4. Summarize the recommended values of these parameters.

2. QUALITY ASSURANCE

This analysis has been determined to be Quality Affecting in accordance with Civilian Radioactive Waste Management System (CRWMS) Management and Operating (M&O) procedure QAP-2-0, *Conduct of Activities,* because the information will be used to support Performance Assessment and other quality-affecting activities. Therefore, this analysis is subject to the requirements of the *Quality Assurance Requirements and Description* document. This analysis is covered by the Activity Evaluation for *Scientific Investigation of Radiological Doses in the Biosphere* (CRWMS M&O, 1999b).

The primary implementing procedure for this work is Office of Civilian Radioactive Waste Management (OCRWM) procedure AP-3.10Q, *Analyses and Models*. To perform this work, several other procedures are invoked by AP-3.10Q. These include the following:

AP-2.13Q, *Technical Product Development Planning*
AP-2.14Q, *Review of Technical Products*
AP-3.4Q, *Level 3 Change Control*
AP-3.15Q, *Managing Document Inputs*
AP-6.1Q, *Controlled Documents*
AP-17.1Q, *Record Source Responsibilities for Inclusionary Records*
AP-SI.1Q, *Software Management*
AP-SIII.2Q, *Qualification of Unqualified Data and the Documentation of Rationale for Accepted Data*
AP-SIII.3Q, *Submittal and Incorporation of Data to the Technical Data Management System*

Personnel performing work on this analysis were trained and qualified according to OCRWM procedures AP-2.1Q, *Indoctrination and Training of Personnel* and AP-2.2Q, *Establishment and Verification of Required Education and Experience of Personnel*. Preparation of this analysis did not require the classification of items in accordance with CRWMS M&O procedure QAP-2-3, *Classification of Permanent Items*. This analysis is not a field activity. Therefore, a Determination of Importance Evaluation in accordance with CRWMS M&O procedure NLP-2-0 was not required.

3. COMPUTER SOFTWARE AND MODEL USAGE

No models or software routines and macros were developed and used in this analysis. The only software used was industry standard software, such as Microsoft Excel (spreadsheet) and Word (word processing). Spreadsheet software was used as an aid in calculations. Use of this software in this manner is exempt from the requirements in AP-SI.1Q, *Software Management*.

4. INPUTS

In this section, the parameters analyzed in this AMR are described. The input sources, including site-specific data from the Technical Data Management System (TDMS) and literature data from reviewed documents, are identified and summarized.

4.1 DATA AND PARAMETERS

4.1.1 Parameter description

Parameter descriptions are summarized in Table 1. Some of the parameter categories contain subsets of the parameters for different plants or animal products. Thus, a total of 53 individual parameters are included in this AMR. The location of each parameter used in the GENII-S code is also given in the table. Most of the parameters are found in the section of environmental parameters in the DEFAULT.IN file, a data file in the GENII-S software package (Leigh et al. 1993, p.5-63).

Most of the values for the environmental transport parameters are somewhat dependent on the local climate, soil, and other environmental conditions. Therefore, site-specific studies to determine values are preferred. However, site-specific data in this field are very limited for Yucca Mountain and surrounding areas. In addition, collection of site-specific data is a very expensive and time-consuming task. Fortunately, many experimental and field studies for collecting related data have been conducted and published during the past several decades. Review and selection of available literature data can provide generic input data for the biosphere dose assessment. Because selected values for these parameters are not site-specific, uncertainty associated with parameter values could be quite large.

4.1.2 Input sources

Most inputs to this AMR were taken from published literature. They are unqualified data and used as corroborative evidence in this analysis. Only one parameter, total suspended particulate (TSP) matter that was used for mass load to calculate the resuspension factor, was actually collected at the Yucca Mountain site during site characterization (CRWMS M&O 1999c). Summary of measured TSP concentration is shown in Table 2. This data set is unqualified and needs to be qualified. The Document Input Reference Sheets in Attachment II of this AMR provides the input source title, input status, and parameters cited from the sources.

Table 1. Parameter Description

Item	Parameter Category	Description	Notes
1	Absolute humidity (L/m^3)	Expression of the moisture content of the air. It is used in a tritium model, as tritium can exist in air moisture.	In DEFAULT.IN file
2	Deposition velocity (m/sec)	The ratio of the amount of material deposited on the surface per unit time to the ground level air concentration. Two types of deposition velocities are used in the GENII-S. 1. For particles settling near the crop 2. Element-specific for three groups of elements and used in the air transport model	 1. An input parameter, and also in DEFAULT.IN file 2. In FTRANS.DAT file of the GENII-S package
3	Crop resuspension factor (1/m)	The fraction of material deposited on the ground that is re-suspended into the air is used for estimating radionuclide deposition on crop surfaces	An input parameter, and also in DEFAULT.IN file
4	Crop Biomass (kg/m^2)	Standing plant biomass above the soil per unit area for interception of air particulate matter. It depends on crop types. Thus, biomass for ten different plants are as follows: 1. Leafy vegetables 2. Root vegetables 3. Fruit 4. Grain 5. Stored feed for beef 6. Stored feed for poultry 7. Stored feed for milk 8. Stored feed for eggs 9. Fresh forage for beef 10. Fresh forage for milk	In DEFAULT.IN file
5	Basic soil data	There are five parameters in this group: 1. Depth of surface soil (cm): this parameter is used in the soil model for separating soil into two compartments: surface soil and deep soil. 2. Surface soil density (kg/m^2): soil mass per unit area for surface soil 3. Deep soil density (kg/m^3): soil mass per unit volume for deep soil 4. Fraction of plant roots in surface soil: a parameter used for modeling the behaviors of plant roots in surface soil. 5. Fraction of plant roots in deep soil: a parameter used for modeling the behaviors of plant roots in deep soil	 1. An input parameter, and also in DEFAULT.IN file 2. An input parameter, and also in DEFAULT.IN file 3. An input parameter, and also in DEFAULT.IN file 4. An input parameter 5. An Input parameter
6	Soil ingestion rate (mg/day)	Inadvertent soil ingestion by humans from food or water	An input parameter, and also in DEFAULT.IN file

Table 1. Parameter Description (cont.)

Item	Parameter Category	Description	Notes
7	Weathering half-life (days)	Time when the amount of radioactive material initially deposited on plant surfaces decays naturally to its half level during plant growth or crop storage	In DEFAULT.IN file
8	Translocation factor	Translocation of radionuclide from the leaf surfaces to edible part of plant. It depends on plant types. Thus, there are translocation factors for ten different crops as follows: 1. Leafy vegetables 2. Root vegetables 3. Fruit 4. Grain 5. Stored feed for beef 6. Stored feed for poultry 7. Stored feed for milk 8. Stored feed for eggs 9. Fresh forage for beef 10. Fresh forage for milk	In DEFAULT.IN file
9	Animal Feed and water consumption rates (kg/day for feed, and L/day for water)	Two parameters for each animal product are used for daily animal feed and water consumption rates. They are dependent on animal product type. Eight parameters are used in the model: 1. Stored feed for beef 2. Stored feed for poultry 3. Stored feed for milk 4. Stored feed for egg 5. Fresh forage for beef 6. Fresh forage for milk 7. Water for beef 8. Water for poultry 9. Water for milk 10. Water for eggs	In DEFAULT.IN file
10	Dry/wet ratio	The ratio of dry weight to wet (fresh) weight of the crop. It depends on crop types. Dry-to-wet ratios are designed for ten different crops as follows: 1. Leafy vegetables 2. Root vegetables 3. Fruit 4. Grain 5. Stored feed for beef 6. Stored feed for poultry 7. Stored feed for milk 8. Stored feed for eggs 9. Fresh forage for beef 10. Fresh forage for milk	in DEFAULT.IN file

Table 2. Summary of Measured Total Suspended Particulate Matter

Parameter Analyzed	Input Data	TDMS Parameter Name (and Number)	Data Tracking Number or Citation	Qualification Status
Crop resuspension factor (a calculated parameter)	Concentration of total suspended particulate matter (TSP)	Particle characteristic (1078)	MO98PSDALOG111.000 TM000000000001.039 TM000000000001.041 TM000000000001.042 TM000000000001.043 TM000000000001.079 TM000000000001.082 TM000000000001.084 TM000000000001.096 TM000000000001.097 TM000000000001.098 TM000000000001.099 TM000000000001.105 TM000000000001.108	Non-qualified data

The literature search for this AMR focused on the summary articles and comprehensive dose assessment reports that included selection of input parameters. Pertinent documents that were reviewed and cited are briefly discussed below. Parameter information cited from a document is given in Attachment II of this report. Parameter values used from these reference sources are listed in Section 6.

U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide (RG) 1.109 (NRC 1977) is the regulatory guide for calculation of annual doses to man from routine releases of reactor effluents for the purpose of evaluating compliance with 10 CFR 50, Appendix I. The document specifies the calculation methods for annual external exposure, inhalation, and ingestion doses due to liquid, noble gas, and particulate matter released from power reactor. Numerical data, including environmental, human, dose factors, and other parameters, for the calculation are provided in Appendix E as the guidance of the NRC recommendation.

International Atomic Energy Agency (IAEA) Safety Series (SS) No. 57 (IAEA 1982) is the product of the international efforts on generic models and parameters for assessing the environmental transfer of radionuclides from routine releases. The concept of critical group, individuals in the population expected to receive the highest dose equivalents from the source of radiation under consideration, is brought into the models. Effluents released into the atmosphere and aquatic environment are considered. Calculation methods of transport of radionuclides through terrestrial and aquatic food chains are given in detail.

NUREG/CR-3160 (Mills et al. 1983) is the document for parameters and variables appearing in radiological assessment codes, such as PABLM, which was developed by B.A. Napier, W.E. Kennedy, and J.K. Soldat and documented in the report of PNL-3209 (Napier et al. 1980). This computer code became a part of GENII code developed in 1988 (Napier et al. 1988, p.1.2). The parameters covered in NUREG/CR-3160 include radionuclide source term calculations, dose to man and health effects, atmospheric transport, and environmental pathway and food chain transport parameters. The typical values and ranges were compiled to guide the selection of these parameters to be used in radiation dose assessments.

NUREG/CR-3332 (Till et al. 1983) is a textbook on environmental dose analysis for radiological assessment. Its Chapter 5, *Terrestrial and Aquatic Food Chain Pathways*, includes the calculation methods of radionuclide concentration in foodstuff, and many suggested values for the environmental transport parameters that are of interest in this AMR.

In 1984, National Council on Radiation Protection and Measurement (NCRP) published its Report No. 76, *Radiological Assessment: Predicting the Transport, Bioaccumulation, and Uptake by Man of Radionuclide Released to the Environment* (NCRP 1984). Similar to NUREG/CR-3332 discussed above, it is one of a few documents that describe radiological assessment in a systematical manner. The example and default values of selected parameters used to predict radionuclide concentration in vegetation and animal products are tabulated in the report.

ORNL-5786 (Baes et al. 1984) is a review and analysis document of parameters for assessing transport of environmentally released radionuclides through agriculture. It describes the specific information on the terrestrial environment computerized database, element-specific transport parameters, such as soil-to-plant transfer factor, animal feed to product transfer coefficients, and other parameters.

PNL-6584 (Napier et al. 1988) is the three-volume document for GENII – the Hanford environmental radiation dosimetry software system. The software can be used to determine radiation dose to individuals or populations from a wide variety of potential exposure scenarios. The first volume of the document describes the mathematical models and parameters that are adapted in GENII-S later. Therefore, this document is one of major sources for the analysis.

NUREG/CR-5512-V1 (Kennedy et al. 1992) is the document that provides generic and site-specific estimates of radiation dose for exposures to residual radioactive contamination after the decommissioning of facilities licensed by the U.S. NRC. Although the document does not directly mention use of GENII model, the calculation methods, input parameters, and default values are very similar to those used in GENII software.

SAND91-0561 (Leigh et al. 1993) is the user's guide for GENII-S, *A Code for Statistical and Deterministic Simulations of Radiation Dose to Human from Radionuclides in the Environment*. The software, based on the GENII dose calculation methods, has the capability to perform sensitivity and uncertainty analyses. It was used in the performance assessment for the Waste Isolation Pilot Plant Project for the U.S. Department of Energy. It will also be used for the biosphere dose assessment in Yucca Mountain Project. The document does not describe the dose calculation methods, but does describe the function of each input parameter, and some default data files.

ANL/EAD/LD-2 (Yu et al. 1993) is the manual for implementing residual radioactive material guidelines using RESRAD, version 5. The manual describes the analysis and models used to derive site-specific guidelines for allowable residual concentrations in soil, and the design and use of the RESRAD computer code for calculating doses, risks, and guideline values. This document provides useful information on selecting the values of the parameters of interest in this analysis.

IAEA Technical Reports Series (TRS) No. 364 (IAEA 1994) is a handbook of parameter values for prediction of radionuclide transfer in temperate environments. This handbook reflects the current efforts, in collaboration with the International Union of Radioecologists, for a convenient and authoritative reference for radionuclide transfer parameter values used in biosphere dose assessment models. It is a supplement to the previously published IAEA SS-57, as described earlier.

CNWRA 95-018 (LaPlante et al. 1995) is the initial analysis of selected site-specific dose assessment parameters and exposure pathways application to a groundwater release scenario at Yucca Mountain prepared by Center for Nuclear Waste Regulatory Analyses (CNWRA) for NRC. This document provides a review of currently available information for determining particular Yucca Mountain site-specific values used in the GENII-S code for an analysis of parameter variation and sensitivity.

AECL-11494-4 (Zach et al. 1996) is the document for biosphere model of the disposal of Canada's nuclear fuel waste by Atomic Energy of Canada Limited (ACEL). It describes a study of postclosure safety of in-room emplacement of used CANDU fuel in copper containers in permeable plutonic rock. A biosphere model, called BIOTRAC (BIOsphere Transport and Assessment Code), was developed and used for their Environmental Impact Statement postclosure assessment case study, AECL-10720 (Davis et al. 1993). Although there are many different biosphere characteristics between Canada case and Yucca Mountain case, it is still helpful to understand their parameter selection.

EPRI TR-107190 (Smith et al. 1996) is the document for biosphere modeling and dose assessment for Yucca Mountain prepared by the Electric Power Research Institute (EPRI). Using a different approach, the results are quite different from those obtained by CNWRA (LaPlante et al, 1997) and YMP (VA 1998). However, the selection of input parameter value still provides useful information.

CNWRA 97-009 (LaPlante et al. 1997) is the updated information and analyses to support selection of critical groups and reference biosphere for Yucca Mountain exposure scenarios. This is the latest work on the Yucca Mountain biosphere dose assessment from CNWRA, and somewhat reflects the NRC position. In addition, the software they used, GENII-S, is the same as what we selected. Therefore, this document has a significant impact on our selection of input parameters and default values.

Additional documents were also reviewed and are cited in this AMR. Some documents did not contain all parameters in the analysis. Therefore, for each parameter this analysis includes only applicable documents.

4.2 CRITERIA

No criteria defined in AP-3.10Q were used for the analysis. The parameter selection criteria, as a part of the analysis, are listed in Section 6.

4.3 CODES AND STANDARDS

No codes or standards were used as a primary source of input in this analysis.

5. ASSUMPTIONS

No assumptions were used for the analysis.

6. ANALYSIS

A scientific literature search was performed to evaluate adequacy of the GENII-S default values for the parameters of interest. Available literature data were evaluated and compared with GENII-S default values. It was found that parameter values from various references were quite different. The selection of a parameter value was based on the following criteria, as the order of preference:

1. Site-specific data for a parameter was used whenever it was available.

2. If one parameter value appeared in more than half of the reviewed documents, it was considered that this generic value was agreed upon by the scientific community and represents the best available data. Thus, this value was selected for use.

3. GENII-S default value was selected if available literature data were not consistent. It was considered that no single agreed upon value was available to replace the default value.

6.1 ABSOLUTE HUMIDITY

Absolute humidity (moisture content of the air) should be measured at the location of interest. This parameter is used for the tritium (H-3) model in the GENII-S code. A recent report, *Status of Radionuclides Screening for the TSPA-SR* (CRMWS M&O, 1999d) showed that tritium was not of interest in the postclosure dose assessment. Therefore, there was no need for further analysis for absolute humidity. Its default value, 0.008 L/m^3, was not modified.

6.2 DEPOSITION VELOCITY

Deposition velocity is a function of many factors, such as particle size, surface roughness, and climate. Because particle size distribution is usually unknown for most dose assessment cases, GENII-S code allows an input value of deposition velocity for an average particle size. There are two types of deposition velocities used in GENII-S, one for particles that settle on crop surfaces, and one for air transport of particles. They are discussed separately as follows.

6.2.1 Deposition velocity for particles that settle on crop surfaces

This deposition velocity is used to calculate the deposition of contaminated particles on crop surfaces. It is an input parameter to GENII-S, and has a default value of 0.001 m/sec.

Three of the five reviewed documents (IAEA 1982, NCRP 1984, and LaPlante et al. 1997) suggested a typical value of 0.001 m/sec for deposition velocity. Till et al. (1983) reported a range of 1E-5 to 1E-1 m/sec for deposition velocity for a large range of particle sizes. Yu et al. (1993) stated that deposition velocity of particles for crop surfaces should be considered element dependent, similar to the atmospheric release case used in the GENII-S model to be discussed in the next subsection. Yu et al. (1993) suggested a value of 0.001 m/sec for most elements except for a few gaseous or halogen elements. A comparison of literature data is shown in Table 3.

The GENII-S default value, 0.001 m/sec for deposition velocity for particles on crop surfaces, was supported by more than half of reviewed documents. Therefore, this value was selected for the reasonable case. This selection met the second criterion in Section 6. This value should be adequate for use in the BDCF calculation.

0.1 m/sec was selected as a high bounding value for deposition velocity for crop surfaces, because it was the highest value from the reviewed documents (Till et al. 1983).

Table 3. Deposition Velocities from Various Sources and the Selected Values

No	Document	Parameter	Value (m/sec)	Comment
1	SAND91-0561 (Leigh et al. 1993, p.5-63, 65)	For crop surfaces For air transport: Gaseous elements Halogen, (iodine et al) Other elements	0.001 0 0.01 0.001	GENII-S default values
2	IAEA SS-57 (IAEA 1982, p.17)	For crop surfaces	0.001	Selected value for particulates (<4 μm) deposited on vegetation
3	NUREG/CR-3332 (Till et al. 1983, p.5-19)	For crop surfaces	1E-5 - 1E-1	Review of literature
4	NCRP-76 (NCRP 1984, p 49)	For crop surfaces	0.001	Typical value
5	ANL/EAD/LD-2 (Yu et al. 1993, p.182-183)	For crop surfaces Gaseous elements Halogen, (iodine et al) Other elements	 0 0.01 0.001	Suggested default values
6	CNWRA 97-009 (LaPlante et al. 1997, p.B-2)	For crop surfaces	0.001	Using GENII-S default value
	Selected values	For crop surface Reasonable estimate High bounding case For air transport: Gaseous elements Halogen, (iodine et al) Other elements	 0.001 0.1 0 0.01 0.001	 GENII-S default value A high value shown in the literature search No evaluation, and keep GENII-S default values

6.2.2 Deposition velocity for atmospheric release as elemental dependent

In GENII-S, three groups of elements are considered for deposition velocity for atmospheric release: gaseous elements, some halogen elements (F, Br, and I), and other elements. However, the period of atmospheric release of radionuclides is not considered in the biosphere radiation dose assessment. Therefore, there is no need for the analysis. The default values, 0 m/sec for gaseous elements, 0.01 m/sec for some halogen elements, and 0.001 m/sec for other elements, was not modified.

6.3 CROP RESUSPENSION FACTOR

Crop resuspension factor analyzed in this AMR is used for estimating radionuclide deposition on crop surfaces. It is an input parameter, and has a default value of 1E-9 m^{-1}. This parameter was calculated based on a method that GENII-S uses for inhalation dose calculation:

$$M = S / \rho \qquad (1)$$

where

M = resuspension factor, (m^{-1})

S = mass load, concentration of suspended particle, (g/m^3)

ρ = surface soil density, 2.25E5 g/m^2, a parameter to be discussed in Section 6.5.

To calculate crop resuspension factor, concentration of total suspended particulate (TSP) can be used for mass load in Equation (1). As part of the site characterization efforts, TSP samples were collected weekly at two locations, Site 1 – the 60m meteorological tower, and Site 5 – at Forty Mile Wash, during 1989 to 1997 (CRWMS M&O 1999e, p.13). Site 5 is located about 13 km north of the proposed location of the critical group at Lathrop Wells, Nevada (CRWMS M&O 1999e, p.5 & 6), but it is closer than Site 1. Therefore, Site 5 TSP data were used for this analysis. There were 481 samples measured over nine years, which sufficiently cover the variation of TSP concentration in air.

Summary information of TSP concentration at Site 5 is listed in Table 4 below (CRWMS M&O 1999c). A histogram plot shows that the measured TSP data result in a lognormal distribution, as shown in Figure 1. Lognormal distribution is one of the distributions used in GENII-S, which is defined by 0.1 percentile and 99.9 percentile values (Leigh et al. 1993, p.5-33). These two values were calculated from the geometric mean and geometric standard deviation of TSP data, $18.6/2.01^{3.09} = 2.15$, and $18.6 \times 2.01^{3.09} = 161$, respectively.

Table 4. Concentration of TSP at Site 5 (1E-6 g/m^3)

Location	Geometric Mean	Geometric Standard Deviation	Calculated 0.1 Percentile Value	Calculated 99.9 Percentile Value	Minimum Measured Value	Maximum Measured Value
Site 5	18.6	2.01	2.15	161	2.0	310

Crop resuspension factor was calculated with Equation (1) using site-specific TSP data and surface soil density. For the reasonable case, the mean was calculated to be 8.3E-11 m^{-1}. A lognormal distribution was suggested for crop resuspension factor with 0.1-percentile value of 9.6E-12 m^{-1} and 99.9-percentile value of 7.2E-10 m^{-1}. For the bounding case, crop resuspension factor was calculated as 1.4E-9 m^{-1} using the highest TSP value, 310 $\mu g/m^3$, measured during 1989 to 1997. A fixed value was suggested for the bounding case.

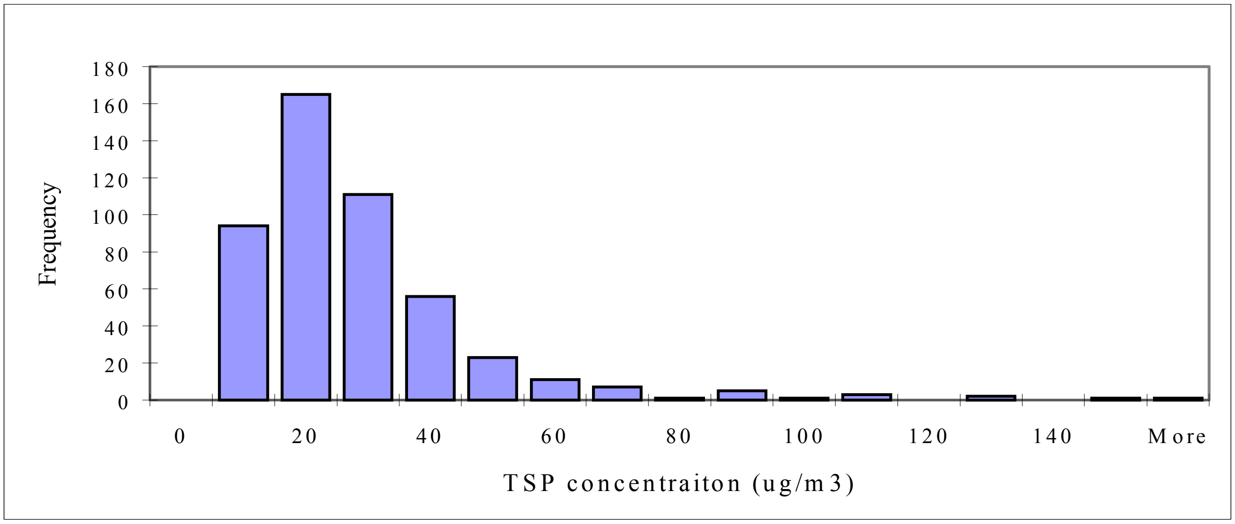

Figure 1. Histogram of TSP Concentration at Site 5 Collected During 1989 to 1997

This data selection met the first criterion in Section 6. The GENII-S default value for resuspension factor and values calculated from site-specific TSP data are shown in Table 5. In a recent biosphere study for Yucca Mountain (LaPlante 1997, p.2-24), the resuspension factor value was also taken as the same value as the resuspension factor for inhalation dose calculation.

Table 5. Resuspension Factor from GENII-S and the Calculated Values

No	Document	Value (1/m)	Comment
1	SAND91-0561 (Leigh et al. 1993, p.5-63)	1E-9	GENII-S default
	Calculated value: For the reasonable case	Mean: 8.3E-11	Calculated from site-specific mass load and surface soil density
		Range: 9.6E-12 – 7.2E-10	Lognormal distribution
	For the bounding case	1.4E-9	Calculated from the highest TSP value measured

6.4 CROP BIOMASS

Crop biomass, or biomass in the GENII-S code, is the amount of standing plant biomass that is available to intercept radionuclides in the atmosphere and in contaminated irrigation water. This parameter is also used for calculating the radionuclide concentration in foodstuff in GENII-S.

However, crop yield is used for this purpose in some documents for the calculation. Therefore, both crop biomass and yield were reviewed and compared from various sources.

Crop biomass varies as a function of plant type. Four types of plant for human food and six types for animal feed are considered in the GENII-S code. The GENII-S default values for each type of plant are shown in Table 6. Nine other documents were reviewed, and their values are also listed in Table 6. Different parameter names were used in some documents. Corresponding GENII-S parameter names are shown in the comment column in Table 6. When a parameter was not directly related to the GENII-S parameter, it was not used for comparison in the analysis.

Table 6. Crop Biomass from Various Sources and the Selected Values

No	Document	Parameter	Value (kg/m^2)	Comment
1	SAND91-0561 (Leigh et al. 1993, p.5-63) PNL-6584 (Napier et ai. 1988, p.4.71)	Leafy vegetables Root vegetables Fruit Grain Fresh forage for beef Fresh forage for milk Stored feed for beef Stored feed for milk Stored feed for poultry Stored feed for eggs	2.0 2.0 3.0 0.8 1.0 1.5 0.8 1.0 0.8 0.8	(1) GENII and GENII-S default values (2) Default value from literature review (3) SAND91-0561 does not indicate which value for which parameter, but PNL-6584 does (4) Other vegetables used in PNL-6584 are equal to root vegetables in SAND91-0561
2	NRC RG 1.109 (NRC 1977, p.1.109-69)	 Vegetation * Forage for milk	 2.0 0.7	Suggested values from references Corresponding GENII-S parameter: fresh forage for milk
3	IAEA SS-57 (IAEA 1982, p.59)	 Leafy vegetables Other above ground vegetable *	 2.0 0.6	Suggested values from references
4	NUREG/CR-3160 (Mills et al. 1983, p.136)	 Leafy vegetables Other above ground vegetable * Root vegetables Fruit Grain Forage for milk Hay for beef Grain feed for eggs	 1.5 0.7 4.0 2.0 1.0 1.3 0.84 0.84	Agricultural product yields. Corresponding GENII-S parameters: fresh forage for milk stored feed for beef stored feed for eggs
5	NCRP-76 (NCRP 1984, p.70)	 Leafy vegetables Produce * Other above ground vegetable * Pasture vegetation	 2.0 2.0 0.6 0.7	Crop yield Corresponding GENII-S parameters: fresh forage for beef or milk
6	ANL/EAD/LD-2 (Yu et al. 1993, p.183 & 178)	 Leafy vegetables Other plants except leafy * Feed for beef Feed for milk	 1.5 0.7 1.1 1.1	Crop yield Corresponding GENII-S parameters: fresh or stored feed for beef fresh or stored feed for milk
7	AECL-10720 (Davis et al. 1993, p.260)	 Plant * Feed for beef Feed for milk Feed for poultry	 0.8 1.0 0.8 1.2	Wet biomass Corresponding GENII-S parameters: fresh or stored feed for beef fresh or stored feed for milk stored feed for poultry or eggs

* indicates the value was not used for comparison in the analysis, and is listed for reference only.

Table 6. Crop Biomass from Various Sources and the Selected Values (cont.)

No	Document	Parameter	Value (kg/m^2)	Comment
8	NUREG/CR-5512 (Kennedy et al. 1992, p.6.23)			Defined as crop yields, more animal feed types than GENII-S used. Corresponding GENII-S parameters:
		Leafy vegetables	2.0	
		Other vegetables	4.0	root vegetables
		Fruit	2.0	
		Grain	1.0	
		Forage for beef	1.5	fresh forage for beef
		Forage for milk	1.5	fresh forage for milk
		Forage for poultry *	1.0	
		Forage for eggs *	1.0	
		Stored hay for beef	1.0	stored feed for beef
		Stored hay for milk	1.0	stored feed for milk
		Stored hay for poultry *	1.0	
		Stored hay for eggs *	1.0	
		Stored grain for beef *	1.0	
		Stored grain for milk *	1.0	
		Stored grain for poultry	1.0	stored feed for poultry
		Stored grain for eggs	1.0	stored feed for eggs
9	EPRI TR-107190 (Smith et al. 1996, p. 5-25)			Edible yield.
		Leafy vegetables	1.5	
		Root vegetables	3.5	
		Fruit	0.7	
		Grain	0.4	Corresponding GENII-S parameters:
		Pasture	1.0	fresh forage for beef or milk
10	CNWRA 97-009 (LaPlante, et al. 1997, p.B-7)	Leafy vegetables	2.0	Using GENII-S default values
		Root vegetables	2.0	
		Fruit	3.0	
		Grain	0.8	
		Fresh forage for beef	1.0	
		Fresh forage for milk	1.5	
		Stored feed for beef	0.8	
		Stored feed for milk	1.0	
		Stored feed for poultry	0.8	
		Stored feed for eggs	0.8	
	Selected values			
	For the reasonable case:	Leafy vegetables	2.0	GENII-S default value for the reasonable cases
		Root vegetables	2.0	
		Fruit	3.0	
		Grain	0.8	
		Fresh forage for beef	1.0	
		Fresh forage for milk	1.5	
		Stored feed for beef	0.8	
		Stored feed for milk	1.0	
		Stored feed for poultry	0.8	
		Stored feed for eggs	0.8	
	For the bounding case:	Leafy vegetables	1.5	The lowest values available from the reviewed documents
		Root vegetables	2.0	
		Fruit	0.7	
		Grain	0.4	
		Fresh forage for beef	0.7	
		Fresh forage for milk	0.7	
		Stored feed for beef	0.8	
		Stored feed for milk	0.8	
		Stored feed for poultry	0.8	
		Stored feed for eggs	0.8	

* indicates the value was not used for comparison in the analysis, and is listed for reference only.

Crop biomass parameters ranged from 1.5-2.0 kg/m^2 for leafy vegetables, 2.0-4.0 kg/m^2 for root vegetables, 0.7-3.0 kg/m^2 for fruit, 0.4-1.0 kg/m^2 for grain, 0.7-1.1 kg/m^2 for fresh forage for beef, 0.7-1.5 kg/m^2 for fresh forage for milk, 0.8-1.1 kg/m^2 for stored feed for beef or milk, and 0.8-1.2 kg/m^2 for stored feed for poultry or eggs. There was no single agreed upon value for a particular type of crop biomass in the literature. Therefore, GENII-S default values were selected for the reasonable case. This selection met the third criterion in Section 6. GENII-S default values should be adequate for the use in the BDCF calculation.

Because crop biomass is used as a denominator in the equation for calculation of radionuclide concentration in plants from direct deposition onto leaves (Napier et al. 1988, p.4.67), a low biomass value is needed for the bounding case. Therefore, the lowest crop biomass values from the literature were selected for the bounding case (Table 6).

6.5 BASIC SOIL PARAMETERS

The soil model used in GENII-S for the postclosure scenario is relatively simple. The surface soil is the only contaminated soil that is considered. Radionuclides may be deposited into the soil through atmospheric release, irrigation water, and particle resuspension. They may be lost from the surface soil through harvest removal, radioactive decay and leaching to deeper soil. Five basic soil parameters were evaluated in this section.

6.5.1 Depth of surface soil

Surface soil depth, or soil plow depth, with a default value of 15 cm, defines the portion of the soil where the deposition from the atmosphere, irrigation, and resuspension occur. Four of the seven reviewed documents suggested 15 cm for this parameter, the same as the GENII-S default value (Table 7). IAEA SS-57 reported surface soil depths of 2 cm, 15 cm and 30 cm. Not many crops can grow in only 2-cm of soil. Since the soil model in GENII-S assumes that radionuclides are uniformly mixed in the surface soil, a low surface soil depth results in a high radionuclide concentration in soil. Therefore, the 30-cm soil depth was less conservative than 15- cm.

Fifteen centimeters was the best generic value for surface soil depth found in the literature. This selection met the second criterion in Section 6. The GENII-S default value was supported by four of seven reviewed documents, and should be adequate for use in the BDCF calculation. In addition, the 15-cm surface soil depth was preferred, because Federal Guidance Report 12 (EPA 1993, Section III) provides sets of external dose conversion factors for 0-cm, 1-cm, 5-cm, 15-cm and infinite contaminated soil depth. It is consistent to use the 15-cm surface soil depth for both plant growth and calculation of external dose.

A 15-cm surface soil depth was also selected for the bounding case, because there was very limited information on this. Even though 2-cm and 10-cm were suggested for this parameter (IAEA 1982, and Sheppard 1995), Federal Guidance Report 12 (EPA 1993) does not provide external dose conversion factors for those depths.

Table 7. Basic Soil Parameters from Various Sources and the Selected Values

No	Document	Soil Surface Depth (cm)	Surface soil Density (kg/m^2)	Deep Soil Density (kg/m^3)	Comment
1	SAND91-0561 (Leigh et al. 1993, p.5-63)	15	224	1500	GENII-S default
2	NRC RG 1.109 (NRC 1977, p.1.109-68)	15	240	-	Surface depth based on assumption
3	IAEA SS-57 (IAEA 1982, p.65)	2 15 30	30 200 400	-	Cited from a reference, based on 1.3 g/m^3 soil density
4	NUREG/CR-5512 (Kennedy et al. 1992, p 6.35)	15	-	-	Based on assumption
5	ANL/EAD/LD-2 (Yu et al. 1993, p.185)	15	240	-	Default value
6	ACEL 11474 (Sheppard 1995, p. 3)	10 (grass) 20 (others)	-	-	Literature data
7	EPRI TR-107190 (Smith et al. 1996, p.5-19)	30	-	1590	Soil density calculated
8	CNWRA 97-009 (LaPlante et al. 1997, p.B-1)	15	225 180 - 270	1500	Site-specific soil density Range for stochastic calculation
	Selected values: For the reasonable case For the bounding case	 15 15	 225 180	 1500	

6.5.2 Surface soil density

Surface soil density can be obtained from depth of surface soil and soil bulk density. The soil bulk densities in farming areas of Amargosa Valley, Nevada range from 1.35 to 1.70 g/cm^3 (LaPlante et al. 1997, Table 2-7). A mean value of 1.5 g/cm^3 (1500 kg/m^3) was selected. Surface soil density can be calculated by:

$$\rho_d = \rho \times d_p \quad (2)$$

where

ρ_d = surface soil density, (kg/m^2)
ρ = soil bulk density, 1500 kg/m^3
d_p = depth of surface soil, 15 cm (0.15 m) from Section 6.5.1.

Surface soil density calculated from Equation (2) was 225 kg/m^2. This selection met both the first criterion (for soil bulk density) and the second criterion (for depth of surface soil). The selected value is similar to the GENII-S default value of 224 kg/m^2 (Table 7).

Because surface soil density is the denominator in the equation for calculation of radionuclide concentration in plants from root uptake (Napier et al. 1988, p.4.67), a bounding value of 180 kg/m^2 was selected based on the minimum value of the range of surface soil density from LaPlante et al. (1997, p.B-2).

6.5.3 Deep soil density

Deep soil density is an input parameter used in the biotic transport model, which is not a scenario under consideration for YMP postclosure. Therefore, there was no need for the evaluation. The GENII-S default value of 1500 kg/m^3 was not modified.

6.5.4 Fraction of roots in upper soil

"Fraction of roots in upper soil" is an input parameter, and does not have a default value. This parameter represents plant root uptake of radionuclides from soil. This parameter is a unique one used in the GENII-S model. No other documents, except for the one used in the GENII-S model (LaPlante et al. 1997), defined this parameter, though the value of the parameter was implicitly set to one in some documents (Kennedy et al 1992, Yu et al. 1993, and Smith et al. 1996).

Soil depth is separated into two compartments: surface soil (upper soil) and deep soil. The upper soil, in which all radionuclides are deposited initially, is more contaminated than the deep soil due to irrigation water. To be conservative, all roots were assumed to be in the upper soil, with no roots in the deep soil. This assumption was also used in a Yucca Mountain biosphere model study by CNWRA (LaPlante et al 1997, page B-1). Therefore, a value of one was selected for this parameter. Since a value of one reflects the maximum fraction for this parameter, the same value was selected for both the reasonable and bounding case based on the conservative assumption.

6.5.5 Fraction of roots in deep soil

"Fraction of roots in deep soil" is also an input parameter. Because the fraction of roots in upper soil is assumed to be one, the fraction of roots in deep soil has to be zero. This assumption was also used in a Yucca Mountain biosphere model study by CNWRA (LaPlante et al 1997, page B-1). Since the value of zero reflects the minimum fraction for this parameter, the same value was chosen for both the reasonable and bounding cases based on the conservative assumption.

6.6 SOIL INGESTION RATE

Ingestion of radioactive contaminated soil is a potential internal source to humans. The amount of soil ingestion depends on age. Children are more likely to ingest more soil than adults as a result of behavioral patterns during childhood. The soil ingestion rate in the GENII-S code is an input parameter, and also has a default value of 410 mg/day. This value was taken from Napier et al. (1988, page 4.84) and is a lifetime weighted average.

A comprehensive review of this topic was conducted by Environmental Protection Agency (EPA) (EPA 1997, Chapter 4). Two soil ingestion rates were recommended for adults (50 mg/day) and children (100 mg/day). The biosphere model receptor is an adult, therefore, a soil ingestion rate for adults should be chosen.

Six documents were reviewed, and their suggested values are shown in Table 8. Three of them suggested a soil ingestion rate of 50 mg/day for adults (Kennedy et al. 1992, EPA 1997, and CNWRA 1997). Two documents suggested higher values, 100 mg/day (Davis et al 1993) and 137 mg/day (Smith et al. 1996) without specifying whether values were for children or for adults. These values are similar to EPA's suggested value for children (Yu et al. 1993, and EPA 1997). Therefore, a soil ingestion rate of 50 mg/day was selected (EPA recommended value for adult). This selection met the second criterion in Section 6. This selection also reflected that the GENII-S default value was not supported by the literature reviewed in this analysis.

A high bounding value of 410 mg/day was selected (GENII-S default value). It was the highest value in the literature reviewed in this analysis.

Table 8. Soil Ingestion Rates from Various Sources and the Selected Values

No	Document	Value (mg/day)	Comment
1	SAND91-0561 (Leigh et al. 1993, p.5-63) PNL-6584 (Napier et al. 1988, p.4.84)	410	GENII and GENII-S Default value based on a lifetime averaged
2	NUREG/CR-5512 (Kennedy et al. 1992 p.6.15)	50	Review and recommend it for residential scenario
3	ANL/EAD/LD-2 (Yu et al. 1993, p.222)	100	EPA recommended mean value for children over 7 years old
4	AECL-10720 (Davis et al. 1993, p.257)	100	Value from literature
5	EPRI TR-107190 (Smith et al. 1996, p.5-23)	137	Calculated from a suggested value of 50 g/yr
6	EPA/600/P-95/002Fa (EPA 1997, p.4-25)	50 100	Recommended mean value for adult Recommended mean value for children
7	CNWRA 97-009 (LaPlante et al. 1997, p.4-1)	50	Replace GENII-S default value by EPA recommended value
	Selected values For the reasonable case For the bounding case	 50 410	 Using EPA recommended value for adult GENII-S default value for bounding case

6.7 WEATHERING HALF-LIFE

Weathering half-life, or weathering time, is a parameter that describes removal of radionuclides that are initially deposited on crop surfaces due to environmental processes such as wind, washout, and possibly volatilization. It has a default value of 14 days in the GENII-S code.

Weathering removal tends to occur in an exponential manner with the characteristic weathering half-life discussed above. A weathering removal constant was used in some documents, instead of weathering half-life. The relationship between weathering half-life and weathering removal constant is:

$$T_w = \ln(2) / \lambda_w \quad (3)$$

where

T_w = weathering half-life, (day)

λ_w = weathering removal constant, (1/day)

Nine documents were reviewed, and their suggested values are shown in Table 9. Five of them suggested a fixed value of 14 days for weathering half-life (NRC 1977, Mills et al. 1983, Bases et al. 1983, NCRP 1984, and CNWRA 1997). Two documents suggested values that are close to the GENII-S default value, 15 days (10 days for iodine) and 12.6 days (IAEA 1984, and Yu et al. 1993). Two other documents suggested a large range for weathering half-life for different plants and elements (Till et al. 1983, and Smith et al. 1996). Because over half of the reviewed documents used 14 days for weathering half-life, this value was selected for the reasonable case. This selection met the second criterion in Section 6. The GENII-S default value should be adequate for use in the BDCF calculation.

Table 9. Weathering Half-life from Various Sources and the Selected Values

No	Document	Value (day)	Comment
1	SAND91-0561 (Leigh et al. 1993, p.5-63)	14	GENII-S default
2	NRC RG 1.109 (NRC 1977, p.1.109-69)	14	Based on NRC staff's judgments as stated in the notes
3	IAEA SS-57 (IAEA 1982, p.59)	15 (particulate) 10 (iodine on pasture vegetation)	Value given by removal constant, and converted by Equation (3)
4	NUREG/CR-3160 (Mills et al. 1983, p.137)	14	Cited from NRC RG 1.109
5	NUREG/CR-3332 (Till et al. 1983, p.5-36)	6-56	Suggested value based on literature review
6	ORNL-5786 (Baes et al. 1984, p.124)	14 8 (for iodine)	Cited from NRC RG 1.109 and other literatures
7	NCRP-76 (NCRP 1984, p.70)	14	Cited from NRC RG 1.109
8	ANL/EAD/LD-2 (Yu et al. 1993, p.183)	12.6	Calculated from weathering removal constant of 20 yr^{-1} using Equation (3) and units conversion
9	EPRI TR-10790 (Smith et al. 1996, p.5-30)	5 14 30	Element and crop dependent: Np, Pu, and Am for grain and leafy vegetables Pasture, root vegetables, fruit, and leafy vegetables, (except Np, Pu, Am) Grain (except Np, Pu, Am)
10	CNWRA 97-009 (LaPlante, et al. 1997, p.B-7)	14	Using GENII-S default value
	Selected value	14	GENII-S default value for the reasonable and bounding cases

Fourteen days was also selected for the bounding case for weathering half-life, because this value was originally suggested by NRC staff (NRC 1977, p.1.109-69). There was little information regarding the bounding case in the literature. Smith et al. (1996) suggested a 30-day weathering half-life for grain only. Till reported a large range of values for weathering half-life under particular conditions.

6.8 TRANSLOCATION FACTOR

Translocation is the process by which a chemical element initially deposited on the leaf surface of a plant is absorbed and translocated to the edible part of the plant. Because washing food is not considered in the GENII-S model, the translocation factor includes surface contamination, which is subjected to weathering decay.

Translocation factors in the GENII-S model consist of ten individual parameters for various plants for both human and animal consumption. They are not radionuclide or plant development stage dependent. Default values for translocation factors in GENII-S are based on the conservative assumptions of 1.0 for leafy vegetables and forage, and 0.1 for other crops. These assumptions were adopted by seven of ten reviewed documents (Table 10).

Although determination of translocation factors could be done experimentally, there were not many published papers on this topic. Uncertainty of the measurement is quite high, because it depends on plant species, stage of plant development, weathering conditions, and the element and its chemical form. One study showed that the range of translocation factors could be as low as 0.0009 for Po-210, and as high as 0.7582 for Sr-89 (Till et al. 1983, p. 5-53). A recent biosphere study by EPRI (Smith et al., 1996, p.5-31) suggested that the parameters be element and crop type dependent. An IAEA document reported translocation factors as a function of time to harvest (IAEA 1994, p.13).

Therefore, translocation factors of 1.0 for leafy vegetables and forage, and 0.1 for other crops were chosen. This selection met the second criterion in Section 6. The GENII-S default values for translocation factors are supported by more than half of the reviewed documents, and should be adequate for the use in the BDCF calculation.

There was not enough information in the literature to select a bounding case for translocation factors. Available data based on one plant species, growing under a particular set of conditions, were too specific for bounding values. Therefore, the same values of 1.0 for leafy vegetables and forage, and 0.1 for other crops were chosen for the bounding cases.

Table 10. Translocation Factors from Various Sources and the Selected Values

No	Document	Parameter	Value	Comment
1	SAND91-0561	Leafy vegetables	1.0	(1)GENII and GENII-S default
	(Leigh et al. 1993, p.5-63)	Root vegetables	0.1	values.
		Fruit	0.1	(2) Data based on conservative
	PNL-6584	Grain	0.1	assumption.
	(Napier et al. 1988, p.4.67)	Fresh forage for beef	1.0	(3) SAND91-0561 does not indicate
		Fresh forage for milk	1.0	which value for which parameter, but
		Stored feed for beef	0.1	PNL-6584 does.
		Stored feed for milk	0.1	(4) Other vegetables was used in
		Stored feed for poultry	0.1	PNL-6584, instead of root
		Stored feed for eggs	0.1	vegetables in SAND91-0561
2	NRC RG 1.109	Leafy vegetables	1.0	Implicitly set to one for vegetation
	(NRC 1977, p.1.109-36)	Forage for beef	1.0	considered
		Forage for milk	1.0	
3	IAEA SS-57	Leafy vegetables	1.0	Implicitly set to one for vegetation
	(IAEA 1982, p.57)	Forage for beef	1.0	considered
		Forage for milk	1.0	
4	NUREG/CR-3160	Leafy vegetables	1.0	
	(Mills et al. 1983, p.135)	Other produce	0.1	For all non-leafy vegetables
		Fresh forage	1.0	
5	NUREG/CR-3332	Bean *	0.0009 –	Translocation of radionuclides in
	(Till et al. 1983, p. 5-53)		0.7582	plants grown in nutrient solutions
6	NCRP-76	Leafy vegetables	1.0	Cited from a reference
	(NCRP 1984, p.70)	Other produce	0.1	For all non-leafy vegetables
		Fresh forage	1.0	
7	NUREG/CR-5512			Based on the assumption similar to
	(Kennedy et al. 1992,			GENII-S
	p.6.41 – 6.42)	Leafy vegetables	1.0	
		Other vegetables	0.1	For root vegetables
		Fruit	0.1	
		Grain	0.1	
		Forage for beef	1.0	
		Forage for milk	1.0	
		Forage for poultry *	1.0	
		Forage for eggs *	1.0	
		Stored hay for beef	1.0	
		Stored hay for milk	1.0	
		Stored hay for poultry *	1.0	
		Stored hay for eggs *	1.0	
		Stored grain for beef *	0.1	
		Stored grain for milk *	0.1	
		Stored grain for poultry	0.1	
		Stored grain for eggs	0.1	
8	ANL/EAD/LD-2	Leafy vegetables	1.0	Foliage-to-food radionuclide transfer
	(Yu et al. 1993, p.178 &	Root vegetables/Fruit/		coefficient
	183)	Grain	0.1	
		Fresh forage	1.0	
9	IAEA TRS-364	Leafy vegetables	-	Elemental and time to harvest
	(IAEA 1994, p.13)	Root vegetables	1E-2	dependent
		Fruit	-	
		Grain	2E-6 – 2E-1	

* indicates the value was for reference only, not for the analysis.

Table 10. Translocation factors from various sources and the selected values (cont.)

No	Document	Parameter	Value	Comment
10	CNWRA 97-009 (LaPlante, et al. 1997, p.B-8)	Leafy vegetables Root vegetables Fruit Grain Fresh forage for beef Fresh forage for milk Stored feed for beef Stored feed for milk Stored feed for poultry Stored feed for eggs	1.0 0.1 0.1 0.1 1.0 1.0 0.1 0.1 0.1 0.1	Using GENII-S default values
11	EPRI TR-107190 (Smith et al. 1996, p.5-31)	Leafy vegetables Root vegetables Fruit Grain	0.038-0.61 0.043-0.53 0.073-0.62 0.056-0.28	Element dependent
	Selected values For the reasonable and bounding cases	Leafy vegetables Root vegetables Fruit Grain Fresh forage for beef Fresh forage for milk Stored feed for beef Stored feed for milk Stored feed for poultry Stored feed for eggs	1.0 0.1 0.1 0.1 1.0 1.0 0.1 0.1 0.1 0.1	GENII-S default values

* indicates the value was for reference only, not for the analysis.

6.9 ANIMAL FEED AND WATER CONSUMPTION RATES

Besides the terrestrial food ingestion pathways, consumption of animal products is another channel of radionuclide intake for humans. Animal products can be contaminated due to contaminated animal feed and water. The animal feed and water consumption rates become important parameters for calculation of contamination levels of animal products. Intake by animals is dependent on the animal species, age, and growth rate.

Four types of animal products are considered in the GENII-S model: beef, poultry, milk, and eggs. The GENII-S default animal feed and water consumption rates are shown in Table 11. The type of feed depends on the animal species. Typical feed are grass products, maize, clover, alfalfa, and sugar beets for dairy cows, grass and maize for beef cattle, and cereals and protein for chickens and laying hens (IAEA 1994, p.33).

There are two types of animal feed, fresh forage and stored feed, for both beef cattle and milk cows. Thus, two parameters are used for animal consumption rates, – fresh forage and stored feed, in the GENII-S model. But the GENII-S default values of animal consumption rates are the same for the two types of feed. In addition, animal feed rates for both beef and milk were not separated into the fresh forage and stored feed in most of the reviewed documents. Therefore, in this analysis, it was considered that animal consumption rates for fresh forage and stored feed are the same. The selected animal consumption rate for beef or milk was used for both fresh forage and stored feed.

Table 11. Animal Feed and Water Consumption Rates from Various Sources and the Selected Values

No	Document	Parameter	Feed (wet kg/day)	Water (L/day)	Comment
1	SAND91-0561 (Leigh et al. 1993, p.5-63) PNL-6584 (Napier et al. 1988, p.4.72)	Beef cattle Milk cow Poultry Hen for eggs	68 (fresh or stored) 55 (fresh or stored) 0.12 0.12	50 60 0.3 0.3	(1) GENII and GENII-S default values. (2) SAND91-0561 does not indicate which value for which parameter, but PNL-6584 does. (3) Other vegetables was used in PNL-6584, instead of root vegetables in SAND91-0561
2	NRC RG 1.109 (NRC 1977, p.1.109-38)	Beef cattle Milk cow	50 50	50 60	Only two pathways considered
3	IAEA SS-57 (IAEA 1982, p.68-69)	Beef cattle Milk cow	12 * 16 *	75 75	Dry weight for feed rates
4	NUREG/CR-3160 (Mills et al. 1983, p.143)	Beef cattle Milk cow Poultry	68 55 0.12	50 60 -	Data from review of literatures
5	NCRP No. 76 (NCRP 1984, p.70 – 71)	Beef cattle Milk cow	12 * 16 *	50 60	Dry weight for feed rates
6	NUREG/CR-5512 (Kennedy et al. 1992, p.6.19)	Beef cattle Milk cow Poultry Hen for eggs	27 (forage) * 14 (hay) * 3 (grain) * 36 (forage) * 29 (hay) * 2 (grain) * 0.13(forage) * 0.09(grain) * 0.13(forage) * 0.09(grain) *	50 60 0.3 0.3	Combination of various feeds, data from review of literatures
7	ANL/EAD/LD-2 (Yu et al. 1993, p.186)	Beef cattle Milk cow	68 55	50 160	Suggested values
8	AECL-10720 (Davis et al. 1993, p.253)	Beef cattle Milk cow Poultry Hen for eggs	50 60 0.4 0.4	40 60 0.4 0.4	Data from review of literatures
9	IAEA TRS-364 (IAEA 1994, p.33)	Beef cattle Milk cow Poultry Hen for eggs	7.2 * 16.1 * 0.07 * 0.1 *	20-60 50-100 0.1-0.3 0.1-0.3	Dry weight for feed rates
10	EPRI TR-10790 (Smith et al. 1996, p.5-24)	Beef cattle Milk cow Poultry Hen for eggs	60 60 0.3 0.3	60 60 0.5 0.5	Cow for both beef and milk Chicken for both poultry and eggs, as indicated in the report.
11	CNWRA 97-009 (LaPlante et al. 1997, p.B-8)	Beef cattle Milk cow Poultry Hen for eggs	33 (fresh or stored) 73 (fresh or stored) 0.08 0.11	60 100 0.3 0.3	Cited from IAEA TRS-364 with updated dry-to-wet ratio conversion.
	Selected values For the reasonable case	 Beef cattle Milk cow Poultry Hen for eggs	 68 (fresh or stored) 55 (fresh or stored) 0.12 0.12	 50 60 0.3 0.3	 GENII-S Default values for reasonable case
	For the bounding case:	Beef cattle Milk cow Poultry Hen for eggs	68 73 0.4 0.4	75 160 0.5 0.5	The highest values available from the reviewed documents

* indicates a dry feed rate and the value was for reference only, not for the analysis.

Ten documents were reviewed, and values for animal feed and water consumption rates are listed in Table 11. Some documents reported animal feed consumption rates on a dry weight basis. These values were not used for comparison in the analysis, because either dry/wet ratios (discussed in Section 6.10) were not given (IAEA 1982, NCRP 1984, and IAEA 1994), or types of animal feed were different from GENII-S (Kennedy et al. 1992).

Animal feed consumption rates ranged from 33-68 kg/day for beef cattle, 50-73 kg/day for milk cows, 0.08-0.4 kg/day for poultry, and 0.11-0.4 kg/day for hens. Animal water consumption rates ranged from 50-75 L/day for beef cattle, 60-160 L/day for milk cows, 0.3-0.5 L/day for poultry, and 0.3-0.5 L/day for hens. There was no single agreed upon value for a particular animal consumption rate in the literature. Because of the disparity in values for animal consumption rates in the literature, the GENII-S default values were selected for the reasonable case. This selection met the third criterion in Section 6. The GENII-S default values should be adequate for use in the BDCF calculation.

The highest values for animal feed and water consumption rates from the literature were selected for the bounding case. The selected values are shown in Table 11.

6.10 DRY/WET RATIO

Dry/wet ratio, or dry-to-wet weight conversion factors, describes dry weight content of fresh crops. Because the soil-to-plant transfer factor defined in the GENII-S model is based on dry weight of the crop to dry weight of soil, dry/wet ratio is needed to calculate radionuclide concentration in fresh crops. In some radiation dose assessments, this ratio is not introduced because the transfer factor is defined on a wet weight basis.

Dry/wet ratio depends on the type of crop. Four types of crop for humans and six types for animals are used in the GENII-S code. But they are still very general, because each type of crop contains many species. For example, leafy vegetables include various green vegetables, such as lettuce, cabbage, broccoli, spinach, and many more. Therefore, values from various sources might be calculated from different crop species.

The GENII-S default values for dry/wet ratios are shown in Table 12. Five other documents were reviewed, and their values or ranges are also listed in Table 12. Dry/wet ratios ranged from 0.05-0.20 for leafy vegetables, 0.06-0.38 for root vegetables, 0.05-0.29 for fruit, 0.55-0.93 for grain, and 0.18-0.31 for fresh forage (for beef cattle and milk cows). Two of the five reviewed documents reported dry/wet ratios for more crop species than GENII-S uses (Till et al. 1983, and IAEA 1994). Thus, a range is shown in Table 12 for the two documents.

Literature data for stored feed were available only in two reviewed documents (Kennedy et al. 1992, and LaPlante et al. 1997). Both documents used the same value, 0.91, for dry/wet ratios for grain, poultry, and eggs, indicating that grain is the feed for poultry and eggs. In addition, both documents used the same value, 0.22, for dry/wet ratios for fresh forage, and stored feed for beef and milk, indicating that the same dry/wet ratio can be used for as fresh forage and stored feed.

Table 12. Dry/Wet Ratios from Various Sources and the Selected Values

No	Document	Parameter	Value	Comment
1	SAND91-0561	Leafy vegetables	0.10	(1) GENII and GENII-S default
	(Leigh et al. 1993, p.5-63)	Root vegetables	0.25	values.
		Fruit	0.18	(2) Default values from review of
	PNL-6584	Grain	0.18	literatures.
	(Napier et al. 1988, p.4.71)	Fresh forage for beef	0.20	(3) SAND91-0561 does not indicate
		Fresh forage for milk	0.20	which value for which parameter, but
		Stored feed for beef	0.18	PNL-6584 does.
		Stored feed for milk	0.18	(4) Other vegetables used in PNL-
		Stored feed for poultry	0.18	6584, are equal to root vegetables in
		Stored feed for eggs	0.18	SAND91-0561
2	NUREG/CR-3332	Leafy vegetables	0.05-0.15	Data vary with crops given by fresh-
	(Till et al. 1983, p.5-48)	Root vegetables	0.06-0.29	to-dry ratio. Ranges are calculated
		Fruit	0.05-0.24	here.
		Grain	0.87-0.93	
		Fresh forage	0.18-0.24	Corresponding GENII-S parameter: Fresh forage for beef or milk
3	ORNL-5786 (Baes et al. 1984, p. 8 and 129)			Review literature data, and a weighted average in the document.
		Leafy vegetables	0.066	Calculated from water content value for leafy vegetables (1-0.934)
		Root vegetables	0.222	
		Fruit	0.126	
		Grain	0.888	
4	NUREG/CR-5512			Data from review of literatures.
	(Kennedy et al. 1992,	Leafy vegetables	0.20	Corresponding GENII-S parameters:
	p.6.28)	Other vegetables	0.25	Root vegetables
		Fruit	0.18	
		Grain	0.91	
		Forage for beef	0.22	Fresh forage for beef
		Forage for milk	0.22	Fresh forage for milk
		Forage for poultry *	0.22	
		Forage for eggs *	0.22	
		Stored hay for beef	0.22	Stored feed for beef
		Stored hay for milk	0.22	Stored feed for milk
		Stored grain for beef *	0.91	
		Stored grain for milk *	0.91	
		Stored grain for poultry	0.91	Stored feed for poultry
		Stored grain for eggs	0.91	Stored feed for eggs
5	IAEA TRS-364	Leafy vegetables	0.05-0.12	Suggested data from literatures.
	(IAEA 1994, p.15)	Root vegetables	0.06-0.38	
		Fruit	0.05-0.16	
		Grain	0.55-0.86	
		Fresh forage	0.19-0.31	Corresponding GENII-S parameter: Fresh forage for beef or milk
6	CNWRA 97-009	Leafy vegetables	0.20	GENII-S default updated using
	(LaPlante et al. 1997, p.B-	Root vegetables	0.25	NUREG/CR-5512
	9)	Fruit	0.18	
		Grain	0.91	
		Fresh forage for beef	0.22	
		Fresh forage for milk	0.22	
		Stored feed for beef	0.22	
		Stored feed for milk	0.22	
		Stored feed for eggs	0.91	

* indicates the value was for reference only, not for the analysis.

Table 12. Dry/Wet Ratios from Various Sources and the Selected Values (cont.)

No	Document	Parameter	Value	Comment
	Selected values			
	For the reasonable case	Leafy vegetables	0.10	GENII-S default values, except for grain, consumed by human and animals.
		Root vegetables	0.25	
		Fruit	0.18	
		Grain	0.91	
		Fresh forage for beef	0.20	
		Fresh forage for milk	0.20	
		Stored feed for beef	0.18	
		Stored feed for milk	0.18	
		Stored feed for poultry	0.91	
		Stored feed for eggs	0.91	
	For the bounding case	Leafy vegetables	0.20	The highest values available from the reviewed documents
		Root vegetables	0.38	
		Fruit	0.24	
		Grain	0.93	
		Fresh forage for beef	0.22	
		Fresh forage for milk	0.22	
		Stored feed for beef	0.22	
		Stored feed for milk	0.22	
		Stored feed for poultry	0.93	
		Stored feed for eggs	0.93	

Based on this information it was assumed that the values for stored feed in Kennedy et al. (1992) and LaPlante et al. (1997) were comparable to fresh forage in the remaining documents. Therefore, there was no single agreed upon value for a dry/wet ratio from the literature, except dry/wet ratios for grain, and stored feed for poultry and eggs. Therefore, the GENII-S default values were selected for the reasonable case, except dry/wet ratios for grain, and stored feed for poultry and eggs, which is discussed later. This selection met the third criterion in Section 6. The GENII-S default values for these parameters should be adequate for use in the BDCF calculation.

Napier et al. (1988, p.4.71) stated that dry/wet ratios used in the GENII code were adapted from NUREG/CR-3332 (Till et al. 1983). However, there was a discrepancy in dry/wet ratio for grain. The default value of 0.18 was used in GENII and in GENII-S later, although NUREG/CR-3332 reported a value of 0.91 (calculated from an averaged fresh-to-dry-weight ratio of 1.1) for dry/wet ratio for grain. Three of five reviewed documents reported 0.91 for dry/wet ratio for grain (Till et al 1983, Kennedy et al. 1992, and LaPlante et al. 1997). Two others reported a value of 0.89 (Baes et al. 1984) and a range of 0.55-0.86 (IAEA 1994), much higher than the GENII-S default value of 0.18. Therefore, 0.91 was selected for dry/wet ratio for grain. Furthermore, based on the assumption that grain is used as stored feed for poultry and eggs, 0.91 was also selected for dry/wet ratios for stored feed for poultry and eggs. This selection met the second criterion. The GENII-S default values for dry/wet ratios for grain, poultry, and eggs are not adequate for use in the BDCF calculation.

The highest values for dry/wet ratios from the literature were selected for the bounding case. The selected values are shown in Table 12.

7. CONCLUSIONS

As a result of the literature search and analysis, the selected values for all parameters in this AMR are summarized in Table 13. In general, most default values in the GENII-S software package were selected for the reasonable case. Only six GENII-S default values were modified, due to use of site-specific data or the values were not supported by the reviewed documents. Most parameter values that were selected for the bounding case were different form the GENII-S default values. Any selected value in this AMR should be updated whenever more suitable or site-specific data become available.

Table 13. The Recommendation of the Parameter Values

Item	Parameter	Value for the Reasonable Case	Value for the Bounding Case	Comment
1	Absolute humidity	0.008 (L/m^3)		Default value
2	Deposition velocity: 1. For crop surface	0.001 (m/sec)	0.1 (m/sec)	Default values for reasonable case, and the highest values available from the reviewed documents for the bounding case
	2. For air transport: 1) Gas elements 2) F, Br, and I 3) Other elements	 0.0 (m/sec) 0.01 (m/sec) 0.001(m/sec)		Default values
3	Crop resuspension factor	8.3E-11 (1/m)	1.4E-9 (1/m)	Calculated from other input parameters
		9.6E-12 – 7.2E-10 (1/m) lognormal distribution		Range for lognormal distribution (0.1% - 99.9%)
4	Crop biomass 1. Leafy vegetables 2. Root vegetables 3. Fruit 4. Grain 5. Stored feed for beef 6. Stored feed for poultry 7. Stored feed for milk 8. Stored feed for eggs 9. Fresh forage for beef 10. Fresh forage for milk	 2.0 (kg/m^2) 2.0 (kg/m^2) 3.0 (kg/m^2) 0.8 (kg/m^2) 0.8 (kg/m^2) 0.8 (kg/m^2) 1.0 (kg/m^2) 0.8 (kg/m^2) 1.0 (kg/m^2) 1.5 (kg/m^2)	 1.5 (kg/m^2) 2.0 (kg/m^2) 0.7 (kg/m^2) 0.4 (kg/m^2) 0.8 (kg/m^2) 0.8 (kg/m^2) 0.8 (kg/m^2) 0.8 (kg/m^2) 0.7 (kg/m^2) 0.7 (kg/m^2)	Default values for reasonable case The lowest values available from the reviewed documents for the bounding case
5	Basic Soil Data: 1. Depth of surface soil	15 (cm)		Default value
	2. Surface soil density	225 (kg/m^2)	180 (kg/m^2)	Calculated / selected value
	3. Deep soil density	1500 (kg/m^3)		Default value
	4. Fraction of plant roots in surface soil	1		Cited from CNWRA
	5. Fraction of plant roots in deep soil	0		Cited form CNWRA

Table 13. The Recommendation of the Parameter Values (cont.)

Item	Parameter	Value for the Reasonable Case	Value for the Bounding Case	Comment
6	Soil Ingestion rate	50 (mg/day)	410 (mg/day)	Replaced by EPA value for the reasonable case, and keep default value for the bounding case
7	Weathering half-life	14 (days)		Default value
8	Translocation 1. Leafy vegetables 2. Root vegetables 3. Fruit 4. Grain 5. Stored feed for beef 6. Stored feed for poultry 7. Stored feed for milk 8. Stored feed for eggs 9. Fresh forage for beef 10. Fresh forage for milk	 1.0 0.1 0.1 0.1 0.1 0.1 0.1 0.1 1.0 1.0		Default values
9	Animal Feed and water consumption rate 1. Stored feed for beef 2. Stored feed for poultry 3. Stored feed for milk 4. Stored feed for eggs 5. Fresh forage for beef 6. Fresh forage for milk 7. Water for beef 8. Water for poultry 9. Water for milk 10. Water for eggs	 68 (kg/day) 0.12 (kg/day) 55 (kg/day) 0.12 (kg/day) 68 (kg/day) 55 (kg/day) 50 (L/day) 0.3 (L/day) 60 (L/day) 0.3 (L/day)	 68 (kg/day) 0.4 (kg/day) 73 (kg/day) 0.4 (kg/day) 68 (kg/day) 73 (kg/day) 75 (L/day) 0.5 (L/day) 160 (L/day) 0.5 (L/day)	Default values for reasonable case The highest values available from the reviewed documents for the bounding case
10	Dry/wet ratio 1. Leafy vegetables 2. Root vegetables 3. Fruit 4. Grain 5. Stored feed for beef 6. Stored feed for poultry 7. Stored feed for milk 8. Stored feed for eggs 9. Fresh forage for beef 10. Fresh forage for milk	 0.10 0.25 0.18 0.91 0.18 0.91 0.18 0.91 0.20 0.20	 0.20 0.38 0.24 0.93 0.22 0.93 0.22 0.93 0.22 0.22	Default values except for grain, poultry, and eggs replaced by literature data for the reasonable case The highest values available from the reviewed documents for the bounding case

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8.3 PROCEDURES

AP-2.1Q, *Indoctrination and Training of Personnel (Rev.0)*

AP-2.2Q, *Establishment and Verification of Required Education and Experience of Personnel (Rev.0)*

AP-2.13Q, *Technical Product Development Planning (Rev.0)*

AP-2.14Q, *Review of Technical Products (Rev.0)*

AP-3.4Q, *Level 3 Change Control (Rev.0)*

AP-3.10Q, *Analyses and Models (Rev.1)*

AP-3.15Q, *Managing Document Inputs (Rev.0)*

AP-6.1Q, *Controlled Documents (Rev.3)*

AP-17.1Q, *Record Source Responsibilities for Inclusionary Records (Rev.1)*

AP-SI.1Q, *Software Management (Rev.1)*

AP-SIII.2Q, *Qualification of Unqualified Data and the Documentation of Rationale for Accepted Data (Rev.0)*

AP-SIII.3Q, *Submittal and Incorporation of Data to the Technical Data Management System (Rev.0)*

QAP-2-0, *Conduct of Activities (Rev.5)*

QAP-2-3, *Classification of Permanent Items (Rev.10)*

NLP-2-0, *Determination of importance Evaluations (Rev.5)*

ATTACHMENT I. ACRONYMS

ACEL	Atomic Energy of Canada Limited
AMR	analysis and model report
BDCF	Biosphere Dose Conversion Factor
CNWRA	Center for Nuclear Waste Regulatory Analyses
CRWMS	Civilian Radioactive Waste Management System
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
IAEA	International Atomic Energy Agency
M&O	Management and Operating
NCRP	National Council on Radiation Protection and Measurement
NRC	Nuclear Regulatory Commission
OCRWM	Office of Civilian Radioactive Waste Management
RG	Regulatory Guide
SS	Safety Series
TBV	to be verified
TDMS	Technical Data Management System
TRS	Technical Report Series
TSP	total suspended particulate
YMP	Yucca Mountain Project

ATTACHMENT II. DOCUMENT INPUT REFERENCE SHEETS

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
DOCUMENT INPUT REFERENCE SHEET

1. Document Identifier No./Rev.:	Change:	Title:
ANL-MGR-MD-000007 / Rev.00	0	Environmental Transport Parameters Analysis,

	Input Document		4. Input Status	5. Section Used in	6. Input Description	7. TBV/TBD Priority	8. TBV Due To		
	2. Technical Product Input Source Title and Identifier(s) with Version	3. Section					Unqual.	From Uncontrolled Source	Un-confirmed
2a									
1	CRWMS M&O 1999c. Particulate Matter Values from 1989 - 1997 Data. Las Vegas, Nevada: CRWMS M&O. DTN: MO9902PARTICLE.000.	paramet-er 1078	TBV 3198	6.3	Total suspended particulate concentration at Site 5 in Yucca Mountain	1	X		
1	(cont.)				(Notes: this data set is also used by the report: ANL-MGR-MD-000001)				
2	Baes, C.F; Sharp, R.D.; Sjoreen, A.L.; and Shor, R.W. 1984. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agricuture. ORNL-5786. Oak Ridge, Tennessee: Oak Ridge National Laboratory. TIC: 233612.	p.124 p.8&129	N/A (corrobora-ting and unqualified	6.7 6.10	Weathering half-life Dry-to-wet ratios	N/A			

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OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

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	2. Technical Product Input Source Title and Identifier(s) with Version	3. Section					Unqual.	From Uncontrolled Source	Un-confirmed
2a									
3	CRWMS M&O 1999b. Scientific Investigation of Radiological Doses in the Biosphere, B00000000-01717-2200-00169, Rev. 2 Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990222.0091.	entire	N/A	2	Information	N/A			
4	CRWMS M&O 1999e. Environmental Baseline File: Meteorology and Air Quality: B00000000-01717-5705-00126. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990302.0186.	entire	N/A	6.3	Information	N/A			
5	Davis, P.A.; et al. 1993. The Disposal of Canada's Nuclear Fuel Waste: The Biosphere Model, BIOTRAC, for Postclosure Assessment. AECL-10720. Pinawa, Manitoba, Canada: Whiteshell Laboratories, Atomic Energy of Canada Limited. TIC: 244741.	p.260 p.257 p.253	N/A (corrobora-ting and unqualified	6.4 6.6 6.9	Crop biomass Soil ingestion rate Animal feed and water consumption rates	N/A			

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Input Document			4. Input Status	5. Section Used in	6. Input Description	7. TBV/TBD Priority	8. TBV Due To		
2a	2. Technical Product Input Source Title and Identifier(s) with Version	3. Section					Unqual.	From Uncontrolled Source	Un-confirmed
6	EPA 1993. External Exposure To Radionuclides In Air, Water, And Soil. Federal Guidance Report No.12. EPA 402-R-93-081. Washington D.C: U.S. Environmental Protection Agency. MOL.19980520.0495.	Section III.	N/A (corrobora-ting and unqualified data)	6.5	Depth of surface soil	N/A			
7	EPA 1997. Exposure Factors Handbook, Volume I: General Factors. EPA/600/P-95/002Fa. Washington, D.C.: U.S. Environmental Protection Agency. TIC: 241060.	p.4-25	N/A (corrobora-ting and unqualified data)	6.6	Soil ingestion rate	N/A			
8	IAEA 1982. Generic Models and Parameters for Assessing the Environmental Transfer of Radionuclides from Routine Releases -- Exposures of critical groups. IAEA Safety Series No.57. Vienna, Austria: International Atomic Energy Agency. TIC: 232649.	p.17 p.59 p.65	N/A (corrobora-ting and unqualified	6.2 6.4 6.5	Deposition velocity Crop biomass Basic soil parameters	N/A			

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Input Document			4. Input Status	5. Section Used in	6. Input Description	7. TBV/TBD Priority	8. TBV Due To		
	2. Technical Product Input Source Title and Identifier(s) with Version	3. Section					Unqual.	From Uncontrolled Source	Un-confirmed
2a	(cont.)								
8		p.59		6.7	Weathering half-life				
		p.57		6.8	Translocation factors				
		p.68&69		6.9	Animal feed and water consumption rates				
9	CRWMS M&O 1999a. Development Plan (DP) Checklist And Cover Sheet, AP-3.10Q AMR, Environmental Transport Parameters Analysis, TDP-MGR-MD-000006, Rev.1. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990817.0208.	entire	N/A	1	Information	N/A			
10	IAEA 1994. Handbook of Parameter Values for the Prediction of Radionuclide Transfer in Temperate Environments. IAEA Technical Report Series No.364. Vienna, Austria: International Atomic Energy Agency. TIC: 232035.	p.13	N/A	6.8	Translocation factors	N/A			
		p.33	(corrobora-ting and	6.9	Animal feed and water consumption rates				
		p.15	unqualified	6.10	Dry-to wet ratios				

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	Input Document		4. Input Status	5. Section Used in	6. Input Description	7. TBV/TBD Priority	8. TBV Due To		
	2. Technical Product Input Source Title and Identifier(s) with Version	3. Section					Unqual.	From Uncontrolled Source	Un-confirmed
2a									
11	Kennedy, W.E.; and Strenge, D.L. 1992. Residual Radioactive Contamination from Decommissioning Technical Basis for Translating Contamination Levels to Annual Total Effective Dose Equivalent. NUREG/CR-5512-V1. Washington D.C.: U.S. Nuclear Regulatory Commission. TIC: 234470.	p.6.23 p.6.35 p.6.15 p.6.41 p.6.28	N/A (corrobora- ting and unqualified data)	6.4 6.5 6.6 6.8 6.10	Crop biomass Surface depth Soil ingestion rate Translocation factors Dry-to wet ratios	N/A			
11	(cont.)	P.6.19		6.9	Animal feed and water consumption rates				
12	LaPlante, P.A.; Maheras, S.J.; and Jarzemba, M.S. 1995. Initial Analysis of Selected Site-specific Dose Assessment Parameters and Exposure Pathways Application to a Groundwater Release Scenario at Yucca Mountain. CNWRA 95-018. San Antonio, Texas: The Center for Nuclear Waste Regulatory Analyses. TIC: 232468.	entire	N/A	4.1	Information				

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	2. Technical Product Input Source Title and Identifier(s) with Version	3. Section					Unqual.	From Uncontrolled Source	Un-confirmed
2a									
13	LaPlante, P.A. and Poor, K. 1997. Information and Analyses to Support Selection of Critical Groups and Reference Biospheres for Yucca Mountain Exposure Scenarios. CNWRA 97-009. San Antonio, Texas: The Center for Nuclear Waste Regulatory Analyses. TIC: 236454.	p.B-2	N/A	6.2	Deposition Velocities	N/A			
		p.B-7	(corrobora-	6.4	Crop biomass				
		p.B-1	ting and	6.5	Basic soil parameters				
		Table2.7	unqualified	6.5	Soil density in Armagosa valley				
		p.4-1	data)	6.6	Soil ingestion rate				
13	(cont.)	p.B-7		6.7	Weathering half-life				
		p.B-8		6.8	Translocation factors				
		p.B-8		6.9	Animal feed and water rates				
		p.B-9		6.10	Dry-to-wet ratios				
14	Leigh, C.D.; Thompson, B.M.; Campbell, J.E.; Longsine, D.E.; Kennedy, R.A.; and Napier, B.A. 1993. User's Guide for GENII-S: A Code for Statistical and Deterministic Simulations of Radiation Doses to Humans from Radionuclides in the Environment. SAND91-0561. Albuquerque, New Mexico: Sandia National Laboratories. TIC: 231133.	p..63&	N/A	6	All parameters	N/A			
		65	(corrobora-						
		p.5-33	ting and		Informaiton				
		S.4.1.2.	unqualified		Information				

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	2. Technical Product Input Source Title and Identifier(s) with Version	3. Section					Unqual.	From Uncontrolled Source	Un-confirmed
2a 15	Liu, N. 1998. Software Qualification Report, GENII-S 1.485 Environmental Radiation Dosimetry Software System, M&O, DI: 30034-2003, Rev.0, RDMS Code: TSPA:VA1-BIO. MOL.19980715.0029.	enttire section	N/A	1	Information	N/A			
16	Mills, M; Vogt, D; and Mann, B. 1983. Parameters and Variables Appearing in Radiological Assessment Codes. NUREG/CR-3160. Washington D.C.: U.S. Nuclear Regulatory Commission. TIC: 206047.	P.136 p.137 p.135 p.143	N/A (corrobora-ting and unqualified data)	6.4 6.7 6.8 6.9	Crop biomass Weathering half-life Translocation factors Animal feed and water consumption rates	N/A			
17	Napier, B.A.; Kennedy, W.E.; and Soldat, J.K. 1980. PABLM - A Computer Program to Calculate Accumulated Radiation Doses from Radionuclides in the Environment. PNL-3209. Richland, Washington: Pacific Northwest Laboratory. TIC: 218637.	entire section	N/A	4.1	Information	N/A			

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	2. Technical Product Input Source Title and Identifier(s) with Version	3. Section					Unqual.	From Uncontrolled Source	Un-confirmed
2a									
18	Napier, B.A., Peloquin, R.A., Strenge, D.L., and Ramsdell, J.V. 1988. GENII: The Hanford Environmental Radiation Dosimetry Software System, Volume 1: Conceptual Representation. PNL-6584 Vol.1. Richland, Washington: Pacific Northwest Laboratory. TIC: 206898.	p.4.84 p.4.72 p.4.71 p.1.2	N/A (corrobora- ting and unqualified data)	6.6 6.9 6.10 4.1	Soil ingestion rate Animal feed and water rates Dry-to-wet ratio Information	N/A			
19	NCRP 1984. Radiological Assessment: Predicting the Transport, Bioaccumulation, and Uptake by Man of Radionuclides Released to the Environment. NCRP Report No. 76. Bethesda, Maryland: National Council on Radiation Protection and Measurement. TIC: 223622.	p.49 p.70 p.70 p.70	N/A (corrobora- ting and unqualified data)	6.2 6.4 6.7 6.8	Deposition velocities Crop Biomass Weathering half-life Translocation factors	N/A			
19	(cont.)	p.70&71		6.9	Animal feed and water consumption rates				

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	2. Technical Product Input Source Title and Identifier(s) with Version	3. Section					Unqual.	From Uncontrolled Source	Un-confirmed
2a / 20	NRC 1977. 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. NRC RG 1.109. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 222641.	p.69 p.68 p.69 p.36 p.38	N/A (corroborating and unqualified data)	6.4 6.5 6.7 6.8 6.9	Crop Biomass Basic soil parameters Weathering half-life Translocation factors Animal feed/water cons. rates	N/A			
21	Sheppard S.C. 1995. Application of the International Union of Radioecologists Soil-to-Plant Database to Canada Settings. AECL-11474. Pinawa, Manitoba, Canada: Whiteshell Laboratories, Atomic Energy of Canada Limited. TIC: 244744.	P.3	N/A (corroborating and unqualified data)	6.5	Basic soil parameters	N/A			
22	Smith, G.M; Watkins, B.M.; Little, R.H.; Jones, H.M.; and Mortimer, A.M. 1996. Biosphere Modeling and Dose Assessment for Yucca Mountain. EPRI TR-107190. Palo Alto, California: Electric Power Research Institute. TIC: 231592.	p.5-25 p.5-19 p.5-23 p.5-30	N/A (corroborating and unqualified	6.4 6.5 6.6 6.7	Crop biomass Basic soil parameters Soil ingestion rate Weathering half-life	N/A			

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	Input Document		4. Input Status	5. Section Used in	6. Input Description	7. TBV/TBD Priority	8. TBV Due To		
	2. Technical Product Input Source Title and Identifier(s) with Version	3. Section					Unqual.	From Uncontrolled Source	Un-confirmed
2a	(cont.)								
22		p.5-31		6.8	Translocation factors				
		p.5-24		6.9	Animal feed and water consumption rates				
23	Till, J.E. and Meyer, H.R. 1983. Radiological Assessment: A Textbook on Environmental Dose Analysis. NUREG/CR-3332. Washington D.C.: U.S. Nuclear Regulatory Commission. TIC: 223809.	P.5-19 to 5-23	N/A (corroborating and unqualified data)	6.2	Deposition velocites	N/A			
		p.5-42		6.5	Density for sandy soil				
		p.5-36		6.7	Weathering half-life				
		p.5-53		6.8	Translocation factors				
23	(cont.)	p.5-48		6.10	Dry-to-wet ratios				

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	2. Technical Product Input Source Title and Identifier(s) with Version	3. Section					Unqual.	From Uncontrolled Source	Un-confirmed
2a 24	Yu, C; Zielen, A.J.; Cheng, J.-J.; Yuan, Y.C.; Jones, L.G.; LePoire, D.J.; Wang, Y.Y.; Loureiro, C.O.; Gnanapragasam, E.; Faillance, E.; Wallo III, A.; Williams, W.A.; and Peterson, H. 1993. Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD, Version 5. ANL/EAD/LD-2. Argonne, Illinois: Argonne National Laboratory. TIC: 244802.	p.182 p.183 p.185 p.186	N/A (corrobora- ting and unqualified data)	6.2 6.4 6.5 6.9	Deposition Velocities Crop biomass Basic soil parameters Animal feed and water consumption rates	N/A			
24	(cont.)	p.222 P.183 p.183		6.6 6.7 6.8	Soil ingestion rate Weathering half-life Translocation factors				
25	Zach, R. et al. 1996. The Disposal of Canada's Nuclear Fuel Waste: A Study of Postclosure Safety of In-Room Emplacement of Used CANDU Fuel in Copper Containers in Permeable Plutonic Rock Volume 4: Biosphere Model. AECL-11494-4. Pinawa, Manitoba, Canada: Whiteshell Laboratories, Atomic Energy of Canada Limited. TIC: 226735.	entire section	N/A	4.1	Information	N/A			

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OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
DOCUMENT INPUT REFERENCE SHEET

1. Document Identifier No./Rev.:	Change:	Title:
ANL-MGR-MD-000007/ Rev.00	0	Environmental Transport Parameters Analysis,

	Input Document		4. Input Status	5. Section Used in	6. Input Description	7. TBV/TBD Priority	8. TBV Due To		
	2. Technical Product Input Source Title and Identifier(s) with Version	3. Section					Unqual.	From Uncontrolled Source	Un-confirmed
2a 26	VA 1998. Viability Assessment of a Repository at Yucca Mountain - Total System Performance Assessment. DOE/RW-0508, Vol. 3. North Las Vegas, Nevada: Office of Civilian Radioactive Waste management, U.S. Department of Energy. MOL.19981007.0030.	entire	N/A	4.1	Information	N/A			
27	CRWMS M&O 1999d. Status of the radionuclide Screening for the TSPA-SR. Input Tracking No. R&E-PA-99217.Ta. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.19990719.0182.	5.0	TBV 3059	6.1	Radionuclides of interest				

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