DEFENSE THREAT REDUCTION AGENCY

NUCLEAR TEST PERSONNEL REVIEW PROGRAM

RADIATION DOSE ASSESSMENT

STANDARD OPERATING PROCEDURE

RA06 – Radiation Dose Assessment for Participants in the Enewetak Cleanup Project

Revision 1.3

Cleared for Release

Key to SOP ID Codes

RA (Radiation Assessment - SOP)
ED (External Dose - Standard Methods)
ID (Internal Dose - Standard Methods)
UA (Uncertainty Analysis - Standard Methods)

Revision Control

Revision	Revision Description	Revision Date	Authorization Official
1.0	Original version	11/15/2019	James D. Franks
1.1	- Section 5.6: changed the content of the pathways' bullets separating out ingestion of local food and ingestion of drinking water - Updated the publication year of the ECUP Technical Report, Revision 1, from 2019 to 2020, throughout - Other editorial changes	04/30/2021	James D. Franks
1.2	- Changes made in Sections 4 and 5 to report skin doses and upper-bound skin doses by radiation type as an alpha dose and a beta+gamma dose - Added a default local food in Table A1-6 - The RDA Report template was revised to reflect the reporting of separate skin doses by radiation type. The revised template includes editorial changes needed to clarify and improve the text - Other editorial changes	02/15/2022	James D. Franks
1.3	- Clarified information in Table A1-6, Table A1-7, and Table A1-15 to better specify inhalation and skin dose calculations for excised soil - Corrected the Skin Dose Modification Factor values for scalp and back of hand in Table A1-16 - Corrected the Pu-239 and Am-241 dose-rate factors for Shoulder and Torso (back, sides) in Table A1-16 - Several editorial changes in Table A1-16 - Updated references and made other editorial changes - Other editorial changes	07/15/2023	Lee A. Alleman

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Standard Operating Procedure

RA06 – Radiation Dose Assessment for Participants in the Enewetak Cleanup Project

1. Purpose/Summary

This standard operating procedure (SOP) provides the detailed activities and tasks required to perform radiation dose assessments (RDAs) and prepare RDA Reports for veterans who participated in the radiological cleanup of the Enewetak Atoll known as the Enewetak Cleanup Project (ECUP) from 1977 to 1980. This SOP addresses the evaluation of radiation doses to the whole body and skin from external exposure, and to internal organs from the intake of radioactive material by inhalation and ingestion. The procedure requires the adaptation of existing dose calculation tools or development of new modules to calculate the radiation doses, along with associated uncertainties and upper-bound doses, for a range of activities performed by a participant in various ECUP radiation environments. It requires the preparation of a dose calculation worksheet personalized to a specific participant's activities and radiation environments, organs and diseases considered, and affected skin locations in the case of skin cancers.

This SOP is written for qualified RDA analysts to perform required tasks using the methods described in a technical report published by the Defense Threat Reduction Agency (DTRA, 2022). Tasks include the modification or development of dose calculation tools and preparation of an RDA Report that is specific to a veteran who files a claim with the Department of Veterans Affairs (VA) for service-connected diseases. This SOP also describes quality control activities performed by technical and management personnel to ensure conformance with approved procedures and methods, as well as established policies and guidelines of the Nuclear Test Personnel Review (NTPR) Program administered by DTRA.

2. Scope

This SOP applies to veteran ECUP participants filing claims with the VA for service-connected diseases. The Population of Interest (POI) consists of about 6,000 military service members who participated in ECUP within the period 1977 to 1980. The POI includes members of the three military service components of the ECUP Joint Task Group (JTG) consisting of the Army, Navy, and Air Force Elements, as well as personnel of the Defense Nuclear Agency (DNA)/JTG itself. This SOP employs approved and published dose estimation methods and documented data that address all aspects of radiation dose assessments. The DoD objectives for radiation dose determinations in 32 CFR 218 have been adapted to apply to ECUP radiation dose assessments (DoD, 2020). The methods, data, and references developed for ECUP RDAs are incorporated in a DTRA technical basis document entitled "Radiation Dose Assessment for Military Personnel of the Enewetak Atoll Cleanup Project (1977–1980), Revision 2" (DTRA,

2022). Radiation dose assessments for ECUP participants prepared according to this SOP provide full consideration of benefit of the doubt throughout the dose assessment process as required by the VA in 38 CFR 3.102 (VA, 2020).

3. Responsibilities

A qualified radiation dose analyst (the RDA Analyst) is assigned the case and performs most tasks required for analyzing the radiation exposure activities, calculating radiation doses, and preparing the RDA Report. The RDA Analyst also consolidates retrieved information and management of RDA case files as needed. A second radiation dose analyst conducts technical reviews for quality control. Management personnel perform additional quality control reviews to ensure that work products submitted to the DTRA Program Manager (PM) are consistently prepared to conform to publication guidelines, templates, and content specifications.

4. Definitions

AEC	U.S. Atomic Energy Commission: federal nuclear regulatory entity 1946–1974; nuclear regulatory functions were assumed by the Nuclear Regulatory Commission and other functions by other predecessor organizations to the current Department of Energy in 1975
Bioassay	Measurements performed to determine the amount of radioactive material in the human body
CFR	Code of Federal Regulations
DoD	Department of Defense
Dose component	Potential contributor to an individual's overall organ dose, including: - External gamma dose - Inhalation dose – alpha and beta+gamma radiation - Ingestion dose – alpha and beta+gamma radiation
DTRA	Defense Threat Reduction Agency: the DoD agency that manages and operates the NTPR Program
DTRA PM	Program Manager assigned by DTRA that is responsible for managing the NTPR program
ECUP	Enewetak Cleanup Project: the project for the radiological cleanup of Enewetak Atoll conducted from 1977 to 1980
JTG	Joint Task Group: a multi-service military group formed to accomplish a specific task

LBDA	Lexington-Blue Grass Depot Activity
Management Review	Final review conducted by the RDA Analyst manager before the Final Draft RDA is forwarded to the DTRA PM
NTPR	Nuclear Test Personnel Review: the DoD/DTRA program that confirms participation and estimates doses for atomic veterans, and is also responsible for preparing ECUP RDAs
NuTRIS	Nuclear Test Research Information System: a computerized database containing veteran information and dosimetry data
QA	Quality Assurance: the process and procedures by which requirements and activities are defined to demonstrate that work products conform to NTPR SOPs
QC	Quality Control: reviews, audits, and discussions conducted to verify the accuracy of NTPR results and work products and their compliance with SOPs, SMs, and other specific program requirements
RDA	Radiation Dose Assessment: a complete analysis and estimation of potential radiological doses to an individual
RDA Analyst	Radiation Dose Assessment Analyst: an individual qualified to conduct or review RDAs
Skin dose	External dose from alpha and beta+gamma radiation
SM	Standard Method: NTPR document that provides technical and computational methods for specific aspects of assessing doses and dose distributions to include upper bounds
SOP	Standard (or Standing) Operating Procedure
Surrogate organ or skin site	An ECUP standard organ/skin site used for dose calculations as a substitute organ/skin site when no published dose coefficients are available for the requested disease or medical condition
VA	Department of Veterans Affairs

5. Procedure: Detailed Activity/Task Description

A radiation dose assessment for an ECUP participant starts with a review of the veteran's ECUP Questionnaire and case file. The case file includes the VA request for dose information, military service records, dosimetry records, military orders, Enewetak Atoll arrival/departure cards, and may also include (as applicable) the veteran's statements, island access cards, boat logs, relevant excerpts from published reports, and other pertinent documentation. The assessment then proceeds with dose and upper-bound dose calculations, and preparation of the RDA Report. Doses are based on either recorded dosimetry from film-badges and thermoluminescent dosimeters (TLD) or calculations

using dose reconstruction methods. Dose estimates determined by dose reconstruction are performed using standard analytical methods with documented assumptions, environmental data, and other dose parameter values that are published in a DTRA technical report (DTRA, 2022).

As stated in Section 2, radiation dose assessments provide full consideration of benefit of the doubt throughout the dose estimating process. To do so, radiation dose analysts rely on veteran's statements and use them unless the statements involve activities that are not plausible or are refuted by documented records. High-sided parameter values and assumptions that reasonably maximize the veteran's dose are employed in calculations of dose and upper-bound doses using fixed uncertainty factors (DTRA, 2022). This section provides the steps used to conduct an ECUP radiation dose assessment and prepare veteran-specific dose calculations and an RDA Report.

5.1 Review Case Information

The RDA Analyst to whom a case is assigned reviews the case file for a veteran's responses to the ECUP Questionnaire and the VA letter request for dose information to identify the diseased organs, skin sites, and other medical conditions. The RDA Analyst reviews other case materials, project reports, previously completed veterans' RDA Reports, the ECUP records collection, and any other available documentation and publications to the extent necessary to determine:

- Whether all required information is available to carry out the dose assessment
- Whether any conflicts or inconsistencies exist between the documented records, publications, and the veteran's statements
- If any additional information is available from other case files of veterans engaged in similar ECUP activities in the same locations.

5.2 Collect Additional Information

If additional information is needed to complete gaps in the case file or resolve inconsistencies, the RDA Analyst:

- Requests searches for specific information of/from the ECUP records collection, the NuTRIS database or other document repositories, such as the Nuclear Testing Archive in Las Vegas, NV and the National Personnel Records Center in St. Louis, MO
- Identifies additional questions for the veteran to answer via the program's veteran assistance unit (DTRA, 2020; DTRA, 2021).

5.3 Identify Exposure Scenario and Define Exposure Pathways

Radiation doses are estimated based on scenarios that characterize the veteran's ECUP activities within radiation environments. In particular, the RDA Analyst identifies ECUP task teams and associated exposure scenarios, as described in DTRA (2022).

Radiation exposures are defined in terms of pathways of exposure each involving a source of radiation, a mechanism (pathway) for the radiation to reach the exposed individual, and, for internal dose assessment, a route of entry into the body. Exhaustive lists of project tasks and activities with associated radiation sources and exposure pathways are presented in DTRA (2022).

5.4 Obtain RDA Team Consensus on Scenario of Exposure and Pathways

After identifying the scenario of radiation exposure and defining relevant exposure pathways by compiling all available information about the veteran's participation, the RDA Analyst consults with members of the RDA team and discusses all case findings and proposed resolutions to complete the dose assessment. These RDA team discussions should result in recommendations to the RDA Analyst to proceed with the proposed decisions, assumptions, and dose parameter input values that are specific to the veteran, or to make modifications to better characterize the scenario of exposure and related pathways. If modifications are recommended, the RDA Analyst iterates with the other RDA team members to complete all necessary changes and obtain consensus to proceed with the veteran's RDA.

5.5 Assess External Whole-Body Dose

External whole-body exposure represents the most common source of potential radiation dose for ECUP veterans who performed duties on contaminated islands identified for cleanup. The island average gamma radiation exposure rates from measurements conducted during the 1972 AEC radiological survey of the Enewetak Atoll islands (AEC, 1973) are presented in Table A1-2. Also, personnel dosimetry records may be available from the ECUP document collection and military services dosimetry centers.

5.5.1 Dose Assessment Hierarchy

External radiation doses are determined using the following hierarchy of methods:

- Valid dosimetry results for the individual, normally from film badge and TLD records
- Reconstructed doses obtained using sound scientific methods and a knowledge of the activities and radiation environments to which the individual was exposed when individual dosimetry is unavailable or unreliable.

5.5.2 Conduct Dosimetry Records Analysis

The validity and applicability of dosimetry records is a critical aspect of the analysis. The various sources for the records are contained in the following documents and files:

- DD Form 1141 "Record of Occupational Exposure to Ionizing Radiation"
- Army Dosimetry Center (ADC) (formerly called LBDA) database
- Department of Army (DA) Form 3484 "Photodosimetry Report"
- Thermoluminescent Dosimetry (TLD) Report
- TLD Control Card.

The review of dosimetry records for ECUP veterans is performed by the RDA Analyst according to the following guidelines to determine their validity and applicability:

- The DD Form 1141 is the official document used by the Military Services to record radiation doses to personnel engaged in radiation work and should be used as the primary source of dosimetry records.
- Reported film badge doses of 20 mrem or less should be superseded with reconstructed doses for the applicable wearing periods.
- Administrative doses reported in dosimetry records should be superseded with reconstructed doses for the applicable periods; these include administrative doses that were substituted for doses from damaged film badges.
- Doses from undamaged film badges that are higher than 20 mrem and all TLD readings should be used as components of the external dose to the veteran for the reported wearing periods.
- A TLD dose takes precedence over a film badge dose that covers the same wearing period because of the finer resolution and accuracy of the TLDs and reading system.

For time periods not covered by valid dosimetry records, radiation doses are estimated using dose reconstruction techniques as described in the following section.

5.5.3 Calculate Additional External Whole-Body Doses

The RDA Analyst determines time periods during the individual's ECUP assignment for which reliable dosimetry records are not available. Radiation doses for these periods are assessed using reconstruction techniques described in this section.

5.5.3.1 Characterize Radiation Environment

Radiation dose assessments require that the radiation environments be properly defined and characterized by potential sources and pathways. Direct exposure to the radiation emitted by radioactive contamination is the primary pathway of external exposure relevant to ECUP personnel. Sources of radiation that may have resulted in direct exposure to radiation of ECUP participants include the following:

- Ground surface contaminated with fallout mixed in the top layer of soil
- Slurry of mixed contaminated soil and cement during preparation, transport, and disposal in the Cactus crater
- Stockpiles of contaminated soil and debris
- Contaminated soil and metal scrap debris during transport by trucks and boats
- Contaminated concrete structures, slabs, and building debris
- Soil-cement mix produced and contained in the Cactus dome
- Lagoon water, lagoon sediment, and ocean water while personnel retrieved debris from offshore locations and during diving or recreational swimming; see note below
- Contaminated equipment
- Contaminated laundry at the decontamination laundry facility.

Note: *For the pathway of external exposure while immersed in lagoon or ocean water, maximized doses have been estimated to be orders of magnitude below 1 mrem using conservative assumptions. Therefore, doses from this pathway are subsumed within applied upper-bound dose uncertainties with no need to estimate them separately. (DTRA, 2022)*

Detailed descriptions of potential sources of external radiation and pathways are provided in DTRA (2022).

5.5.3.2 Identify Project Tasks and Activities with Potential for Radiation Exposure

Based on the review of the returned questionnaire and the VA statement of claim (if included) combined with information in operational records, the RDA Analyst develops the veteran's detailed activities and considers external sources of gamma radiation in the following ECUP activities:

- Soil cleanup
- Debris cleanup
- Radiological support
- Project activities on the southern islands (except Enewetak Island)

- Project support on the residence island of Enewetak
- Project support on the forward residence island of Lojwa
- Intra-atoll transport
- Pre-cleanup and demobilization activities
- Recovery and disposal of unexploded ordnance by Explosive Ordnance Disposal teams.

5.5.3.3 Compile Assumptions and Input Parameters

The scenario description in the RDA Report includes statements of all significant assumptions required to complete the dose assessment. When details of the components cannot be determined from the veteran's responses to the questionnaire or other pertinent documentation, activities must be assumed. In rare cases, it might be necessary for the RDA Analyst to ask the veteran to answer additional questions.

5.5.3.4 Estimate Doses by Reconstruction

The RDA Analyst uses the methods described in DTRA (2022) and related dose calculation tools to reconstruct doses from each source of external radiation. The RDA Analyst estimates the veteran's doses from external radiation sources and pathways based on activities described in the case file and pertinent historical records and reports.

In particular, the RDA Analyst uses island exposure rate data compiled in Section 4 and other dose parameter values reported in Section 6 of DTRA (2022) to estimate external doses for most ECUP veterans. The island exposure rate data were derived from the 1972 radiological survey of ground contamination from previously deposited fallout (AEC, 1973) and are incorporated in ECUP RDA calculation tools.

Dose parameter input values reported in DTRA (2022) are compiled in Attachment 1 and should be used in the external dose calculations in the absence of veteran-specific exposure information and data. The input values compiled in Attachment 1 are based on information documented and extracted from ECUP historical reports and other documentation. Additional details on assumptions and high-sided parameter values can be found in DTRA (2022).

For exposure scenarios for which no calculation tools specific to ECUP are available, RDA analysts must develop the necessary worksheets for the relevant dose assessment.

5.5.4 Calculate Total Whole-Body External Dose and Upper-Bound Dose

Available dose calculation tools generate total external doses and upper-bound doses in accordance with the methods included in DTRA (2022). The total and upper-bound doses combine doses from film badges, TLDs, and reconstruction of individual scenario

components. Newly developed worksheets must include calculation of total and upper-bound doses using the methods presented in DTRA (2022).

5.6 Assess Dose from Intakes of Radioactive Materials

The RDA Analyst reviews the request for a dose assessment and determines the internal organ(s) of interest. If dose coefficients are not available for an organ of interest, a surrogate organ is substituted in the dose assessment. A surrogate organ is similar to the organ of interest with respect to its biokinetic modeling (see NTPR SOP RA07, Attachment 1 for guidance in determining surrogate organs).

Over 2,300 24-hour urine samples were analyzed during ECUP. When available, the RDA Analyst reviews the veteran's urine bioassay results to verify that they are in the range reported in DNA (1981). However, these results are not used for internal dose estimation as discussed in DTRA (2022). Consequently, the RDA Analyst estimates doses from internal exposure pathways using the methods described in DTRA (2022) and available or newly developed dose calculation tools.

The RDA Analyst considers the following pathways to the internal or surrogate organs for internally deposited radioactive material:

- Inhalation of suspended soil
- Incidental ingestion of soil and dust
- Incidental ingestion of lagoon and ocean water; see note below
- Ingestion of drinking water; see note below
- Ingestion of local food
- Absorption of radionuclides through puncture wounds or cuts.

> ***Note:*** *For the pathways of incidental ingestion of lagoon and ocean water, and ingestion of drinking water, maximized doses have been estimated to be orders of magnitude below 1 mrem using conservative assumptions. Therefore, doses from these sources and pathways are subsumed within applied upper-bound dose uncertainties with no need to estimate them separately. (DTRA, 2022)*

Using the applicable exposure pathway description and other dose parameter values reported in Section 7 of DTRA (2022), the RDA Analyst calculates 50-year committed equivalent doses (CED) for each diseased or each surrogate organ separately for alpha particles, and for beta particles plus gamma rays for each pathway. The alpha dose equals the total organ dose from all alpha-emitting radionuclides considered for each pathway, and the beta+gamma dose equals the total dose from all other radionuclides included in the dose assessment also for each pathway. The RDA Analyst then estimates each

organ's total alpha and beta+gamma doses from all pathways and determines upper-bound doses using the methods described in DTRA (2022).

Default dose parameter input values reported in DTRA (2022) are compiled in Attachment 1 and should be used in the internal dose calculations in the absence of veteran-specific exposure information and data. The default input values compiled in Attachment 1 are based on information documented and extracted from ECUP historical reports and other documentation. Additional details on assumptions and high-sided parameter values can be found in DTRA (2022).

For exposure scenarios with no available calculation tools specific to ECUP, RDA analysts must develop the necessary worksheets for the relevant dose assessment to include calculation of total and upper-bound doses using the methods presented in DTRA (2022).

5.7 Assess Doses to the Skin

Using information in the veteran's case file and relevant DTRA guidance, the RDA Analyst identifies the applicable reference body location(s) for skin cancer(s) claimed by the veteran and requested by the VA. If necessary, standard surrogate skin sites are identified.

Using the review of the veteran's case file combined with information and guidance contained in DTRA (2022), the RDA Analyst determines potential exposure to ground, suspended, or waterborne sources of alpha, beta, and gamma radiation during the veteran's participation in ECUP. Exposures from these sources are assumed to be concurrent with exposures to external gamma radiation addressed in Section 5.5 above. The following sources of external exposure to the skin are considered for skin dose assessments:

- Direct (non-contact) exposure from residual beta and gamma activity in soil or other contaminated material
- Dermal contamination due to radioactive material in suspended soil deposited on the skin or clothing.

Using applicable calculation tools, the RDA Analyst calculates the veteran-specific beta dose and the total beta+gamma dose from non-contact exposure for each identified skin location. Where applicable, scenario parameter values should be consistent with assumptions used for the veteran's external dose assessment. In the absence of detailed information from the veteran or other appropriate sources, the veteran is assumed to be standing during his skin exposures.

The RDA Analyst uses applicable calculation tools to estimate the alpha and beta+gamma doses from dermal contamination for each affected skin location using the methods and dose parameter values contained in DTRA (2022). Dose parameter values

reported in DTRA (2022) are compiled in Attachment 1 and should be used in the skin dose calculations in the absence of veteran-specific exposure information and data. Parameter values for factors such as length of a workday and resuspension factors should be consistent with assumptions used for the veteran's external and internal dose assessments.

The doses from all exposure pathways are combined to determine skin dose from alpha and beta+gamma radiation for each affected skin location. Total upper-bound doses are calculated using the methods and uncertainty factors provided in DTRA (2022).

When applicable calculation tools are not available for a specific ECUP scenario, RDA analysts must develop the necessary worksheet(s) for the relevant skin dose assessment. Newly developed worksheets must include calculation of total and upper-bound skin doses using the methods presented in DTRA (2022).

5.8 Prepare Internal Draft RDA Report

The RDA Analyst drafts an RDA Report that contains all dose results and pertinent scenario information and assumptions. A detailed description of the content of RDA Reports and a standardized template is included as Attachment 2.

All doses reported in the summary table and dose results tables in the RDA Report are listed with two significant figures obtained by rounding up the third figure. For doses equal to 0.9 to 9 mrem, results are reported by rounding up the calculated dose to one significant figure. In addition, rounded doses less than 0.001 rem are reported as "<0.001 rem" when provided in tables and as "less than 1 mrem" or "less than 0.001 rem" when reported in the text.

For cases where skin doses are assessed, these should be reported separately by radiation type as a dose from alpha radiation and a dose from beta+gamma radiation.

If a veteran's assignment spans two calendar years, the sum of the doses is assigned to the first year of exposure for both internal organ and skin doses.

5.9 Perform Reviews

The RDA Analyst submits the draft RDA Report and associated dose calculations for technical review by another RDA Analyst. Particularly, newly developed calculation worksheets require a full review cycle, whereas existing worksheets that are applied for a veteran's RDA should be reviewed primarily for accuracy of veteran-specific input and transcription of results in the RDA Report. Once the review is completed, the authoring RDA Analyst revises the draft RDA Report and dose calculations to address comments from the reviewer and then resubmits the revised draft RDA Report and dose calculations for final review by the same or another RDA Analyst.

The reviewers document comments and suggested revisions on the draft documents and include their initials in the filename of the reviewed copy. The reviewed copy is saved in the veteran folder for the case. Each reviewer completes the Technical Review Checklist

for Radiation Dose Assessments for Participants in the Enewetak Cleanup Project provided in Attachment 3.

Once comments from technical reviews are addressed and incorporated in the draft RDA Report, the RDA Analyst forwards the revised draft RDA Report for management review.

The RDA Analyst records the date of the completion of each review on the NTPR RDA Internal Tracking and Quality Assurance Checklist included in NTPR SOP RA04.

5.10 Prepare Final Draft RDA Report

The RDA Analyst revises the draft RDA Report and dose calculations to address comments from the Management Review, prepares a Final Draft RDA Report, and assembles all relevant information for transmittal to the DTRA PM.

5.11 Transmit RDA Report

Once the Final Draft RDA Report is completed, staff from the RDA team performs the following tasks:

- Prepare an official electronic version (portable document format [pdf] or an approved equivalent format) of the Final Draft RDA Report and supporting dose calculation worksheet(s) for transmittal to DTRA
- Transmit the Final Draft RDA Report and worksheet(s) to the DTRA PM or designee for final review.

5.12 Receive DTRA PM Review Comments

The RDA Analyst evaluates and resolves DTRA PM comments, if any, and prepares a revised Final Draft RDA Report and dose calculation worksheets that incorporate DTRA PM comments. If no DTRA PM comments are received, the Final Draft RDA Report is considered final.

5.13 Transmit Revised Final Draft RDA Report

Once the Final Draft RDA Report is completed, the RDA Analyst or other designated personnel perform the following tasks:

- Prepare an official electronic version (portable document format [pdf] or equivalent approved format) of the RDA Report and supporting dose calculation worksheet(s), if any changes were required during the revision process
- Complete transmittal of documents to the DTRA PM. The transmitted version is filed in the applicable case archive folder.

6. Data and Records Management

This SOP is used to produce RDA Reports and dose calculation worksheets for individualized veteran dose assessments. Drafts and final electronic versions of these dose assessment documents are filed by the RDA Analyst in an individual veteran RDA folder on a dedicated storage device. In addition, copies of the veteran's case file, associated data tables, reference material relevant to the case, etc., are placed in the veteran's folder. Electronic copies of all files used or cited in the assessment are stored electronically under the same veteran RDA folder.

Official copies of the final veteran ECUP RDA Report, dose calculation worksheets, and supporting information are transmitted to DTRA PM who maintains these files in accordance with the NTPR Program Support and Management SOP (DTRA, 2021a).

7. Quality Assurance and Quality Control

The NTPR Quality Assurance SOP (DTRA, 2021b) describes the quality procedures for controlling the NTPR processes and products to ensure that defensible, consistent, and objective case processing is accomplished. In addition, NTPR Program Support SOPs and RDA SOPs have been written to ensure that QA requirements will be met, by documenting the procedures for all aspects of the program, including records research, case processing, dose assessments, and report formats. Finally, NTPR Standard Methods describe methods, conservative default assumptions, and parameter values to further ensure consistency and defensibility of all RDAs.

Internal quality control checks are performed throughout the RDA development process. The RDA Analyst discusses with members of the RDA team proposed assumptions to perform the dose assessment until a consensus on best approach to proceed is reached. Reviews of draft RDA Reports and dose calculation worksheets are conducted by peer analysts from the RDA team as described in Sections 5.4 and 5.9. Management reviews provide further assurance that RDAs are prepared consistently and in accordance with established policies, guidelines, and procedures.

Further quality control actions are conducted by independent external reviewers according to the NTPR Quality Assurance SOP (DTRA, 2021b). Regarding this procedure, external reviews are defined as reviews conducted by qualified analysts who are not part of the RDA team. RDA Reports and calculation worksheets are revised in response to significant comments from such external reviews. Significant comments are those that impact major elements of information provided in the RDA Report, such as those that could materially affect the dose results in a manner that is not already accounted for within the bounds of the uncertainty calculations. An RDA Report that requires revision after external reviews is revised, reviewed, and transmitted to DTRA as described above in Section 5.

8. Referenced SOPs and Standard Methods from the NTPR/RDA SOP Manual

(1) SOP ED02 Whole Body External Dose Assessment

(2) SOP RA04 Internal RDA Reviews

(3) SOP RA07 Expedited Processing of Radiation Dose Assignments for Enewetak Cleanup Project Veterans

(4) SM ED04 Skin Dose from Dermal Contamination

9. References

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ICRP (International Commission on Radiological Protection), 2011. *ICRP Database of Dose Coefficients: Workers and Members of the Public, Version 3.0*. The International Commission on Radiological Protection.

NCRP (National Council on Radiation Protection and Measurements), 2009. *Radiation Dose Reconstruction: Principles and Practices.* Report No. 163, Bethesda, MD. November 13.

VA (Department of Veterans Affairs), 2020. *Reasonable Doubt*. Title 38, Code of Federal Regulations, Part 3.102. July 1.

Attachment 1.

Dose Parameter Values to Use in Radiation Dose Assessments for ECUP Participants

The values of input parameters used in RDAs for ECUP participants are provided in Table A1-1 to Table A1-5 for external doses, Table A1-6 to Table A1-11 for internal doses, and Table A1-12 to Table A1-16 for skin doses. The parameter values included in these tables are default numbers that are applicable in most cases. They should be replaced with veteran-specific values when available. Most of these default parameter values are described in DTRA (2022) and are based on historical documents and technical basis documents, as well as ECUP veteran recollections. The environmental characterization data and recommended/default dose input parameter values included in this attachment are extracted from DTRA (2022).

Table A1-1. General parameter values for external dose assessments for ECUP participants

Parameter	Value	Rationale/Reference/Comment
Duration of duty tour	Variable (default = 6 months [26 wk])	Based on individual's arrival and departure records. Default is used only if arrival and departure records are not available.
Work schedule	10 h d^{-1} for 6 d wk^{-1}	This is the default assumption for all participants.
External exposure rate on residence and work island	Island-specific or multi-island average (See Table A1-2)	See Table A1-3 for guidance when multiple islands are involved. For debris cleanup on multiple islands, use debris data in Table A1-4 for averaging.
Time spent outdoors and indoors on residence island	See Table A1-5	
Protection factor	Tent: 1.5 Building: 2.0	NTPR SOP ED02
Film badge conversion factor (for 3 orientations relative to a source)	Facing source: 1.0 rem R^{-1} Standing upright: 0.7 rem R^{-1} Facing away: 0.5 rem R^{-1}	NTPR SOP ED02
Fraction of workday exposed to source	0.1 to 1 (default = 1)	Fraction of a workday or of work duration that a worker is exposed to a radiation source.

Table A1-2. External exposure rates and surface soil activity concentrations for all islands

Island Name	Site Name	Average Exposure Rate (μR h^{-1} at 1 m)*	Mean Island-average Soil Concentrations in top 15 cm (pCi g^{-1})				
			Co-60	Sr-90	Cs-137	Pu-239/240	Am-241
Northern Islands							
Bokoluo	Alice	81	5.9	107.9	44.1	15.6	10.4
Bokombako	Belle	115	10	148.9	47.5	27.1	18.1
Kirunu	Clara	42	6.4	99.2	35.4	31.6	21.1
Louj	Daisy	21.3	11	107.7	10.5	31.6	21.1
Bocinwotme	Edna	6	0.43	68.6	4.7	19.4	12.9
Boken	Irene	80	5.4	52.8	7.3	26.2	5.2
Enjebi	Janet	40	1.9	72.9	27.0	16.2	3.2
Mijikadrek	Kate	19	2.7	43.5	13.1	11.3	7.5
Kidrinen	Lucy	14	1.5	30.1	10.3	7.7	5.1
Taiwel	Percy	5	0.47	34.6	7.3	9.0	6.0
Bokenelab	Mary	10	1.5	34.8	8.4	10.1	6.7
Elle	Nancy	12	1.6	39.3	11.6	10.1	6.7
Aej	Olive	11	1.5	21.5	7.7	8.4	5.6
Lujor	Pearl	70	12	28.3	12.4	38.3	7.7
Eleleron	Ruby	14	0.93	24.3	3.2	14.5	9.7
Aomon	Sally	7	0.54	16	5.7	11.0	2.2
Bijire	Tilda	6	1.2	19.1	4.2	6.5	4.3
Lojwa	Ursula	5	0.31	8.2	2.6	1.8	1.2
Alembel	Vera	5	0.3	12.5	4.4	4.3	2.9
Billae	Wilma	2	0.12	6.0	2.0	1.8	1.2
Runit	Yvonne	33	0.64	3.3	1.00	8.7	1.7

Table A1-2. External exposure rates and surface soil activity concentrations for all islands (cont.)

Island Name	Site Name	Average Exposure Rate ($\mu R\ h^{-1}$ at 1 m)*	Mean Island-average Soil Concentrations in top 15 cm ($pCi\ g^{-1}$)				
			Co-60	Sr-90	Cs-137	Pu-239/240	Am-241
Southern Islands							
Boko	Sam†	0.31	0.04	0.72	0.38	0.09	0.06
Munjor	Tom†	0.31	0.04	0.72	0.32	0.08	0.05
Inedral	Uriah†	0.49	0.15	0.45	0.11	0.08	0.05
n/a	Van†	0.33	0.09	0.41	0.14	0.08	0.05
Jinedrol	Alvin†	0.31	0.68	0.44	0.11	0.06	0.04
Ananij	Bruce	1.2	0.12	0.59	0.40	0.09	0.06
Jinimi	Clyde†	0.15	0.04	0.23	0.06	0.06	0.04
Japtan	David†	0.31	0.03	0.55	0.40	0.05	0.03
Jedrol	Rex†	0.53	0.09	0.51	0.51	0.04	0.03
Medren (Parry)	Elmer†	0.31	0.06	0.76	0.32	0.21	0.14
Bokandretok	Walt†	0.18	0.04	0.41	0.15	0.04	0.03
Enewetak	Fred†	0.26	0.04	0.61	0.25	0.08	0.05
Ikuren	Glenn†	0.53	0.21	1.37	0.60	0.11	0.07
Mut	Henry†	0.34	4.3	0.75	0.25	0.14	0.09
Boken	Irwin†	0.54	0.62	0.69	0.13	0.13	0.09
Ribewon	James	3	6.5	0.69	0.08	0.08	0.05
Kidrenen	Keith†	0.64	0.17	0.88	0.28	0.11	0.07
Biken	Leroy	7.6	0.58	16.8	5.06	1.15	0.77

* Converted from 1972 aerial survey results for each island (DTRA, 2022).

† Exposure rates on these islands are lower than the limit of sensitivity of the aerial survey equipment; for these, exposure rates are derived from soil sample activity concentration data (AEC, 1973).

Table A1-3. Averaging methods to determine exposure rates or soil activity concentrations for scenarios where ECUP veterans worked on multiple islands

Type of Work	If work islands are known		If work islands are not known
	Durations on specific islands are known	Durations on specific islands are not known	
Work involving or supporting soil-removal activities*	TWA† using values for known soil-removal islands	VWA‡ using values for known soil-removal islands	VWA using values for all soil-removal islands
General work only on northern islands§, **	TWA using values for known northern islands	SA†† using values for known northern islands	SA using values for all northern islands
General work only on southern islands	TWA using values for known southern islands	SA using values for known southern islands	SA using values for all southern islands
General work on northern and southern islands	TWA using values for known northern and southern islands	SA using values for known northern and southern islands	SA using values for all northern islands‡‡

* Soil-removal islands and the volume of contaminated soil removed from each of the five soil-removal islands are shown in Table A1-7.

† TWA = Time-weighted average of values, e.g., exposure rates or soil activity concentrations. Time-weighted averages are based on the amount of time spent on each identified island.

‡ VWA = Volume-weighted average of values, e.g., exposure rates or soil activity concentrations. Volume-weighted averages are based on the volume of soil or debris removed from each identified island.

§ Northern and southern islands are identified in Table A1-2.

** "General work" can be any work other than participation in direct soil-removal or debris-removal work, such as sampling, monitoring, and surveying.

†† SA = Simple average (arithmetic mean) of values.

‡‡ Using SA for all northern islands for this scenario will likely result in a high-sided average exposure rate or soil activity concentration.

Table A1-4. ECUP debris cleanup volumes at Enewetak Atoll

Island Name [*]	Site Name	Total volume of debris [†,‡,§] (yd^3)
Northern Islands		
Bokoluo	Alice	1,575
Bokombako	Belle	28
Kirunu	Clara	505
Louj	Daisy	5
Bokaidrik	Helen	15
Boken	Irene	1,890
Enjebi	Janet	16,477[**]
Mijikadrek	Kate	1,073
Kidrinen	Lucy	257
Taiwel	Percy	2
Bokenelab	Mary	158
Elle	Nancy	<1
Aej	Olive	1
Lujor	Pearl	271[**]
Eleleron	Ruby	251[**]
Aomon	Sally	2,914[**]
Bijire	Tilda	720
Lojwa	Ursula	2,115
Alembel	Vera	<1
Billae	Wilma	64
Runit	Yvonne	15,602[**]
Southern Islands		
Ananij	Bruce	95
Japtan	David	790[††]
Jedrol	Rex	28
Medren (aka Parry)	Elmer	41,028[††]
Enewetak	Fred	110,780[††]
Ikuren	Glenn	908
Mut	Henry	215
Boken	Irwin	270
Ribewon	James	254
Kidrenen	Keith	140
Biken	Leroy	197

Table A1-4. ECUP debris cleanup volumes at Enewetak Atoll (cont.)

Island Name [*]	Site Name	Total volume of debris [†,‡,§] (yd^3)
N/A (no native name)	Van	10
Bokandretok	Walt	10
	Total	**198,650**

[*] Nine islands that had no debris removed are not included in this table.

[†] Debris volumes are from DTRA (2022).

[‡] The debris volumes in this table include debris used as shore protection.

[§] Volumes in this table are volumes of uncontaminated debris unless indicated otherwise.

[**] The total volumes for these five islands include the following volumes of contaminated debris: Enjebi (530 yd^3), Lujor (255 yd^3), Eleleron (250 yd^3), Aomon (728 yd^3), Runit (4,120 yd^3).

[††] A total of 55,000 yd^3 of debris were removed from these three islands by a scrap contractor (DNA, 1981). The volumes removed by the scrap contractor are not included in the values in this table.

Table A1-5. Time spent outdoors and indoors on residence islands

Work Location, Day of Week, and Worker Category	Daily Duration (h d^{-1})		Rationale/Reference/Comment
	Outdoor	Indoor*	
Enewetak and Lojwa Support Workers†			
Workdays (6 d wk^{-1}):			
Outdoor Workers	15	9	Outdoor time is working and recreation; indoor time is sleeping and eating.
Indoor Workers	5	19	Outdoor time is recreation; indoor time is sleeping, eating, and working.
Non-Workdays (1 d wk^{-1}):			
Outdoor and Indoor Workers	15	9	Outdoor time is recreation; indoor time is sleeping and eating.
Northern Island Workers (Lojwa Island)‡ and Southern Island Workers (Enewetak Island)§			
Workdays (6 d wk^{-1})	5	9	Outdoor time is recreation; indoor time is sleeping and eating.
Non-Workdays (1 d wk^{-1})	15	9	Outdoor time is recreation; indoor time is sleeping and eating.

* On all days, sleeping and eating indoors are assumed to take 8 h and 1 h, respectively (DTRA, 2022).

† Participants normally assigned to work locations on Enewetak Island or Lojwa Island with billeting on the same island.

‡ Northern-Island Workers are those participants who were billeted on Lojwa Island but were normally assigned to work locations on other northern islands. These workers may have also occasionally conducted work on Lojwa Island.

§ Southern Island Workers are those participants who were billeted on Enewetak Island but were normally assigned to work locations on other southern islands. These workers may have also occasionally conducted work on Enewetak Island.

Table A1-6. General parameter values for ECUP internal dose assessments

Parameter	Value		Rationale/Reference/ Comment
Duration of duty tour	Variable (default = 6 months)		Default is used only if arrival and departure records are not available.
Work schedule	10 h d^{-1} for 6 d wk^{-1}		This is the default assumption for all participants.
Activity concentrations of undisturbed soil	Island-specific or multi-island average (See Table A1-2)		See Table A1-3 for guidance if multiple islands are involved.
Activity concentrations of excised soil, for soil-removal islands only*	Island-specific (See Table A1-2 and Table A1-7)		Island-average for non-TRU radionuclides and total TRU activity concentrations.
Average daily time outdoors • Outdoor workers: • Indoor workers – Workdays: – Non-workdays:	15 h d^{-1} for 7 d wk^{-1} 5 h d^{-1} for 6 d wk^{-1} 15 h d^{-1} for 1 d wk^{-1}		All non-work time other than sleeping and eating is recreational time spent outdoors on residence island. See also Table A1-5.
Resuspension factor (RF) and soil mass loading (ML): – Ambient dust loading – Generic default – Vehicle/truck traffic – Soil pile work – Clearing vegetation – Soil excision/windrowing	RF (m^{-1}) 8×10^{-9} 2×10^{-8} 2×10^{-8} 5×10^{-8} 6×10^{-8} 1.2×10^{-7}	ML (µg m^{-3}) 40 100 100 250 300 600	The numerical relationship between RF and ML is based on the values for "depth of suspended soil," "soil density," and "enhancement factor" shown below.
Depth of suspended soil	1 cm		DTRA (2022)
Soil density	1.5 g cm^{-3}		DTRA (2022)
Enhancement factor	3		DTRA (2022)
Breathing rate	1.2 m^3 h^{-1}		DTRA (2022)
Respiratory protection factor	See Table A1-8		
Inhalation and ingestion dose coefficients	See Table A1-9 and Table A1-10		
Fraction of time exposed to source (inhalation)	0.1 to 1.0 (Default = 1.0)		Based on questionnaire responses and task durations.
Incidental soil ingestion rate	0.05 g d^{-1}		DTRA (2022)
Frequency and type of local food consumption	Veteran-specific (Default = 1 serving per week)† (Default food = Fish)‡		Include this pathway only if stated by the veteran.
Internal dose per serving from local food consumption	See Table A1-11		

* For dose estimates for inhalation of excised soil on 5 soil-removal islands, non-TRU activity concentrations are shown in Table A1-2. TRU activity concentrations for excised soil are shown in Table A1-7 and are assumed to be Pu-239 for this pathway. This simplification for TRU activity has been shown to be acceptable for estimating ECUP inhalation doses. (DTRA, 2022, Appendix G-1)

† Default frequency should be used if a frequency is not specified by the veteran, e.g., in his ECUP Questionnaire. This default frequency is considered a high-sided average per ECUP veteran's anecdotes (DTRA, 2022).

‡ When not specified by the veteran, fish should be selected as the default food because it was the most commonly available local food that personnel may have consumed.

Table A1-7. Estimated activity concentration of contaminated soil excised and moved to Cactus crater and dome

Island with Contaminated Soil	Total TRU Activity (Ci)*	Soil Volume Removed (yd^3)*			Average TRU Activity Concentration ($pCi\ g^{-1}$)†,‡
		Crater	Dome	Total volume	
Medren	0	110	0	110	0§
Aomon	1.29	10,603	0	10,603	106
Aomon Crypt	0.93	448	9,328	9,776	83
Boken	1.01	421	4,516	4,937	178
Enjebi	2.57	43,023	9,984	53,007	42
Lujor	1.70	0	14,929	14,929	99
Runit	7.22	0	10,735	10,735	587
Overall totals (Runit not included)	7.50	54,605	38,757	93,362	**70****
Overall Totals (Runit included)	14.72	54,605	49,492	104,097	**123****

* Total TRU activity values and soil volumes are from DNA (1981).

† Soil activity concentrations are based on an average bulk soil density of 1.5 g cm^{-3} (DTRA, 2022).

‡ For internal organ and dermal contamination skin dose calculations involving excised soil, all TRU activity is assumed to be Pu-239. This assumption results in ECUP inhalation and skin dermal contamination doses that are generally 1–4 percent lower but are overall within 10 percent and 15 percent, respectively, of the doses calculated using a mixture of TRU radionuclides (DTRA, 2022, Appendix G-1)

§ The 110 cubic yards of soil removed from Medren was contaminated only with Co-60, with hotspots ranging between 20–2000 pCi g^{-1}. Based on soil volumes removed and their maximum concentrations, the average Co-60 activity concentration in this soil is estimated to be less than 170 pCi g^{-1}. (DTRA, 2022)

** These values are weighted averages calculated using soil volumes removed from each island (DNA, 1981).

Table A1-8. ECUP personnel protection levels and respiratory protection factors

ECUP Personnel Protection Level	ECUP Respiratory Protection*	Respiratory Protection Factor†
I or II-A	None	1
II-B	Surgical mask (dust mask)	1
III-A or III-B	Full-face negative pressure respirator	50
	Half-face positive pressure respirator	50
	Full-face positive pressure respirator	1,000
IV	Full-face positive pressure respirator	1,000

* Half-face, negative pressure respirators (protection factor of 10) are mentioned in some ECUP documentation (e.g., FCCR SOP 608-10 "Decontamination Laundry Procedures." However, this respirator type is not listed in the ECUP "Personnel Protection Levels" documentation (EAI No. 5707.1). (DNA, 1981; DTRA, 2022)

† For use in ECUP dose assessments, the respiratory protection factor for work in controlled access areas can normally be determined from the Personnel Protection Level specified in relevant Controlled Island Access forms. When Level III-A or III-B is indicated in the Controlled Island Access form, a respiratory protection factor of 50 should be used unless it is known that a full-face, positive pressure respirator was worn.

Table A1-9. Inhalation dose coefficients for use in internal dose assessments for ECUP participants

Organ/Tissue†	Inhalation Dose Coefficients* (rem pCi^{-1})						
	Co-60	**Sr-90**	**Sb-125**	**Cs-137**	**Eu-155**	**Pu-239**	**Am-241**
Adrenals	2.41×10^{-8}	2.22×10^{-9}	4.07×10^{-9}	1.81×10^{-8}	6.66×10^{-9}	9.25×10^{-6}	9.99×10^{-6}
Bladder Wall	8.88×10^{-9}	4.81×10^{-9}	1.15×10^{-9}	1.85×10^{-8}	7.03×10^{-10}	9.25×10^{-6}	9.99×10^{-6}
Bone Surface	1.37×10^{-8}	1.37×10^{-6}	3.03×10^{-8}	1.78×10^{-8}	4.07×10^{-7}	5.55×10^{-3}	5.92×10^{-3}
Brain	7.03×10^{-9}	2.22×10^{-9}	9.99×10^{-10}	1.52×10^{-8}	9.99×10^{-10}	9.25×10^{-6}	9.99×10^{-6}
Breast	2.15×10^{-8}	2.22×10^{-9}	3.55×10^{-9}	1.44×10^{-8}	1.48×10^{-9}	9.25×10^{-6}	9.99×10^{-6}
Esophagus	2.52×10^{-8}	2.22×10^{-9}	4.07×10^{-9}	1.67×10^{-8}	1.74×10^{-9}	9.25×10^{-6}	9.99×10^{-6}
St Wall	1.59×10^{-8}	2.29×10^{-9}	2.41×10^{-9}	1.70×10^{-8}	2.26×10^{-9}	9.25×10^{-6}	9.99×10^{-6}
SI Wall	1.22×10^{-8}	2.41×10^{-9}	1.92×10^{-9}	1.81×10^{-8}	2.44×10^{-9}	9.25×10^{-6}	9.99×10^{-6}
ULI Wall	1.44×10^{-8}	7.03×10^{-9}	3.66×10^{-9}	1.85×10^{-8}	4.07×10^{-9}	9.25×10^{-6}	9.99×10^{-6}
LLI Wall	1.81×10^{-8}	1.92×10^{-8}	7.40×10^{-9}	2.15×10^{-8}	4.81×10^{-9}	9.25×10^{-6}	9.99×10^{-6}
Colon	1.59×10^{-8}	1.22×10^{-8}	5.18×10^{-9}	1.96×10^{-8}	4.44×10^{-9}	9.25×10^{-6}	9.99×10^{-6}
Kidneys	1.41×10^{-8}	2.22×10^{-9}	1.92×10^{-9}	1.74×10^{-8}	4.81×10^{-9}	2.18×10^{-5}	3.00×10^{-5}
Liver	3.00×10^{-8}	2.22×10^{-9}	4.81×10^{-9}	1.74×10^{-8}	1.30×10^{-7}	1.11×10^{-3}	3.59×10^{-4}
Muscle	1.33×10^{-8}	2.22×10^{-9}	2.07×10^{-9}	1.63×10^{-8}	1.70×10^{-9}	9.25×10^{-6}	9.99×10^{-6}
Ovaries	1.15×10^{-8}	2.22×10^{-9}	1.67×10^{-9}	1.85×10^{-8}	1.70×10^{-9}	7.03×10^{-5}	1.15×10^{-4}
Pancreas	2.00×10^{-8}	2.22×10^{-9}	3.07×10^{-9}	1.85×10^{-8}	5.18×10^{-9}	9.25×10^{-6}	9.99×10^{-6}
Red Marrow	1.52×10^{-8}	5.92×10^{-7}	5.92×10^{-9}	1.67×10^{-8}	3.63×10^{-8}	2.59×10^{-4}	2.04×10^{-4}
ET Airways	6.29×10^{-8}	6.66×10^{-9}	2.33×10^{-8}	2.89×10^{-8}	1.22×10^{-8}	3.52×10^{-5}	3.66×10^{-5}
Lungs	1.81×10^{-7}	2.29×10^{-9}	1.11×10^{-7}	1.63×10^{-8}	6.29×10^{-8}	1.11×10^{-4}	1.26×10^{-4}

Table A1-9. Inhalation dose coefficients for use in internal dose assessments for ECUP participants (cont.)

Organ/Tissue†	Inhalation Dose Coefficients* (rem pCi^{-1})						
	Co-60	**Sr-90**	**Sb-125**	**Cs-137**	**Eu-155**	**Pu-239**	**Am-241**
Skin	8.51×10^{-9}	2.22×10^{-9}	1.22×10^{-9}	1.37×10^{-8}	8.14×10^{-10}	9.25×10^{-6}	9.99×10^{-6}
Spleen	1.85×10^{-8}	2.22×10^{-9}	2.81×10^{-9}	1.74×10^{-8}	1.59×10^{-9}	9.25×10^{-6}	9.99×10^{-6}
Testes	7.03×10^{-9}	2.22×10^{-9}	7.40×10^{-10}	1.63×10^{-8}	2.96×10^{-10}	7.03×10^{-5}	1.15×10^{-4}
Thymus	2.52×10^{-8}	2.22×10^{-9}	4.07×10^{-9}	1.67×10^{-8}	1.74×10^{-9}	9.25×10^{-6}	9.99×10^{-6}
Thyroid	1.33×10^{-8}	2.22×10^{-9}	1.89×10^{-9}	1.67×10^{-8}	9.25×10^{-10}	9.25×10^{-6}	9.99×10^{-6}
Uterus	9.99×10^{-9}	2.22×10^{-9}	1.26×10^{-9}	1.85×10^{-8}	1.18×10^{-9}	9.25×10^{-6}	9.99×10^{-6}
Effective dose	3.55×10^{-8}	8.88×10^{-8}	1.67×10^{-8}	1.78×10^{-8}	2.41×10^{-8}	1.74×10^{-4}	1.44×10^{-4}

* Dose coefficients obtained from ICRP 68 (ICRP, 2011).

† Abbreviations used in this table: SI Wall = Small Intestine Wall; ULI Wall = Upper Large Intestine Wall; LLI Wall = Lower Large Intestine Wall; ET Airways = Extra-thoracic Airways.

Table A1-10. Ingestion dose coefficients for use in internal dose assessments for ECUP participants

Organ/Tissue†	Ingestion Dose Coefficients* (rem pCi^{-1})						
	Co-60	**Sr-90**	**Sb-125**	**Cs-137**	**Eu-155**	**Pu-239**	**Am-241**
Adrenals	9.25×10^{-9}	2.44×10^{-9}	1.55×10^{-9}	5.18×10^{-8}	4.81×10^{-11}	5.18×10^{-8}	5.55×10^{-8}
Bladder Wall	9.62×10^{-9}	5.55×10^{-9}	1.59×10^{-9}	5.18×10^{-8}	1.11×10^{-10}	5.18×10^{-8}	5.55×10^{-8}
Bone Surface	7.40×10^{-9}	1.52×10^{-6}	3.33×10^{-8}	5.18×10^{-8}	2.44×10^{-9}	3.03×10^{-5}	3.33×10^{-5}
Brain	5.18×10^{-9}	2.44×10^{-9}	9.62×10^{-10}	4.44×10^{-8}	5.55×10^{-12}	5.18×10^{-8}	5.55×10^{-8}
Breast	4.81×10^{-9}	2.44×10^{-9}	7.77×10^{-10}	4.07×10^{-8}	7.03×10^{-12}	5.18×10^{-8}	5.55×10^{-8}
Esophagus	6.29×10^{-9}	2.44×10^{-9}	9.25×10^{-10}	4.81×10^{-8}	7.40×10^{-12}	5.18×10^{-8}	5.55×10^{-8}
St Wall	9.25×10^{-9}	3.33×10^{-9}	1.81×10^{-9}	4.81×10^{-8}	3.66×10^{-10}	5.55×10^{-8}	5.92×10^{-8}
SI Wall	1.55×10^{-8}	4.07×10^{-9}	3.59×10^{-9}	5.18×10^{-8}	9.99×10^{-10}	6.29×10^{-8}	6.66×10^{-8}
ULI Wall	2.41×10^{-8}	2.15×10^{-8}	9.25×10^{-9}	5.18×10^{-8}	4.44×10^{-9}	1.18×10^{-7}	1.30×10^{-7}
LLI Wall	4.44×10^{-8}	8.14×10^{-8}	2.29×10^{-8}	6.29×10^{-8}	1.30×10^{-8}	2.48×10^{-7}	2.74×10^{-7}
Colon	3.22×10^{-8}	4.81×10^{-8}	1.52×10^{-8}	5.55×10^{-8}	8.14×10^{-9}	1.74×10^{-7}	1.92×10^{-7}
Kidneys	8.88×10^{-9}	2.44×10^{-9}	1.41×10^{-9}	4.81×10^{-8}	6.29×10^{-11}	1.22×10^{-7}	1.70×10^{-7}
Liver	1.63×10^{-8}	2.44×10^{-9}	2.89×10^{-9}	4.81×10^{-8}	7.77×10^{-10}	6.29×10^{-6}	2.00×10^{-6}
Muscle	7.03×10^{-9}	2.44×10^{-9}	1.15×10^{-9}	4.44×10^{-8}	4.44×10^{-11}	5.18×10^{-8}	5.55×10^{-8}
Ovaries	1.59×10^{-8}	2.44×10^{-9}	2.92×10^{-9}	5.18×10^{-8}	3.52×10^{-10}	4.07×10^{-7}	6.29×10^{-7}
Pancreas	9.62×10^{-9}	2.44×10^{-9}	1.41×10^{-9}	5.18×10^{-8}	6.29×10^{-11}	5.18×10^{-8}	5.55×10^{-8}
Red Marrow	7.77×10^{-9}	6.66×10^{-7}	5.55×10^{-9}	4.81×10^{-8}	2.59×10^{-10}	1.44×10^{-6}	1.15×10^{-6}
ET Airways	6.29×10^{-9}	2.44×10^{-9}	9.62×10^{-10}	4.81×10^{-8}	4.44×10^{-12}	5.18×10^{-8}	5.55×10^{-8}
Lungs	6.66×10^{-9}	2.44×10^{-9}	1.07×10^{-9}	4.81×10^{-8}	2.04×10^{-11}	5.18×10^{-8}	5.55×10^{-8}

Table A1-10. Ingestion dose coefficients for use in internal dose assessments for ECUP participants (cont.)

Organ/Tissue†	Ingestion Dose Coefficients* (rem pCi^{-1})						
	Co-60	**Sr-90**	**Sb-125**	**Cs-137**	**Eu-155**	**Pu-239**	**Am-241**
Skin	4.81×10^{-9}	2.44×10^{-9}	7.77×10^{-10}	4.07×10^{-8}	1.30×10^{-11}	5.18×10^{-8}	5.55×10^{-8}
Spleen	7.77×10^{-9}	2.44×10^{-9}	1.11×10^{-9}	4.81×10^{-8}	3.40×10^{-11}	5.18×10^{-8}	5.55×10^{-8}
Testes	6.66×10^{-9}	2.44×10^{-9}	9.25×10^{-10}	4.44×10^{-8}	2.55×10^{-11}	4.07×10^{-7}	6.29×10^{-7}
Thymus	6.29×10^{-9}	2.44×10^{-9}	9.25×10^{-10}	4.81×10^{-8}	7.40×10^{-12}	5.18×10^{-8}	5.55×10^{-8}
Thyroid	6.29×10^{-9}	2.44×10^{-9}	9.62×10^{-10}	4.81×10^{-8}	4.44×10^{-12}	5.18×10^{-8}	5.55×10^{-8}
Uterus	1.11×10^{-8}	2.44×10^{-9}	1.81×10^{-9}	5.18×10^{-8}	1.59×10^{-10}	5.18×10^{-8}	5.55×10^{-8}
Effective dose	1.26×10^{-8}	1.04×10^{-7}	4.07×10^{-9}	4.81×10^{-8}	1.18×10^{-9}	9.25×10^{-7}	7.40×10^{-7}

* Dose coefficients obtained from ICRP 68 (ICRP, 2011).

† Abbreviations used in this table: SI Wall = Small Intestine Wall; ULI Wall = Upper Large Intestine Wall; LLI Wall = Lower Large Intestine Wall; ET Airways = Extra-thoracic Airways.

Table A1-11. Organ doses from potential consumption of local food by ECUP participants

Organ/Tissue[†]	Ingestion Doses (rem per serving)[*]				
	Fish	**Lobster**	**Coconut Meat**	**Coconut Milk**	**Coconut Crab**
Adrenals	4.98×10^{-6}	4.60×10^{-7}	7.86×10^{-5}	7.34×10^{-5}	2.57×10^{-5}
Bladder Wall	5.06×10^{-6}	4.80×10^{-7}	7.91×10^{-5}	7.35×10^{-5}	2.61×10^{-5}
Bone Surface	9.83×10^{-4}	2.49×10^{-5}	5.03×10^{-4}	1.27×10^{-4}	1.72×10^{-4}
Brain	4.03×10^{-6}	3.08×10^{-7}	6.74×10^{-5}	6.29×10^{-5}	2.19×10^{-5}
Breast	3.84×10^{-6}	2.88×10^{-7}	6.19×10^{-5}	5.77×10^{-5}	2.01×10^{-5}
Esophagus	4.35×10^{-6}	3.53×10^{-7}	7.30×10^{-5}	6.82×10^{-5}	2.37×10^{-5}
Stomach Wall	4.97×10^{-6}	4.57×10^{-7}	7.32×10^{-5}	6.82×10^{-5}	2.41×10^{-5}
SI Wall	6.41×10^{-6}	6.83×10^{-7}	7.91×10^{-5}	7.36×10^{-5}	2.64×10^{-5}
ULI Wall	9.77×10^{-6}	1.05×10^{-6}	8.24×10^{-5}	7.41×10^{-5}	2.87×10^{-5}
LLI Wall	1.82×10^{-5}	1.98×10^{-6}	1.10×10^{-4}	9.12×10^{-5}	4.11×10^{-5}
Colon	1.33×10^{-5}	1.43×10^{-6}	9.28×10^{-5}	7.99×10^{-5}	3.35×10^{-5}
Kidneys	7.40×10^{-6}	4.89×10^{-7}	7.35×10^{-5}	6.83×10^{-5}	2.40×10^{-5}
Liver	1.58×10^{-4}	5.02×10^{-6}	1.11×10^{-4}	7.39×10^{-5}	2.57×10^{-5}
Muscle	4.35×10^{-6}	3.70×10^{-7}	6.75×10^{-5}	6.29×10^{-5}	2.20×10^{-5}
Ovaries	1.93×10^{-5}	9.30×10^{-6}	8.09×10^{-5}	7.39×10^{-5}	2.63×10^{-5}
Pancreas	5.04×10^{-6}	4.72×10^{-7}	7.86×10^{-5}	7.34×10^{-5}	2.58×10^{-5}
Red Marrow	4.91×10^{-5}	2.90×10^{-6}	1.88×10^{-4}	8.10×10^{-5}	8.56×10^{-5}
ET Airways	4.35×10^{-6}	3.53×10^{-7}	7.30×10^{-5}	6.82×10^{-5}	2.37×10^{-5}
Lungs	4.41×10^{-6}	3.65×10^{-7}	7.30×10^{-5}	6.82×10^{-5}	2.38×10^{-5}
Skin	3.84×10^{-6}	2.88×10^{-7}	6.19×10^{-5}	5.77×10^{-5}	2.01×10^{-5}
Spleen	4.60×10^{-6}	4.03×10^{-7}	7.30×10^{-5}	6.82×10^{-5}	2.39×10^{-5}
Testes	1.74×10^{-5}	6.04×10^{-7}	6.96×10^{-5}	6.33×10^{-5}	2.21×10^{-5}
Thymus	4.35×10^{-6}	3.53×10^{-7}	7.30×10^{-5}	6.82×10^{-5}	2.37×10^{-5}
Thyroid	4.35×10^{-6}	3.53×10^{-7}	7.30×10^{-5}	6.82×10^{-5}	2.37×10^{-5}
Uterus	5.29×10^{-6}	5.22×10^{-7}	7.87×10^{-5}	7.35×10^{-5}	2.59×10^{-5}
Effective dose	3.13×10^{-5}	1.40×10^{-6}	9.46×10^{-5}	7.08×10^{-5}	3.38×10^{-5}

[*] Dose calculations are described in DTRA (2022).

[†] Abbreviations used in this table: SI Wall = Small Intestine Wall; ULI Wall = Upper Large Intestine Wall; LLI Wall = Lower Large Intestine Wall; ET Airways = Extra-thoracic Airways.

Table A1-12. General parameter values for use in non-contact skin dose assessments for ECUP participants

Parameter	Default Value	Reference/Comment
Duration of duty tour	Variable (default = 6 mo [26 wk])	Default is used only if arrival and departure records are not available.
Work schedule	10 h d^{-1} for 6 d wk^{-1}	This is the default assumption for all participants.
Exposure duration	Variable	Calculated using values for "Duration of duty tour" and "Work schedule" above.
Fraction of workday	1.0 (range is 0.1–1)	Fraction of a workday or work duration that a worker is exposed to a radiation source.
Gamma exposure rate on island	Island-specific or multi-island average (See Table A1-2)	See Table A1-3 for guidance when multiple islands are involved.
Ratio of beta dose to gamma dose	See Table A1-13	Values are applicable to exposure above a planar, contaminated source (e.g., soil).
Heights of various skin locations	See Table A1-14	"Standard" heights are provided in cited table.
Modification Factor	1 (range is 0–1)	The default value assumes bare skin and no other modifying factors.

Table A1-13. Beta-to-gamma dose ratios for external non-contact radiation sources for all islands at Enewetak Atoll

	Skin Height from Contaminated Ground Surface (cm)							
	1	**20**	**40**	**80**	**100**	**120**	**160**	**200**
Beta-gamma Dose Ratio*	1.2	0.72	0.45	0.34	0.29	0.25	0.18	0.14

* Beta-gamma dose ratios are from DTRA (2022).

Table A1-14. Reference heights of body locations from surface

	Reference Heights for Three Positions* (cm)		
Anatomical Location	**Standing**	**Sitting (chair/bench)**	**Sitting (ground/deck)**
Foot and ankle	1.0	1.0	5.1
Shin	20.3	20.3	15.2
Knee	40.6	40.6	15.2
Mid-thigh	71.1	53.1	15.2
Waist	99.1	56.4	14.0
Forearms	99.1	56.4	20.3
Stomach	119	76.7	34.3
Mid-chest	140	97.0	54.6
Neck	150	107	64.8
Face and head/eyes	160	117	74.9
Top of head	173	130	87.6

* Reference heights are for a veteran stature of 173 cm (68 inches). Skin location heights for veterans that are shorter or taller than the reference height can be obtained using a ratio of the heights. (DTRA, 2022)

Table A1-15. General parameter values for use in dermal contamination skin dose assessments for ECUP participants

Parameter	Default Value		Reference/Comment
Duration of duty tour	Variable (default = 6 months [26 wk])		Default is used only if arrival and departure records are not available.
Work schedule	10 h d^{-1} for 6 d wk^{-1}		This is the default assumption for all participants.
Dose-rate factors	See Table A1-16		
Skin dose modification factor	See Table A1-16		For use with beta-emitters
Daily exposure to dermal contamination	12 h d^{-1}		Value is the daily work hours plus an average 2 hours at which time removal of contaminated soil is assumed.
Resuspension factor (RF) and soil mass loading (ML): – Ambient dust loading – Generic default – Vehicle/truck traffic – Soil pile work – Clearing vegetation – Soil excision/windrowing	RF (m^{-1}) 8×10^{-9} 2×10^{-8} 2×10^{-8} 5×10^{-8} 6×10^{-8} 1.2×10^{-7}	ML ($\mu g\ m^{-3}$) 40 100 100 250 300 600	The numerical relationship between RF and ML is based on the depth of suspended soil, soil density, and "enhancement factor" given below and in Table A1-6.
Deposition velocity	3600 m h^{-1}		DTRA (2022)
Interception and retention fraction	See Table A1-16		
Fraction of workday exposed	0.1 to 1.0 (Default = 1.0)		Fraction of a workday exposed to suspended soil
Depth of suspended soil	0.01 m		DTRA (2022)
Soil density	1.5×10^{6} g m^{-3}		DTRA (2022)
Activity concentrations of undisturbed soil	Island-specific or multi-island average (See Table A1-2)		See Table A1-3 for guidance if multiple islands are involved.
Activity concentrations of excised soil*	Island-specific (See Table A1-2 and Table A1-7)		Based on island-average non-TRU radionuclide concentrations and total TRU activity concentrations.

* For estimates of dermal contamination skin doses from excised soil on 5 soil-removal islands, non-TRU activity concentrations are shown in Table A1-2. TRU activity concentrations for excised soil are shown in Table A1-7 and are assumed to be Pu-239 for this pathway. This simplification for TRU activity has been shown to be acceptable for estimating ECUP dermal contamination skin doses (DTRA, 2022, Appendix G-1).

Table A1-16. Radionuclide-dependent and skin site-dependent default parameter values for use in dermal contamination skin dose assessments for ECUP participants

Skin Site	SDMF[*, †]	Interception and Retention Fraction[‡]	Dose-rate Factor[§] (rem h^{-1} per pCi cm^{-2})				
			Co-60	Sr/Y-90	Cs-137	Pu-239/240	Am-241
Scalp	0.9	0.23	3.830×10^{-6} (all sites)	1.204×10^{-5} (all sites)	5.687×10^{-6} (all sites)	6.40×10^{-3}	7.40×10^{-3}
Face	1.3	0.015				6.40×10^{-3}	7.40×10^{-3}
Forehead	1.3	0.015				6.40×10^{-3}	7.40×10^{-3}
Behind ear	1.3	1.5				6.40×10^{-3}	7.40×10^{-3}
Neck	1.3	0.015				6.40×10^{-3}	7.40×10^{-3}
Back of neck	0.9	1.5				6.40×10^{-3}	7.40×10^{-3}
Shoulder	1.3	0.015				6.70×10^{-3}	8.20×10^{-3}
Chest	1.3	0.03				6.70×10^{-3}	8.20×10^{-3}
Torso (back, sides)	1.3	0.015				6.70×10^{-3}	8.20×10^{-3}
Under belt	1.3	1.5				6.70×10^{-3}	8.20×10^{-3}
Forearm	0.9	0.06				7.40×10^{-4}	1.30×10^{-3}
Upper leg	1.3	0.06				7.40×10^{-4}	1.30×10^{-3}
Palm of hand	0.3	0.015				0	0
Back of hand	0.9	0.06				0	0
Lower leg	0.9	0.06				7.40×10^{-4}	1.30×10^{-3}
Sole of feet	0.3	0.015				0	0
Under boot edge	0.9	1.5				7.40×10^{-4}	1.30×10^{-3}

[*] Skin Dose Modification Factor (SDMF) is applicable only to beta-emitting radionuclides (Co-60, Sr/Y-90, and Cs-137).

[†] SDMF values are from Apostoaei and Kocher (2010) and SM ED04.

[‡] Interception and retention fractions are from Apostoaei and Kocher (2010) and SM ED04.

[§] Dose-rate factors are from Cross et al. (1992) and NCRP (2009).

Attachment 2.

Template of a Standard RDA Report for Participants in the Enewetak Cleanup Project

A copy of the template for a standard RDA Report for Participants in the Enewetak Cleanup Project is provided starting on the next page. All text inserts between brackets and in red color should be replaced with case-specific information.

DRAFT
Review by: _____ Tech
Review by: _____ CHP
Review by: _____ Mgt

Nuclear Test Personnel Review Program
Radiation Dose Assessment Report
Enewetak Cleanup Project (1977–1980)

Veteran's Name:	[*First M. Last*]	**Key Number:**	
Service/Branch and Unit during ECUP:		**Job/Duty during ECUP and (Rank/Rate):**	[*Insert Job/Duty during ECUP and rank/rate in parentheses*]
ECUP Service Element/Team:		**Dates of Participation:**	[*month day, yyyy to month day, yyyy*]
Duty Station:	[*Lojwa/Enewetak Isl.*]	**Organs/Diseases:**	[*Affected organs or medical conditions as requested in VA Letter*]
Date RDA Prepared:	[*month day, yyyy*]		

1. Summary

This radiation dose assessment (RDA) report describes the evaluation of the external and internal doses that the veteran accrued as a result of participation in the Enewetak Cleanup Project (ECUP) in [*list year(s) of participation, e.g., 1977–1978*]. Radiation doses are estimated for the veteran's [*list affected organs and/or medical conditions as requested by the VA; DO NOT include surrogate organs used in the dose estimations*]. The RDA was performed using the methods described in the ECUP RDA technical report (DTRA, Year1) and in accordance with the standard operating procedure for ECUP dose assessments SOP RA06 (DTRA, Year2). Information specific to the veteran's dose assessment is provided in this RDA report, and the results are summarized in Table 1. The parameter values and assumptions used for determining the veteran's radiation doses are provided in the dose calculations documentation available in the case file (DTRA, Year3).

Table 1. Veteran's dose summary

External Dose (rem)*				
Radiation Type (Year assigned)	**Dose**		**Upper-Bound Dose**	
Gamma (Year)	x.x		x.x	
Internal Dose (rem)*				
	Dose		**Upper-Bound Dose**	
Organ/Disease (Year Assigned)	Alpha	Beta+Gamma	Alpha	Beta+Gamma
Organ or medical condition (Year)	x.x	x.x	x.x	x.x
Organ or medical condition (Year)	x.x	x.x	x.x	x.x
Skin Dose from External Sources (rem)*				
	Dose		**Upper-Bound Dose**	
Skin Site (Year Assigned)	Alpha	Beta+Gamma	Alpha	Beta+Gamma
Skin cancer site #1 (Year)	x.x	x.x	x.x	x.x
Skin cancer site #2 (Year)	x.x	x.x	x.x	x.x

* Rounded doses less than 0.001 rem are reported as "< 0.001 rem"

2. Background Information

About 6,000 service members participated in the cleanup of the Enewetak Atoll in the Marshall Islands from 1977 to 1980. In addition, military personnel on transient ships and transport aircraft spent short periods of time at the Atoll during ECUP to deliver supplies and equipment, perform maintenance and repairs, pick up retrograde cargo, etc. The administrative facilities for ECUP were located on Enewetak Island and a forward camp was established on Lojwa Island (site Ursula). Cleanup efforts consisted mainly of removing soil and debris contaminated with low levels of radioactive material as well as large quantities of non-contaminated debris. All contaminated soil excised from the islands of Boken (site Irene), Enjebi (site Janet), Lujor (site Pearl), Aomon (site Sally), and Runit (site Yvonne) and some of the contaminated debris were transported for encapsulation in the Cactus crater on Runit Island. Less-contaminated debris was disposed of at three disposal sites in the Atoll's lagoon. Additional information can be found in several ECUP-related publications (DNA, 1981; DTRA, Year 1; DTRA, 2021).

3. Veteran Duties and Activities during the Enewetak Cleanup Project

The veteran participated in ECUP while serving as a [*rank/rate*] with duties of [*job*] [*at/on location(s), e.g., island names (use Marshallese names, with site name in parentheses at first occurrence), "several islands", small boat names, etc.*]. He lived and worked on [*cite island or islands where veteran was billeted and where he worked*] from [*arrival date*] to [*departure date*]. His duties [*included or would have involved*] [*describe veteran's specific duties during his participation in ECUP*]. The veteran's ECUP Questionnaire responses indicate that in addition to his work islands and residence on [*select Enewetak or Lojwa*] Island, he visited [*include specific information about visits to other islands*]. [*Describe other veteran's statements from sources such as the VA forms "Statement in Support of Claim", "Radiation Risk Activity Information Sheet", etc.*]. Relevant Controlled Island Access forms [*were/were not*] located. [*If located, add: These forms show that the veteran was on (list islands recorded on forms) Islands for (a, b, c and d) days, respectively.*] The veteran's Questionnaire responses [*did not indicate any /OR/ indicated*] special exposure circumstances [*if indicated, add:* consisting of [*include information on things such as local food consumption, special exposure circumstances not covered by RA06, etc.*]. (DTRA, Year3)

4. External Dose Assessment

Personal dosimetry information for the veteran was [*available/not available*] in his military service records or from other sources (DTRA, Year3).

[*a- If dosimetry records ARE available, use the following text and table*]

The veteran's dosimetry records were reported in his DD Form 1141 [*if no DD 1141, list other types of applicable dose records*]. These dose records cover [*the entire/a partial*] period of the veteran's ECUP participation and are shown in Table 2. The total of the external gamma doses in the veteran's dosimetry record for the combined wearing periods is [*total dose from records*] rem. However, an evaluation of ECUP dosimetry records by DTRA resulted in a recommendation that all previously estimated administrative doses and film badge doses that are equal to or less than the minimum detectable level of 0.020 rem should be superseded with reconstructed doses that are based on environmental data (DTRA, Year1). [*If dose records cover*

a partial period of the veteran's participation, add: Doses are also estimated for all relevant periods that are not covered by a valid film badge or thermoluminescent dosimeter (TLD) dose.]

Table 2. Veteran's ECUP dosimetry record

Wearing Period		Type of Record	Reported Dose (rem)
From	**To**		
mmm day, yyyy e.g., Mar 9, 1978	*mmm day, yyyy*	[*Film Badge/TLD/Admin*]	x.xxx
mmm day, yyyy	*mmm day, yyyy*	[*Film Badge/TLD/Admin*]	x.xxx
mmm day, yyyy	*mmm day, yyyy*	[*Film Badge/TLD/Admin*]	x.xxx
mmm day, yyyy	*mmm day, yyyy*	[*Film Badge/TLD/Admin*]	x.xxx

[*b- If dosimetry records ARE NOT available, continue the opening sentence with the following text*]

Therefore, the veteran's external doses are reconstructed using the methods described in DTRA (Year1).

[*For all cases, (a) or (b), where all or some doses are estimated by reconstruction, use the following text*]

The following sources and pathways of potential external radiation exposure [*to the veteran's affected organ(s) /OR/ that may have caused the veteran's medical condition(s)*] are considered:

- [*Potential source and pathway (#1), e.g., residual radiation from previously deposited fallout in the soil while working outdoors on Lojwa Island*].
- [*Potential source and pathway (#2)…*].
- [*Potential source and pathway (#3)…*].

[*Insert additional discussion about minor or additional sources, e.g.:* Any external dose due to the veteran's assistance with locating and collecting potentially contaminated debris is included in the external dose estimate for exposure to contaminated soil while on Enjebi Island (DTRA, Year1).]

Based on the Questionnaire responses, it was assumed that [*insert key dose parameter values specific to the veteran, e.g.:* the veteran spent 12 h on Runit and Lujor Islands for each day of presence on those islands]. Other dose parameter values and assumptions are included in the dose calculation sheets in the veteran's case file. A summary of the veteran's external doses, the total dose, and the upper-bound dose is given in Table 3.

Table 3. Summary of veteran's external doses and upper-bound external dose

Period of Exposure		Dose	Comment	
From	To	(gamma, rem)		
mmm day, yyyy e.g., Mar 9, 1978	*mmm day, yyyy*	x.xxx	[*Film Badge/TLD/Reconstructed – include comment about the dose, such as location and/or activity*]	
mmm day, yyyy	*mmm day, yyyy*	x.xxx	[Same as 1st row]	
mmm day, yyyy	*mmm day, yyyy*	x.xxx	[Same as 1st row]…	
Total external dose (rounded up)		x.x	Upper-bound gamma dose*	x.x rem

*The veteran's upper-bound external gamma dose is based on an uncertainty factor of 3 applied to each independent component of the total reconstructed dose [*Insert the following only if film badge or TLD doses are used:* and appropriate uncertainty factors applied to his film badge or TLD doses]. Uncertainties are combined using standard statistical methods. (DTRA, Year1)

5. Internal Dose Assessment

[*a- If 24-hour urine bioassay results are available for the veteran, use the following text*]

The bioassay results of a 24-hour urine sample for the veteran are available from his medical records. The result for Pu-239 was reported as [*insert result in quotes, e.g.,* "< 0.04 pCi per 24 hours" (DTRA, Year3)]. These results were reviewed and fall in the range reported in DNA (1981). However, based on an evaluation by DTRA, these results are not used for the veteran's internal dose estimation because Pu-239 activity concentrations for all ECUP participants who were sampled were below the minimum detectable activity (MDA). (DTRA, Year1)

[*b- If urine bioassay results are NOT available for the veteran, start the following paragraph with:* Bioassay results for the veteran were not located.]

[*c- Continue with the following text for both (a) and (b) situations*]

To calculate the veteran's potential internal doses, dose coefficients were selected for the organ/s affected by the diagnosed medical condition/s, or their surrogate/s. [*If surrogate organ/s are used, add the following*: The organ/s selected as surrogate/s for the veteran's disease/s are [*surrogate organ name #1*] for [*organ disease or medical condition #1*], [*surrogate organ name #2*] for [*organ disease or medical condition #2*], and [*surrogate organ name #3*] for [*organ disease or medical condition #3*] (DTRA, Year2, SOP RA07)]. The veteran is assumed to have accrued internal doses concurrently with the accrual of external gamma doses described above in "External Dose Assessment." Therefore, his locations and activities described above establish the radiological environment in which the intake of contaminated materials occurred.

The following sources and pathways of potential internal radiation exposure [*to the veteran's affected organs /OR/ that may have caused the veteran's medical conditions*] are considered:

- [*Potential source and pathway (#1), e.g., Inhalation of airborne contaminated soil and dust suspended from routine activities, such as wind and vehicle traffic, during veteran's time outdoors on Lojwa Island*].

- [*Potential source and pathway (#2), e.g., Incidental ingestion of contaminated soil and dust while on Lojwa Island*].
- [*Potential source and pathway (#3), e.g., Consumption of local fish and coconuts that may have been contaminated with radioactive material*].

Fifty-year committed equivalent doses (CEDs) to internal body organs were estimated for the veteran from radiological measurements, living habit factors, and related assumptions that are presented in DTRA (Year1), unless indicated otherwise.

[*Describe veteran-specific key dose parameters values or assumptions, such as:* To account for the possibility of consuming contaminated local fish and coconuts, it was assumed that during participation in ECUP, the veteran ate one serving of fish each week and one serving of coconut meat each month.]

To estimate internal doses, the dose parameter values and assumptions used are based on information in the veteran's case file and other relevant data and information that are associated with the sources of contamination and related pathways listed above. The 50-year CEDs to the veteran's [*affected organ #1 /OR/ disease/medical condition #1 (surrogate is (insert surrogate organ #1), affected organ #2 /OR/ disease/medical condition #2 (surrogate is (insert surrogate organ #2), and affected organ #3 /OR/ disease/medical condition #3 (surrogate is (insert surrogate organ #3),*] are shown in Table 4.

Table 4. Summary of internal doses

Organ / Disease	Dose (rem)*		Upper-bound Dose (rem)*,†	
	Alpha	Beta+Gamma	Alpha	Beta+Gamma
[*Organ/Disease #1*]	x.x	x.x	x.x	x.x
[*Organ/Disease #2*]	x.x	x.x	x.x	x.x
[*Organ/Disease #3*]	x.x	x.x	x.x	x.x

* Rounded doses less than 0.001 rem are reported as "< 0.001 rem"

† The upper-bound internal doses are determined by multiplying the total internal doses by an uncertainty factor of 10 (DTRA, Year1)

6. Skin Dose Assessment

For the veteran's skin cancers, doses were determined for the basal cell layer of the epidermis, which lies at an average depth of 70 micrometers below the surface of the skin (DTRA, Year 1). To assess the veteran's skin doses, surrogate skin sites were used as needed for the dose calculations as shown in Table 5. Surrogate skin sites are standard ECUP skin sites with available dose calculation parameters documented in DTRA (Year 1), which are similar to the veteran's actual skin cancer sites.

Table 5. Skin sites assessed

Veteran skin cancer site	Assessed skin site*
[*Skin cancer site #1*]	[*Standard site #1*]
[*Skin cancer site #2*]	[*Standard site #2*]
[*Skin cancer site #3*]	[*Standard site #3*]

* A surrogate skin site is used if the veteran's skin cancer site is not a standard ECUP skin site as identified in DTRA (*Year1*)

The following sources and pathways of potential radiation exposure of the veteran's skin cancer sites are considered:

- Radiation from ground-deposited fallout and neutron-activated soil while outdoors (beta and gamma) and indoors (gamma only) on [*list of islands*].
- Radiation (alpha, beta and gamma) from contaminants resuspended from the ground on [*list of islands*] that were deposited directly on the veteran's skin or clothing.

Doses to the veteran's skin cancer sites are assessed for the sources and pathways listed above. As a high-siding measure, exposures are assumed to have occurred to the bare skin with no intervening clothing or other shielding. The estimated doses to the veteran's skin cancer sites that resulted from exposure to radioactive material during participation in ECUP are shown in Table 6. The application of uncertainty factors to doses from each source of exposure results in the upper-bound doses to the veteran's skin cancer sites shown in Table 6.

Table 6. Summary of skin doses

Skin Cancer Site	Dose (rem)*		Upper-bound Dose (rem)*,†	
	Alpha	Beta+Gamma	Alpha	Beta+Gamma
[*Skin cancer site #1*]	x.x	x.x	x.x	x.x
[*Skin cancer site #2*]	x.x	x.x	x.x	x.x
[*Skin cancer site #3*]	x.x	x.x	x.x	x.x

* Rounded doses less than 0.001 rem are reported as "< 0.001 rem"

† The upper-bound skin doses are determined by multiplying the estimated skin doses by an uncertainty factor of 3 for non-contact exposure and 10 for exposure from dermal contamination (DTRA, Year1)

7. References

DNA (Defense Nuclear Agency), 1981. *The Radiological Cleanup of Enewetak Atoll*. Defense Nuclear Agency, Washington, D.C.

DTRA (Defense Threat Reduction Agency), Year1. *Radiation Dose Assessment for Military Personnel of the Enewetak Atoll Cleanup Project (1977-1980), Revision #*. DTRA-TR-17-003(R#), Defense Threat Reduction Agency, Fort Belvoir, VA. Month day.

DTRA (Defense Threat Reduction Agency), Year2. *Nuclear Test Personnel Review, Standard Operating Procedures for Radiation Dose Assessments – List and Overview, Update: Month Year2*. DTRA-SOP-17-01(R#), Defense Threat Reduction Agency, Fort Belvoir, VA. Month day.

DTRA (Defense Threat Reduction Agency), Year3. Pertinent documents in the veteran's case file, including dosimetry records, service records, unit reports, correspondence, interviews, and questionnaires.

DTRA (Defense Threat Reduction Agency), 2021. *Factsheet: The Radiological Cleanup of Enewetak Atoll*. Defense Threat Reduction Agency, Fort Belvoir, VA. September.

Attachment 3.

Technical Review Checklist for Radiation Dose Assessments for Participants in the Enewetak Cleanup Project

A copy of the "Technical Review Checklist for Radiation Dose Assessments for Participants in the Enewetak Cleanup Project" is provided starting on the next page.

Technical Review Checklist for Radiation Dose Assessments for Participants in the Enewetak Cleanup Project

Participant's Name: _____ Case Key Number: _____

Dates of Assignment: From: _____ to: _____

Primary Analyst(s): _____ RDA Draft Date: _____

Reviewer: _____ Date of Review: _____

Instructions to Reviewer

- *Place a check mark for items that are addressed and reported correctly in the Radiation Dose Assessment Report (RDAR) and/or in the dose calculation worksheet(s) in accordance with NTPR RDA SOP RA06.*
- Write "n/a" in the space next to the checkbox for items that do not apply.
- A sequential comment number should be entered in the space next to the checkbox for any item that needs an explanation; numbered comments should be added in Section 5. This is required for any applicable item that is not checked.

1. Information in the VA Request

- ☐ ____ Disease/Organ
- ☐ ____ Unit and duty description
- ☐ ____ Assignment and participation dates
- ☐ ____ Attached military and VA forms with any veteran statements

2. Information in Case File

- ☐ ____ Important information from the ECUP Questionnaire is captured
- ☐ ____ Veteran's Unit, job assignment, and residence island are correctly identified
- ☐ ____ Dosimetry records are correctly transcribed
- ☐ ____ Arrival/Departure cards are provided
- ☐ ____ Information in the Controlled Island Access forms is correctly used
- ☐ ____ Any unusual exposure scenario is documented and addressed, i.e., exposure scenarios not previously characterized in DTRA's Technical Reports
- ☐ ____ Additional instructions from DTRA are taken into consideration

3. Radiation Dose Assessment Report

General

- ☐ ____ RDA Report is consistent with Case File (e.g., veteran's personal information, scenario, etc.)
- ☐ ____ Veteran's pertinent statements are addressed completely and adequately
- ☐ ____ Adequate description of exposure sources and pathways is contained in RDA Report
- ☐ ____ References are cited correctly and completely
- ☐ ____ Typos or other errors are addressed and corrected (e.g. veteran's name, service number, service, rank/rate, etc.)

External Dose Assessment

- ☐ ____ Dosimetry records are reported and assessed per SOP RA06
- ☐ ____ All potential exposure pathways are included
- ☐ ____ Basis/rationale/references are stated for each non-default assumption and selected parameter value

☐ ____ Non-standard exposures are adequately documented and assessed
☐ ____ Doses are tabulated and summed correctly, and reported in accordance with SOP RA06
☐ ____ Upper-bound doses are calculated correctly and reported in accordance with SOP RA06
☐ ____ Total doses and upper-bound doses are rounded up and reported to the number of significant digits specified in SOP RA06
☐ ____ Magnitude of doses is reasonable

Internal Dose Assessment

☐ ____ Correct dose quantity is calculated for appropriate organ/disease as requested using appropriate surrogates if needed
☐ ____ All potential exposure pathways are included
☐ ____ Basis/rationale/references are stated for each non-default assumption and selected parameter values
☐ ____ Non-standard exposure pathways are adequately documented and assessed
☐ ____ Doses are summed and tabulated correctly, and reported in accordance with SOP RA06
☐ ____ Upper-bound doses are calculated correctly and reported properly in accordance with SOP RA06
☐ ____ Total doses and upper-bound doses are rounded up and reported to the number of significant digits specified in SOP RA06
☐ ____ Magnitude of doses is reasonable

Skin Dose Assessment

☐ ____ Non-standard exposure pathways are adequately documented and assessed
☐ ____ Surface-deposited beta doses are reasonable based on associated gamma doses
☐ ____ Dermal contamination doses are correctly assessed
☐ ____ Upper-bound doses are calculated correctly
☐ ____ Total doses and upper-bound doses are rounded up and reported to the number of significant digits specified in SOP RA06

4. Calculation files

☐ ____ Dosimetry records are reported and assessed per SOP RA06
☐ ____ All potential exposure pathways for external, internal and skin doses are included
☐ ____ Parameter values are correctly selected in dose calculation worksheets
☐ ____ Basis/rationale/references are stated for each non-default assumption and selected parameter value
☐ ____ Non-standard exposures are adequately documented and assessed
☐ ____ All dose calculations are accurate and applicable high-sided parameter values are used
☐ ____ Calculations are organized and explained so that they can be followed without difficulty during reviews/audits.

5. Additional Comments:

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