SOP-5203, Revision 0

Waste & Environmental Services

Standard Operating Procedure

for

Radiological Dose Calculations For The Annual Environmental Surveillance Report

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Wiliam F. Eisele	Signature on File	7/11/2008
Procedure Owner	Signature	Date

HISTORY OF REVISIONS

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1.0 SCOPE AND APPLICABILITY

This procedure describes the process to perform dose calculations to be reported in annual environmental surveillance reports (ESRs), as required by DOE Orders 450.1 and 5400.5 and implementation guidance DOE/EH-0173T. This procedure also includes methodology for dose calculations (beyond the DOE requirements) to provide supplemental information concerning nearby populations and other potentially affected parties.

This procedure applies to the calculation of doses, to be reported in the annual ESRs, from all significant pathways to hypothetical individuals identified as potentially receiving the largest doses and to the population within 80 km (50 miles) of the Laboratory. Other doses may be calculated for hypothetical individuals as part of special studies that may be short term or one-time evaluations.

1.1 Background

DOE Order 5400.5 Chapter II Section 6b states "Doses to members of the public in the vicinity of DOE activities shall be evaluated and documented…" "Collective doses to the public within 80 km of the site shall also be evaluated and documented at least annually." Regarding doses calculated for hypothetical individuals, Chapter II Section 6b(3)(b) states "Doses calculated should be as realistic as practicable. Consequently, the individuals subject to the greatest exposure shall be identified, to the extent practicable, so that the highest dose might be determined." The Order also states (Chapter I Section 10) that dose calculations include routine and unplanned releases and that all significant exposure pathways be considered.

Individuals can receive doses from several LANL sources via several pathways and various scenarios. The primary pathways are: air (inhalation, direct exposure, and ingestion of contaminants originally dispersed via the air); water and food (ingestion); direct exposure to photons and neutrons from experimental or other facilities; or direct exposure to direct penetrating radiation sources in contaminated ground or water. This procedure describes the calculation of:

- Collective dose to the exposed population within 80 km of the Lab
- All-pathways dose to the maximally exposed individual outside of Lab boundaries (referred to as the off-site MEI)
- All-pathways dose to the maximally exposed member of the public within Lab boundaries (referred to as the on-site MEI)
- Average all-pathways doses to residents of Los Alamos and White Rock from all sources and pathways
- Doses from ingestion of produce at various locations in northern New Mexico
- Doses from ingestion of drinking water
- Doses from ingestion of surface waters and associated sediments
- Doses from the soils pathway
- Special scenario doses, including doses from exposure to contaminated material

2.0 PRECAUTIONS AND LIMITATIONS

1. Calculations performed in accordance with this procedure include doses from all significant pathways to hypothetical individuals identified as potentially receiving the largest doses and to the population within 80 km (50 miles) of the Laboratory.
2. Other doses may be calculated for hypothetical individuals as part of special studies that may be short term or one-time evaluations.
3. Each year, the dose evaluator should review activities at LANSCE, TA-54 Area G, and any other facilities with potentially significant exposure pathways to a member of the public and the monitoring near these facilities to assess potential locations of maximum exposure for on-site and off-site MEI scenarios. It may be necessary to perform preliminary calculations to determine the greatest exposure potential.
4. If doses to be included in Chapter 3 of the ESR are obtained from either the draft EPA (Rad-NESHAP) report or draft tables, the dose evaluator shall confirm that the doses specified in the EPA report and/or tables have not changed once the EPA report and other ESR chapters have been finalized and submitted
5. Care should be taken with regard to attributing uranium, Sr-90, and Cs-137 concentrations higher than the threshold levels in section A7 of MAQ-DOSE to Laboratory operations, as uranium is naturally occurring in these media, and Sr-90 and Cs-137 from global fallout can exceed these thresholds.
6. Actions specified within this procedure, unless preceded with “should” or “may,” are to be considered mandatory guidance (i.e., “shall”).

3.0 PREREQUISITES AND INITIAL CONDITIONS

1. Prior to commencing, obtain either the final or draft EPA report from the RAD-NESHAP Project, as much of the data needed is contained within this report. The majority of the doses to be reported in Chapter 3 of the ESR will be extracted from either the annual “U.S. Department of Energy Report, LANL Radionuclide Air Emissions” report that is submitted to the EPA (hereafter referred to as the “EPA report”) or draft tables (typically in the form of EXCEL spreadsheets) to be included in other chapters of the ESR.

4.0 EQUIPMENT AND TOOLS

None

5.0 TRAINING

Personnel responsible for calculating doses reported in ESR shall be trained in accordance with the provisions of the division training program (EP-ERSS-SOP-2011) and documented. The training method for this procedure is self-study.

The following training/education is required prior to performing this procedure:

- Advanced health physics, e.g., certification by the American Board of Health Physics or courses in radiation physics, dispersion modeling, biological effects of radiation, and public health.
- Use of RESRAD (familiarity can be gained through running the program, reading the user guides and other support materials, and/or working with someone familiar with the program).

6.0 DEFINITIONS

Collective Dose Equivalent and Collective Effective Dose Equivalent: The sums of the dose equivalents or effective dose equivalents of all individuals in an exposed population within an 80-km radius, and they are expressed in units of person-rem (or person-sievert). When the collective dose equivalent of interest is for a specific organ, the units would be organ-rem (or organ-sievert). The 80-km distance shall be measured from a point located centrally with respect to major facilities or DOE program activities.

Committed Dose Equivalent: The predicted total dose equivalent to a tissue or organ over a 50-year period after a known intake of a radionuclide into the body. It does not include contributions from external dose. Committed dose equivalent is expressed in units of rem (or sievert).

Committed Effective Dose Equivalent (CEDE): The sum of the committed dose equivalents to various tissues in the body, each multiplied by the appropriate weighting factor. Committed effective dose equivalent is expressed in units of rem (or sievert).

Direct dose: a general term to describe doses received from radiation sources external to the body such as a photon or neutron source. Potential sources include radioactive materials in air, radioactive materials on the ground or in buildings, accelerators, or criticality experiments.

Dose: A general term used to describe any radiological dose received. In general, this refers to the effective dose equivalent and may or may not be a committed dose depending on whether the radiation was internal or external.

Dose Equivalent: The product of absorbed dose in rad (or gray) in tissue and a quality factor. Dose equivalent is expressed in units of rem (or sievert).

Effective Dose Equivalent (EDE): The summation of the products of the dose equivalent received by specified tissues of the body and a tissue-specific weighting factor. This sum is a risk-equivalent value and can be used to estimate the health-effects risk of the exposed individual. The tissue-specific weighting factor represents the fraction of the total health risk resulting from uniform whole-body irradiation that would be contributed by that particular tissue. The effective dose equivalent includes the committed effective dose equivalent from internal deposition of radionuclides and the effective dose equivalent due to penetrating radiation from sources external to the body. Effective dose equivalent is expressed in units of rem (or sievert).

Inhalation dose: The committed effective dose equivalent (see definition above) received from inhalation of radioactive material.

Ingestion dose: The committed effective dose equivalent (see definition above) received from ingesting radioactive material.

Location group: A group of stations or sampling sites that are grouped on the basis of some commonality to provide a set of data for comparison. For example, a group of sampling locations distant from the Lab can be grouped and averaged to provide a background value. These would likely be referred to as the "Off-site Regional" or simply as "Background" group.

Member of the public (the definition from DOE Order 5400.5 is used): a person who is not occupationally associated with a LANL/DOE facility or operation.

Maximally exposed individual (MEI): Individuals who are characterized as receiving the largest dose from the LANL facility from all pathways. We define an off-site MEI as a member of the public not on LANL or DOE property and an on-site MEI as a member of the public who received the majority of their hypothetical dose while on DOE/LANL property or on publicly accessible roads that pass by LANL facilities.

Penetrating radiation: Penetrating radiation; which includes photon radiation and neutrons, is emitted by radioactive atoms (such as cobalt-60) or from manmade sources such as accelerators or criticality experiments, and from terrestrial and cosmogenic sources. When the source of the penetrating radiation is removed, there is no longer any exposure.

Penetrating radiation dose: The effective dose equivalent received from penetrating radiations such as photons and neutrons.

RESRAD: A collection of computer codes developed for implementing the DOE's residual radioactive material guidelines. The program allows calculations of doses based on ingestion of produce, water, and soil; inhalation of soil and radon progeny; and direct radiation exposure to soils and sediments. The web link to these codes is: http://web.ead.anl.gov/resrad/home2/.

Regional statistical reference level (RSRL): Upper-level background concentration (mean plus three standard deviations = 99 percent confidence level) for radionuclide calculated from soil data collected from regional locations away from the influence of the Laboratory over at least the last five sampling period.

Total Effective Dose Equivalent (TEDE): The sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures). This dose term is typically expressed in units of rem or mrem.

7.0 STEP-BY-STEP PROCESS DESCRIPTION

7.1 Collective Population Dose within 80 km

Field Team Members (FTM)

NOTE:

This modeled population dose is based on all sources and pathways from LANL. However, stack sources and diffuse air emissions are usually dominant; and are therefore based on CAP88 model code runs. We use the local population distribution to calculate the dose from Laboratory operations to the population within 80 km (50 miles) of LANL. Approximately 280,000 persons live within an 80-km radius of the Laboratory. County population estimates are provided by the University of New Mexico Bureau of Business and Economic Research. These statistics are available at *http://www.unm.edu/~bber/*.

1. The annual population dose from monitored stacks and air activation products from diffuse air emission sources should be obtained from the RAD-NESHAP Project in tabular form.

   The population dose is available within this table as the sum of the monitored stacks and calculated diffuse air emissions for the year of concern and is listed in the table as “total” in units of person-rem.

NOTE:

Currently, the majority of the collective dose is from the short-lived air activation products such as carbon-11, nitrogen-13, and oxygen-15 from LANSCE and tritium from the tritium facilities.

2. If desired, the dose contributions from the LANSCE short-lived air activation products may be characterized in the ESR as a fraction of the total collective dose by summing the population doses from LANSCE emission sources with ESIDNUM numbers 53000303, 530003sy, 53000702, 53000711, and 530007ip in the table and dividing by the total collective dose.

3. Similarly, the tritium dose contribution may be characterized as a fraction of the total dose by summing the population doses attributed to tritium emissions sources, and dividing by the total collective dose.

4. There is no specific dose limit for collective population dose within 80 km. However, the dose obtained for the year in question should be compared and contrasted with the dose obtained for past years and any differences should be explained in the ESR.

7.2 Calculating Off-Site MEI Dose

7.2.1 General Overview

FTM

1. The off-site MEI dose is the sum of all pathways doses to the off-site hypothetical receptor with the highest dose.

   These pathways include air emissions from monitored point sources, unmonitored point sources, diffuse emissions sources, direct radiation sources (e.g., from facilities and soils), and ingestion pathways (e.g., drinking water, produce, and soils).

2. The direct radiation pathway dose for soils and ingestion pathway doses are typically negligible (< 0.1 mrem) when compared to the air emissions pathway and some facility direct radiation doses, and are typically not included.

3. Base the determination of the major off-site MEI dose contributor and the location of the off-site MEI receptor location on:

   a. The air emissions pathway dose determined through CAP88 model computations and the AIRNET system, and

   b. Review of direct radiation doses determined through the DPRNET system and the calculation of direct radiation dose.

NOTE:

The LANSCE accelerator facility and the tritium facilities such as WETF have historically been the major air emissions pathway dose contributors. Other sources of facility air emissions are currently not major contributors, but include the plutonium facilities such as TA-55 and CMR, and the Radiochemistry facility, TA-48.

Because stack emissions are expected to remain low in the future, the major contributor to the air pathway MEI dose will most likely be from low levels of transuranic radionuclides in suspended wind-blown soil from environmental remediation projects.

4. Review sources of direct radiation exposure within the Lab to determine if they are a likely source of dose that would make a nearby member of the public the maximally exposed individual. Sources of direct radiation exposure that have been identified in the past include LANSCE, TA-18, and the storage domes at TA-54.

7.2.2 Calculating Off-Site MEI Dose – LANCE/East Gate Scenario

7.2.2.1 Determine LANSCE Contribution to the Off-Site MEI Dose

NOTE:

This section assumes the major air emissions dose contributor is the LANSCE accelerator and the off-site MEI receptor location is the East Gate. However, due to limited accelerator operations, potential upgrades to the gaseous waste treatment system, or new or modified facilities or operations contributing a higher off-site dose, LANSCE may not be the major air emissions dose contributor and the East Gate may not be the off-site MEI receptor location.

Confirm the major air emissions dose contributor and the associated off-site MEI receptor location with the RAD-NESHAP Project prior to determination of the off-site MEI dose.

Because emissions from LANSCE are short-lived photon emitters and are not measured effectively with the ambient air monitoring network (AIRNET), the dose from these sources is modeled with CAP88 using emissions data provided by LANSCE operations personnel. Evaluate the air pathway dose from Lab operations other than LANSCE by using data from the AIRNET stations.

FTM

1. Review the EPA report to determine the LANSCE contribution to the off-site MEI dose. Typically, this dose will be found in the report in a table entitled “LANSCE Monthly Assessments and Summary,” and is the sum of the monthly or annual stack doses (whichever is greater) at the appropriate receptor location (typically East Gate) as well as the LANSCE non-CAP88 radionuclide and LANSCE “fugitive emissions” doses to this receptor that are calculated on an annual basis.

2. The sum to be reported in the ESR is listed in the table as “LANSCE Summary” at the bottom of the table and is in units of mrem. Report this dose in its entirety. (Refer to Section 2.0, Step 5)

7.2.2.2 Determining Other Air Emissions Contributions to the Off-Site MEI Dose

NOTE:

In addition to the LANSCE contribution to the off-site MEI dose listed in the EPA report, other point source and diffuse source air emissions also contribute dose to the off-site MEI. These include monitored point sources such as the tritium facilities, CMR, TA-55, TA-48, and TA-50. They also include unmonitored stacks and diffuse emissions sources.

To obtain the annual dose from other air emissions sources to the off-site MEI and the total air emissions dose to the MEI (including the LANSCE contribution), perform the following steps:

FTM

1. Refer to a table entitled “Highest Effective Dose Equivalent Summary” in the EPA report. The “total” at the bottom of the column titled “Dose at East Gate Receptor” (or equivalent maximum off-site MEI receptor location) is the total air emissions dose to the off-site MEI, including the LANSCE contribution. This dose is to be reported in the ESR in its entirety. (Refer to Section 2.0, Step 5)

2. Compare the total air emissions dose to the 10 mrem/year EPA (40 CFR, Part 61, EPA 1986) air pathway limit. This dose should be reported, and compared and contrasted to the limit and previous years’ total air emissions doses in the ESR.

3. To obtain the air emissions dose from those sources other than LANSCE, subtract the LANSCE dose contribution found in the “LANSCE Monthly Assessments Summary” table of the EPA report and the “Air Sampler Net Dose” in the “Highest Effective Dose Equivalent

Summary" table in the EPA report from the total air emissions dose ("total") in the same table. Report this dose in its entirety in the ESR in units of mrem.

4. The "Air Sampler Net Dose" in the "Highest Effective Dose Equivalent Summary" table is typically the AIRNET Station dose at station 10, East Gate. The dose reported in this table should approximate the dose reported in AIRNET station compliance dose table as described below.

   a. Select the "total" dose in mrem in the "Highest Effective Dose Equivalent Summary" table as the value to be reported in the ESR. This dose is to be reported in its entirety.

   b. It should be noted that the dose calculated for these AIRNET stations has already been background-corrected (using concentrations measured at regional stations throughout the calendar year).

   c. This dose (from either the AIRNET station compliance dose table or the "Highest Effective Dose Equivalent Summary" table) has already been captured in the CAP88 model calculations from the identified air emissions sources, but is not subtracted from the CAP88 modeled dose contribution.

5. Typically, the "total" dose for the MEI receptor from all air emissions sources in the "Highest Effective Dose Equivalent Summary" table will also be reported in the ESR as the maximum off-site MEI dose from all pathways. This is the case when all other pathways such as the ingestion and direct radiation pathways are negligible (< 0.1 mrem) when compared to the total air emissions pathways dose.

6. If the location is residential, and produce, soil, and drinking water concentrations are available for this location or nearby locations, a screening of the radionuclide concentrations in these media should be performed with regard to the thresholds in section A7 of MAQ-DOSE (representative of radionuclide concentrations that could deliver greater than 0.1 mrem per year),.

   Care should be taken with regard to the caveats in Section 2.0, Step 6. A "sum of the fractions" approach is recommended when multiple radionuclides are detected in a particular type of sample media to ensure that the 0.1 mrem/year dose threshold is not exceeded.

7. If the radionuclides in the media are attributable to Laboratory operations, the annual ingestion doses should be calculated and added to the air pathway dose above and reported in the ESR. Refer to the sections below titled "Calculating dose from ingestion of produce, drinking water, surface water, and sediments" and "Calculating dose from soils pathway" for the procedural steps.

8. Refer to Section 7.2.4.1 below to determine if the direct radiation pathway is significant enough to be included in the total off-site MEI dose at this location.

7.2.3 Calculating Off-Site MEI Dose - Other Air Emissions Source/ Receptor Location

FTM

1. When LANSCE or another single facility is not the obvious source of the largest potential dose, an initial screening using AIRNET data from public locations may be used to help identify the location of the off-site MEI.

2. Determine the site (as defined as a potential MEI location in 40 CFR, Part 61) that would have the highest dose based on ambient, net isotopic concentrations. To this dose calculated from AIRNET data, add the CAP88 modeled doses for that location, and doses from other pathways, if applicable.

3. The review and identification of the alternative air emissions sources and receptor locations for the off-site MEI dose determination should be performed in conjunction with the RAD-NESHAP Project as they have the primary responsibility for making this determination for EPA reporting purposes.

7.2.4 Calculating Off-Site MEI Dose - Direct Radiation Scenario

NOTE:

During some years, there may be a potential, alternative off-site MEI as a result of direct radiation from facilities or operations. The alternative off-site MEI dose resulting from direct radiation should be compared to the off-site MEI dose resulting from air emissions.

7.2.4.1 Determine Off-Site MEI through Direct Radiation Pathway

FTM

1. Obtain the annual/quarterly DPRNET direct radiation results for the calendar year in question.

2. Review the data for any outlier doses. The data should be presented as annual/quarterly gamma and neutron dose in mrem for each DPRNET station uncorrected for background.

NOTE:

It is important to realize that the annual gamma dose at any one station may range from approximately 100 mrem to 200 mrem, whereas the typical annual neutron dose will be approximately 2 mrem, without any contribution from Laboratory operations.

3. If there appears to be the presence of outlier, as defined below:

   1. gamma > 200 mrem per year or > 65 mrem in any quarter at off-site locations [refer to DPRNET Project Plan, MAQ-DPRNET] and/or

   2. neutron doses > multi-year cumulative mean plus 3 standard deviations measured at off-site locations

   examine the data for patterns related to the locations of these DPRNET stations relative to facilities or activities that are known to produce external radiation fields or are suspected of producing these fields, e.g., neutron fields associated with the domes at TA-54, Area G.

4. If a Laboratory operation appears to be the source of increased direct radiation dose at a particular off-site DPRNET station, attempt to establish a quantitative relationship between the location of the operation and intervening DPRNET station readings.

   It may, however, be somewhat difficult to model this quantitative relationship beyond such simple concepts such as the inverse-square relationship and attenuation of photons in air.

5. If the operation is ongoing, it may be appropriate to go into the field to make measurements with the appropriate portable survey instrument to ascertain the presence of a direct radiation field attributable to the operation. Other factors to consider are listed in MAQ-DPRNET, section A7, "Inputs to decision."

NOTE:

It may also be helpful to correlate these external dose outliers with occupational external doses received by workers associated with these facilities or activities.

6. If implementing the note above, contact the RP-2 Radiation Dosimetry and Records team leader to obtain the external radiation dosimetry report for all workers for the year of interest. A strong correlation between high worker doses (> 500 mrem/year as specified in LA-UR-03-6493) and higher than normal doses measured by the environmental TLDs in the same vicinity may point to gamma or neutron doses attributable to Laboratory operations. Consult the appropriate team leader(s) in RP-1, -2, and/or -3 to ascertain if these correlations are valid.

7. Annual neutron doses measured at off-site locations that exceed the investigation level of the background cumulative mean plus 3 standard deviations are usually easily discernable and attributable to a specific Laboratory operation.

8. It is appropriate to subtract a background station neutron dose of 2 mrem from those annual station doses that exceed the investigation level.

9. The highest background-corrected neutron dose for the off-site station(s) should be considered part of the alternative off-site MEI dose and reported in the ESR as such.

NOTE:

Annual gamma doses measured at off-site locations that exceed the investigation level of > 200 mrem/year are somewhat more difficult to attribute to specific Laboratory operations.

10. If through the investigation process described above, it is determined that some part of the gamma dose measured at the off-site station is attributable to Laboratory operations, consult

with the DPRNET Project leader for guidance on the determination of the Laboratory contribution.

11. A simple background subtraction may not be appropriate. In any case, document how the Laboratory contribution was determined and file it as a record.

12. The highest background-corrected gamma dose for the off-site station(s) should be considered part of the alternative off-site MEI dose and reported in the ESR as such.

13. Select the highest of the neutron or gamma background-corrected off-site dose locations as the alternative off-site MEI location.

14. In the unlikely situation that the highest neutron and gamma background-corrected dose locations are the same, sum the neutron and gamma doses.

15. Multiply the direct radiation dose determined above by the appropriate occupancy factor; 1 for continuous occupancy at a residence or business or 1/16 for intermittent occupancy and report the resulting dose and location in the ESR.

7.2.4.2 CAP88 and AIRNET Dose Contribution to Alternative Direct Radiation of the Off-Site MEI

FTM

1. Request from the RAD-NESHAP Project, the CAP88 modeled dose at the location of the alternative direct radiation off-site MEI.

NOTE:

This is not a standard product of the project and will not necessarily be located in the EPA report.

2. Apply the appropriate occupancy factor (1 for continuous occupancy at a residence or business or 1/16 for intermittent occupancy) and report the resulting dose in the ESR.

3. Obtain from the RAD-NESHAP Project the background-corrected annual AIRNET dose for the AIRNET station located closest to the DPRNET station selected above.

4. Multiply the direct radiation dose determined above by the appropriate occupancy factor (1 for continuous occupancy at a residence or business or 1/16 for intermittent occupancy) and report the resulting dose and location in the ESR.

5. Sum the occupancy-corrected direct radiation dose (gamma and/or neutron), CAP88 dose, and AIRNET dose to obtain the alternative direct radiation off-site MEI dose for the calendar year in question. Report this summed dose in the ESR.

NOTE:

It should be noted that produce and drinking water ingestion doses and soils pathway doses for such a location are typically insignificant (< 0.1 mrem) and are usually not reported.

6. If the location is residential and produce, soil, and drinking water concentrations are available for this location or nearby locations, a screening of the radionuclide concentrations in these media should be performed.

7. Concentrations in excess of the threshold values in section A7 of MAQ-DOSE and/or the RSRLs are considered “detects” and should be further investigated with the appropriate project leaders to ascertain if they are attributable to Laboratory operations. Refer to Section 2.0, Step 6.

8. If the radionuclides in the media are attributable to Laboratory operations, the annual ingestion and soils pathway doses should be calculated as described below and added to the direct radiation and air pathway summed dose and reported in the ESR.

7.2.5 Selection of the Off-Site MEI Dose

FTM

1. At this point, an off-site MEI dose primarily attributable to air emissions and an off-site MEI dose primarily attributable to direct radiation will have been calculated. The higher of these two doses will be the official off-site MEI dose and should be designated as such in the ESR.

2. Compare and contrast the official off-site MEI dose to the 100 mrem/year all pathways limit in DOE 5400.5.

NOTE:

A very unlikely scenario is that neither air emissions nor direct radiation will be the pathway that determines the off-site MEI. In that case, an ingestion dose or soils pathway dose will most likely be the primary driver and will be calculated and reported as such in the ESR.

7.3 Calculating the On-Site MEI Dose (Optional)

7.3.1 Location of On-Site MEI

FTM

1. Experience and enhanced environmental monitoring during the past few years have shown that facilities that emit direct penetrating radiation are generally the source of maximum potential exposure to a member of the public temporarily on DOE/LANL property.

   For several years, the largest contributor to the on-site MEI was determined to be the Nuclear Criticality Facility at TA-18. The hypothetical maximum annual dose from that facility was presumed to be to an individual who jogged along Pajarito Road, passing TA-18 twice each working day.

2. Periodically check for new facilities or new sources that could change the location of the on-site MEI. The following steps describe how to calculate these doses and the all-pathway

components.

7.3.2 Calculate On-site MEI Dose

FTM

1. To calculate the total on-site MEI dose, add facility-specific doses to those calculated for an "average" Los Alamos resident.
2. Multiply the total on-site MEI dose by an intermittent occupancy factor of 1/16.
3. Compare and contrast this dose to the limit of 100 mrem/year.
4. In some years, there may not be an on-site MEI and no dose will be reported in the ESR for this scenario.

7.4 Calculating Average Dose to Residents of LA and WR

7.4.1 General Overview

FTM

1. "Average" doses may be calculated in order to evaluate the doses that members of the local population are likely to have received from all reasonable sources and pathways. These doses are calculated for "average" residents of Los Alamos (LA) and White Rock (WR).

   The dose calculation is based on AIRNET measured air concentrations (which includes all Lab contributors except LANSCE) and incorporates the dose contribution from LANSCE by performing CAP88 runs based on reported or calculated emissions from those facilities. Produce and drinking water ingestion doses, as well as soils pathway and direct radiation doses are added to these if appropriate.
2. A specific set of AIRNET stations in Los Alamos town site and another set in White Rock comprise the "average LA resident" and the "average WR resident," respectively. An annual AIRNET dose based on background-corrected concentrations is calculated for each of these stations.
3. Currently, the following stations have been selected to represent the "average" LA resident:

   Station 6 at 48th Street

   Station 8 at McDonalds

   Station 12 at Royal Crest

   Station 61 at LAMC

   Station 62 at Crossroads Bible Church

   Station 68 at Airport Road
4. Currently, the following stations have been selected to represent the "average" WR resident:

Station 13 at Rocket Park

Station 14 at Pajarito Acres

Station 15 at White Rock Fire Station

Station 16 at White Rock Nazarene Church

Station 63 at Monte Rey South

5. Other AIRNET station locations may be chosen to represent the "average" LA or WR resident if the reason(s) for making the change is documented and filed as a record.

7.4.2 Calculate Average LA and WR Resident Dose

FTM

1. Refer to the AIRNET station compliance dose table in the EPA report. Typically, the last column is entitled "Rounded total (mrem) and is the sum of the EDE for all detected radionuclides for each station.

2. Average all doses reported for each LA station listed above to determine the "average" LA resident air pathway dose.

   For example, there are six LA AIRNET stations listed above, You would sum the six doses and divide by six to obtain the "average" LA resident air pathway dose based on AIRNET results alone. Report this as separate dose in the ESR.

4. Calculate the CAP88 dose at the 5000 m WNW location from LANSCE to determine the "average" LA resident CAP88-modeled dose contribution from all stacks (i.e., include all LANL emissions using LANSCE as the location of the emissions source).

5. Report this dose in the ESR as the CAP88-modeled dose for this location.

6. Sum the average AIRNET dose calculated in Step 3 with the CAP88-modeled dose determined in Step 4.

7. Compare and contrast the "average" LA resident air pathway dose calculated in Step 6 to the 10 mrem/year air pathway dose limit.

8. If calculated, radionuclide-specific doses may be reported in the ESR, e.g., tritium-specific doses or transuranic-specific doses.

9. Screen available produce, drinking water, and soil concentrations for LA residents against the thresholds as described in the following section.

10. If the measured media concentrations are attributable to Laboratory operations then perform appropriate dose calculations as described in this procedure and sum the doses for these pathways and add this sum to the air pathway dose determined in Step 3 above.

11. Compare and contrast this “average” LA resident total dose to the 100 mrem/year all pathways dose.

NOTE:

It is highly unlikely that a direct gamma or neutron radiation dose measured at DPRNET stations within LA town site will exceed normal background levels [refer to section titled “Determining off-site MEI through direct radiation pathway”] and will need to be added to the total “average” LA resident dose.

12. Perform Steps 3 through 11 for the WR AIRNET stations listed above to determine the “average” WR resident air pathway AIRNET dose, WR CAP88-modeled dose at 6800m SE from LANSCE, and the “average” WR resident total dose. Report these doses in the ESR, comparing and contrasting them to the appropriate dose limits.

7.5 Calculating Dose from Ingestion of Produce

7.5.1 General Overview

FTM

1. There are generally three ways to determine if the concentration of a radionuclide in produce is real and attributable to Laboratory operations:
   1. Comparison to the threshold values presented in section A7 of MAQ-DOSE.
   2. Determination if the measured concentration is real, i.e., a true “detect”.
   3. Comparison to RSRL values.

   Any of these approaches may be used to determine if a dose calculation is warranted.

2. If the measured media concentrations do not exceed the appropriate screening levels (taking into account caveats referred to in Section 2.0, step 6), a dose calculation is not required.

3. For multiple radionuclides, a “sum of the fractions” approach is recommended to ensure that the entirety of radionuclides detected in a sample would not result in a dose higher than 0.1 mrem.

4. A “detect” concentration is generally presumed to be a value ≥ the analytical method detection limit (MDL) ***and*** three times (3X) the analytical laboratory-reported uncertainty for the value reported.

5. If a measured concentration in a sample does not exceed the RSRL value, it may be assumed that the concentration of the radionuclide in the sample is not attributable to Laboratory operations.

6. Produce grown or gathered locally are sampled and analyzed from numerous locations in northern New Mexico. These produce data allow the calculation of food ingestion doses at a

number of sites. The doses are calculated on the basis of measured produce; no modeling is performed. Where appropriate, certain produce ingestion doses are added to hypothetical receptor doses as described above. These are described for each receptor as appropriate in the preceding chapters.

7. Annual consumption rates for average and maximum individuals are listed in Table 3-1 (p. 49) of the 1996 Annual Environmental Surveillance Report, are available from USNRC Regulatory Guide 1.109, Revision 1, Oct. 1977, or the EPA Exposure Factors Handbook. This information is also available in scenario-specific form in LA-UR-00-4084. Alternatively, results of local surveys on food consumption may be used if they are available. The consumption rates used should be documented in the dose calculation spreadsheets and included in the ESR.

7.5.2 Calculate Doses from Produce

FTM

1. Obtain produce data from the SFB Project or ESR Chapter 8 tables. Typically, for the year of assessment, data will be provided by specific produce type for regional stations (considered to be background concentrations) and perimeter stations (Los Alamos, White Rock/Pajarito Acres, Cochiti/Sile, and San Ildefonso).

2. For each produce type (e.g., squash, peaches, tomatoes, etc.) at each regional and perimeter location, convert the dry concentration provided by the project to wet concentration based on the dry/wet concentration ratio specified for each foodstuff type in LA-UR-04-4122 (for all radionuclides except tritium).

   This is performed by multiplying the isotopic dry concentration by the dry/wet ratio in the report to determine the wet concentration.

NOTE:

Wet concentrations should be in units of pCi/g, except for tritium [HTO].

3. For tritium (HTO), ensure that the activity concentration is reported in, or converted to, pCi/mL of tissue water to obtain the wet tritium concentrations for each vegetable and fruit at each regional and perimeter location.

4. Calculate the mean ($\mu_{R\ HTO}$) and standard deviation ($\sigma_{R\ HTO}$) for tritium for the collection of vegetables and fruits harvested from the regional stations (R), i.e., there should be one tritium mean and standard deviation for the regional stations in pCi/mL to represent the tritium background. This will be the background mean value to subtract from mean produce concentrations at each perimeter station (P).

NOTE:

Although μ typically refers to the population mean and σ refers to the population standard deviation, for purposes of this procedure, both symbols refer to the quantities specific to the sample set of data.

5. Calculate the mean (μ_{Rr}) and standard deviation (σ_{Rr}) for each of the non-tritium radionuclides(r) for the collection of produce harvested from the regional stations (R), i.e., there should be one non-tritium mean and standard deviation for the regional stations in pCi/g (wet) to represent the non-tritium radionuclide background for each radionuclide.

6. Perform Steps 4 and 5 for each of the perimeter stations (i.e., there should be a mean (μ_{Pr}) and standard deviation (σ_{Pr}) for each radionuclide (r), measured for each perimeter station (P)). This is the gross wet concentration for each radionuclide for the mean and standard deviation.

7. To obtain the net wet mean concentration for each radionuclide for each perimeter station, subtract the regional station mean concentrations calculated in Steps 4 and 5 from each of the perimeter station mean concentrations for each radionuclide, e.g., for Los Alamos perimeter station: $\mu_{LA\ Nr} = (\mu_{LAr} - \mu_{Rr})$ for each radionuclide

8. Compute one standard deviation (1σ) of the net concentrations for each radionuclide (r), at each perimeter station(P), according to the following formula:

$$\sigma_{Nr} = \sqrt{[(\sigma_{Pr})^2 + (\sigma_{Rr})^2]}$$

where:

σ_{Nr} = standard deviation of the net concentration for radionuclide r

σ_{Pr} = standard deviation of the wet concentration for each radionuclide, r, at each perimeter station P (gross concentration)

σ_{Rr} = standard deviation of the wet concentration for each radionuclide, r, at the regional stations R (background concentration)

NOTE:

The calculated σ_{Nr} values should be carried through all subsequent steps to report 1 σ of the calculated dose at each location group.

9. Multiply the net mean activity and background activity concentrations and their 1σ values (pCi/g or pCi/mL) by a units conversion factor of 3.7×10^3 (Sv/Bq to mrem/pCi) and the highest radionuclide-specific ingestion effective dose conversion factor (Sv/Bq) from Table 2.2 of EPA 1988 (e.g., $D_{r\mu}$ (or $D_{r\sigma}$) = $\mu_{LA\ Nr} * 3.7 \times 10^3$ * EPA ingestion DCF). Alternatively, age-specific ingestion dose conversion factors from ICRP 72 may be used in lieu of the EPA DCFs. Age-appropriate ingestion rates should be used.

NOTE:

This gives the dose (mrem/g or mrem/mL) per unit of produce ingested for each radionuclide for each location group, i.e., there will be a background-corrected mean dose for each radionuclide from the consumption of a unit quantity of produce and its associated standard deviation and there will be a mean dose for each radionuclide from the consumption of a unit quantity of produce from the regional station and its associated standard deviation.

10. Calculate the mean dose from consuming a "unit" quantity of produce (typically per pound) by summing the mean doses for each radionuclide (assume a density of 1 g /mL for produce with tritium) for each perimeter station and the regional stations, i.e., there will be a mean dose for each perimeter station and there will be a mean dose for the regional stations for each unit quantity of produce consumed. For example, for the perimeter stations: $D_{P\mu}=\Sigma_r D_{r\mu}$.

11. Calculate the standard deviation of the mean dose for each perimeter station by taking the square root of the sum of the squares of each radionuclide dose standard deviation associated with that station (e.g., $D_{P\sigma}=\sqrt{[(D_{r1\sigma})^2 + (D_{r2\sigma})^2 +(D_{r3\sigma})^2 + . . .]}$). Do the same for the regional stations to determine a regional station dose standard deviation. At this point, there should be two doses calculated for each perimeter station, the mean dose for consuming a unit quantity of produce and a standard deviation dose associated with the mean. There will also be two doses associated with the regional stations; a mean dose from consuming a unit quantity of produce from the regional stations and a standard deviation dose associated with the mean.

12. Report the CEDE (mrem) and associated 1σ value for ingestion of unit quantities of produce from each location in the ESR. There is no specific dose limit associated with the ingestion of produce only on either a "per unit intake" basis or annual consumption basis. If this is the only pathway being analyzed, the single pathway dose guideline of 25 mrem/year would be the appropriate value to use for comparison purposes.

NOTE:

These calculations provide the CEDE for the annual per unit intake of produce for each location group. There is no assumption made regarding the intake quantity so that individuals can reach their own conclusions as to their dose from this pathway taking into account their own consumption habits. However, for purposes of adding these doses to other pathways doses as calculated above, the doses per unit quantity intake should be multiplied by an annual intake quantity as described in the section above titled "Obtaining annual consumption rates."

7.6 Calculating Dose from Ingestion of Drinking Water

NOTES:

1. Perform the following steps, as appropriate, to determine the dose contribution from drinking water consumption taking into account the caveats referred to in Section 2.0, step 6.

2. Los Alamos and White Rock use the same food and water sources and, in general, have the same food and water ingestion doses. However, if a drinking water well is delivering a dose to the public and it can be shown that it serves either White Rock or Los Alamos but not the other, then it would be appropriate to report the dose only for the part of the county served.

3. Consult with the LANL Water Stewardship Project (WSP) for the appropriate drinking water concentrations to be used to calculate annual water ingestion doses. Tap water samples are not collected and analyzed by the Laboratory. Specific wells used for the community drinking water supply system are sampled, but certain wells supply specific areas of the Los Alamos/White Rock community. Typical community drinking water well samples would be obtained from the Guaje [G], Pajarito Mesa [PM], Otowi [O], Black Mesa, and Westside Artesian wells.

FTM 1. Obtain drinking water sampling results (to include samples from drinking water wells and springs) and include the original data in the records file. Convert units to pCi/L if necessary.

2. If drinking water results (other than uranium isotopes) for the Los Alamos/White Rock community exceed the screening levels in section A7 of MAQ-DOSE and are considered "detects," (consult with WSP) calculate the incremental dose attributable to LANL according to the equation below. Otherwise, no LANL dose needs to be calculated.

Calculate the 50-year annual dose commitment according to the following equation:

$$D_r = WC_r * DF_r * 2.70 \times 10^6$$

Where:

D_r = water ingestion dose in mrem from radionuclide, r (mrem).

WC_r = concentration in water of radionuclide, r. (**NOTE:** Except for tritium and naturally occurring radionuclides. "Detects" for those radionuclides that could be attributed to Laboratory operations are not expected. Before calculating a dose for any other radionuclide, consult with the WSP to ensure that the radionuclide is actually present in the sample. The radionuclide concentrations may be specific to certain wells and regions, certain towns and/or regions, or some statistical "clumping" (e.g., mean) of all well concentrations and regional concentrations. This will be the decision of the WSP.)

DF_r = ingestion dose conversion factor for radionuclide, r (Sv/Bq) taken from Table 2.2 of EPA 1988. (**NOTE:** Use the most conservative (largest) ingestion effective dose conversion factor ("effective" extreme right-hand column) of those listed for each radionuclide.). Alternatively, age-specific ICRP 72 ingestion dose conversion factors may be used with age-appropriate ingestion rates.

$2.70x10^6$ = a unit conversion factor (mrem Bq L Sv^{-1} pCi^{-1}) that incorporates an annual water ingestion rate of 730 liters, considered an upper-normal ingestion rate (Exposure Factors Handbook, Konz et al, 1989).

Example calculation:

- EPA 1988 dose factor is 3.85e-08 Sv/Bq for ^{90}Sr
- Hypothetical annual Sr-90 average is 20 pCi/L
- Calculated dose from Sr-90 = 20 pCi/L * 3.85e-08 Sv/Bq * $2.70x10^6$ mrem Bq L Sv^{-1} pCi^{-1} = 2.1 mrem

NOTE:

Uranium isotopic ratio is not a reliable indicator of origin in groundwater. Therefore, it is not possible at this time to evaluate whether there is a LANL uranium contribution in tap water samples by our methodology. It should also be noted that uranium is naturally present at very high concentrations in the Buckman field wells and in the wells in the Española valley.

4. Sum the doses calculated above from all radionuclides above regional concentrations ($\sum_r D_r$) to calculate the LANL contribution to the total annual drinking water ingestion dose. Compare and contrast this dose to the 4 mrem/year water ingestion pathway dose limit (DOE 5400.5).

5. Multiple sample results per well throughout the year and for all radionuclides detected should be propagated through to a final mean dose result and 1σ value as described in the produce section above.

7.7 Total Annual Ingestion Dose

FTM

1. Sum the produce and drinking water ingestion doses to calculate the total annual ingestion dose for both Los Alamos and White Rock residents.

   For example, if a drinking water ingestion dose was calculated for White Rock, that dose should be added to the produce ingestion dose also calculated for White Rock.

NOTE:

Surface water and sediment ingestion as discussed below is not considered part of the normal ingestion scenario for inclusion in the annual ESR. Surface water and sediment ingestion doses are not added to the Los Alamos and White Rock resident ingestion doses.

7.8 Calculating Does from Ingestion of Surface Water and Sediments

7.8.1 General Overview

FTM

1. There is minimal potential for members of the public to ingest surface waters that have been

significantly affected by past and present Laboratory operations. Those surface waters that typically contain concentrations of radionuclides above applicable standards result from storm water and snow melt runoff and contain levels of sediment that make these waters unsuitable for drinking water purposes. In addition, the majority of these surface waters are located onsite and only run intermittently.

2. Because some of these surface waters are located near the Laboratory boundary and could potentially be accessed by members of the public, it may be appropriate to assess and, in some cases, calculate the dose to an individual from the ingestion of these waters. Typical locations of these surface waters include the Rio Grande River near Frijoles (White Rock Canyon), Guaje Canyon at SR-4, Los Alamos Canyon below the ice rink, DP Canyon above TA-21, Los Alamos Canyon above SR-4, Los Alamos Canyon below the LA weir, Pueblo Canyon above Acid Canyon, Acid Canyon above Pueblo Canyon, Pueblo Canyon above SR-502, Los Alamos Canyon near the Otowi Bridge, Sandia Canyon above SR-4, Pajarito Canyon below SR-501, Pajarito Canyon above SR-4, and Water Canyon below SR-4.

3. Sediments associated with these surface waters may also be contaminated with radionuclides associated with Laboratory operations. Any contact with these sediments by members of the public would most likely occur through recreational activities that could cause dry sediments to become airborne. The most likely exposure pathways would therefore include inhalation and ingestion of airborne sediments. Direct radiation from these sediments could also be another exposure pathway.

4. The concentrations of radionuclides in surface waters and sediments should be compared to the drinking water and soil screening thresholds in section A7 of MAQ-DOSE, respectively, as described below. Other screening thresholds may also be appropriate, as described below. Concentrations in excess of these screening levels are considered “detects” should be further investigated with the WSP.

7.8.2 Steps to Calculate Dose from Surface Water

FTM

1. Obtain from the WSP, either the draft or final version of Table S6-1 which contains surface water radionuclide concentrations of samples taken from various sources throughout the calendar year.

NOTE:

Surface water samples may either be filtered or unfiltered depending on the source of the sample. If there is a choice between using filtered or unfiltered sample results from the same source, it would be conservative to use the unfiltered results as most of the radioactivity would be contained in the suspended sediments.

2. For those surface waters identified by the WSP as having the potential for contact by members of the public, perform a radionuclide-by-radionuclide screen for each field sample taken from these waters against the drinking water screening thresholds in section A7 of

MAQ-DOSE and other applicable thresholds (e.g., 15 pCi/L for gross alpha sample measurements, 40 pCi/L for gross beta sample measurements, DOE DCGs, DOE BCGs).

3. If the concentrations do not exceed the thresholds, then no further action is required and it can be assumed that no member of the public would receive greater than 0.1 mrem from ingestion of surface waters.

4. For multiple radionuclides in a single sample, it would be appropriate to use the "sum of fractions" approach to ensure the 0.1 mrem/year screening threshold has not been exceeded for the combination of these radionuclides.

5. If the concentration exceeds the MAQ-DOSE screening level and is considered a "detect," modify the sample concentration to take into account the amount of time the surface water is present during the year and the quantity of water that could be ingested given the unsuitability of the water for drinking purposes.

   Each particular surface water will have its own unique annual time-weighted flow fraction, i.e., annual time-weighted fraction that water was flowing in the particular stream channel, arroyo, etc. These fractions are obtained from the WSP each year and may range from < 0.l to 1.0. Also, because these surface waters are turbid and sediment-laden, it is assumed that only 10% of water ingested per year is from this source, i.e., only 73 liters ingested rather than the standard 730 liters ingested.

   For example, if the Pu-239 concentration of a water sample taken from a surface water source is 10.9 pCi/L and the annual time-weighted flow fraction is 0.82, the modified concentration would be 0.9 pCi/L, i.e., 10.9 pCi/L * 0.82 *0.1 = 0.9 pCi/L. Because the drinking water screening threshold for transuranics is 0.03 pCi/L, a dose assessment would be appropriate and the dose assessor should proceed to step 6. Otherwise, if the modified concentration is below the screening threshold, a dose assessment is not required and it may be assumed that no member of the public would receive greater than 0.1 mrem from ingesting water from this source. Again, a "sum of the fractions" approach would be appropriate for a sample with multiple radionuclides detected.

6. If a dose calculation is warranted, use the following formula:

$$D_r = WC_r * DF_r * 2.70 \times 10^5 * f$$

   Where:

   D_r = water ingestion dose in mrem from radionuclide, r (mrem).

   WC_r = concentration in water of radionuclide, r, above the regional concentration (pCi/L) determined from samples taken at the regional stations. This, of course, will require the subtraction of the regional level for the radionuclide of interest, r, (in many cases, these are "non-detects") from the measured concentration of the same radionuclide, r, in the surface water sample(s).

   DF_r = ingestion dose conversion factor for radionuclide, r (Sv/Bq) taken from Table 2.2 of

EPA 1988. Use the most conservative (largest) ingestion effective dose conversion factor ("effective" extreme right-hand column) of those listed for each radionuclide. Alternatively, ICRP 72 age-specific ingestion dose conversion factors may be used with age-appropriate ingestion rates.

2.70×10^5 = a unit conversion factor (mrem Bq L Sv-1 pCi-1) that incorporates an annual water ingestion rate of *73* liters, considered a conservative ingestion rate for water containing sediments

f = annual time-weighted fraction that water was flowing in the particular stream channel, arroyo, etc.

Example calculation:

- EPA 1988 dose factor is 9.56×10^{-7} Sv/Bq for ^{239}Pu
- Pueblo Canyon water sample result for ^{239}Pu is 10.9 pCi/L (assume regional station concentration is a "non-detect")
- f = 0.85
- Calculated dose from ^{239}Pu = 10.9 pCi/L * 9.56×10^{-7} Sv/Bq * 2.70×10^5 mrem Bq L Sv^{-1} pCi^{-1} * 0.85 = 2.39 mrem

7. If multiple samples are available for a sampling location throughout the year, the radionuclide concentration used to calculate dose should be the background-corrected mean of these samples. In addition, if multiple samples are available, the standard deviation of these concentrations should also be determined and converted to dose

8. Sum the doses from all radionuclides present in the surface water sample (i.e., $\sum_r D_r$) as calculated in the steps above to calculate the LANL contribution to the total annual surface water ingestion dose. The standard deviation of this dose should also be determined and reported for all radionuclides present by using the square root of the sum of the squares method. There is no specific dose limit associated with the ingestion of surface water that is not recognized as a drinking water source.

9. If this is the only pathway being analyzed, compare the calculated dose to the single pathway dose guideline of 25 mrem/year.

7.8.3 Steps to Calculate Dose from Sediment

FTM

1. Obtain from the WSP, either the draft or final version of Table S6-8 (for tritium results only) and Table S6-9, which contains sediment "above background" radionuclide concentrations of samples taken from various sources throughout the calendar year. Table S6-9 lists those sediment concentrations greater than river or reservoir sediment background levels.

2. For those sediments identified by the WSP as having the potential for contact by members of the public perform a radionuclide-by-radionuclide screen for each field sample taken against

the soil screening thresholds in section A7 of MAQ-DOSE. If the concentration for a specific radionuclide does not exceed its screening threshold, then no further action is required and it can be assumed that no member of the public would receive greater than 0.1 mrem from contact with these sediments. If multiple radionuclides are present in the sediment sample, a "sum of the fractions" approach is recommended.

Examples of sediments identified by the WSP as having the potential for contact by members of the public: Rio Grande River near Frijoles (White Rock Canyon), Guaje Canyon at SR-4, Los Alamos Canyon below the ice rink, DP Canyon above TA-21, Los Alamos Canyon above SR-4, Los Alamos Canyon below the LA weir, Pueblo Canyon above Acid Canyon, Acid Canyon above Pueblo Canyon, Pueblo Canyon above SR-502, Los Alamos Canyon near the Otowi Bridge, Sandia Canyon above SR-4, Pajarito Canyon below SR-501, Pajarito Canyon above SR-4, and Water Canyon below SR-4.

3. If the concentration(s) exceeds the screening level and is considered a "detect," a RESRAD dose calculation will be required for that sediment sample using the recreational (trail) user parameters described in LA-UR-4084, "Standard Human Health Risk Assessment Scenarios," in the section "Estimation of Radionuclide Dose" and Table 22.

4. As the surface water ingestion dose has already been calculated above, only the external gamma, soil inhalation, and soil ingestion pathways need to be considered. Consult with appropriate SMEs in WES-EDA and the WSP to ensure appropriate RESRAD parameters have been selected for the sediment dose calculation.

5. Correct sample concentrations for regional background levels.

    a. For onsite samples it is appropriate to subtract the radionuclide-specific "ER Canyon Sediment Background" value in Table S6-9 from the sample value. For offsite river samples it is appropriate to subtract the radionuclide-specific "River Sediment Background" value in Table S6-9 from the sample value.

    b. If multiple samples are available for a single sampling location, the RESRAD calculation should be based on the mean of the background-corrected radionuclide concentrations for that sampling location.

6. The standard deviation for these multiple samples should also be calculated and converted to a dose using RESRAD.

7. The standard deviation dose for all radionuclides detected should also be calculated for multiple samples using the square root of the sum of the squares method.

NOTE:

Instead of performing specific RESRAD runs, it is acceptable to use the recreational scenario soil concentrations in Attachment 1, Soil Contamination Guidelines for 15 mRem/Year," of RRES-MAQ-513 as a starting point for performing the dose calculations.

The soil concentrations in this attachment were developed using a RESRAD recreational exposure scenario and default and site-specific parameters. As the value in the recreational column is the soil concentration that will deliver 15 mrem in a year, just take the ratio of the background-corrected mean and standard deviation sediment concentrations per radionuclide to the concentration in the table and multiply by 15 to obtain the annual mean and standard deviation doses in mrem per radionuclide.

8. If this is the only pathway being analyzed, compare the calculated dose to the single pathway dose guideline of 25 mrem/year.

7.9 Calculating Other Ingestion Doses

FTM

1. Doses for consumption of piñon nuts, honey, steer, deer, elk, fish, milk, eggs, and tea follow similar steps as above for produce, Section 7.5.2.

2. Sample spreadsheets that were used to calculate doses for the 2000 ESR may be viewed (and copied) electronically from the Ingestion Doses folder in the ESR Dose Calculations folder on the Pueblo Er5 drive.

3. It is appropriate to subtract an appropriate background value from the concentration measured in the foodstuffs to allow for background subtraction. Specifically for fish, samples are caught upstream of the Laboratory (e.g., Abiquiu Reservoir) and downstream of the Laboratory (e.g., Cochiti Reservoir). It would therefore be appropriate to subtract the mean concentration of a radionuclide detected in fish caught in Abiquiu Reservoir from the mean concentration of the same radionuclide detected in fish caught in Cochiti Reservoir to allow for the calculation of dose from only those radionuclides attributable to Laboratory operations (assuming a waterborne pathway only).

7.10 Calculating Dose From Soils Pathway

NOTES:

1. There are generally three ways to determine if the concentration of a radionuclide in soil is real and attributable to Laboratory operations. Any of these approaches may be used to determine if a dose calculation is warranted:

1. Comparison to the threshold values presented in section A7 of MAQ-DOSE
2. Determination if the measured concentration is real, i.e., a true "detect".
3. Comparison to RSRL values.

If the measured media concentrations do not exceed the appropriate screening levels (taking into account caveats noted in Section 2.0, step 5), a dose calculation is not required.

For multiple radionuclides, a "sum of the fractions" approach is recommended to ensure that the entirety of radionuclides detected in a sample would not result in a dose higher than 0.1 mrem.

A "detect" concentration is generally presumed to be a value ≥ the analytical method detection limit (MDL) ***and*** three times (3X) the uncertainty for the value reported. If a measured concentration in a sample does not exceed the RSRL value, it may be assumed that the concentration of the radionuclide in the sample is not attributable to Laboratory operations.

2. Soils are collected by the Soils, Foodstuffs, and Biota (SFB) Project in the vicinity and in regional locations and analyzed for radionuclides. The soil analysis data will typically be in the form of dry concentrations in pCi/g (except for HTO) for each radionuclide detected in the sample for the collection of sites that make up the "Regional Background Stations" and "Perimeter Stations."

3. Soil samples for Los Alamos and White Rock locations are only obtained and analyzed every three years. Therefore, these data will not always be available for dose determinations and reporting in the ESR.

FTM

1. Obtain soil analysis data from the SFB Project or ESR Chapter 7 tables and include the data in the records file.

2. Determine the gross mean ($C_{\mu r\ gross}$) and standard deviation ($C_{\sigma r\ gross}$) soil concentrations for each radionuclide, r, for locations of interest, e.g., Los Alamos, White Rock, San Ildefonso Pueblo, and other perimeter stations, and the collection of sites that make up the regional background stations.

   In most cases, this will have already been performed by the SFB Project. (A mean, a standard deviation, and RSRL will most likely be provided for each radionuclide, r, detected for the collection of sites that make up the "Regional Background Stations." A mean and standard deviation will most likely be provided for each radionuclide detected for the collection of sites that make up a perimeter station.)

Do not select locations on LANL property that are not representative of public areas. In certain situations, only one sample may be available at the location of interest. In this case, the mean and standard deviation for a sample population cannot be calculated, but the counting uncertainty for the single sample may be propagated through the calculations below to determine an overall dose uncertainty.

3. Determine net, mean soil concentrations, $C_{\mu r\ net}$, for each location of interest for each radionuclide, r, by subtracting background soil concentrations available from the SFB Project from the gross mean concentrations, $C_{\mu r\ gross}$.

$$C_{\mu r\ net} = C_{\mu r\ gross} - C_{\mu r\ Bkgd}$$

NOTE:

If the radionuclides of concern are from fallout (Pu-238, Pu-239/240, Am-241, Sr-90, and Cs-137), you may optionally multiply the background soil concentrations by the ratio of the annual rainfall in Los Alamos or White Rock to the annual rainfall of the location where the background samples were taken. Typically, this ratio will be about a factor of 2. The rainfall information may be obtained from the Meteorology Project of WES-EDA.

4. Determine the 1σ of the net soil concentration, $C_{\sigma r\ net,}$ for each radionuclide, r, by taking the square root of the sum of the squares of the standard deviations of the gross (at a location of interest) and the background concentration for that radionuclide, $C_{\sigma r\ gross}$ and $C_{\sigma r\ Bkgd}$, respectively:

$$C_{\sigma r\ net} = \sqrt{[(C_{\sigma r\ gross})^2 + (C_{\sigma r\ Bkgd})^2]}$$

5. If the result is significant (i.e., above RSRLs and/or screening action levels [SALs]), perform RESRAD runs. Include direct exposure to, inhalation of, and ingestion of contaminated soil pathways, as appropriate.

6. Check the table in past ESRs for values that have been used in past RESRAD calculations.

7. Do not include plant or drinking water ingestion pathways, as they are included elsewhere.

8. Document the choice of input parameters. Perform runs for the net mean ($C_{\mu r\ net}$) and 1σ of the net mean value ($C_{\sigma r\ net}$) for each radionuclide to obtain $D_{\mu r\ net}$ and $D_{\sigma r\ net}$. The dose to be reported is listed as **"0Maximum TDOSE (t): [actual dose result] mrem/yr"** in the RESRAD results printout.

Note:

Instead of performing specific RESRAD runs, it is acceptable to use the recreational scenario soil concentrations in Attachment 1, Soil Contamination Guidelines for 15 mRem/Year," of RRES-MAQ-513 as a starting point for performing the dose calculations. The soil concentrations in this attachment were developed using a RESRAD recreational exposure scenario and default and site-specific parameters. As the value in the recreational column is the soil concentration that will deliver 15 mrem in a year, just take the ratio of the mean and standard deviation/counting uncertainty dry soil concentrations per radionuclide to the concentration in the table and multiply by 15 to obtain the annual mean and standard deviation/counting uncertainty doses in mrem per radionuclide.

9. Sum across all radionuclides to obtain the total mean dose ($D_{\mu\ net} = \sum_r D_{\mu r\ net}$) and propagate either the standard deviation or counting uncertainty dose per radionuclide to obtain the standard deviation or counting uncertainty dose for all radionuclides. (i.e., square root of the sum of the squares of each radionuclide-specific standard deviation or counting uncertainty dose), e.g., $D_{\sigma\ net} = \sqrt{[(D_{\sigma r1\ net})^2 + (D_{\sigma r2\ net})^2 + (D_{\sigma r2\ net})^2 + \ldots]}$.

10. Report both the mean and the 1σ dose (or counting uncertainty converted to dose) to show the spread or uncertainty in the soils exposure dose.

7.11 Calculating Special Scenario Doses

1. Laboratory operations have resulted in contamination of water, soil, and sediments, generally in canyon bottoms. Some of these areas are publicly accessible. Visitors of these areas can incur doses by several pathways:

    1. Inhalation of radioactive materials exposed by wind or water erosion and suspended in air.
    2. Ingestion of contaminated soil, sediments, water, or food products grown in contaminated soils or with contaminated water.
    3. Direct radiation exposure to gamma emitters in soil, sediment, or water.

    As contaminated areas are identified, an evaluation may be needed to assess the significance of potential public exposures. These calculations cannot easily be converted to procedures because of the wide variability in source configurations and exposure scenarios.

2. In general, according to DOE orders and guidance, we should develop as realistic scenarios and doses as possible. To develop realistic exposure estimates, modeling may be the best choice. Computer models such as RESRAD have provisions to perform this type of modeling. However, the results of these models are directly dependent on the exposure parameters and scenario that are input. Reliance on default parameters may provide very conservative results.

    If modeling is used, it will be necessary to assess which potential exposure scenarios are important and realistic. Alternatives to modeling that should be considered are: make direct measurements with appropriate field instruments and then calculate a dose based on those measurements assuming a specific occupancy factor; calculate dose rates in an area based on soil sampling results and then assess potential exposures based on an assumed occupancy.

3. These dose calculations need not be performed each year. Rather, they are special case evaluations that will be performed as the need arises. Generally, the contamination in these areas is reasonably static and a calculation should remain valid until the presumed exposure scenario changes or until a new or changed contamination source is identified.

4. The results of the dose calculation may be reported in the ESR whether or not the exposures are significant. If a potentially significant dose is discovered, a further evaluation should be performed to assess contributions from other Lab sources.

7.12 Completing EXCEL Spreadsheet Records

NOTE:

The EXCEL spreadsheet is a powerful tool for performing ESR dose calculations. Once an equation is developed for a certain type of dose calculation, the calculation may be repeated many times for different exposure scenarios. With the spreadsheet's inherent flexibility comes the potential for inadvertently changing the equation itself, fixed factors, or variables. It is important to preserve the integrity of a spreadsheet that has been used to calculate a dose for the ESR. The requirements listed below will help maintain the integrity of these spreadsheets.

1. Spreadsheet records shall be maintained as a protected file on either a read-only CD or on the Projects drive (preferably both)

2. All spreadsheets shall include:
   1. the appropriate title(s) for the workbook and worksheets
   2. appropriate units,
   3. an indication whether data has been background-corrected.

   There should also be some means of indicating revisions by date or revision number, preferably both.

3. All computer files, such as spreadsheets, generated or obtained as a result of performing this procedure shall be located on the Projects drive in a folder easily identifiable as the ESR dose calculation folder for the year in question. Within this folder should be folders specific to each pathway or project, e.g., AIRNET, DPRNET, soils, produce, for easy access to files.

7.13 Completing Attachment A

NOTE:

In order to ensure that all doses have been correctly calculated in accordance with this procedure and that all doses are correctly transferred into the ESR, Attachment A, Dose Calculation Peer Review Checklist, is provided at the end of this procedure and shall be used.

1. As each set of calculations are performed in accordance with this procedure, enter the appropriate dose into the field provided on the attachment. Once all doses have been calculated and entered onto the attachment, and the preparer checklist has been completed, route the completed attachment (signed and dated) to the technical reviewer along with any records generated, as specified in Section 8. Also, provide a draft of ESR, Chapter 3, to the technical reviewer.

2. The technical reviewer shall review the doses entered onto the attachment, the records provided with the attachment, and the draft Chapter 3 of the ESR. The technical reviewer shall ensure that the doses have been calculated in accordance with this procedure and have been correctly transferred into Chapter 3 of the ESR. It may be appropriate for the preparer to meet with the technical reviewer to describe the dose calculations and review the records with the technical reviewer. The technical reviewer shall complete the technical reviewer checklist, and sign and date the attachment and pass it on to the approver (typically the WES-EDA Group Leader).

3. The approver shall review the attachment to ensure that it has been correctly filled out and that all appropriate records are available for transfer to the records center. The approver shall then complete the approver checklist, sign and date the attachment, and return it to the preparer with any records provided for ultimate transfer to the records center.

8.0 RECORDS

FTM

1. The following records generated as a result of this procedure are to be submitted as records to the records coordinator **within 8 weeks** of submittal of the final ESR to DOE:
   - Draft EPA report tables (if provided as drafts by RAD-NESHAP Project) or final EPA report
   - AIRNET EXCEL spreadsheets, if provided
   - DPRNET EXCEL spreadsheets, if provided
   - Soils EXCEL spreadsheets, if provided
   - Foodstuffs EXCEL spreadsheets, if provided
   - Custom CAP88 reports
   - Draft AIRNET, DPRNET, surface water, ground water, soil, and foodstuffs ESR tables used as basis for calculations performed for this procedure, if provided
   - Printouts of output from model runs in RESRAD
   - Any other documentation (including spreadsheets) provided to dose evaluator in support of performing this procedure
   - Any other calculations, assumptions, or documentation (including spreadsheets)

	generated by dose evaluator as a result of performing this procedure.

9.0 PROCESS FLOW CHART

None.

10.0 REFERENCES

1. LA-UR-00-4084, Standard Human Health Risk Assessment Scenarios, 2000, Environmental Restoration Project

2. LA-UR-03-6493, Siting of Environmental Direct –Penetrating Radiation Dosimeters, 2003, M. McNaughton

3. LAU-UR-04-4122, Moisture Conversion Ratios for the Foodstuffs and (Nonfoodstuffs) Biota Environmental Surveillance Programs at Los Alamos National Laboratory, (most recent version), P.R. Frequez et al.

4. RRES-MAQ-DOSE, “Quality Assurance Project Plan for Environmental Dose Assessment”

5. RRES-MAQ-DPRNET, “Quality Assurance Project Plan for the Direct Penetrating Radiation Monitoring Network (DPRNET)”

6. EP-DIR-SOP-2011, “Personnel Training and Qualification”

7. RRES-MAQ-513, “Posting of Soil Contamination Areas”

8. EPA Exposure Factors Handbook, Konz et al, 1989

9. Annals of the ICRP (International Commission on Radiation Protection), Volume 26, ICRP Publication 72: Age-Dependent Doses To The Members Of The Public From Intake Of Radionuclides Part 5, Compilation Of Ingestion And Inhalation Coefficients, September 1996.

10. DOE/EH-0071, “Internal Dose Conversion Factors for Calculation of Dose to the Public,” DOE 1988

11. EPA-520/1-88-020, “Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion,” EPA 1988

12. 40 CFR, Part 61, Appendix E, Table 2, “Concentration Levels for Environmental Compliance”

13. Regulatory Guide 1.109, "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," Revision 1, Oct. 1977

Using a CRYPTOCard, click here to record "self-study" training to this procedure.

If you do not possess a CRYPTOCard or encounter problems, contact the EP training specialist.

11.0 ATTACHMENTS

Attachment A: Dose Calculation Peer Review Checklist,

Attachment 1

Dose Calculation Peer Review Checklist

Dose to the exposed population within 80 km of the Lab: ____________________ person-rem

Dose to the maximally exposed individual outside of Lab boundaries (referred to as the off-site MEI):
____________________ location
____________________ mrem

Dose to the maximally exposed member of the public within Lab boundaries (referred to as the on-site MEI) (optional): ______________________ location
______________________ mrem

Average doses to residents of Los Alamos and White Rock:
Los Alamos AIRNET dose: _______________ mrem
Los Alamos CAP88 dose: _______________ mrem
Total Los Alamos dose: _______________ mrem
White Rock AIRNET dose: _______________ mrem
White Rock CAP88 dose: _______________ mrem
Total White Rock dose: _______________ mrem

Doses from ingestion of produce at various locations in northern New Mexico:
Location: ____________ ___________ mrem
Location: ____________ ___________ mrem
Location: ____________ ___________ mrem

Doses from ingestion of drinking water:
Source: ______________ _______________ mrem
Source: ______________ _______________ mrem
Source: ______________ _______________ mrem

Doses from ingestion of surface waters and associated sediments:
Source: ______________ _______________ mrem
Source: ______________ _______________ mrem
Source: ______________ _______________ mrem

Doses from the soils pathway: ___________________ mrem

Location: ____________ ___________ mrem
Location: ____________ ___________ mrem
Location: ____________ ___________ mrem

Special scenario doses, including doses from exposure to contaminated material:
Scenario: ____________ ___________ mrem
Scenario: ____________ ___________ mrem
Scenario: ____________ ___________ mrem

Preparer Review Checklist:

Scenario parameters correct? Y/N

Radionuclides correct? Y/N

Concentrations or activities correct? Y/N

Dose conversion factors correct? Y/N

Receptor locations correct? Y/N

Calculated doses correct? Y/N

Doses correctly entered into ESR? Y/N

ESR text correctly describes scenarios, radionuclides, concentrations or activities, and receptor locations? Y/N

Preparer: _________________________ _________________________ ____________
Print Name Signature Date

Technical Reviewer Checklist:

Scenario parameters correct? Y/N

Radionuclides correct? Y/N

Concentrations or activities correct? Y/N

Dose conversion factors correct? Y/N

Receptor locations correct? Y/N

Calculated doses correct? Y/N

Doses correctly entered into ESR? Y/N

ESR text correctly describes scenarios, radionuclides, concentrations or activities, and receptor locations? Y/N

Technical Reviewer: ____________________ ________________________ _____________
Print Name Signature Date

.____

Approver Checklist:

Technical Review signed and dated? Y/N

Documents/records OK to forward to records? Y/N

Other reviews or notes:

Approver: __________________________ _________________________ ____________
Print Name Signature Date