Fermilab	ES&H Section Procedures	
Procedure Number/Name ESH-RP-ERPP-04 – Environmental ALARA Program Plan		**Original Date:** 04/18/2022
Written by: Ben Russell	**Reviewed and Updated By:** Holly Hall	**Date:** 04/18/2022

Environmental ALARA Program Plan

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Revision History

Updated by	Description of Change	Revision Number	Revision Date
Ben Russell	Initial Release	0	04/18/2022

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Procedure

1.0 Introduction

The Fermi National Accelerator Laboratory's (FNAL or Fermilab) stated environmental policy is to protect the environment from radiation exposure and radioactive contamination in accordance with the ALARA principle. In keeping with this policy, Fermilab is committed to keeping radioactive emissions and external exposures as low as is reasonably achievable (ALARA). The Fermilab Environmental ALARA Program was developed and implemented to systematically verify and document that potential radiological exposures to members of the public are ALARA, in accordance with the U.S. Department of Energy (DOE) Order 458.1, *Radiation Protection of the Public and the Environment, Contractor Requirements Document*. Implementation of the Contractor Requirements Document is established in Fermilab's Environmental Radiological Protection Program (ERPP).

2.0 Scope

Doses to the public from effluents, emissions, and residual radioactive material must be maintained as low as reasonably achievable (ALARA) below the primary dose limits. Under DOE O 458.1 a documented ALARA process must be implemented to optimize control and management of radiological activities so that doses to members of the public (individual and collective, on site and off site) and releases to the environment are kept ALARA. The ALARA process must be applied to DOE activities and the design or modification of facilities that expose the public or the environment, no matter how small the dose. In all cases, the scope and detail of the ALARA analysis should be commensurate with the potential benefit of the dose reduction.

3.0 Definitions

ALARA - Means "As Low As is Reasonably Achievable," which is an approach to radiation protection to manage and control releases of radioactive material to the environment, and exposure to the work force and to members of the public so that the levels are as low as reasonable, taking into account societal, environmental, technical, economic, and public policy considerations. As used in DOE O 458.1, ALARA is not a specific release or dose limit but a process that has the goal of optimizing control and management of release of radioactive material to the environment and doses so that they are as far below the applicable limits of the Order as reasonably achievable. ALARA optimizes radiation protection.

ALARA Process – Means a graded process for evaluating alternative operations, processes, and other measures, for optimizing releases of radioactive material to the environment, and exposure to the work force and to members of the public taking into account societal, environmental, technical, economic, and public policy considerations to make a decision concerning the optimum level of public health and environmental protection. A graded approach provides the flexibility to perform qualitative or quantitative ALARA analyses. For low doses, qualitative evaluations normally will suffice.

ALARA Program – Refers to the set of design specifications, operating procedures, techniques, monitoring and surveillance programs, records, instructions, and other elements that have been used to implement the ALARA process.

Potential Impact Category - A ranking classification of potential radiological impact, based on factors such as potential effective dose. It is used to implement a graded approach to sampling and monitoring. The potential for impact is based on facility source characteristics, assuming loss of containment of radioactive materials that would otherwise be released to the effluent stream under consideration.

4.0 Responsibilities

4.1 The Senior Radiation Safety Officer
Has overall responsibility for programs with radiological impacts to the public and environment due to Fermilab operations. The SRSO works with the Radiation Safety Subcommittee to oversee facility and worker ALARA reviews.

4.2 The Radiation Physics Operations Department Head
Responsible for general oversight of the ALARA program. The RPO Department Head also ensures that any necessary reports are generated and disseminated, and that staff in appropriate disciplines are available to support ALARA analyses and evaluations.

4.3 Radiation Safety Officers (RSOs)
Authorize work with radioactive materials and radiation-producing devices through the use of ESH-RPO-WPC-03, Design ALARA Review Process. They also perform and review ALARA plans through the use of ESH-RPO-WPC-02, Formal Job ALARA Review Process. Analyses and information gathered by these staff members are used to assist the Environmental Radiological Protection Program (ERPP) Manager in performing environmental ALARA evaluations.

4.4 Environmental Radiological Protection Program (ERPP) Manager
Responsible for managing the Environmental ALARA Program, which includes the following activities:

- Interfacing with the Radiation Physics (RP) and Environmental Protection (EP) Departments to determine environmental emissions, source inventories, and external radiation requirements.
- Identifying and evaluating site activities that have the potential for radiological impacts on the environment and the public.
- Maintaining this plan and implementing its procedures.
- Coordinating RP and EP monitoring programs to ensure appropriate monitoring is in place from an environmental ALARA standpoint.
- Establishing and maintaining records of environmental ALARA activities as directed by DOE O 458.1 and 40 CFR 61.

4.5 National Emission Standards for Hazardous Air Pollutants (NESHAP) Radiation Physicist
Radiation Physicist responsible for calculating and reporting dose through the NESHAP process. This individual may be the same as the ERPP Manager.

5.0 Environmental ALARA Process Overview

This section describes the steps taken to implement the environmental ALARA policy, as follows (DOE, 2014):

5.1 The RSO and ERPP Manager should identify site activities with the potential for environmental radiological impacts. Avenues to consider include:

- The Environmental Review Form
- Shielding Assessments
- Unreviewed Safety Issue Determinations (USIDs)
- Facilities Engineering Services Section (FESS) Comment and Compliance
- eJULIEs
- IMPACT/electronic Worklist
- FESS' FAMIS – Fermi's Computerized Maintenance Management System
- FESS Design Review Form
- Job Plans and Radiological Work Permits
- Verbal/email requests for work
- Other forms not included in this list.

5.2 Review radiological impacts of a proposed activity by estimating the dose to the Maximally Exposed Individual (MEI) and the collective population using the methods described in ESH-RP-ERPP-03. The MEI may be located onsite or offsite.

5.3 Perform qualitative ALARA analyses when the dose to the MEI from the proposed activity is less than 1.0 mrem in a year or the collective dose is less than 10 person-rem in a year to determine whether further ALARA analyses are required.

5.4 Perform semi-quantitative ALARA analyses when the dose to the MEI from the proposed activity equals or exceeds 1.0 mrem but is less than 10 mrem or the collective dose begins to approach or exceeds 10 person-rem but is less than 100 person-rem in a year to determine whether further ALARA analyses are required.

5.5 Perform quantitative ALARA analyses when individual dose to the MEI from the proposed activity begins to approach or exceeds 10 mrem in a year or if the collective dose exceeds 100 person-rem in a year.

NOTE: It is recognized that this trigger differs from the DOE-HDBK-1214-2014 recommendation for quantitative ALARA analyses when this threshold is met from all sources/all pathways; however, because of conservative assumptions from the MEI from onsite activities, Fermilab will perform quantitative ALARA reviews when this threshold is met for new activities.

Table 5.1. General Guidance for Determining the Level of ALARA Analysis Required

Analysis	Maximum Exposed Individual (mrem in a year)	Collective-Dose (person-rem in a year)
Qualitative	< 1.0	< 10
Semi-Quantitative	≥ 1.0 to < 10	≥ 10 to < 100
Quantitative	≥ 10	≥ 100

6.0 Details of the Environmental ALARA process

6.1 Identify Potential Radiological Impacts

Through design ALARA reviews, each new facility or operation using radiological materials or penetrating radiation generating devices is subjected to reviews before radiation work begins to ensure that radiation exposures to workers, the public, and the environment are

ALARA. Through the FRCM Chapter 3 work authorization programs, worker ALARA reviews are conducted for all operations, practices, and procedures that have potential for high individual or collective dose to workers. To the extent practicable and when appropriate, the environmental ALARA process is coordinated with that of the occupational ALARA Process ESH-RPO-WPC-02, Formal Job ALARA Review Process, and ESH-RPO-WPC-03, Design ALARA Review Process, as outlined in FRCM Chapter 3. Facility and worker reviews culminate in reports such as safety analysis documents (i.e., Safety Assessment Document (SAD) chapters, Shielding Assessments, NEPA Reviews, etc.), Work, Process, and Control (WPC) documents (i.e., Hazard Analyses (HAs), Radiological Work Permits (RWPs), etc.), and other such authorizations and permits.

These reports are used to identify activities that have potential for radiological environmental impacts that could require environmental ALARA analysis. If the activity would result in a potential dose to the maximally exposed offsite individual (MEOI) equal to or greater than 0.1 mrem in a year or when the NESHAP potential impact category increases, the NESHAP Radiation Physicist communicates the results of the authorization review to the Environmental Protection Department Head, the Radiation Physics Operations Department Head, the Senior Radiation Safety Officer, and to the principal investigator responsible for the authorized work. Appropriate technical assistance will be provided to the principal investigator to assist in reducing the public dose below the threshold for additional NESHAP monitoring requirements if feasible or implementing the additional monitoring.

Table 6.1. Graded Approach to Sampling and Monitoring

NESHAP Potential Impact Category from ANSI N13.1-2021	Monitoring and sample analysis procedures	Potential fraction of allowable limit (10 mrem)	Potential Dose to Maximally Exposed Offsite Individual (MEOI)
1	Continuous sampling for a record of emissions and in-line, real-time monitoring with alarm capability; consideration of separate accident monitoring system	> 0.5	> 5 mrem
2	Continuous sampling for record of emissions, with retrospective, off-line periodic analysis	> 0.01 and ≤ 0.5	> 0.1 mrem and ≤ 5 mrem
3	Periodic confirmatory sampling and off-line analysis	> 0.0001 and ≤ 0.01	> 0.001 mrem and ≤ 0.1 mrem

4	Annual administrative review of facility uses to confirm absence of radioactive materials in forms and quantities not con forming to prescribed specifications and limits	≤ 0.0001	≤ 0.001 mrem

6.1.1 Pre-Operational Monitoring

Prior to the startup of a new site, facility or process with the potential to expose the public or environment to radiation or radioactive material, it is necessary to ensure that adequate knowledge exists to understand: 1) radiological background; 2) pertinent environmental and ecological parameters; and 3) potential pathways for human exposures or ecological/natural resource impacts either from existing data or documents (for example, NEPA evaluations or existing monitoring and surveillance programs, etc.) or from the conduct of a pre-operational study initiated at least one year prior to startup of a new operation.

6.2 Review Radiological Impacts

The ERPP Manager is responsible for the following section with input and assistance from RP Department and the EP Department.

6.2.1 Reviews Fermilab's radiological environmental impacts using ESH-RP-ERPP-03 and summarizes the results annually in the Fermilab Annual Site Environmental Report (*ASER)*, which is available to employees and the public. Radiological impacts from Fermilab operations to the environment and the public are due primarily to accelerator operations and to air emissions. The Environmental ALARA Program uses the results from monitoring accelerator operations and air emissions, as well as from monitoring soil, sediment, surface water, groundwater, and sewer discharges, to assess the radiological impacts of Fermilab activities.

6.2.2 Determines environmental radiological impacts from penetrating radiation produced by accelerator operations using multiple methods:

- A network of passive area monitors (dosimeters) throughout the Fermilab site, both inside and outside, and in both publicly accessible and restricted areas, to monitor dose.
- A network of ion chambers (Chipmunks, Scarecrows, Foxes, Hippos, etc.) throughout the Fermilab site, both inside and outside, and in both publicly accessible and restricted areas, to monitor dose.
- Results of monitoring for muon dose from various beam lines.
- Estimates of skyshine from the proposed activity.

6.2.3 Monitors radionuclides in stack air emissions. For facilities where radionuclides are handled, the department measures or calculates stack emissions and resulting doses to the public and reports them annually in the *NESHAP Report*. Operations that have the potential to emit radionuclides to the environment that could result in an annual effective dose of 0.1 mrem or greater to the public are monitored using stack air sampling and analysis procedures that comply with the NESHAP (EPA, 1989).

6.2.4 Analyzes Fermilab's wastewater, soil, stream sediment, and creek water samples for radionuclides. The results of these analyses are used to confirm that the FNAL facility is in compliance with biota and public dose limits. The compliance evaluation is documented annually and summarized in the *ASER*.

6.2.5 When a new facility or operation is proposed with the potential for environmental impact, the ERPP Manager estimates the potential dose using the methods described in ESH-RP-ERPP-03 and assistance from RPS and RPO staff and other subject matter experts. Professional judgement should be applied, and it should be considered an iterative process if the initial estimate seems too high or too low. In many cases, reasonable estimates of the radionuclide source term, site-specific meteorology, and dose screening factors should provide a reasonable dose estimate that allows the level of analysis to be determined.

6.3 Perform Qualitative ALARA Analyses

6.3.1 Periodically throughout the year, radiological impacts of Fermilab operations are assessed when Fermilab reviews and approves all facility changes and work authorizations with potential exposures to the public or releases to the environment and determines potential individual doses to the public; i.e., the MEI or the collective public within 50 miles (80 km). The results of work authorization reviews are maintained in the Environmental Radiological Protection Program files.

6.3.2 If an activity has a potential dose to the MEI equal to or greater than 0.1 mrem in a year, 10 person-rem to the collective population, or when the NESHAP potential impact category increases, the results are communicated to the Radiation Physics Operations and Radiation Physics Science Department Heads and to the individual responsible for the authorized work (i.e., machine/system owner, job leader, supervisor, etc.). A review of potential strategies to reduce exposures from Fermilab activities is then conducted. All appropriate attributes or criteria of the strategies should be identified, described as low, medium, or high, and compared. The costs of mitigation strategies should be described similarly.

6.4 Perform Semi-Quantitative ALARA Analyses

If the total effective dose from a proposed activity to the MEI exceeds 1.0 mrem in a year or exceeds the collective dose of 10 person-rem in a year, then semi-quantitative analyses may be warranted. Semi-quantitative analysis combines the elements of both qualitative and quantitative analyses. This level of analysis considers more than the dose levels and involves reviewing alternative actions depending on their quantity, types, and complexities. This level of analysis is applicable when a qualitative analysis is insufficient to describe ALARA attributes and document the differences in the selected alternatives. In such a case, semi-quantitative analyses may be necessary. (DOE, 2014)

Perform this analysis by completing a multi-attribute and cost-benefit analysis; however, without the rigor of a quantitative analysis. The multi-attribute analysis follows a sliding scale to rank and score attributes based on the dose levels. Identify and characterize each attribute then weigh and score them. Finally, the attributes are compared to inform the decision-making process for selecting the most appropriate ones. For a cost-benefit analysis, the relative costs are appropriate for consideration thus avoiding extensive effort to accurately determine fiscal impacts. (DOE, 2014)

6.5 Perform Quantitative ALARA Analyses

If the total effective dose from a proposed activity to the MEI begins to approach or exceed 10 mrem in a year or if the collective dose exceeds 100 person-rem in a year then quantitative analyses may be warranted. However, other attributes should be considered when deciding to conduct a more rigorous evaluation, e.g., overall environmental performance, worker risk, cost, and resource utilization attributes. Additionally, if there are large number of non-health factors to evaluate then quantitative analysis may be important. Quantitatively determining the alternative with the greatest total radiation protection benefit is called optimization (DOE, 2014).

Quantitative ALARA analyses include societal, technological, economic, environmental, and public policy considerations. In addition, the ALARA analyses consider DOE guidance for performing the following environmental ALARA assessments (DOE, 2014):

- Identify and quantify the sources of radiation.
- Identifying possible candidate radiation protection systems, such as alternative operating methods or controls, which would reduce the exposures or doses. The options should range from the most rudimentary (base case) to the most technologically sophisticated systems.
- Quantifying exposures and doses to individuals and populations in the vicinity of the DOE activity for each candidate radiation protection system.
- Quantifying the economic factors, including the costs of purchasing, installing, operating, and maintaining the radiological protection system equipment, and the potential health effects associated with the exposure of people and any other direct or indirect cost resulting from exposures to radiation.

- Identifying and estimating the health risk and non-health detriments and benefits.
- Evaluating process alternatives using a quantitative cost-benefit analysis optimization, when possible. If evaluations include assumptions, judgments, and limitations that cannot be quantified, and potential doses are well below the dose limit, qualitative analyses can be used with full documentation.
- Selecting one or more of the candidate radiation protection systems.
- Implementing recommendations of the ALARA analysis and monitoring the results.

Additional information or analyses may be required in accordance with DOE guidance for performing environmental ALARA evaluations (DOE, 2014). Results of a quantitative ALARA analysis are provided to the individual responsible for the authorized work (i.e., machine/system owner, job leader, supervisor, etc.).

If the potential dose from a chosen ALARA alternative results in a NESHAP potential impact category 1 or 2 (both deemed major sources) potential dose, then the EPA Regional office will be notified (40 CRF 61.96). A Category 1 potential dose is greater than or equal to 5.0 mrem to the MEOI from all ambient air emissions while a Category 2 potential dose is greater than or equal to 0.1 mrem but less than 5.0 mrem in a year to the MEOI from all ambient air emissions. Such operations shall require the approval of the Senior Radiation Safety Officer and Chief Safety Officer and require the notification of the Fermi Site Office before they may begin.

6.6 Other Factors and Issues Related to the ALARA Process

When optimizing resource allocations for radiation protection additional factors should be considered. These factors are considered good ALARA practice as follows:

- Resource allocation can be evaluated based on a maximum dollar value that could be justified for health concerns.
- Evaluating the uncertainties in estimating collective dose which can be substantial.
- Reducing releases to the environment can increase dose to workers in the facilities.
- Evaluation of exposure time from brief exposures to a receptor's lifetime, and possibly beyond.
- Discounting cost when the health detriment that is being reduced is several hundreds or thousands of years in the future.
- Describing the perspective of the dose analysis by comparison of collective dose with background dose.
- Consideration for other applicable factors and criteria, for example, selection of remedial actions under Comprehensive Environmental Response, Compensation, and Liability Act regulations.

Additional information on each of these factors is found in DOE's ALARA guidance (DOE, 2014).

7.0 Training

An ERPP Manager is required to have the expertise to review and evaluate work authorizations for their application to the Environmental ALARA Program. In addition to having expertise in radiation physics,

the ERPP Manager must have knowledge of laboratory operations, radiological material handling, emission source characterization, radiation protection procedures, and dose modeling.

If semi-quantitative or quantitative ALARA analysis must be performed, a broad array of disciplines is required, including computer modeling, dose and risk assessment, environmental monitoring and surveillance, engineering, and environmental sciences. Since one or two individuals may not have all of the requisite expertise for quantitative ALARA evaluations, discipline specialists should be available to support the ERPP Manager.

8.0 Records

Records are kept demonstrating that sufficient information was assembled and considered to support ALARA decisions. In accordance with DOE Order 458.1, records of actions taken to implement the ALARA policy in regulating exposures to the environment and the public, such as cost-benefit analyses performed for quantitative ALARA assessments and other factors that were important to the ALARA decision-making process, must be retained (DOE, 2013). Qualitative, semi-quantitative, and quantitative environmental ALARA analysis records are filed by the Radiation Control Organization on Sharepoint and retained for 75 years. Radiological work authorization and permit files are kept by the Radiation Physics Operations Department.

9.0 References

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