CANADIAN STANDARDS ASSOCIATION

N288.4-10

Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills

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Preface

This is the second edition of CSA N288.4, *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills*. It supersedes the first edition, published in 1990 under the title *Guidelines for Radiological Monitoring of the Environment*. It is part of a series of Standards and Guidelines on environmental management for nuclear facilities.

The first edition of this Standard addressed only the monitoring of radioactive contaminants in the environment in pathways leading to human exposure. The scope of this edition has been expanded to explicitly include protection of the environment in conformance with the regulations under the *Nuclear Safety and Control Act*, which came into force on May 31, 2000. This edition addresses monitoring of radioactive and non-radioactive contaminants, physical stressors, potential biological effects, and pathways for both human and non-human biota. Although the first edition considered environmental monitoring only in areas outside the nuclear facility boundary, the inclusion of non-human biota in this edition necessitates consideration of monitoring within the facility boundary as well. Similar to the first edition, the design of the monitoring program in this edition is risk informed. It is assumed that a risk assessment such as an environmental risk assessment has been completed for the facility and the results can be used in the application of this Standard.

Users of this Standard are reminded that additional and site-specific requirements might be specified by federal, provincial, or municipal authorities. This Standard should not be considered as a replacement for the requirements contained in the *Nuclear Safety and Control Act* and its Regulations or other legislation, standards, or guides.

This Standard was prepared by the Subcommittee on Environmental Monitoring at Class I Nuclear Facilities and Uranium Mines and Mills, under the jurisdiction of the Technical Committee on Environmental Management for Nuclear Facilities and the Strategic Steering Committee, and has been formally approved by the Technical Committee.

May 2010

Notes:

(1) *Use of the singular does not exclude the plural (and vice versa) when the sense allows.*

(2) *Although the intended primary application of this Standard is stated in its Scope, it is important to note that it remains the responsibility of the users of the Standard to judge its suitability for their particular purpose.*

(3) *This publication was developed by consensus, which is defined by* CSA Policy governing standardization — Code of good practice for standardization *as "substantial agreement. Consensus implies much more than a simple majority, but not necessarily unanimity". It is consistent with this definition that a member may be included in the Technical Committee list and yet not be in full agreement with all clauses of this publication.*

(4) *CSA Standards are subject to periodic review, and suggestions for their improvement will be referred to the appropriate committee.*

(5) *All enquiries regarding this Standard, including requests for interpretation, should be addressed to Canadian Standards Association, 5060 Spectrum Way, Suite 100, Mississauga, Ontario, Canada L4W 5N6.*

Requests for interpretation should

(a) define the problem, making reference to the specific clause, and, where appropriate, include an illustrative sketch;

(b) provide an explanation of circumstances surrounding the actual field condition; and

(c) be phrased where possible to permit a specific "yes" or "no" answer.

Committee interpretations are processed in accordance with the CSA Directives and guidelines governing standardization *and are published in CSA's periodical* Info Update*, which is available on the CSA Web site at www.csa.ca.*

N288.4-10
Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills

0 Introduction

0.1 Background

0.1.1
Throughout the course of its lifecycle, a nuclear facility can
(a) release hazardous and/or nuclear substances to the surrounding environment; and
(b) impose physical stressors on the components of the surrounding environment.

0.1.2
Regulations require licensees to demonstrate, through performance assessments, monitoring, or other methods, that they have made adequate provision for the protection of the environment and human health and safety. Consequently, regulations can require licensees to perform a number of interrelated assessments/programs, which might include:
(a) an environmental risk assessment (ERA), which can be part of an environmental assessment (EA), or any other document that contains the required information;
(b) an environmental management system (EMS);
(c) an environmental monitoring program (EMP); and
(d) any other assessment and monitoring activity (e.g., entrainment, impingement, bird strikes, or temperature change).

Note: *See CNSC S-296 and G-296 for information on EMS programs.*

0.2 Environmental monitoring program

0.2.1
An EMP consists of a risk-informed set of integrated and documented activities to sample, measure, analyze, interpret, and report
(a) the concentration of hazardous and/or nuclear substances in environmental media to assess one or both of
    (i) exposure of receptors to those substances; and
    (ii) the potential effects on human health, safety, and the environment;
(b) the intensity of physical stressors and/or their potential effect on human health and the environment; and
(c) the physical, chemical, and biological parameters of the environment normally considered in design of the EMP.

0.2.2
An EMP is a program that can encompass many stages of the lifecycle of the facility from pre-development to post-decommissioning. The nature and extent of the program are likely to change throughout the lifecycle of the facility due to changes in data requirements or increased understanding of the potential effects of the facility or activity on the environment. Thus periodic reviews are needed to identify and act upon any changes that might have occurred (see Clause 5.3).

0.2.3
An EMP can include
(a) pathways monitoring (PM, see Clause 0.4);
(b) biological effects monitoring (BEM, see Clause 0.5); and
(c) supplementary studies (see Clause 0.6).

0.3 Conceptual models
Conceptual models (see Clause A.2.4) are invaluable in providing representations of the factors and elements to be considered in designing a monitoring program. These models can range from broad facility-wide models exhibiting generic project-environment interactions, to site-specific focused representations of specific contaminants and/or physical stressors and their environmental pathways to be considered for environmental monitoring. Conceptual models can be presented in tabular form, or schematic or diagrammatic form, as shown in the examples in Annex A. While generic conceptual models are available, a site-specific conceptual model usually developed during the course of an ERA should be used whenever possible.

0.4 Pathways monitoring
PM involves sampling and analyzing abiotic and biotic media that lie along the pathways connecting a source to a receptor to determine the concentration or level of a contaminant and/or physical stressor in that medium. These data, combined with environmental transfer parameters that describe the movement of contaminants or physical stressors through the environment, may be used to assess the exposure to the receptor. PM is based on conceptual environmental transfer models such as the one shown in Figure 1.
Note: *Examples of media that can be collected and analyzed during PM include*
(a) foodstuffs (consumed by humans);
(b) air;
(c) water;
(d) soil and sediment;
(e) vegetation consumed by herbivorous receptors; and
(f) tissues of prey animals consumed by carnivorous receptors.

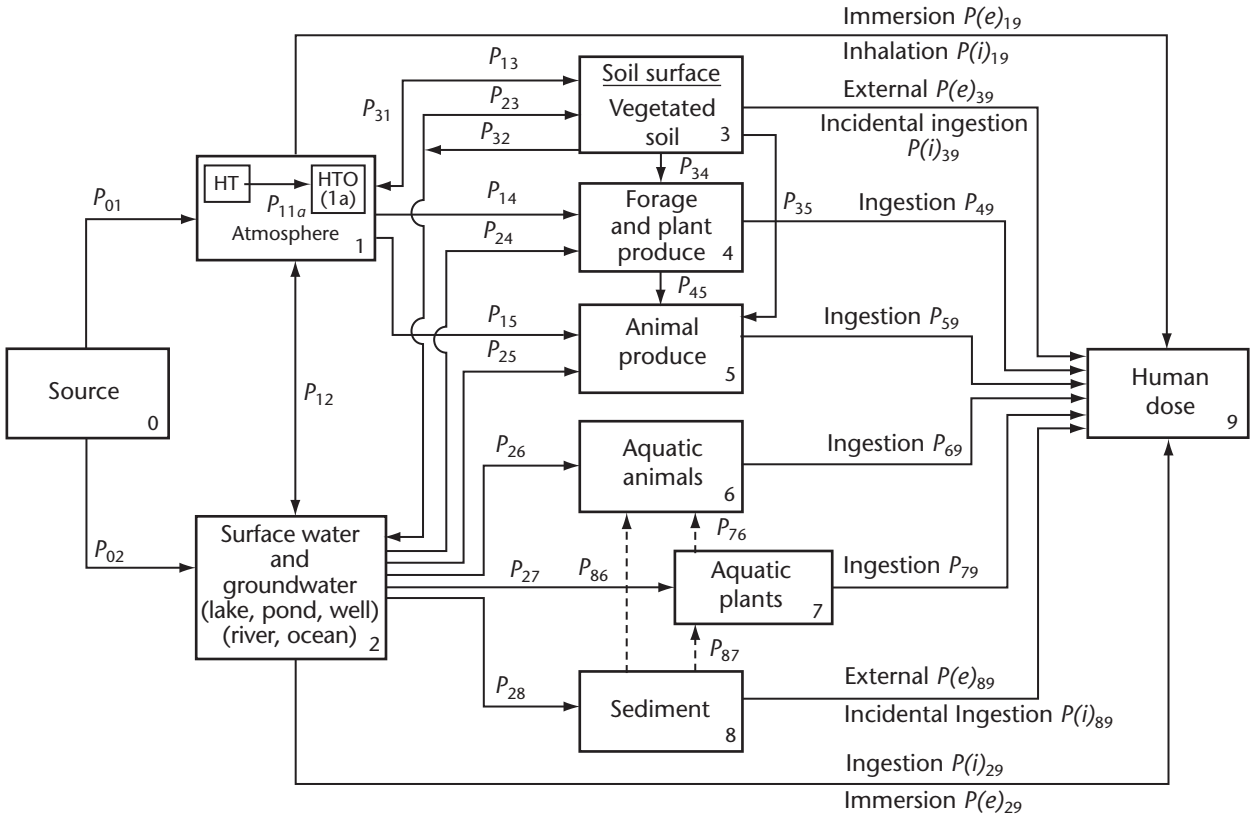
0.5 Biological effects monitoring
PM identifies the presence of a contaminant and/or physical stressor in environmental media (abiotic or biotic) and estimates exposure of a receptor. However, the objective of BEM for non-human biota is to monitor for biological responses that might be attributed to exposure to the contaminant and/or physical stressor(s) of interest. Responses at low levels of biological organization (cellular or molecular level) are often considered to be biomarkers of exposure. Responses at higher levels of biological organization (individual, population, or community) (Figure 2) are considered to be more relevant as indicators of biological effect. Responses at the lower level of biological organization occur rapidly, thereby providing early warning of potential future effects at higher levels of organization. Conversely, monitoring at the population or community level has the benefit of being highly ecologically relevant; however, detection of effects at this level provides little or no early warning, and recovery to the previous ecological state might not be possible even with mitigation. The specific level of biological organization selected for monitoring will depend on the objectives of the program and the trophic level or biota of interest. Most commonly, BEM programs focus on individual level indicators of potential population level effects (e.g., somatic or

reproductive indicators measured in individual organisms) for long-lived biota (e.g., fishes), or they focus on population or community-level indicators (e.g., abundance, number of taxa) for short-lived biota (e.g., invertebrates).

Note: *Examples of BEM include*

(a) fish surveys conducted by collecting fish in both the exposure area and a reference area and comparing measurements of length, weight, gonad size, liver size, fecundity, and egg size; and

(b) benthic macroinvertebrate community surveys conducted by collecting benthic macroinvertebrates in both the exposure area and a reference area and comparing benthic macroinvertebrate density, taxa richness, measures of biodiversity, or differences in community structure.



Notes:

(1) *Pij describes transfer from compartment i to compartment j; e.g., P_{13} describes transfer from atmosphere to soil.*

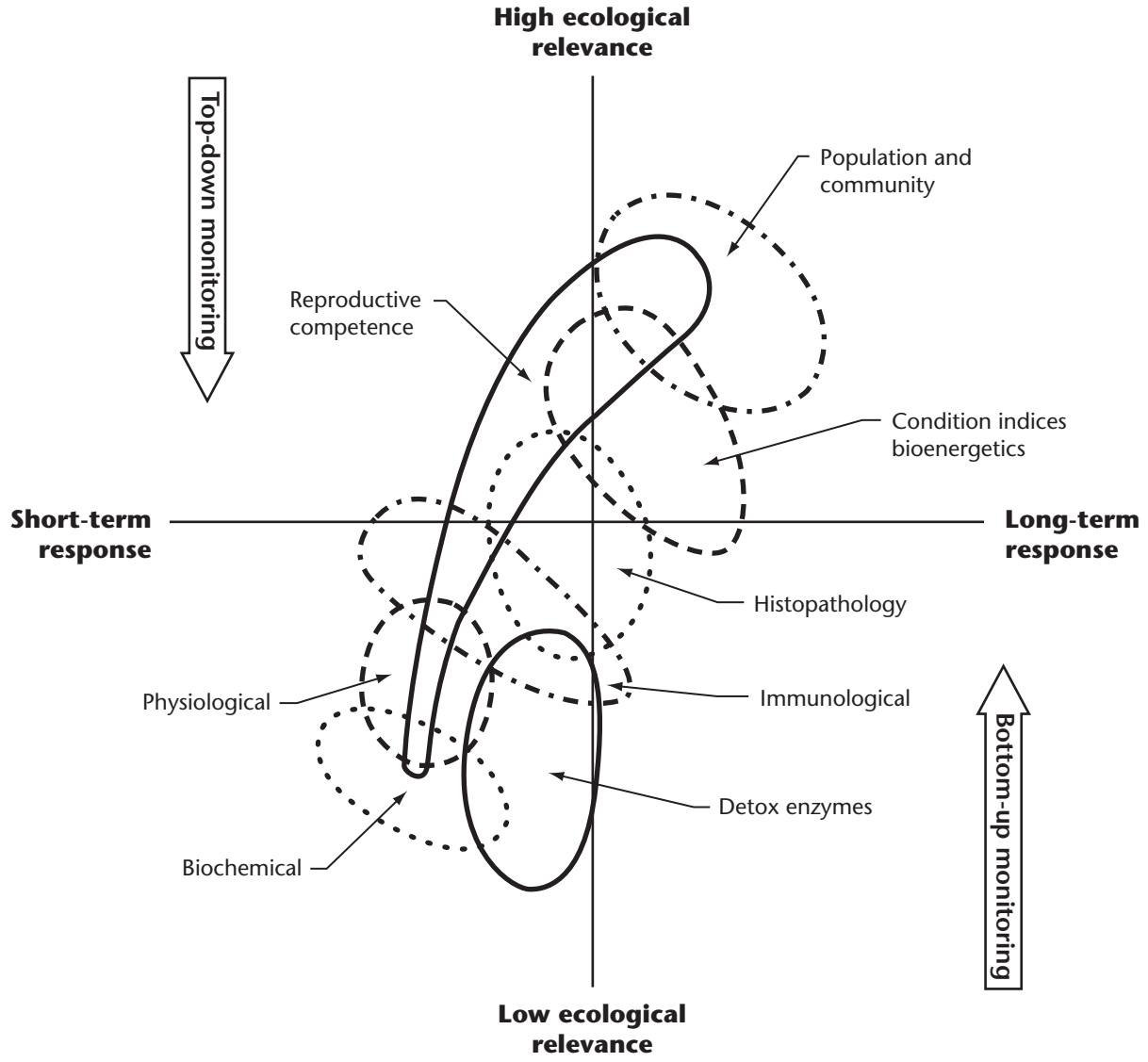
(2) *The broken lines represent pathways that are not explicitly considered in the model, or are considered only in special circumstances.*

(3) *Factors include multiple transfers where appropriate.*

(4) *This figure has been adapted from CSA N288.1.*

Figure 1
An example of an environmental transfer model

(See Clauses 0.4, 6.1.3, 6.1.4, 13.4, and A.2.4.)



Notes:

(1) *The figure is situated along gradients of response time to stressor exposure and potential ecological relevance of the effect.*

(2) *This figure has been adapted from Adams, 1990.*

Figure 2
Potential bioindicators for biological effects monitoring
(See Clause 0.5.)

0.6 Supplementary studies

0.6.1

Supplementary studies can occasionally be conducted to achieve specific, well-defined objectives such as

(a) providing the data required to reduce uncertainty and confounding factors in the risk assessment;
(b) increasing knowledge of the behaviour of contaminants and physical stressors in the environment (e.g., refining environmental transfer parameters);
(c) investigating specific EMP findings; and
(d) follow-up monitoring of mitigation activities implemented following an EA.

0.6.2
These studies become part of the EMP until the objective of the study has been achieved. At that time, the supplementary study would be terminated.

0.7 Relationship to ERA

0.7.1 ERA

0.7.1.1
The decision criteria for the scope and complexity of an EMP provided in this Standard require some understanding of the environmental risk posed by the facility. Consequently, this Standard assumes that an ERA of the nuclear facility has been completed and can be used for the design of the EMP.

0.7.1.2
ERA is a process for identifying potential adverse biological effects and for predicting the magnitude, probability, and significance of the identified effects associated with the nuclear facility. The ERA, or equivalent risk assessment, can be part of an EA, or any other document that contains the required information, and all references to an ERA in this Standard are to be understood as referring to any document that contains the required information. With respect to identifying monitoring requirements for normal operating conditions and reasonably foreseeable upset events, the ERA should
(a) identify and provide rationale for selecting the contaminants and physical stressors of concern;
(b) identify the sources or points of release of the contaminants and physical stressors of concern;
(c) identify the potential receptors (human and non-human biota) of concern;
(d) include a conceptual model of the environment linking sources to receptors;
(e) provide an assessment of the exposure to the contaminants and physical stressors of concern [to be used with the benchmark value (BV) to assess the risk];
(f) identify the BVs used to assess the potential effects of the contaminants and physical stressors of concern on the receptors;
(g) provide an assessment of the environmental risk posed by the facility; and
(h) identify and, if possible, quantify the uncertainties in the assessment of the environmental risk.

0.7.1.3
The ERA for the facility should include or identify the information required to address the decision criteria for the scope and complexity of an EMP provided in this Standard.

0.7.2 Components of an ERA

0.7.2.1
In this document, the term ERA refers to an assessment that considers both risks to humans and risks to non-human biota.

0.7.2.2
For humans, the ERA is intended to
(a) identify the risk of adverse health effects to individuals caused by the contaminants and/or physical stressors produced throughout the lifecycle of a nuclear facility; and
(b) quantify the likelihood of those effects.

0.7.2.3

For non-human biota, the ERA is intended to

(a) identify the risk of adverse biological effects to populations and/or communities caused by the contaminants and/or physical stressors produced throughout the lifecycle of a nuclear facility; and
(b) quantify the likelihood of those effects.

Note: *For further guidance on ERA, see Clause A.1.*

1 Scope

1.1 Facilities

1.1.1 Types of facilities

1.1.1.1

This Standard addresses the design and operation of EMPs for Class I nuclear facilities and uranium mines and mills. These facilities include

(a) nuclear reactors;
(b) uranium mines, mills, refineries, and conversion plants;
(c) uranium fuel fabrication plants;
(d) isotope-processing facilities;
(e) particle accelerators; and
(f) waste-management facilities.

1.1.1.2

Parts of this Standard could also be relevant to the design and operation of EMPs for

(a) Class II nuclear facilities;
(b) institutions operating under the authority of a nuclear substances and radiation devices licence; and
(c) facilities that use or store naturally occurring radioactive materials.

However, in these situations, the operator of the facility or institution is responsible for determining the applicability and suitability of the guidance.

The monitoring described in this Standard could also be applicable to low-level emissions of nuclear and hazardous substances released to the environment due to existing exposure situations such as those resulting from the contamination of areas with radioactive materials produced or used in past activities. However, in these cases, the operator of the facility is responsible for determining the applicability of the guidance.

1.1.2 Monitoring program boundary

This Standard addresses monitoring conducted in the environment within the spatial boundaries defined in the ERA. This monitoring starts beyond

(a) the final point of control for an airborne or waterborne release; or
(b) the facility boundary (which may be the outer wall or foundation of the building housing the licensed activity or the boundary of the protected area as defined in Section 9 of the Nuclear Security Regulations for nuclear facilities to which those Regulations apply).

The monitoring extends out to locations determined in the ERA by receptors and receptor range.

Notes:

(1) *This Standard does not address effluent monitoring, which involves the monitoring of the release of nuclear and hazardous substances to the environment.*

(2) *This Standard assumes that the exposure to nuclear substances or hazardous substances of persons working or visiting inside the facility boundary will be controlled through the facility radiation protection program, environmental protection program, or health and safety program.*

1.1.3 Facility lifecycle

The nature and extent of environmental monitoring requirements will change during the lifecycle of the facility. This Standard addresses monitoring performed during

(a) site preparation, construction, and commissioning;
(b) operations;
(c) decommissioning; and
(d) any period of institutional control that might follow closure of the facility.

Baseline monitoring occurs prior to the submission of an application for a licence to prepare a site. Data from baseline monitoring are generally used as an input into the ERA. This Standard does not address pre-licensing baseline monitoring. However, many of the recommendations and considerations provided within this Standard are applicable to environmental baseline activities. In addition, pre-licensing baseline data collection should place special emphasis on environmental factors and elements that might be carried forward to the EMP.

Note: *See CNSC RD-346 for more information on pre-licensing baseline monitoring.*

1.2 Operating conditions

The monitoring described in this Standard is applicable where human and/or non-human biota might routinely be exposed to

(a) low-level emissions of nuclear and hazardous substances released to the environment as the result of the normal operation of a nuclear facility; or
(b) physical stressors imposed on the environment as the result of the normal operation of a nuclear facility.

This Standard does not address acute or high-level exposures that can result from accident scenarios, although some parts of this Standard might be applicable to the monitoring of the long-term effect of such an event. In these cases, the operator of the facility is responsible for determining the applicability of the guidance.

1.3 Contaminants and physical stressors

This document provides guidance on monitoring for the contaminants and physical stressors in environmental media, as identified in the ERA and/or in the statutes, regulations, licenses, and permits that govern the operation of the facility. These contaminants and physical stressors can include one or more of the following:

(a) hazardous substances such as toxic, corrosive, or environmentally deleterious substances;
(b) nuclear substances and radiation; and
(c) physical stressors such as heat and noise.

1.4 Receptors and biological effects

1.4.1

This document provides guidance on designing an EMP that can

(a) measure direct biological effects on receptors; and
(b) provide the data necessary to assess potential biological effects on receptors.

Note: *Measurements of effects in non-human biota (measurement endpoints) can occur at the level of an individual organism, a population, or a community. Often measurement endpoints at the individual level are intended to represent the potential for higher level effects (assessment endpoints) that are of primary concern to environment managers.*

1.4.2

Receptors should be identified in the ERA and/or in the statutes, regulations, licences, and permits that govern the operation of the facility. The receptors can include human or non-human biota.

1.5 Interpretation of data

This Standard provides guidance on the interpretation of data collected by an EMP. However, users are cautioned that the statutes, regulations, licences, and permits that govern the operation of the nuclear facility can impose requirements regarding data analysis and interpretation that differ from those described in this Standard. The operator of the nuclear facility is responsible for determining what data analysis and interpretation are necessary to ensure compliance with the statutes, regulations, licences, or permits that govern the operation of the nuclear facility.

1.6 Dose assessment

Although one of the objectives of an EMP may be to provide the data required to support radiation dose assessments or assessments of exposure to non-radioactive hazardous substances, this document does not address dose assessment methods for either human or non-human biota.

Note: *Assessments of dose/exposure are normally part of the ERA and any subsequent assessments based on environmental monitoring data should be done the same way, using the same standards and guidance that were used in the ERA or their most recent updates. Monitoring to support dose assessment is further addressed in Clause 7.5.*

1.7 Reporting

This Standard provides guidance on reporting the results of an EMP. However, users are cautioned that the statutes, regulations, licences, and permits that govern the operation of the nuclear facility may impose reporting requirements that differ from those described in this Standard. The operator of the nuclear facility is responsible for determining the required frequency and content of reports to regulatory agencies necessary to ensure compliance with the statutes, regulations, licences, or permits that govern the operation of the nuclear facility.

1.8 Terminology

In CSA Standards, "shall" is used to express a requirement, i.e., a provision that the user is obliged to satisfy in order to comply with the standard; "should" is used to express a recommendation or that which is advised but not required; and "may" is used to express an option or that which is permissible within the limits of the standard.

Notes accompanying clauses do not include requirements or alternative requirements; the purpose of a note accompanying a clause is to separate from the text explanatory or informative material.

Notes to tables and figures are considered part of the table or figure and may be written as requirements.

Annexes are designated normative (mandatory) or informative (non-mandatory) to define their application.

2 Reference publications

This Standard refers to the following publications, and where such reference is made, it shall be to the editions listed below, including all amendments published thereto.

CSA (Canadian Standards Association)

N288.1-08
Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities

N292.3-08
Management of low- and intermediate-level radioactive waste

Z763-96 (R2006)
Introduction to environmental risk assessment studies