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Environmental Modeling of Remediation of Urban Contaminated Areas

Environmental Modeling for Radiation Safety Programme (EMRAS)

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DRAFT SAFETY REPORT

INTERNATIONAL

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VIENNA

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CONTRIBUTORS TO DRAFTING AND REVIEW OF THE DOCUMENT

1. INTRODUCTION

1.1. BACKGROUND

The general objectives of the IAEA's international programmes on radioecological modelling are to test the accuracy of model predictions, to improve models and specify their parameters, to provide a forum for exchange of ideas, experience and information, and to recommend priorities for future research. In keeping with these objectives, the EMRAS (Environmental Modelling for RAdiation Safety) programme has three major areas of interest: Theme 1, Radioactive Release Assessment; Theme 2, Remediation Assessment of Sites with Radioactive Residues; and Theme 3, Protection of the Environment. Theme 2 consists of two working groups, one designed to deal with modelling of naturally occurring radioactive materials (NORM) releases and of the remediation benefits for sites contaminated by extractive industries, and the other concerned with remediation assessment for urban areas contaminated with dispersed radionuclides. This report describes the activities of the Urban Remediation Working Group.

There are several types of events that could result in dispersal or deposition of radionuclides in an urban situation. These include both intentional and unintentional events, and releases could range from major events involving a nuclear facility or a nuclear weapon to small events such as a transportation accident. The extent of the contamination and impact on the environment would depend greatly on the specific event and the radionuclides involved. However, many aspects of assessing and remediating the situation will be the same or similar regardless of the spatial scale and specific radionuclides involved.

The intent of the Urban Remediation Working Group is to compare and test approaches and models to describe the behavior of radionuclides in an urban setting. The Working Group has sought to develop realistic scenarios for use in comparing and testing modelling approaches and models. Major issues that must be considered include a high density of buildings, relative lack of importance of agricultural issues, disposal of contaminated debris or water as a result of remediation measures, high potential for resuspension due to vehicular traffic, and movement of contamination within and outside the initial area of contamination due to human, vehicular or other means.

1.2. OBJECTIVES

The primary objective of the Urban Remediation Working Group is to test and improve the prediction of dose rates and cumulative doses to humans for urban areas contaminated with dispersed radionuclides, including (1) prediction of changes in radionuclide concentrations or dose rates as a function of location and time, (2) identification of the most important pathways for human exposure, and (3) prediction of the reduction in radionuclide concentrations, dose rates, or doses expected to result from various countermeasures or remediation efforts. Specific objectives include (1) the identification of realistic scenarios for a wide variety of situations, (2) comparison and testing of approaches and models for assessing the significance of a given contamination event and for guiding decisions about countermeasures or remediation measures implemented to reduce doses to humans or to clean up the contaminated area, and (3) improving the understanding of processes and situations that affect the spread of contamination (e.g., fire, high winds, runoff, uncontrolled access and egress) to aid in the development of appropriate models and parameter values for use in assessment of these situations. The Working Group's report is intended to describe what models are currently available and in what situations they might be

useful, and to assist in the development of tools to be used for assessing the radiological impact (in terms of dose rates and doses) of a situation, for determining when remediation is required, and for evaluating proposed remediation measures in terms of the expected reduction of dose rates and doses.

1.3. SCOPE

The major activities of the Working Group have included three areas. The first of these is a review of the available modelling approaches and computer models for use in assessing urban contamination and potential countermeasures or remediation activities. The second area of work is a modelling exercise based on data obtained in Ukraine following the Chernobyl accident. This exercise provides an opportunity to model large-scale contamination events such as the result of a nuclear accident. The exercise is designed to permit intercomparison of model results from different participants as well as, for some endpoints, comparison of model results with actual measurements. The third area is a modelling exercise based on a hypothetical situation involving a point-release of a radionuclide in an urban situation, specifically a release resulting from a radiological dispersal device involving an explosion. This exercise is intended to provide an opportunity for intercomparison of model results among participants. For both modelling exercises, the intent is to model the radiological situation over time in the absence of any remediation and with the effects of selected remedial measures. This approach is intended to permit comparison of the effects of various remedial measures in terms of their short- or long-term effect on dose rates and resulting doses in the areas of interest, for the purpose (in part) of aiding decisions about when to remediate and which remedial measures to use.

1.4. STRUCTURE OF THE REPORT

Section 1 provides a brief description of the background of the Urban Remediation Working Group, the Working Group's objectives, and the scope of its activities. Section 2 provides a review of major models and modelling approaches designed for assessment of urban contamination situations. This section also includes a brief description of each model used by a participant in the Working Group's modelling exercises. Section 3 describes the first modelling exercise, based on Ukrainian data following the Chernobyl accident. Section 4 describes the second modelling exercise, based on a hypothetical situation of a point release of a radionuclide in an urban setting. Sections 3 and 4 include comparative analyses of model predictions and reasons for different predictions or mispredictions. Section 5 provides the conclusions and recommendations of the Working Group based on the model review and the modelling exercises. Annexes I and II include the scenario descriptions and documentation for each of the modelling scenarios. Annex III includes more detailed descriptions of the models used in these exercises by Working Group participants, including individual evaluations of their model performance. Annex IV includes tables of the model predictions and (where available for the Ukrainian scenario) measurements. A CD accompanying the printed version of this report contains full scenario descriptions and supporting information (electronic files) for both scenarios, as well as a complete report (in French and English) on available models and modelling approaches for assessing urban contamination and remediation measures.

APPENDIX III-1. DESCRIPTION OF MODELS

Generic Model Descriptions [*TO BE COMPLETED BY EACH PARTICIPANT SUBMITTING MODEL CALCULATIONS]*

1. **Introduction**
   - model name
   - purpose of the model (research, assessment or scoping; conservative or realistic)
   - type of model (steady-state or dynamic; analytical or numerical; compartment or process-oriented)
   - biological/environmental compartments considered
   - transport processes considered
   - endpoints
   - references

2. **Key assumptions**

3. **Modelling approaches** (conceptual and mathematical)
   - how transfers between compartments are modelled
   - how concentrations in compartments are calculated
   - temporal and spatial discretization of the model
   - input data required

4. **Parameter values**
   - values of the parameters used in the model
   - spatial and temporal averaging

5. **Uncertainties**
   - approach to estimating uncertainties in the model predictions

6. **Application of the model to Scenario 1 (Ukrainian scenario)**
   - how the data given in the scenario description was used to drive the model
   - what assumptions were made to match the model to the conditions of the scenario

7. **Application of the model to Scenario 2 (Hypothetical scenario)**
   - how the data given in the scenario description was used to drive the model
   - what assumptions were made to match the model to the conditions of the scenario

CONTENTS OF ACCOMPANYING CD

1. Bibliographic survey of modeling approaches for radionuclide transfer in contaminated urban environments, associated dose calculations and assessment of rehabilitation strategies. [Report by Ms. Gallay, versions in French and English]

2. Ukrainian scenario (complete version, including GIS files)

3. Scenarios for District 1 and District 4 of Pripyat, with supporting files

4. Hypothetical scenario (complete)