

## RADIATION SURVEYS IN CONTAMINATED COMMUNITIES

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### 1. Introduction

In Port Hope and other communities where radiation levels above the accepted criteria have been found, the overall cleanup program is proceeding in three major phases as follows:-

Investigational  
Remedial  
Compliance

During each phase, radiation surveys are performed with particular objectives in mind. The surveys may involve a variety of radiation measurements and laboratory analyses of samples of air, soil, water, etc.

In Port Hope and Uranium City, a Program Manager has been hired to carry out the Remedial Phase of the program, and during the fiscal year 1976/77, the Manager in Port Hope was James F. MacLaren Limited, and in Uranium City was Eldorado Nuclear Limited.

Most of the radiation surveys required during the Remedial Phase are performed by the Program Manager's staff; at the same time, while staff of the Federal and Provincial Government agencies perform some surveys during this phase, they perform all of the surveys during the other two phases.

The types of survey, their purpose, and who is expected to perform them are discussed briefly below under the headings of the three major phases.

### 2. Investigational Phase

During the Investigational Phase, the primary concern is to find out whether a problem exists or not; if it does, then further investigation is required to establish the extent (how many homes are affected?) and the seriousness (how high are the radiation levels?) of the problem. Since there is usually considerable pressure to provide answers as quickly as possible at this point, measurement methods are chosen for their speed, primarily.

The strategy employed in Port Hope was to perform a series of gamma ray exposure rate measurements in order to indicate the 'worst' areas with minimum delay, and then to follow up with radon concentration measurements in air samples taken inside the homes where higher than normal gamma exposure rates were found. Due to the poor correlation between measured gamma exposure rates and the radon concentrations found inside homes, this strategy was modified in Port Hope to that of making radon measurements in all homes and buildings. This modified strategy was employed from the start of the investigation in Uranium City and Elliot Lake, where radon decay product Working Levels were measured in all homes and gamma exposure rates were measured only in the higher cases to give an indication of the presence of identifiable source material.

In order to provide information on the source material and the extent of the contamination, samples of soil, water, and produce grown in contaminated soil are

taken at this time. Sampling is usually carried out by staff of the Government agencies involved, but the laboratory analysis may be performed either in Government Laboratories or under contract by University or commercial laboratories.

In summary, the radiation surveys made during this phase are tabulated below:

TABLE 1

INVESTIGATIONAL PHASE RADIATION SURVEYS

Performed by:	staff of Government agencies
Purpose:	to establish extent and seriousness of hazard as quickly as possible
Measurements made:	radon concentrations and/or radon decay product Working Levels, and gamma ray exposure rates
Samples analysed:	soil, water, and possibly produce grown in gardens

3. Remedial Phase

It is expected that the remedial work at a particular site will proceed in a series of stages as follows:-

- Design
- Removal
- Post - removal inspection
- Restoration
- Post - restoration inspection

Radiation surveys will be required at the three stages of Design, Post-removal inspection, and Post-restoration inspection.

3.1 Design Stage

It is recognized that the radiation survey of a particular property made during the Investigational Phase is not detailed enough to enable the Program Manager to draw up the sub-contract specification, therefore further radiation surveys are required with the objectives of establishing the reference radiological conditions, locating and determining the extent of the source material, and providing sufficient details to draw up the sub-contract specification. These surveys will be carried out by staff of the Program Manager and may include all or some of the following measurements:

- radon concentrations in air
- radon decay product Working Levels in air
- radon flux measurements
- gamma radiation exposure rates both inside and outside buildings
- alpha surface contamination levels
- soil sampling and laboratory analysis
- water sampling and laboratory analysis

### 3.2 Post-removal inspection

During this stage, assurance is required that the removal stage has been carried far enough. The Program Manager's staff will provide guidance based on the following measurements the results of which will be examined for indications of trends and compared with the recommended values for the natural background, the reference radiological conditions noted in Section 3.1 above, and measurements made in similar structures in the immediate neighbourhood.

- i) Measurements of gamma radiation exposure rates both inside and outside the structure and in the excavation (if relevant).
- ii) Analysis of representative soil samples taken in and around the excavation. (Note: owing to the length of time required to perform a laboratory analysis for radium - 226, gross gamma counting of weighed samples might provide useful information.)
- iii) Visual inspection in and around the excavation for the presence of residues from the refining of uranium or radium.
- iv) Other measurements as deemed to be appropriate.

Measurement results will be submitted to the AECB at this stage for review by their staff. The AECB may request additional measurements and after consultation with the Program Manager may request further removal of soil and materials or other appropriate remedial action. If further work is undertaken, the inspection measurements must be repeated upon completion of this work. When the AECB staff are satisfied with the post-removal inspection results, they will authorize the Program Manager to proceed to the Restoration stage.

### 3.3 Post-restoration inspection

Upon essential completion of the restoration stage, measurements will be required to show that the radon levels are not likely to build up again in excess of the recommended limits, and, if relevant, that the gamma background will also remain within the recommended limits. Judgement will be required that is based upon experience, but guidance can be obtained from repeating the measurements made previously and from some additional ones.

The Program Manager will repeat the reference measurements made during the Design stage and will submit both sets of measurements to the AECB.

Upon notification by the Program Manager that he is satisfied that the remedial work has been completed at a particular site, AECB staff will make independent measurements that are intended to confirm that the radiation levels at that site are not above the acceptable limits. These measurements include gamma exposure rates and radon or radon daughter concentrations in air as follows:

#### Gamma measurements outdoors

The minimum number of measurements required will be on a 10' x 10' grid over the whole outside property with notations of any significant deviations from normal.

#### Gamma measurements inside buildings

At least one measurement in the centre of every room (or equivalent space) at a height of 1 m above the floor. Measurements in contact with any detectable or previously identified 'hot spots'. Contact measurements in the vicinity where contaminated building materials have been removed.

## Radon or radon daughter measurements

Measurements will be made under reproducible conservative conditions which should be the same as those assumed during the Design Stage, and, if possible, those that applied when the original measurements were taken. In a residence, at least two samples of air will be taken (one in the basement and one in a representative living area, e.g. living room, bedroom). These should be taken after a delay of at least 30 days after the essential completion of remedial work in order to permit radon to establish an alternative diffusion path. (This is based on experience at Grand Junction, Colorado, U.S. and may require revision in the light of experience in Port Hope). In business premises, or a school, it may be necessary to take samples in more than two locations - this will be left to the judgement of the inspector. Measurements will be repeated if the concentration is less than the Remedial Action Level but more than half of that Level.

The radiation surveys made during the Remedial Phase are summarized in Table 2.

### 4. Compliance Phase

When all remedial and rehabilitation work has been completed, the AECB will follow up with the Compliance Phase during which further measurements will be made by staff of the AECB and the Provincial regulatory bodies to confirm that in the long-term the radiation levels do not exceed the acceptable limits. Measurements of the radon and/or daughter concentrations in air will be made with integrating instruments and may extend over a period of one year after satisfactory completion of the remedial work at a particular site. Further gamma radiation measurements will not be required normally, but will be carried out if the radon and/or daughter measurements indicate that the remedial work was not successful with the specific objective of locating possible source material which may have been overlooked.

TABLE 2

REMEDIAL PHASE RADIATION SURVEYS

Design Stage Surveys

Performed by: Program Manager's staff

Purposes: a) to establish reference radiological conditions  
b) to locate and determine extent of source material  
c) to obtain sufficient information for contract specification

Measurements made: radon concentration in air  
radon daughter concentration in air  
gamma exposure rates indoors and outdoors  
radon flux at surfaces  
alpha contamination levels (loose and fixed)

Samples analyzed: soil and water for radium, uranium, radon  
soil for toxic chemicals and heavy metals

Post-removal Inspection

Performed by: Program Manager's staff

Purpose: to determine whether remedial action has been carried far enough

Measurements made: gamma exposure rates indoors and outdoors  
gross gamma counting of soil samples

Other measures: visual inspection  
other measurements deemed to be appropriate

Post-restoration Inspection

Performed by: Program Manager's staff

Purpose: to satisfy the Program Manager that remedial work has been completed satisfactorily.

Measurements made: repeat those made during Design Stage

Performed by: AECB staff

Purpose: to confirm short-term absence of radiation levels above the acceptable limits

Measurements made: gamma exposure rates indoors and outdoors  
radon and/or daughter concentrations in air

Other measures: visual inspection