ANALYSIS OF AN ANALYTICAL TECHNIQUE FOR DISTRIBUTING AIR SAMPLING LOCATIONS AROUND NUCLEAR FACILITIES

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Abstract

A new analytical mechanism for distributing air sampling locations around nuclear facilities, including reactors, fuel fabrication, fuel reprocessing and research centers, has been devised. This method was developed to facilitate the efficient incorporation of past experiences into environmental surveillance programs for new installations. The technique provides an initial distribution of air samplers around a site which correlates well with placements on sites which have been occupied by long-established programs with their inherent evolution and refinements. Sensitivities of calculated sampler distributions to various meteorologic and demographic input parameters will be discussed. The applicability of this approach has been examined by comparing sampling locations in well-established air monitoring programs scattered worldwide with location distributions recommended by this mechanism. Results of these comparisons will be detailed.

Introduction

In recent years public pressure has compelled an increase in attention to environmental surveillance around industrial complexes of all types. Information involving probabilities of detecting short duration releases in the environment have been widely circulated. It is seldom noted, however, that in contrast to emergency monitoring, the worth of systems for routine environmental surveillance is judged on the basis of long-term productivity. Even though this fundamental difference exists between monitoring accident and routine conditions, the publicity in some cases has had an adverse influence on industrial confidence in data obtainable from routine surveillance programs. This lack of confidence is reflected in some environmental surveillance programs.

An examination of existing programs indicates a need for the development of surveillance system design techniques which can be easily and economically applied by environmental surveillance personnel to yield sampling location distributions which correlate well with placements on sites which have been occupied by long-established programs. Even though there are recognized techniques for designing surveillance systems around nuclear installations,[1,2] there is little evidence to show that these are being widely applied by those responsible for operating the programs. These more sophisticated design methods are generally regarded as expensive to utilize.

In an attempt to provide a consistent, uncomplicated, economical mechanism for the examination of surveillance systems, an evaluation was begun of variables which influence a program's ability to assess population exposures and which could be incorporated into a workable sampling location distribution procedure. Acceptability of the procedure would be based, it was decided, upon: (a) its ability to provide an initial distribution of air samples around a site which correlated well with placements on sites which have been occupied by long established programs with their inherent evolution and refinements, and (b) respectable agreement between distributions derived by well-recognized techniques and this method.

An examination of parameters involved in release mechanisms, transport models and exposure pathways for airborne releases from nuclear fuel cycle facilities, revealed that population exposure magnitudes were most directly related to population distribution and contaminant transport characteristics of the local environment involved.

Procedure

Examination of existing surveillance programs indicated that distances of environmental media sampling locations from the source of contamination are generally selected to correspond to plant boundaries, maximum potential concentration points, population centers and relatively unaffected areas and that the most needed guidance was in the radial partitioning of sampling locations. The relationship,

$$\text{Weighting Factor (W)} = \frac{\text{fraction of total population}}{\text{distance}} + \text{fraction of time sector is downwind of sources,}$$

associating demographic and meteorological variables was found to yield useful recommendations when applied to a site on an octant basis.

The application of this method to sites in coastal or agricultural areas requires only minor modification of the basic procedure.[3] In coastal zones it is usually appropriate to adjust the number of radial divisions to the number required to cover the surrounding inhabited land mass. For agricultural areas an equivalent population index is necessarily applied. This index is derived by multiplying the number of people who are direct recipients of produce, dairy products, etc., from the area by the biological discrimination factor for the critical nuclide in the exposure pathway involved.

The sum of eight calculated weighting factors is scaled to equal the desired number of sampling locations. The scaling factor, when multiplied by each octant weighting factor, yields the number of sampling locations within that octant when rounded to the nearest integer. For an octant which is downwind of the source twenty percent of the time and has fifty percent of the regional population at fifteen miles from the site, the calculation of its portion of a seventeen sampling location program would go as follows:

$$W = \frac{.50}{15} + .2 = .23$$

Assuming the sum of eight weighting factors is 1.0, the scaling factor (SF) is 17/1.0 = 17. Number of locations per octant = W x SF = 3.97 which would be rounded to 4 to indicate the number of locations to be allotted to that sector.

Analysis

To test acceptability of the method on the basis of its ability to provide distributions which correlate well with placements on sites with well-established programs, eleven mature sites were selected as models for testing. The sites were located in the United States, India, Japan, and Germany. The facilities included power reactors, uranium enrichment facilities, fuel fabrication plants and nuclear research establishments. Sampling locations per site varied from eight to forty. Results of sampling location distribution comparisons are shown in Figure I below. The deviation noted on the abscissa is the difference between the calculated and actual number of sampling locations present per octant. It should be noted that over thirty percent of the octants had zero deviations. Most of the greater deviations can be attributed to the relatively arbitrary divisions formed by the octant boundaries and to criteria applied in the rounding off of calculated values.

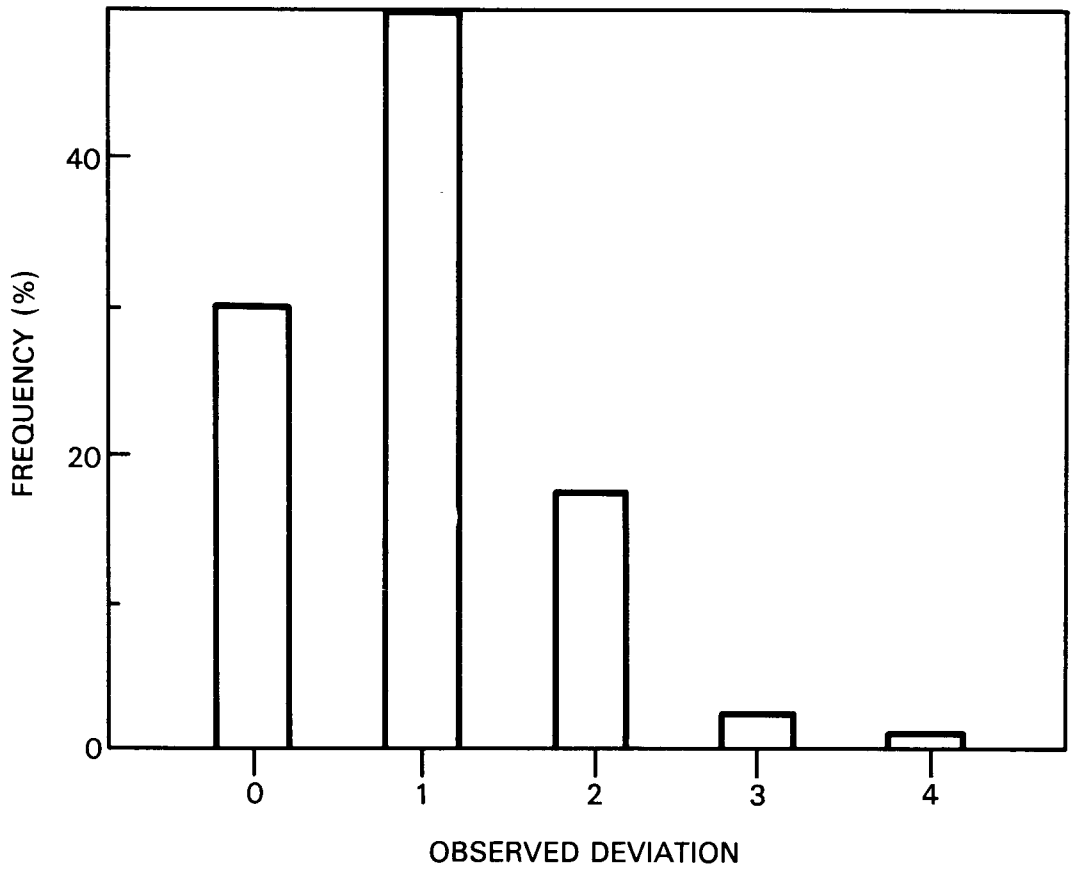

FIGURE I: Deviations in Location Distributions

The model site chosen to test agreement of this calculational method with distributions derived by recognized techniques with the Nine Mile Point Power Reactor.[4] The land environmental monitoring system includes five inner and six outer stations. The determination of the necessary number of on-site stations was based on meteorological data collected over a two-year period. The inner stations are located onsite at points in each land sector calculated to give the maximum average annual ground concentration. The outer stations are designed to measure background for comparison with onsite measurements. The layout of the land program is indicated in Figure II below.

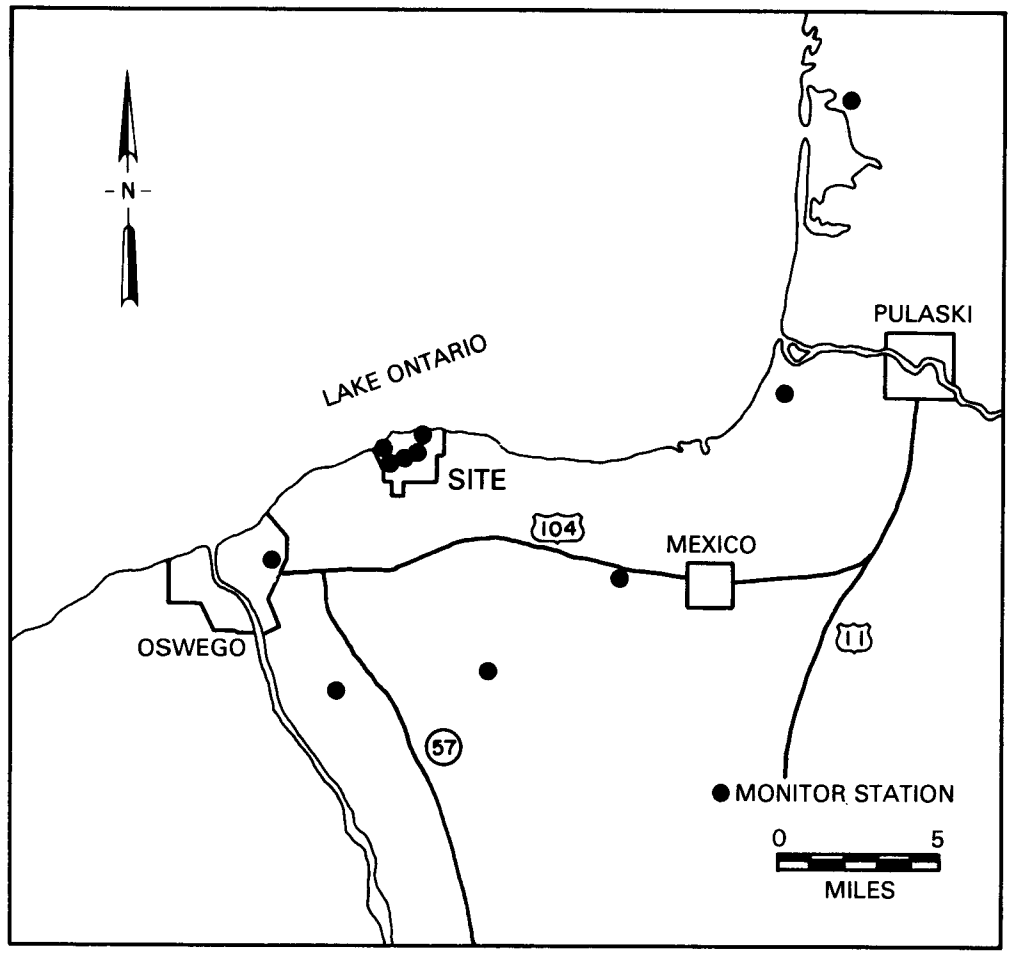

FIGURE II: Land Monitoring Station Locations

Applying the weighting factor procedure to demographic and meteorologic data for this site to distribute eleven sampling locations yielded the following comparison of programs:

Octant No.	Model Sampling Locations	Calculated Sampling Locations	Deviation
1	0	0	0
2	1	1	0
3	2	3	1
4	2	2	0
5	4	3	1
6	2	2	0
7	0	0	0
8	0	0	0

On the basis of this favorable comparison and the eleven mature sites comparison, the acceptability criteria were met.

References

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4. Philbin, T.W. and G.H. Whipple. "An Environmental Survey for the Nine Mile Point Power Reactor," Environmental Surveillance in the Vicinity of Nuclear Facilities, Charles C. Thomas, Publ., Springfield, Ill., 1970.