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IDENTIFYING HIGH RISK AREAS IN NEW YORK STATE: MAPPING INDOOR RADON DATA

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ABSTRACT

A project is underway to map the indoor radon potential for New York State at the township level. Through a detector distribution program the New York State Department of Health has a database of over 36,000 basement screening measurements. The address field for the indoor measurement data is being linked to latitude and longitude coordinates using data files containing coordinate information. Using a geographic information system (GIS) the mapped data are being correlated to surficial geology, soils, bedrock geology, and other spatially located information. The combination of indoor measurement averages and correlations to surficial geology and other factors will be used to assign radon risk at the township level.

INTRODUCTION

It is essential to have the best radon-risk maps available to effectively target high risk areas for measurement, mitigation, and the implementation of radon resistant building codes. Without these maps, many high-risk areas will be overlooked and considerable effort and expense will be directed to low-risk areas.

The New York State Department of Health has a growing database of over 36,000 homes in New York State for which basement radon levels have been measured with charcoal canisters exposed for two to four days. The most direct and reliable method to determine the radon risk for an area is to measure the indoor concentration for a number of homes in that area. When sufficient measurement data are available, mapping the average or geometric mean indoor radon concentrations for the counties or by zip code is the preferred method to estimate the radon risk for an area. Most of the measurements are concentrated in and around the cities and villages. In many townships encompassing rural areas there are few measurements. When the indoor data are not available it is necessary to estimate risk from the geology for that area.

Computer-based Geographic Information Systems (GIS) are being utilized to map spatially located information such as roads, buildings, and geology. The geologic features that affect indoor radon concentrations often vary over smaller spatial dimensions than county, zip code, township, or other politically defined areas. When the individual radon measurements are located by latitude and longitude, the distribution of indoor concentrations can be correlated with areas of practically any size or shape. Surficial and bedrock geology maps have been drawn for New York State at a scale of 1:250,000. These maps are being digitized into a GIS so that the surficial and bedrock geology can be readily correlated with spatially located radon data.

In this radon mapping project methods are being developed to locate most of the indoor measurement database with latitude and longitude coordinates. Using a GIS the mapped data will be correlated with the surficial geology of the state. The correlation results will be used to identify the types of surficial geology associated with above-average indoor radon. The combination of indoor radon measurements and correlations with geology will be combined to assign radon risk at the township level. Preliminary results have been reported for Albany County (Schwenker, et al. 1992).

INDOOR RADON DISTRIBUTION BY COUNTY

The geometric mean basement screening indoor-radon concentrations for the counties in New York State are shown on figure 1 (top of page). Various regional differences are evident and have been correlated with the surficial geology of the State (Laymon et al. 1990). The counties with the highest average indoor radon are located in the southwestern part of the state, generally in an arc south of the Finger Lakes. Gravelly glacial out-wash deposits forming highly permeable soils in the valleys of this region are the principal factor resulting in above-average indoor radon for these counties (Kunz et al. 1988). The counties with the lowest average indoor-radon concentrations are located in the Adirondack Mountains and on Long Island. The soil in both these areas has below-average radium and is of moderate permeability. Regional differences for indoor-radon concentrations can usually be understood from the general characteristics of the regional surficial geology.

The soils and surficial bedrock near several hundred homes and about twenty schools in New York State have been tested for radium, soil-gas radon, and permeability (Kunz, 1989). Most of the soil tests were conducted at homes and schools with above-average levels of indoor radon. The most important factor correlating with above-average indoor radon for the homes and schools in New York State is the permeability of the soils for gas flow. Soil permeabilities vary over many orders of magnitude; in general the gravelly soils with permeability greater than $1 \times 10^{-6} cm^2$ correlate with above-average indoor radon. Soil radium concentrations generally vary between 0.7 and 2.0 pCi/g, with most soils at about 1.0 pCi/g. Soil-gas radon concentrations measured at a depth of 4 ft. generally vary between 400 to 2,000 pCi/L averaging about 700 pCi/L. Most of the areas in New York State with above-average indoor radon have average to 1.5 times average concentrations of soil radium and soil-gas radon. A few areas in the southeastern part of the State (Hudson Highlands) have been identified with relatively high levels of radium in the soil and surficial rock and high levels of soil-gas radon. However, these areas are small and affect only a few homes.

The soil and surficial rock within a few meters of a home or building's substructure is generally the source for the radon entering the structure. There are exceptional cases where interconnected cavities or fractures in the rock or soil under a structure can act as conduits allowing radon to be transported over considerable distances before entering a home or building. However, the soil testing in New York State indicates that it is the surficial soil and rock immediately under and around the substructure that is the predominant source for indoor radon. Therefore our correlation studies have been primarily directed toward the surficial geology. Correlations to digital soils information prepared by the Soil Conservation Service will also be examined as will correlations to bedrock geology and aerial radioactivity data.

The Environmental Protection Agency (EPA) working with the US Geological Survey (USGS) has produced a map of radon zones for the entire United States. The radon-zone map for New York State is shown on figure 1 (bottom of page) (EPA 1993). The USGS identified 13 geological provinces for New York State. Each of the geologic provinces was evaluated for indoor radon potential by considering five factors: indoor radon measurements, geology, aerial radioactivity, soil parameters, and foundation types. The three radon zones correspond to predicted average indoor screening levels of: zone 1 $>$ 4 pCi/L, zone 2 $\geq$ 2 pCi/L and $\leq$ 4 pCi/L and zone 3 $<$ 2 pCi/L. Well over 50% of the counties in the state have been designated as high-risk, zone 1 counties. The intent of the current project is to map the radon potential at the township level.

INDOOR RADON MEASUREMENT DATABASE

Since 1985 the New York State Department of Health has maintained an ongoing program of distributing radon detectors upon request to residents of New York State. As of Dec. 31, 1993 indoor measurements were made in 53,059 homes. The database is reduced to 36,002 homes when only charcoal canister, basement screening measurements are considered. First-floor and longer-term measurements were eliminated so that the database would be more consistent when comparing one area with another and for comparisons with other data sets.

A key element in this project is to locate as many of the 36,002 homes with latitude and longitude coordinates as possible without expending too much time and effort. We are investigating three approaches to link coordinates with the addresses for the indoor radon measurement data. One method is to use the US Bureau of the Census Topologically Integrated Geographic Encoding and Referencing (TIGER) database, the second is to locate homes using the centroid for the home's nine-digit zip code and the third is to use the New York State Department of Equalization and Assessment (NYSDEA) tax assessment database. Commercially available digital street network files that are compatible with GIS mapping software programs can also be used. Using a commercially available program, 75% of the 36,002 addresses were located with latitude and longitude coordinates. 66% of the homes were located using the number and street address and an additional 9% of the homes were located using the centroid for the nine-digit zip code. Most of the homes not linked to coordinates are rural homes with post office box or rural delivery addresses. Statewide, 32,150 addresses were located with both number and street coordinates and nine-digit zip code centroids. The average distance between homes located using the two techniques is 110 meters. A sampling of homes will be located using a global positioning system for comparison with locations using data-file techniques.

There is considerable variability in the number of homes measured for radon and in the percentage of homes located with coordinates for the 62 counties in New York State. In general, more homes have been measured and a higher percentage located for the more urban areas. There are large areas in the state where there are few measurements. The coordinate-matching results for five counties are shown in Table 1. For Albany, Cortland, and Erie County a high percentage of the homes have been located. In Albany County most of the measured and located homes are in and around Albany with hardly any homes measured and located for over half of the County (Schwenker et al. 1992). Although 4,055 homes with radon measurements have been located in Erie County, there still are large areas with only a few measurements. In Columbia County 271 homes were measured for indoor radon, but only 29 of these homes were located with coordinates. In this county most of the addresses are either rural delivery or post office box. In Hamilton County only 3 of the 19 homes measured for indoor radon have been located with coordinates. In townships where there are sufficient indoor measurement data, the radon potential will be based primarily on averages for the measurement data. There are many townships with little or no measurement data and indoor radon potential will be based on correlations to surficial geology. The correlations to geology and other spatially located factors will be greatly facilitated by having located the indoor data with latitude and longitude coordinates.

ERIE COUNTY

Preliminary results for Erie County are shown in figures 2-4. Erie County is of particular interest because of the large number of measurements and the diverse geology resulting in considerable differences for indoor radon concentrations in different parts of the County. The geometric mean for 4,432 basement screening measurements for Erie County is 1.4 pCi/L. The geometric mean for the state is 2.5 pCi/L, making Erie County a below- average county for indoor radon. The EPA designated Erie County as a zone 1 or high-radon-potential county because it is mostly in the Allegheny Plateau Province, which has been rated as a zone one province.

The mapped indoor radon data are shown on figure 2, where the area of the circles is proportional to the indoor radon concentration. Most of the measurements were made in the northeastern part of the county around the city of Buffalo. The Buffalo area is generally below average for indoor radon; however, some above-average areas can be seen, particularly in the eastern central part of the county. To ensure the confidentiality of the measurement data, publication and presentation of mapped data will be at scales such that individual homes cannot be identified. The geometric-mean indoor concentration for the townships and some villages are show in figure 3. Most of the below-average townships have a surficial geology of lacustrine silt and clay, which has low permeability for gas flow, and would be expected to have low indoor radon potential. The above-average areas have highly permeable outwash gravel deposits, particularly in the valleys where most of the population in these rural areas are living. The correlations to surficial geology and other factors obtained in counties such as Erie County, where there is a high density of measurement data, will be used to determine radon risk levels for townships having few measurements. This approach will allow us to ascribe radon risk at the township level throughout the state. In figure 3 we have arbitrarily used a geometric mean above 4 pCi/L for the screening measurements to consider an area at high risk for indoor radon. The criteria used to determine high, average, or low-risk areas will be developed by the New York State Health Department. One of the benefits of mapping the indoor data (figure 2) is that it is clear that even in low-risk areas there are a few homes with above-average indoor radon concentrations. This may encourage people in low and average-risk areas to measure their homes for indoor radon. One option being considered is to indicate the predicted percentage of homes that will have indoor radon concentrations above 4 pCi/L for each township instead of ranking a township as high, average, or low for indoor radon potential.

Interestingly, a disproportionately large number of measurements relative to the population have been made in the towns of Marilla and Aurora (figure 3). These areas were identified as potentially high-risk areas several years ago, which has prompted people to participate in the indoor measurement program. The concentration of measurements in the higher-risk townships illustrates two factors. The identification of high-risk areas can result in prompting people to measure their homes, causing the voluntary detector distribution programs to preferentially sample high-risk areas. The state-wide and county-wide averages derived from these programs should not be considered as random averages but tend to be biased high.

The Erie County Department of Environment and Planning has an ongoing active indoor radon program and has encouraged residents in high-risk areas to measure their homes for indoor radon. As of June 1994 the Erie County Department of Environment and Planning has made over 3,000 screening measurements in the county. The results from these measurements show a distribution similar to that shown on figure 2.

Although correlations to surficial geology, soils information, bedrock geology, aerial radioactivity, field measurements for soil radon potential, and other factors are helpful and in areas with few measurements, necessary to predict indoor radon levels, the preferred approach is to base indoor radon predictions on indoor measurement data. As more indoor data are acquired the radon maps should be periodically updated. The results for Erie County presented in this paper are preliminary and will be upgraded following a more thorough analysis of the data.

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REFERENCES

EPA's Map of Radon Zones, New York, Radon Division, Office of Radiation and Indoor Air, US Environmental Protection Agency, Sept. 1993.

Kunz, C. Influences of Surficial Soil and Bedrock on Indoor Radon in New York State Homes, New York State Energy Research and Development Authority, Report 89-14, Oct. 1989.

Kunz, C.: Laymon, C.: and Parker, C. Gravelly Soils and Indoor Radon. In: Proceedings for the 1988 International Symposium on Radon and Radon Reduction Technology, Denver, CO, Oct. 1988.

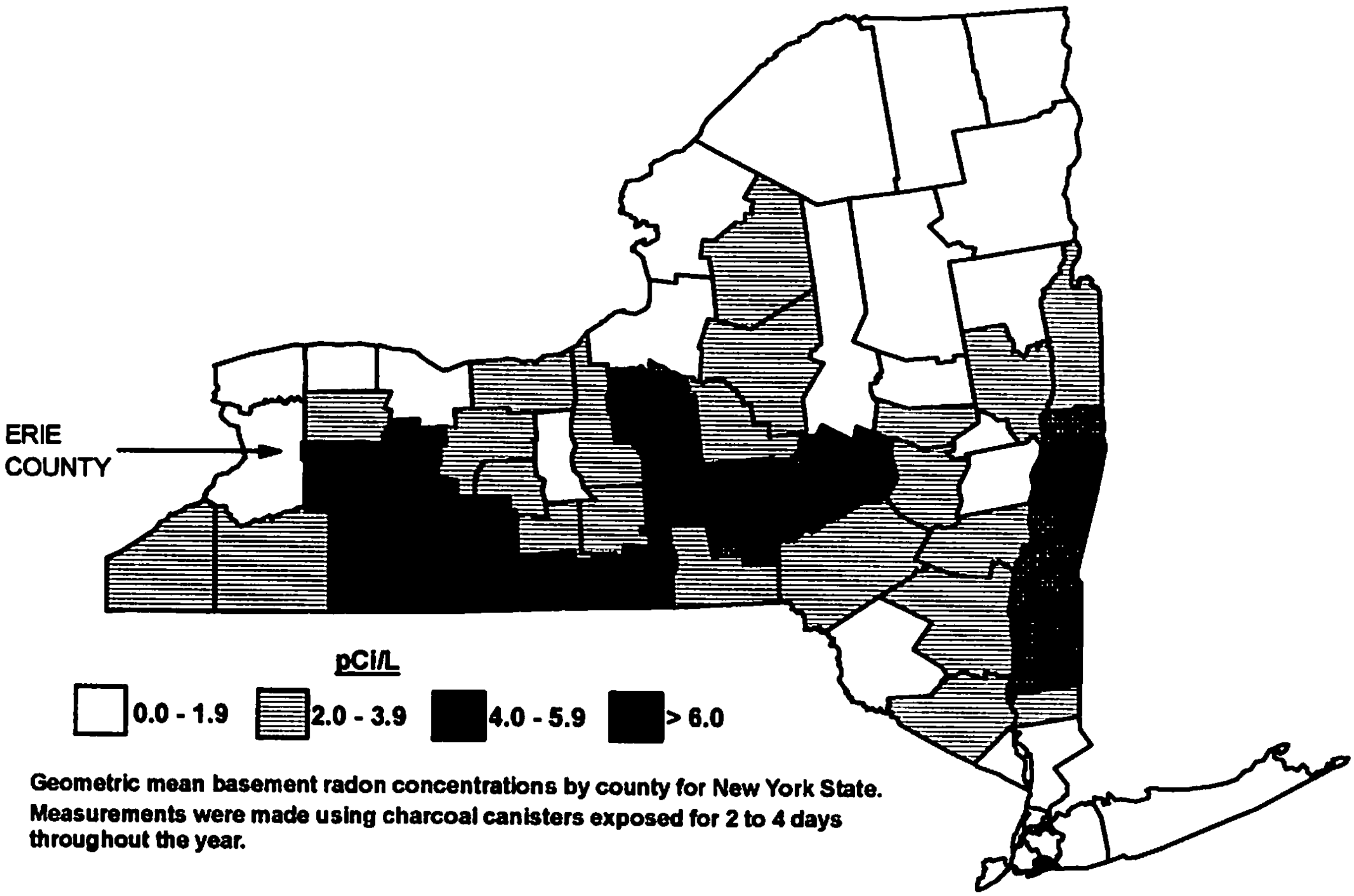
Laymon, C.: Kunz, C.: and Keefe, L. Indoor Radon in New York State: Distribution, Sources and Controls, New York State Department of Health, Technical Report, Nov. 1990.

Schwenker, C.: Ku, J.Y.: Laymon, C.: and Kunz, C. Correlation of Indoor Radon Screening Measurements with Surficial Geology Using Geographics Information Systems. In: Proceedings for the 1992 International Symposium on Radon and Radon Reduction Technology, Vol. 5, Minneapolis, MN, Sept. 1992.

TABLE 1

Examples of Coordinate Matching to the Indoor Basement Radon Measurement Data

COUNTY	NO. SITES	SITES LOCATED		
		ST. ADDRESS	ZIP+4	% MATCHED
ALBANY	1,120	810	113	82
CORTLAND	846	563	97	78
ERIE	4,446	3,414	641	91
COLUMBIA	271	24	5	11
HAMILTON	19	2	1	16
STATE-WIDE	36,002	23,755	3,340	75


ERIE
COUNTY
pCi/L
0.0 - 1.9
2.0 - 3.9
4.0 - 5.9
> 6.0
Geometric mean basement radon concentrations by county for New York State.
Measurements were made using charcoal canisters exposed for 2 to 4 days
throughout the year.

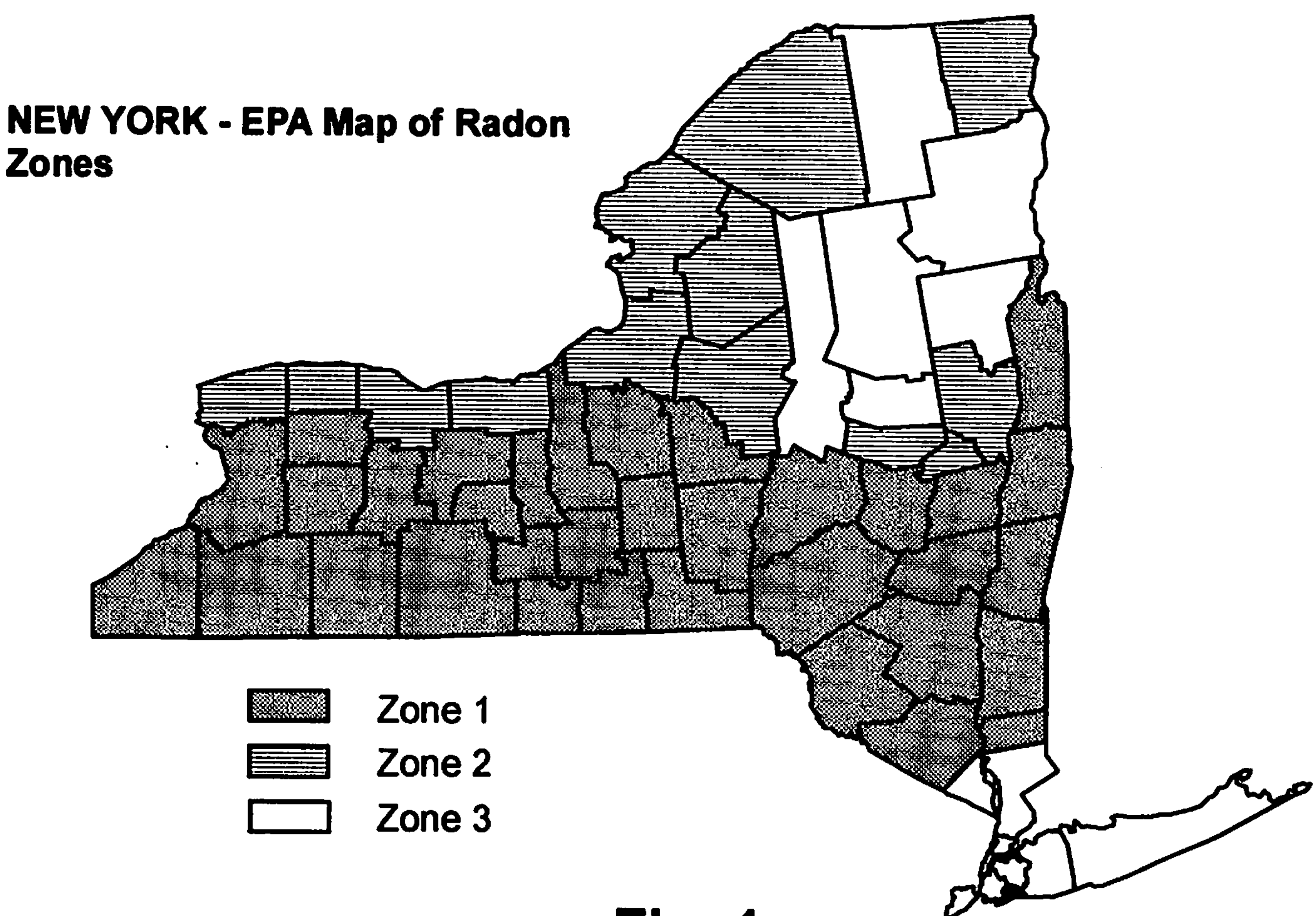

NEW YORK - EPA Map of Radon
Zones
Zone 1
Zone 2
Zone 3

Fig. 1

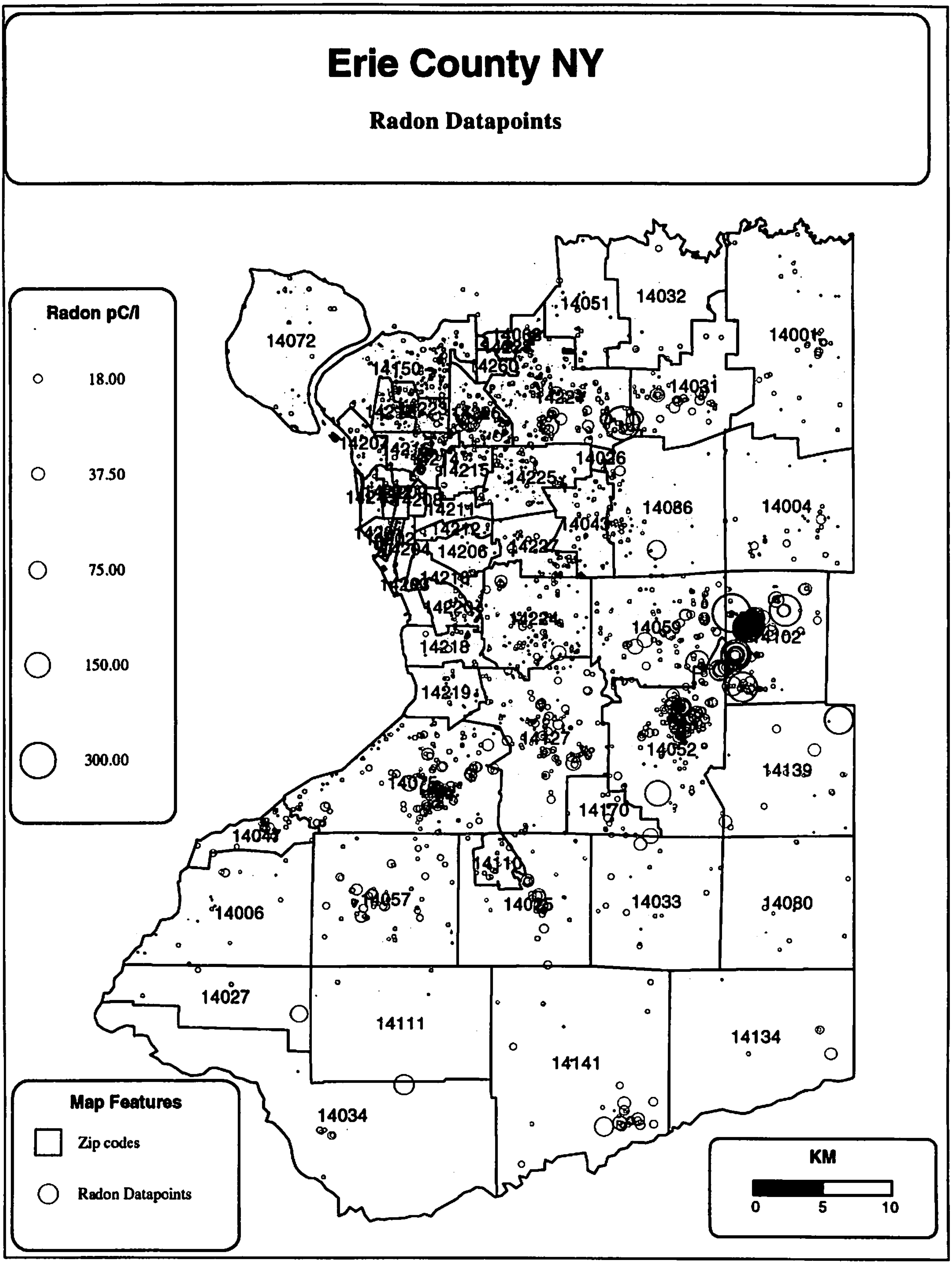
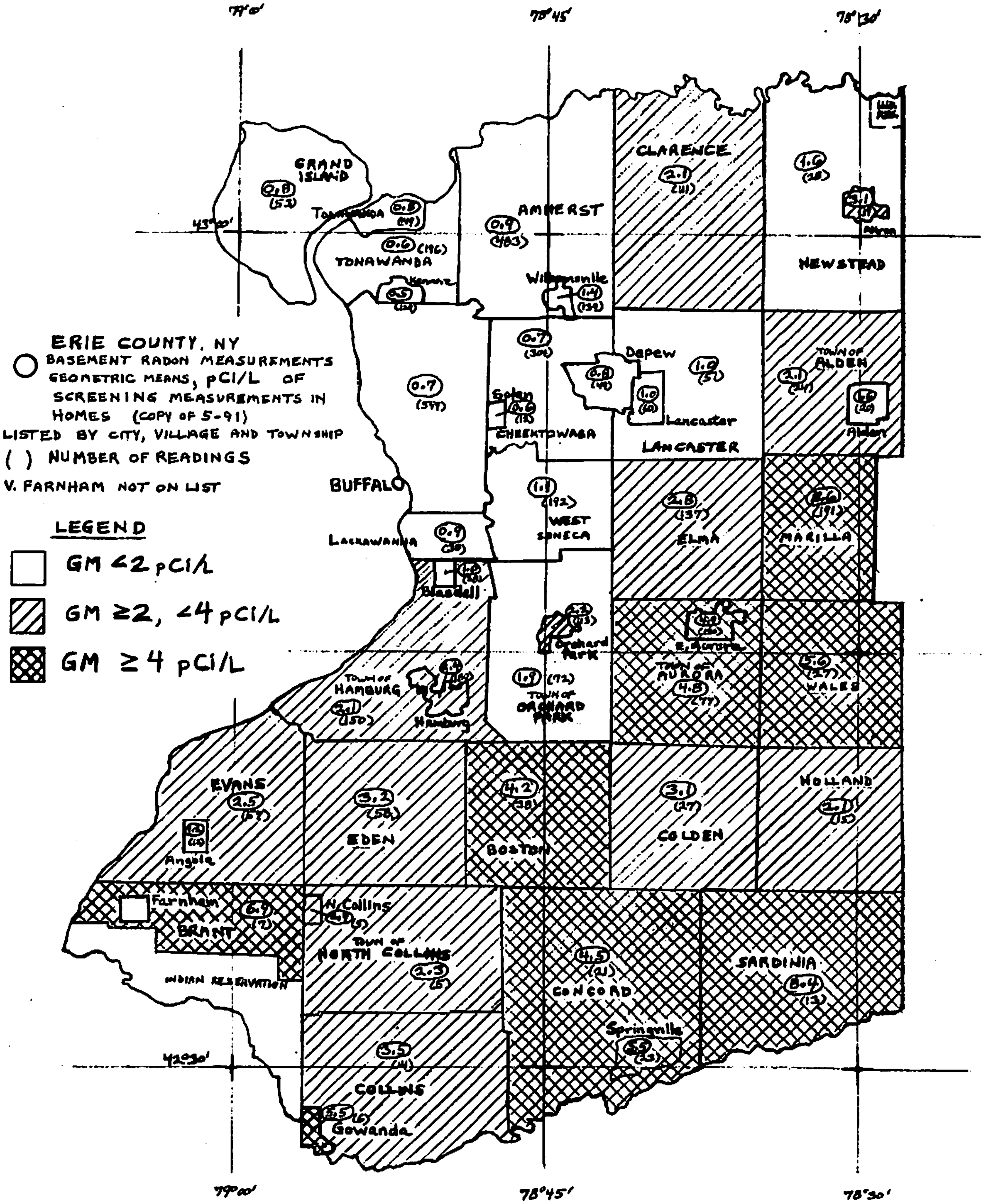

Erie County NY
Radon Datapoints
Radon pC/l
18.00
37.50
75.00
150.00
300.00
Map Features
Zip codes
Radon Datapoints
KM
0
5
10
14072
14051
14032
14001
14150
14031
14260
14207
14226
14215
14225
14086
14004
14211
14043
14206
14227
14218
14219
14052
14139
14170
14006
14033
14027
14111
14141
14134
14034

Fig. 2



ERIE COUNTY, NY
BASEMENT RADON MEASUREMENTS
GEOMETRIC MEANS, pCi/L OF SCREENING MEASUREMENTS IN HOMES (COPY OF 5-91)
LISTED BY CITY, VILLAGE AND TOWNSHIP
( ) NUMBER OF READINGS
V. FARNHAM NOT ON LIST
LEGEND
GM <2 pCi/L
GM ≥2, <4 pCi/L
GM ≥ 4 pCi/L
79°00'
78°45'
78°30'
43°00'
42°30'
GRAND ISLAND
0.8
(52)
TONAWANDA
AMHERST
0.9
(483)
CLARENCE
2.1
(41)
1.6
NEWSTEAD
BUFFALO
0.7
(599)
0.7
(304)
Depew
1.0
(51)
ALDEN
2.1
Lancaster
LANCASTER
CHEEKTOWAGA
LACKAWANNA
WEST SENECA
ELMA
2.8
(137)
MARILLA
Blasdell
Orchard Park
E. Aurora
TOWN OF AURORA
4.8
(77)
5.6
(27)
WALES
TOWN OF HAMBURG
2.1
(150)
Hamburg
TOWN OF ORCHARD PARK
EVANS
2.5
Angola
EDEN
3.2
(58)
4.2
(38)
BOSTON
3.1
(27)
COLDEN
HOLLAND
Farnham
BRANT
6.9
(7)
N. Collins
TOWN OF NORTH COLLINS
2.3
(5)
INDIAN RESERVATION
4.5
(21)
CONCORD
SARDINIA
8.4
(13)
Springville
3.5
COLLINS
5.5
(6)
Gowanda

Fig. 3