RADIUM AND RADON IN GROUND WATER OF THE OZARK REGION IN ARKANSAS, KANSAS, MISSOURI, AND OKLAHOMA

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INTRODUCTION

In 1991, the U.S. Geological Survey (USGS) began a water-quality study of the Ozark Plateaus region as part of the National Water-Quality Assessment (NAWQA) Program. The Ozark Plateaus study unit, one of 60 study units in the NAWQA Program, is approximately 48,000 square miles in area and includes parts of four States (fig. 1) (Freiwald, 1991). The study unit includes most of the Ozark Plateaus Province and parts of the Osage Plains section of the Central Lowland Province and the Mississippi Alluvial Plain section of the Coastal Plains Province. The Ozark Plateaus Province is divided into three sections—the Salem Plateau including the St. Francois Mountains, the Springfield Plateau, and the Boston Mountains (Adamski and others, 1995) (fig. 1). Two of the eight major hydrogeologic units in the study unit—the Springfield Plateau and Ozark aquifers—were investigated as part of this study. Both of these aquifers consist of flat-lying sedimentary rocks, primarily limestone and dolomite, ranging from Cambrian through Mississippian in age. The unconfined parts of the Springfield Plateau and Ozark aquifers coincide with the Springfield Plateau and Salem Plateau, respectively (fig. 1). The Ozark aquifer is confined in the Springfield Plateau, Boston Mountains, and Osage Plains (Adamski and others, 1995).

Radium and radon are naturally occurring radioactive elements that result from the radioactive decay of uranium which is present in small concentrations in common rocks and minerals. Radium and radon have several isotopes based on their atomic weight (number of protons plus number of neutrons); radium-226 and radon-222 are the most common isotopes. Radium-226 is the daughter product generated by the fifth step in the uranium-238 decay series. Radon-222 and alpha particles—a type of radiation—are generated directly from the decay of radium-226 (fig. 2). Radon-222 also decays to other radioactive elements or daughter products.

Radium and radon can be present in ground water. Radium generally is soluble in ground water only in the absence of dissolved oxygen (such as in confined aquifers). Radon is soluble in ground water; however, because it is an inert gas, radon diffuses to air when ground water is exposed to the atmosphere. Radium and radon concentrations are expressed as picoCuries per liter of water, a measure of their radioactivity. Radon also can be measured as picoCuries per liter of air.

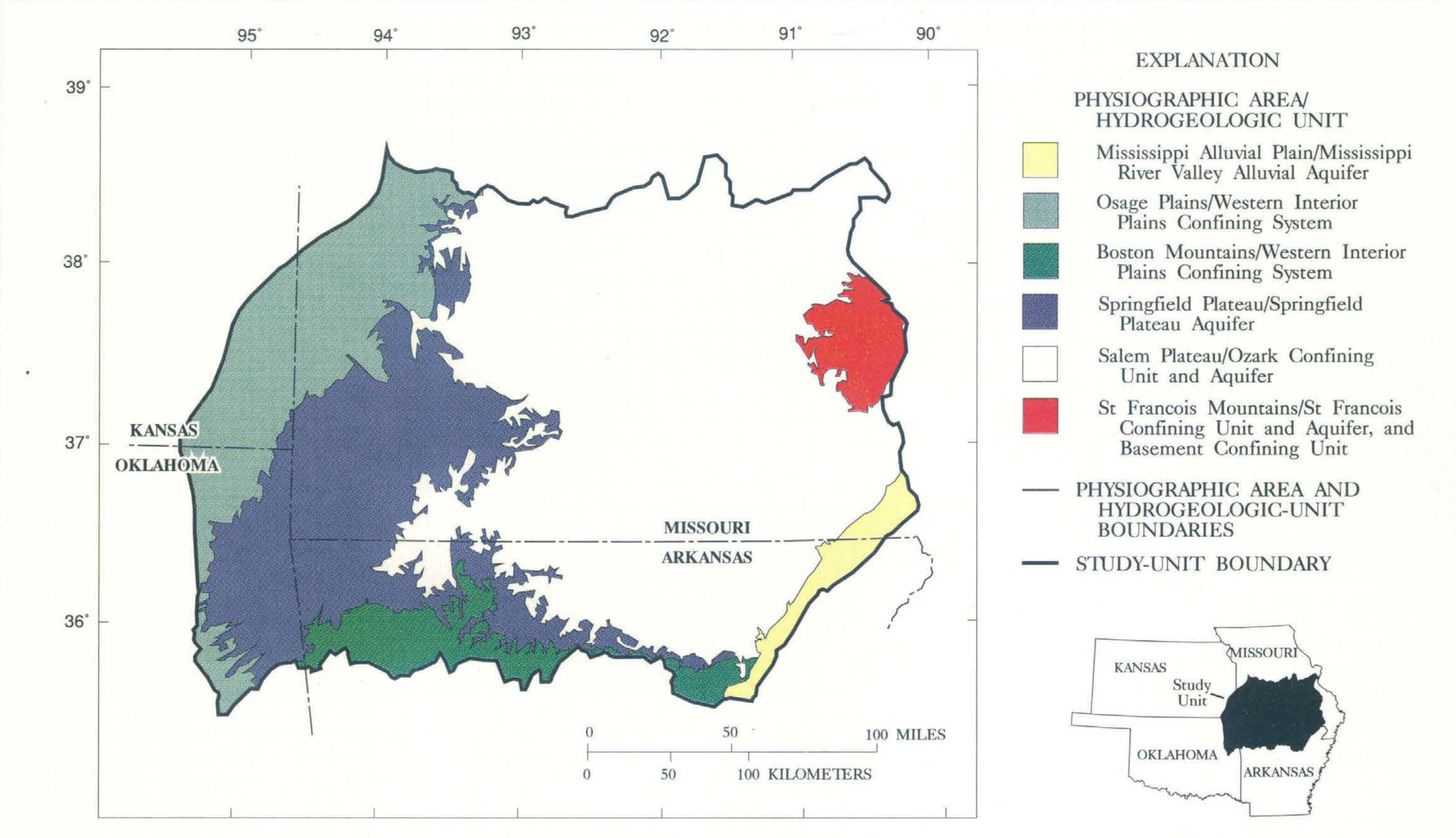

Figure 1. Location of study unit, physiographic areas, and hydrogeologic units.

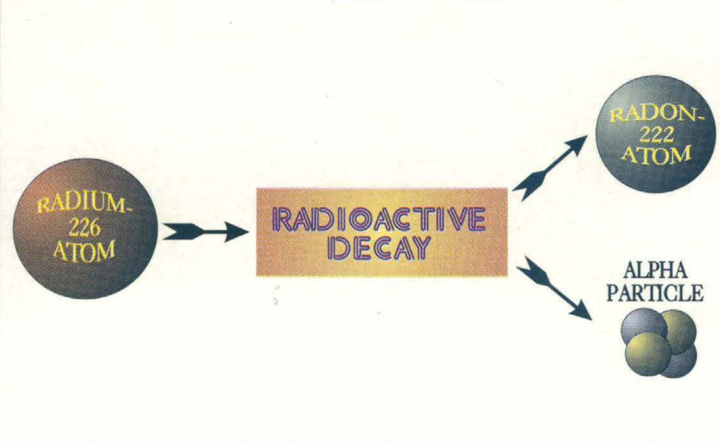

Figure 2. Generation of radon-222 through radioactive decay of radium-226.

HEALTH EFFECTS ASSOCIATED WITH RADIUM AND RADON

Both radium-226 and radon-222 can cause cancer. Radium-226 can cause bone cancer by substituting for calcium in bones, thereby causing long-term exposure resulting even from short-term ingestion. The U.S. Environmental Protection Agency (EPA) has established an interim maximum contaminant level (MCL) for radium-226 plus radium-228 in drinking water of 5 pCi/L (picoCuries per liter). The EPA has proposed a new MCL for radium-226 in drinking water of 20 pCi/L (U.S. Environmental Protection Agency, 1991). The primary health risk (lung cancer) associated with radon-222 results from breathing in radon and its daughter products. Radon-222 can be released into the air of buildings or private residences from the water supply. Furthermore, ingesting water with radon could also pose cancer risks to internal organs. The EPA had formerly proposed a MCL for radon-222 in drinking water of 300 pCi/L (U.S. Environmental Protection Agency, 1991, 1994), which has been withdrawn pending further study.

ANALYZING RADIUM AND RADON IN GROUND WATER

For this study, ground-water samples were collected and analyzed for radium-226 and radon-222 (referred to as radium and radon, respectively, throughout the rest of this report) in 1993 and 1994 during three studies that differed in spatial scale and objectives. The first study, the study-unit survey, was largest in area and consisted of collecting ground-water samples from 44 randomly-selected domestic wells to determine the distribution of radon in the unconfined parts of the Springfield Plateau and Ozark aquifers. The second study, the confined Ozark aquifer study, consisted of collecting 22 samples from 20 randomly-selected municipal-supply wells to determine the distribution of radium and radon in the confined parts of the Ozark aquifer. The small-watershed study was smallest in area (14.7 square miles) and consisted of collecting samples from 9 domestic wells in the Flint Creek Basin of northwestern Arkansas to determine the local-scale spatial variability of radon in the unconfined Springfield Plateau aquifer. The data were statistically analyzed to determine if radium and radon in ground water were related to factors such as hydrogeology (aquifer and presence of confining unit), well characteristics (total depth and casing length), or field measurements (water temperature, specific conductance, dissolved oxygen, pH, and alkalinity).

SIGNIFICANT RADIUM RESULTS

- Radium concentrations ranged from 0.1 to 14 pCi/L with a median of 1.9 pCi/L in samples from the confined Ozark aquifer. One concentration exceeded the interim MCL of 5 pCi/L. No concentration exceeded the proposed MCL for radium in drinking water of 20 pCi/L (fig. 3).
- Radium concentrations were greatest near the western and southern boundaries of the study unit (fig. 3).
- Radium concentrations were not statistically correlated to site characteristics or field measurements.

SIGNIFICANT RADON RESULTS

- Radon concentrations ranged from 99 to 2,065 pCi/L with a median of 269 pCi/L (figs. 4 and 5).
- Radon concentrations exceeded the formerly proposed MCL of 300 pCi/L in 33 of 75 (44 percent) samples.
- Radon concentrations indicated no apparent geographical trends in distribution.
- Radon concentrations were not statistically different between samples from the Springfield Plateau aquifer and samples from the unconfined part of the Ozark aquifer. However, radon concentrations were statistically less in samples from the confined part of the Ozark aquifer than in samples from the Springfield Plateau aquifer or the unconfined part of the Ozark aquifer (figs. 4 and 5).

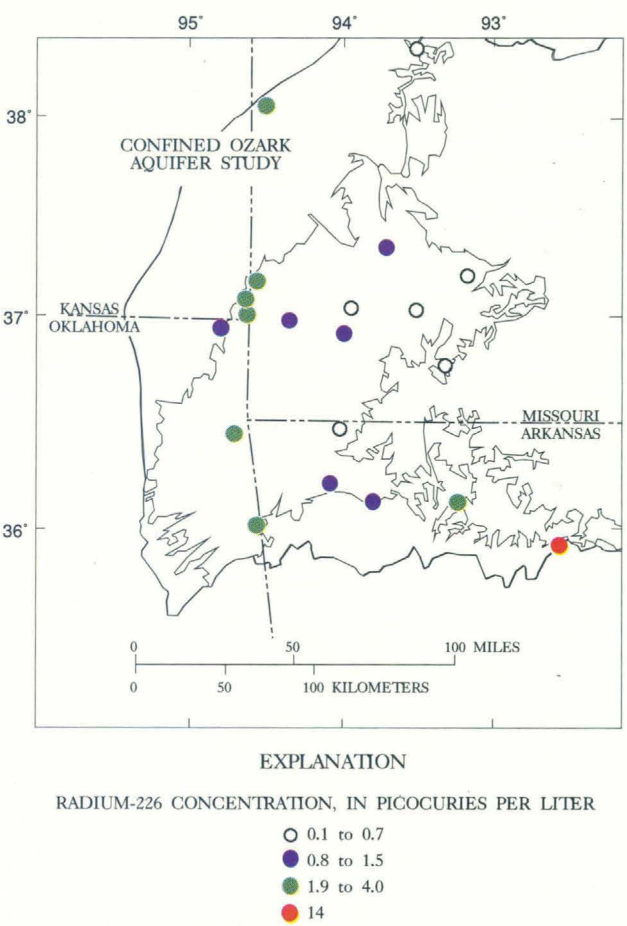

Figure 3. Distribution of radium in ground-water samples collected from municipal-supply wells in the confined Ozark aquifer.

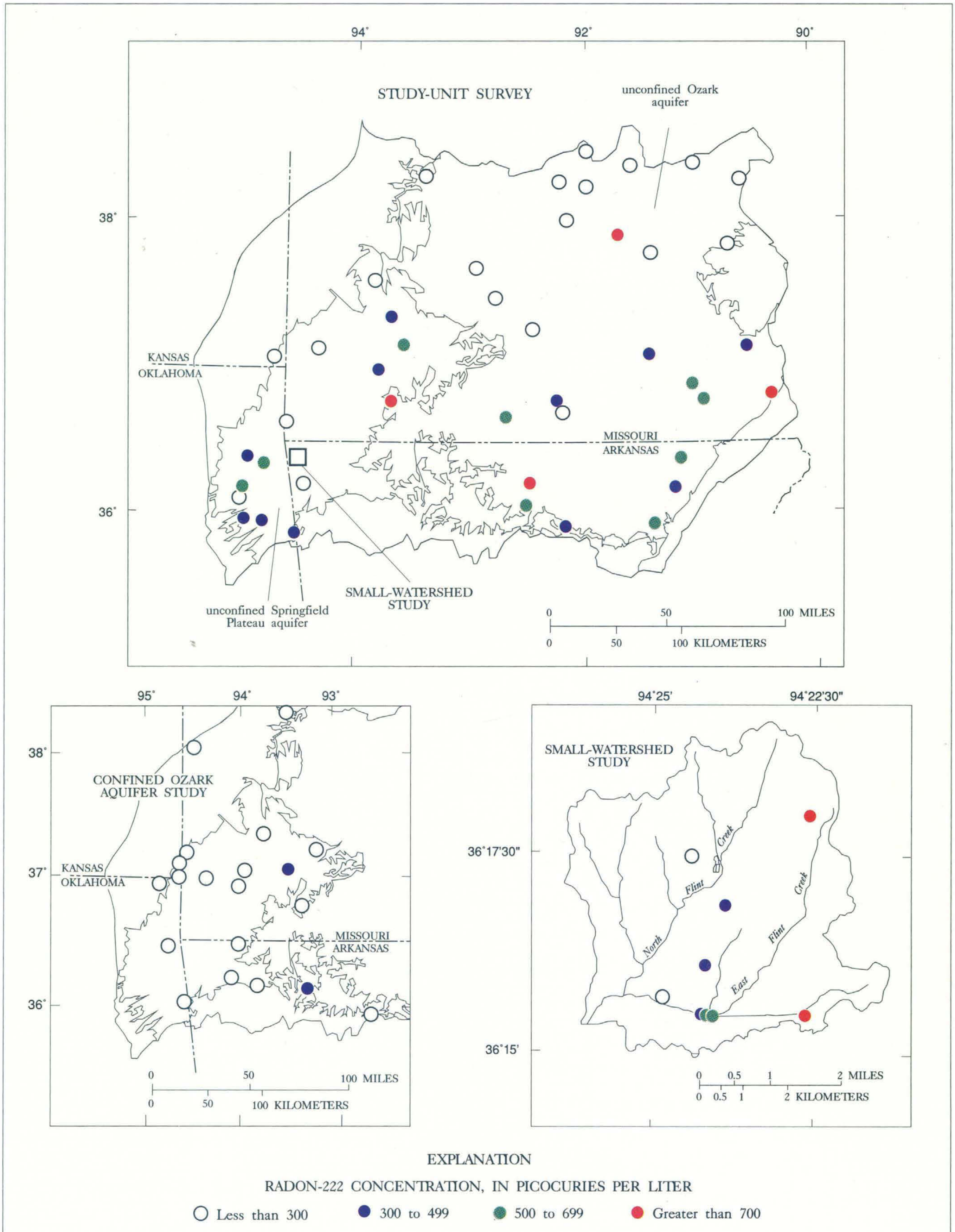

Figure 4. Distribution of radon in ground-water samples collected from domestic and municipal-supply wells.

SIGNIFICANT RADON RESULTS—Continued

- Median radon concentrations were not statistically different between samples collected during the small-watershed study and samples collected from the Springfield Plateau aquifer during the study-unit survey, although the range of radon concentrations in samples was greater during the small-watershed study than during the study-unit survey (fig. 5).
- Radon concentrations were not statistically correlated to site characteristics or field measurements.
- Radon concentration at any particular site is very difficult to accurately predict, based on factors considered in this study.

SUMMARY

- Radium and radon are naturally occurring radioactive elements that can be present in ground water.
- Both radium and radon can cause cancer.
- Radium concentrations ranged from 0.1 to 14 pCi/L in samples from the confined Ozark aquifer. One concentration exceeded the interim MCL of 5 pCi/L.
- Radon concentrations ranged from 99 to 2,065 pCi/L in samples from the Springfield Plateaus and Ozark aquifers. Radon concentrations exceeded the formerly proposed MCL of 300 pCi/L in 33 of 75 (44 percent) samples.

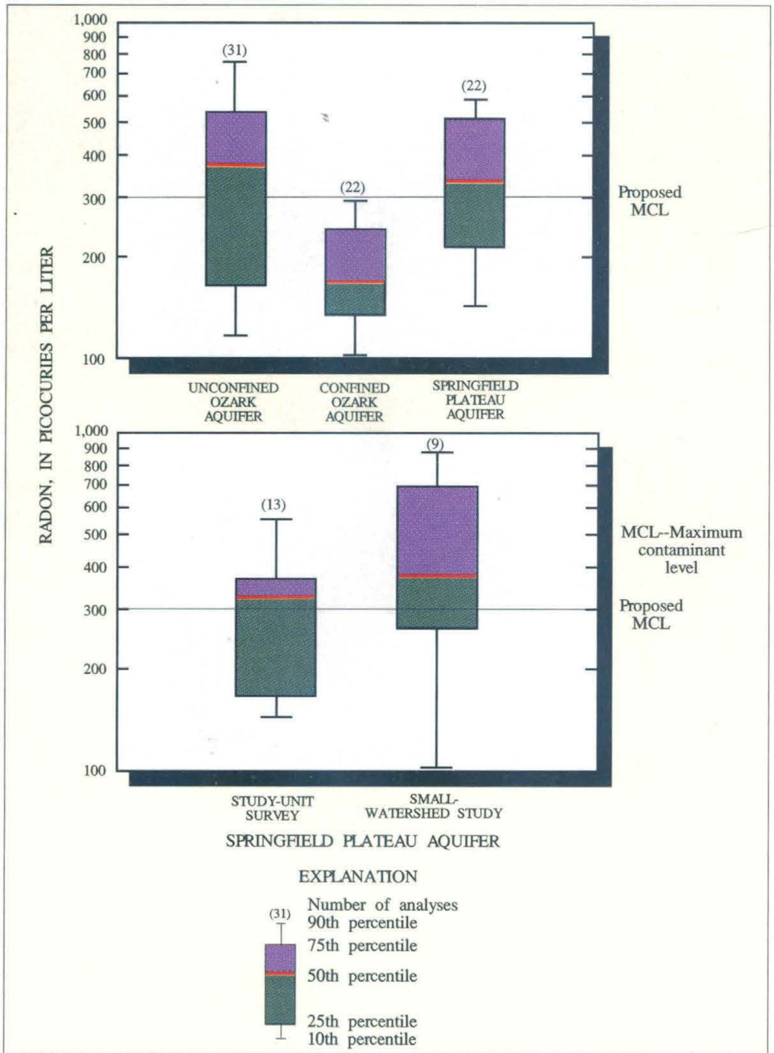

Figure 5. Comparison of radon in ground-water samples collected from the Ozark and Springfield Plateau aquifers.

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Oklahoma
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Radiation Management Section
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National Radon Hotline (800) SOS-RADON

REFERENCES

Adamski, J.C., Petersen, J.C., Freiwald, D.A., and Davis, J.V., 1995, Environmental and hydrologic setting of the Ozark Plateaus study unit, Arkansas, Kansas, Missouri, and Oklahoma: U.S. Geological Survey Water-Resources Investigations Report 94–4022, 69 p.

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U.S. Environmental Protection Agency, 1991, National primary drinking water regulations—radionuclides, proposed rule Federal Register v. 56, no. 138, p. 33050-33127.

____1994, Part one: Introduction *in* Report to the United States Congress on radon in drinking water—multimedia risk and cost assessment of radon: U.S. Environmental Protection Agency EPA 811–R–94–001, 14 p.

U.S. Department of the Interior
U.S. Geological Survey
Fact Sheet FS–181–96

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