REPORT OF THE
SECRETARY OF HUMAN
RESOURCES' TASK FORCE ON

Radon

TO THE GOVERNOR AND
THE GENERAL ASSEMBLY OF VIRGINIA

House Document No. 11

COMMONWEALTH OF VIRGINIA
RICHMOND
1988

COMMONWEALTH of VIRGINIA

Eva S. Teig
Secretary of Human Resources

Office of the Governor
Richmond 23219

December 1, 1987

TO THE MEMBERS OF THE GENERAL ASSEMBLY:

In February of this year, you requested that a study be conducted regarding the problems associated with radon gas in homes, the methods by which radon gas can be detected, and the means by which hazards to the public can be reduced (HJR 229). In order to fully meet this objective, information on the nature of radon was reviewed, including data collected on the occurrence of radon in the Commonwealth of Virginia.

The findings and recommendations of the Radon Study Task Force are reported herein. The growing interest in this issue has allowed the participation of a wide variety of contributors to this study. In addition to the Task Force membership, representatives from the United States Environmental Protection Agency, the Virginia Association of Realtors, the Virginia Association of Home Builders, the radon testing and radon mitigation industries, and other interested parties have contributed to the meetings and the final conclusions of this group.

The proposals recommended by this Task Force will increase the quality and quantity of the information available to the citizens of Virginia about this problem. While assisting them to make appropriate decisions about radon testing and radon mitigation, the Task Force has preserved the rights and responsibilities of the homeowners.

We will be pleased to discuss this report with you and to assist you in any way possible.

Sincerely,

Eva S. Teig

Eva S. Teig

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HP9001426

1987 SESSION
ENGROSSED

HOUSE JOINT RESOLUTION NO. 229

House Amendments in [ ] - February 8, 1987

Requesting [~~that a joint subcommittee be established~~ the Secretary of Human Resources] to study the problems associated with hazardous radon gas in homes.

Patrons--Brickley, Keating, Andrews, Mayer, Byrne, Cunningham, R. K., Allen, Plum, Brown, Wilkins, Harris, Parrish, Morgan, Van Yahres, Thomas and Smith; Senators: Colgan, Saslaw, Waddell, DuVal and Houck

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Referred to the Committee on Rules

WHEREAS, radon gases are produced by the natural decay of uranium found in certain soils and rocks; and

WHEREAS, these radon gases are emitted from the soil in high levels in various areas and occasionally seep into homes and accumulate, causing a health hazard for occupants; and

WHEREAS, hazardous levels of radon gases have been detected by the Environmental Protection Agency and the Virginia Department of Health in homes in certain locations in the Commonwealth; and

WHEREAS, radon gases are odorless, tasteless, and chemically inert, making their detection very difficult; and

WHEREAS, several methods of testing for and removing radon gas from the home are being used or developed; and

WHEREAS, much of the public is unaware of the health risk and potential dangers that are caused by the existence of radon gas in their homes; now, therefore, be it

RESOLVED by the House of Delegates, the Senate concurring, That [~~a joint subcommittee be established to study the problems associated with radon gas in homes, the methods by which radon gas can be detected, and the means by which the hazards to the public can be reduced.~~

~~The joint subcommittee shall consist of seven members to be appointed as follows: two members shall be from the House Committee on Health, Welfare and Institutions, and one member from the House Committee on Conservation and Natural Resources, to be appointed by the Speaker of the House of Delegates; one member shall be from the Senate Committee on Education and Health and one member from the Senate Committee on Agriculture, Conservation and Natural Resources, to be appointed by the Senate Committee on Privileges and Elections; and two citizen members, one to be appointed by the Speaker of the House of Delegates and one to be appointed by the Senate Committee on Privileges and Elections.~~

~~The joint subcommittee shall submit its recommendations to the 1988 Session of the General Assembly.~~

~~The costs of this study, including direct and indirect costs, are estimated to be $16,110.~~ the Secretary of Human Resources is requested to cause a study to be conducted, using the resources within her secretariat and within the secretariats of Natural Resources and Economic Development, regarding the problems associated with radon gas in homes, the methods by which radon gas can be detected, and the means by which the hazards to the public can be reduced. All agencies of the Commonwealth are requested to participate in this study as requested.

This study should be completed by December 1, 1987, and the results reported by the Secretary of Human Resources to the General Assembly prior to its 1988 Session.]

ACKNOWLEDGMENTS

The Task Force is indebted to Vickie L. O'Dell, Information Systems Specialist, Bureau of Toxic Substances (VDH), for her assistance in preparation of this report and the minutes for each of the meetings; and to Philip A. Shaheen, Administrator, Office of Epidemiology (VDH), for his assistance in providing staff support.

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PREFACE

It is the position of this Task Force that the function of government includes the duty to inform citizens of the Commonwealth of both the potential hazards of radon and the mitigation of its effects, while not unduly alarming them. It is also recognized that recommendations made in this context should be those which are most cost-effective for the citizens of the Commonwealth. The extant body of information on indoor radon is both small and in a state of evolution. That radon gas exists, that it caused lung cancer in miners who were exposed to large doses of radon over long periods of time, and that it can accumulate in certain private homes are matters of general consensus. Debate begins, however, with the discussion of the effects of low doses of radon on human health and continues through the impact of geology on indoor radon, applicability of specific testing methods to specific situations, appropriateness of building techniques for radon prevention and/or mitigation, and the advisability of government intervention. Over the next five years, several epidemiologic studies will be completed, the results of which will substantially clarify the health risks associated with exposure to low doses of indoor radon. Other research is being done on the correlation of geologic conditions and rock type to radon accumulation, the prevalence of indoor radon in Virginia, and the effectiveness of a variety of building techniques being tested for radon prevention or mitigation. The results of this research will also be available in the next few years. This report attempts to accurately recount the known facts, the prevalent theories, and the current research on this topic of growing concern.

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I. EXECUTIVE SUMMARY

Radon is a radioactive gas generated by the natural decay of uranium. It is odorless, tasteless, colorless, chemically inert, and highly mobile in the environment. As radon undergoes radioactive decay, it produces new radioactive elements called radon progeny. Radon progeny are solids, chemically active, and electrically charged which allows them to adhere to dust particles in the air or the inner lining of the lungs. Prolonged exposure of miners to high levels of radon progeny in underground mines has caused an increased risk of lung cancer. Since uranium is found in trace amounts throughout the earth's crust, radon can be found in soil or rock and in groundwater which has passed through soil or rock containing radioactive isotopes.

The information available on the concentration of radon or radon progeny in American homes is meager. Collection of data is continuing; however, conclusions drawn are often contradictory. The database of measurements of radon or radon progeny in homes in Virginia is also small; nevertheless, indoor radon appears to be a significant problem for some of the citizens of the Commonwealth.

In order to appropriately address this issue, the Radon Study Task Force recommends 1) that reliable information based on current research continue to be made available to the public; 2) that persons living in or purchasing homes in the piedmont and mountain (Blue Ridge and Valley/Ridge) regions of the Commonwealth be encouraged to test their homes for radon and to become knowledgeable on the topic; 3) that other residents of Virginia who are concerned about the presence of indoor radon have their homes tested; 4) that the results of ongoing radon research be monitored so that risks associated with indoor radon may be better quantified; 5) that home construction techniques being developed to minimize radon exposure be monitored and the results be disseminated to builders, building inspectors, realtors, and other interested parties, statewide; and 6) that the Commonwealth refrain, at this time, from mandating either radon testing prior to real estate transactions or licensing of companies engaged in radon testing or mitigation.

II. BACKGROUND INFORMATION

Radon is a radioactive gas produced by the normal decay of uranium. Uranium is a naturally occurring radioactive element found in trace amounts throughout the earth's crust. It is not distributed uniformly; some geologic areas may be relatively barren while other areas may contain higher concentrations of uranium-bearing minerals. It decays through a series of radioactive isotopes to produce radium which decays to produce radon. Radon, the only gaseous member of the decay chain, is highly mobile in the environment, moving through fractures in rocks and the pore spaces between soil particles to the earth's surface where it usually is dispersed and diluted to very low concentrations. Buildings can act as traps collecting radon as it enters through porous or cracked foundations, spaces around pipes, drains, and sumps. Radon also may escape from groundwater contaminated with radon or be released from building materials. Radon is colorless, odorless, tasteless, and chemically inert (Windholz, 1983). Being inert, radon can move through permeable materials without being absorbed.

Radon, which has a half-life of 3.8 days, continues to undergo radioactive decay, emitting alpha and gamma particles, and produces new radioactive elements called radon daughters (NCRP, 1984a), radon decay products, or radon progeny (EPAORD, 1986b). These new materials are solids, not gases; they are chemically active and electrically charged which allows them to adhere to surfaces such as dust particles in the air or the inner lining of the lungs (Parkes, 1982). Several of the radon progeny also emit alpha radiation which has high energy, but is the least penetrating of the different kinds of radiation. Research has indicated that the prolonged exposure of underground miners to high levels of radon progeny can lead to an increased risk of lung cancer (NAS, 1981).

A. Sources of Radon

The primary sources of radon are soil or rock; building materials, such as cinder blocks or concrete; and groundwater that has passed through soil or rock containing radioactive elements (NCRP, 1984a). In some parts of the country, uranium mining wastes have been used as fill dirt around the foundation of houses, causing radon contamination (NCRP, 1984a). Radon problems have been found in areas of the country having high uranium concentrations in the soil and rock. Indoor radon problems also have been found in areas having moderate to low concentrations of uranium in the soil and rock. Building materials have been important sources of radon in only a few known cases in the

United States (NCRP, 1984b). Groundwater contamination by radon will occur if the soil and rock in an aquifer contains uranium in the rock and if the water storage time is especially short, as in private wells or other small water systems. When the water enters the house and is agitated by showers, washing machines, or other appliances, the waterborne radon will be released into the home (NCRP, 1984a).

B. Indoor Radon Concentrations in the USA

Concentrations of radon gas are expressed as picocuries per liter (pCi/l) of air. The curie is a measure of radioactivity; pico means one-trillionth (0.000000000001) (EPAORD, 1986b). A picocurie represents the decay of about two radon gas atoms per minute in about a quart of air (VDH, 1986b). Concentrations of radon progeny in air are expressed in units called Working Levels (WL). At the characteristic equilibrium (50%) conditions of radon and its progeny found in most indoor environments, 1 WL equals 200 pCi/l (Parkes, 1982). Conversely, 1 pCi/l of air will produce a radon progeny concentration of 0.005 WL (VDH, 1986b). [Radon progeny exposure is expressed as a Working Level Month (WLM). By definition, a Working Level Month is only 170 hours long, based on hours on the job (Parkes, 1982); however, a calendar month is 720 hours long so corrections must be made in figures for conditions in a home, depending on the time spent in the home (VDH, 1986b).]

The outdoor radon concentration in the northern hemisphere is approximately 0.1 to 0.15 pCi/l and the corresponding radon progeny concentration is 0.0006 to 0.0009 WL. Outdoor concentrations vary according to barometric pressure, precipitation, time of day, local uranium presence, soil structure, and land use (NCRP, 1984a).

Information on the concentration of radon or radon progeny in homes across America is not abundant and the data that exist are sometimes contradictory. The U.S. EPA reports that houses in this country normally have radon progeny ranging from 0.002 to 0.04 WL, depending upon the site (EPAORD, 1986b). Recent monitoring of houses in the Reading Prong (Pennsylvania) area, known to contain high concentrations of uranium, detected radon progeny concentrations ranging from 0.1 to 10 WL in many of the houses (EPAORD, 1986b). The U.S. DOE estimates that a million homes have radon concentrations exceeding 8 pCi/l or radon progeny concentrations of 0.04 WL (DOE, 1986). Since most radon enters the home from the soil, the radon and radon progeny concentrations are generally two times higher in basements than in non-basement living areas (NCRP, 1984a). Terradex, a private radon monitoring company, has accumulated data from the testing of an estimated 30,000 homes. While they were not attempting a representative national study, Terradex has tested homes in all fifty states and they have found an arithmetic average radon concentration of 7.2 pCi/l, a median of 1.77 pCi/l, and a geometric mean of 1.89 pCi/l (Alter and Oswald, 1987). These data represent the largest database of radon measurements in the United States.

C. Health Risks Associated with Radon Exposure

Although much has been written about the risks from prolonged exposure to radon, it is important to distinguish between risks which have been estimated and risks which have been observed epidemiologically. Current risk estimates for persons living in homes with radon levels near the EPA action level invoke at least two assumptions. The first is that risk estimates obtained from studies of underground miners can be used for radon exposures in the home. The second is that the observed risks associated with high cumulative doses of radon can be extrapolated (in a linear fashion) to estimate the risk associated with lower cumulative doses to which many home occupants are expected to be exposed. Such extrapolation cannot be done without making a number of scientifically controversial assumptions which need to be validated by current and future epidemiologic research. Assumptions must be made about the duration of exposure; the dose-response relationship (including the presence or absence of a dose threshold below which health effects would not occur); and the influence of individual variations in age, gender, and genetic predispositions. Much of the fear connected with radiation exposure is due to uncertainty in the estimation of outcome and the period of latency (Adelstein, 1987).

Much of what is known about the health risks associated with exposure to radon and radon progeny comes from analysis of the effects on underground miners of high exposures over long time periods (NAS, 1981). There is considerable controversy over the appropriate application of such data to the general public exposed to radon in their homes alone. Some refer to lung cancer from indoor radon as a "statistical illness" created by multiplying a very small risk by very large populations to give rise to frightening figures (Goldsmith, 1987). Discrepancies between anticipated and actual cases of lung cancer have caused some researchers to propose the possibility of another cancer-causing agent in the mines to account for the discrepancies (Cohen, 1985). All of the miners in these studies were men and most of them were cigarette smokers. Their environment was subject to a variety of airborne particles (NCRP, 1984b).

Radon guidelines recommended by the EPA and other organizations are based on extrapolations of data gathered under circumstances quite different from those found in homes (IDNS, 1986). The data that do exist have been interpreted in different ways. The U.S. EPA has recommended that radon concentrations at or above 4 pCi/l should be lowered. This EPA "action level" applies to annual average exposure under normal living conditions. According to the EPA, projected health effects resulting from 70 years of exposure for 18 hours per day at this level of exposure to radon increases the risk of developing lung cancer by approximately 3 times the normal risk (EPAORD, 1986b).

Currently, the National Cancer Institute and other researchers have begun epidemiologic studies in an effort to more clearly document the link between indoor radon and lung cancer. These studies are being conducted in Maine (600 female cases, 600 controls); in New Jersey (500 female cases, 500 controls); in Pennsylvania (2,000 female cases, 4,000 controls); in Sweden (200 female cases, 400 controls); and in Canada (1,000 male and female cases, 2,000 controls). In most of these studies, only women are being observed since it is likely that women spend more time at home than men and they are less likely to smoke or to be exposed to occupational carcinogens (Goldsmith, 1987). Research of this nature requires extensive amounts of manpower, money, and time. These studies mentioned above will be completed in the next five years (by 1992). The applicability of the findings of such studies will not be restricted to the localities in which they were conducted i.e. the findings will be of immense value in assessing the radon problem in Virginia.

In conclusion, a number of statements can be made about the health risk from radon. First, a number of epidemiologic studies have documented an increased risk of lung cancer in miners exposed to radon (NAS, 1981). Few authorities question radon's role in causing cancer in those mining populations. Second, the exact magnitude of the risk to miners is still uncertain. The reasons for this include the fact that the miner studies did not quantitate the radon levels in the mines, or parts of a single mine, over the time period of exposure (doses were estimated retrospectively); miners were exposed to other pollutants in the mines; many miners smoked tobacco products; and miner cohorts studied have not yet been followed for a lifetime, necessitating an estimation of total lifetime lung cancer deaths (those observed to date plus an estimate of future deaths among those still living). Third, based on the studies of miners, it is reasonable to assume that there is a risk associated with prolonged exposure to high levels of radon in the home. The exact magnitude of that risk is, however, unknown at this time. In addition, it is not clear whether or not there is a risk associated with prolonged exposure to low levels of radon in the home; most authorities, however, believe it is prudent practice, in the absence of evidence to the contrary, to assume the risk at low dose exposures is a linear or curvilinear function of the risk at higher dose exposures.

D. Factors Influencing Radon Concentrations in Homes

There is wide variety in the factors that control the accumulation of radon or radon progeny in a home. At this time, prediction, with any degree of accuracy, of potential indoor radon problems for a particular home is impossible without testing.

1. Characteristics of Soil and Underlying Rock

Uranium can be found in some concentration in almost all rock and soil. Acidic rock, such as granite, usually produces higher radon concentrations, while less acidic rock, such as limestone or sandstone, usually produces lower concentrations (NCRP,1984a). Homes found to have a problem with the accumulation of radon and radon progeny are usually built in areas with higher concentrations of uranium or radon in the soil or underlying rock; however, some homes with elevated concentrations of radon have been noted in areas with only moderate levels of natural uranium in the soil and underlying rock (NCRP, 1984a).

A small amount of uranium can result in an indoor radon problem when found in an area of highly fractured rock and porous, well-drained soils allowing radon to diffuse more rapidly through the soil and into the lower levels of the home. Generally, clays and high moisture soils are impermeable and soil that is saturated with water restricts the movement of radon (IDNS, 1986).

2. <u>Weather and Season</u>
Since radon is a gas, it responds to environmental conditions in a predictable manner. If there is greater air pressure inside the house than outside, the gas will migrate out of the house through any available opening. The usual condition, however, is greater pressure outside the house; therefore, radon can diffuse into the house, if there are openings available. Lowered air pressure inside a house can be caused inadvertently by many factors, including: opening windows only on the downwind side of the house; the use of exhaust fans in the kitchen, bathroom or attic; and the consumption of air by appliances such as furnaces or clothes dryers (EPAORD, 1986a). Windy conditions cause rapid dispersion of radon, while lack of wind allows radon to build up in an area. Rain will carry radon out of the air and into the soil or surface water. Indoor radon is considered a greater problem in the winter because people keep doors and windows closed (allowing any radon present to accumulate) and because the use of fireplaces and furnaces creates a "stack effect" which draws radon into the home, assuming radon is present in the soil and that there are available openings.

3. <u>Ventilation</u>
A low ventilation rate may contribute to indoor radon pollution. If a house is situated over soil with a high level of radon and if that radon is entering the house at the subsoil level, poor ventilation may cause radon to accumulate inside the house. Some homeowners' efforts to increase the energy efficiency of their homes may contribute to radon accumulation, but this is not always the case. Studies have shown that homes can be energy efficient, as well as properly ventilated, by using appropriate methods (Gammage, 1985). Conversely, a high ventilation rate can increase the subsoil radon pulled into the house by creating a "stack effect". A high ventilation rate can be implemented to vent radon from the living areas of a home, if ventilation is done properly. The impact of high or low ventilation rate on the accumulation of indoor radon will vary depending on other contributory factors, such as points of entry and the strength of the source of the radon. The significance of the ventilation rate can be minimized by preventing radon entry at the subsoil level or by increasing the air pressure inside the structure. If the air pressure gradient is higher inside the house than

outside, the radon will not enter at all and therefore cannot accumulate (Gammage, 1985).

4. <u>House Structure and Condition</u>
The structure and condition of a house are major factors in its susceptibility to radon pollution. Since the primary source of radon is the soil, any openings between the house and the soil are potential routes of entry for the gas. The type of foundation and the materials from which the foundation is constructed are critical to the permeability of the house to radon gas. The presence of hairline cracks in a concrete basement floor may allow radon to seep in, if the pressure gradient is favorable. Openings for a sump pump or for plumbing fixtures will allow radon entry as will loose mortar joints below grade level. Radon entry is not always a significant problem since good ventilation methods and/or proper venting of the radon gas can remove it from the living areas rapidly. Nevertheless, a house constructed to prevent radon entry will allow radon gas to enter, if the radon prevention techniques have been circumvented by later building modifications. As a well built home settles over time, small cracks and crevices may develop which would allow radon entry also.

E. <u>Techniques for Measuring Radon</u>
There are several methods available to measure radon or radon progeny in a home. Different methods are suited to differing situations. Variations occur in the time needed for the testing, the skill needed by the tester, the need for electrical power, the precision of the test results, portability of the device, and the cost. "The U.S. EPA has developed measurement protocols for seven different methods and believes that any of them, <u>when used in accordance with the protocol</u>, can produce valid results" (EPAORP, 1987). The methods are:

1. Continuous Radon Monitoring and Continuous Working-Level Monitoring.
This test device gives short-term, precise results (the hourly average concentrations) on-site. It is relatively expensive ($100 to $300) and requires a skilled operator and controlled environment.

2. Alpha-Track Detection.
Alpha-track detectors are relatively inexpensive and require no special skills to install. They can be distributed through the mail and need no

external power source. They are used for long-term measurements (three to twelve months). The detectors must be sent to an analytical laboratory for processing and evaluation.

3. Activated Charcoal Adsorption.
These detectors claim low costs and no special skill to install. They can be distributed through the mail and need no external power source. They are used for short-term testing only and require a controlled environment. Some charcoal adsorbers are more sensitive than others to temperature and humidity.

4. Radon Progeny Integrating Sampling Unit.
These units are expensive and some of them are quite heavy and awkward to handle. Generally speaking, they must be installed and picked up by skilled operators and they use AC power. Because there is extensive experience in the use of these units, measurement errors are well established and results are precise. Radon progeny measurements are much more susceptible to sampling error than radon gas measurements.

5. Grab Sampling - Radon and Radon Progeny.
With this technique, results are obtained quickly. Several samples can be evaluated per day. The equipment is lightweight and some of the systems are able to sample both radon and radon progeny at the same time. A skilled operator and a controlled environment are needed. The test is relatively expensive and the short-term measurements may not be indicative of the actual long-term concentrations.

There is no one best way to detect radon or radon progeny in a house. Each method is suited to a particular set of circumstances. All of those discussed above are considered to be commonly used methods.

F. <u>Procedures for Reducing Radon Concentrations in Homes</u>
Even though radon gas appears to be a problem for a number of homeowners, it is not an impossible one to solve. The U.S. EPA and several private groups, including the National Home Builders' Association, are currently doing research on the effectiveness of mitigation and prevention methods (EPAOARRD, 1987). Early results of research indicate that all homes with radon problems can have significant reduction of the hazard, if correct methods are implemented (Gammage,

1985). Complicating matters is the fact that no two houses are alike where radon accumulation is concerned. Small differences in construction and in underlying soil characteristics will affect the likelihood of radon entry and accumulation in each house; therefore, mitigation and prevention techniques must be suited to each individual situation. There are several methods available for radon reduction; however, the effectiveness of any one method will depend upon the individual characteristics of the house, the level of radon found, the routes of radon entry, and how well the method is implemented. In many cases, several methods must be combined to reduce radon to acceptable levels in one house (VDH, 1986a).

Most radon reduction methods should be implemented by trained or experienced construction professionals. Do-it-yourself efforts are not recommended (EPAORD, 1986a). However, homeowners must be actively involved in mitigation decisions and be aware of counterproductive nonmitigation-related modifications to avoid in the future. Since this is a relatively new field, contractors generally will not be willing to guarantee a reduction in radon levels in a home. After modifications are made for the purpose of radon reduction, testing must be repeated to verify the effectiveness of the mitigation techniques. The optimum situation is one in which all new construction includes implementation of radon prevention and mitigation methods which could be used should problems with radon accumulation ever develop.

Three of the nine methods suggested by the EPA for radon reduction in private homes encompass increasing the ventilation in the lowest levels of the house. Whether natural, forced, or heat-recovery ventilation is used, the basic concept is to increase the air exchange rate, exchanging radon-laden indoor air for outdoor air. Care must be taken to avoid creating negative pressure inside the house as this would pull radon into the structure from the soil. Increasing ventilation will probably increase the cost of climate control in a home in addition to the installation and/or operating costs (EPAORD, 1986a).

A fourth method demands the provision of an external air supply for all appliances requiring an air supply. This prevents the use of indoor air and reduces the negative pressure that such use can cause. Appliances needing air supplies include clothes dryer, furnace, woodstove, and fireplace.

Houses which have areas of exposed earth in the basement have no seal to prevent radon entry through the soil into the living area of the house. Storage areas, drains, sumps, and crawl spaces are often major points of entry for radon. To prevent this entry the exposed earth must be covered, sealed off, or ventilated away from the living areas. This may mean pouring a concrete slab, covering soil with a gas-proof liner or aluminum sheet metal, and sealing joints with caulk. The effectiveness of this method is directly proportional to the degree of impermeability reached by the various coverings and seals.

Sealing all subsurface cracks, openings around utility pipes, joints between floors and walls, and holes in the top row of concrete blocks will reduce the entry of radon into the home. Some sealing can be done by a homeowner knowledgeable in preparing a surface for sealing and the use of sealants (VDH, 1986a). Some areas needing sealing may be inaccessible, if not impossible to reach, without considerable expense. Settling of a house and weathering may cause new cracks over time; therefore, periodic maintenance is necessary.

Some homes use drain tile systems to drain water away from their foundations. Drain tiles are perforated pipes laid in a continuous loop around the base of the house. With an exhaust fan installed at the collection pipe or to the sealed sump, this drain tile system can also be used to draw radon away from the house. A water-filled trap installed beyond the fan will prevent air flow in the wrong direction (EPAORD, 1986a). The tiles must be in a continuous loop and not blocked at any point. The system will reduce radon unless there are block walls dividing the interior of the basement.

Hollow concrete block walls are more permeable to radon infiltration than solid concrete walls. Block wall suction will remove radon from walls before it can enter the living space of a home. Pipes are installed into the exterior walls at the lowest level of the house and fans are used to draw the radon through the pipes and out of the house. The top of the concrete block wall, the space between the walls and any exterior brick veneer, and all openings in the walls must be sealed or the block wall ventilation will not work as it should (EPAORD, 1986a). Future penetration of the wall by objects such as nails must be avoided.

The last method for radon reduction being studied by the EPA currently is sub-slab suction. This method also pulls radon from underlying soil before it can enter a home. Sub-slab suction pertains only to homes built over a concrete slab. Radon accumulates under the slab and may be vented by drilling holes through the slab and inserting pipes which are connected to an outside fan. This method works best if the concrete slab is poured over a bed of crushed stone or highly permeable soil. Often, this method must be used in conjunction with block wall suction or some other method to prevent radon from penetrating the living spaces. The EPA and the National Home Builders' Association are currently investigating the efficacy of this method and the value of suggesting crushed stone as a base for all new construction in order to facilitate radon mitigation as the need arises (McLeister, 1987). This technique affords the advantage of causing no decrease in the energy efficiency of the home.

Once again, there is no one best way to reduce radon. Each situation will be slightly different and the typical case will require a combination of methods determined by the characteristics of the house and the specific points of radon entry. As the research continues, the development of additional techniques may occur and the building of new homes will incorporate these ideas; however, all new construction can be expected to follow the basic principles for radon reduction (EPAOARRD, 1987):

a) Minimize pathways for soil gas to enter.

b) Maintain a neutral pressure differential between indoors and outdoors.

c) Incorporate features during construction which will facilitate radon removal after completion of the home if prevention techniques prove to be inadequate.

III. GEOLOGY OF VIRGINIA AS IT RELATES TO RADON

A. General Information

Virginia can be divided into five large belts of rocks based on overall rock similarity. These five belts, which are roughly parallel to the physiographic provinces of the Commonwealth are, from east to west: the Coastal Plain, Piedmont, Blue Ridge, Valley and Ridge, and Appalachian Plateaus. Each province has distinctive characteristics that relate to bedrock, which has influenced development of both topography and soil. The rock types in some of these provinces lend themselves to a greater frequency of uranium-bearing minerals. As a general rule, uranium is more likely to be present in greater concentration in acidic (felsic) rocks, such as granite, than in basic (mafic) rocks, such as basalt.

1. Coastal Plain Province

   The Coastal Plain is underlain by unconsolidated to semiconsolidated sand, gravel, clay, and shell marl that dip eastward. The topography of the Coastal Plain is a dissected oceanward-sloping surface of low relief. Igneous and metamorphic rocks similar to those in the Piedmont form the "basement" of the Coastal Plain. Buried basins that contain Mesozoic-age rocks comprise a portion of the "basement".

2. Piedmont Province

   The Piedmont is made up of igneous and metamorphic rocks and lies west of the Coastal Plain Province. It has a rolling landscape that is interrupted by a more rugged terrain in places. The Piedmont is about 30 miles wide at the Potomac River and increases in width to about 165 miles at the North Carolina boundary. Because the Piedmont rocks have been subjected to a long period of weathering, a saprolite zone of up to 160 feet thick is not uncommon.

   The most common rock types are mica schist, phylite, gneiss, diorite, gabbro, granite, granodiorite, metabasalt, amphibolites, and diabase. Also contained within the Piedmont are Mesozoic-age sedimentary rocks preserved in fault-bound basins. The sedimentary rocks in these basins are non-marine sandstone and siltstones with minor amounts of conglomerate and limestone. Black and gray shales are also present. Minor interbedded basalt flows occur in the Culpeper basin. The sedimentary units in the basins (mainly the Culpeper basin) are intruded and locally metamorphosed by dikes, sills, and stocks of diabase. The intrusions have locally altered the surrounding sedimentary units into quartzites, hornfels, and marbles.

3. Blue Ridge Province

   The Blue Ridge is composed of very ancient high rank metamorphosed igneous rocks overlain by younger metasedimentary and metavolcanic rocks. Younger igneous rocks have intruded these older rocks. The province occupies a relatively long and narrow zone that extends from the Potomac River to the North Carolina boundary in a general northeast-southwest trend. The rocks in this province are mainly granulite gneiss, charnockite, granite, metabasalt, and metamorphosed clastic sedimentary and volcanic rocks.

4. Valley and Ridge Province

The Valley and Ridge Province is characterized by well defined linear valleys and intervening sharp crested ridges. The rocks that underlie the province are sandstone, siltstone, shales, conglomerate, limestone, and dolomite. Igneous intrusive rocks occur sporadically in the province.

5. Appalachian Plateaus Province

The Appalachian Plateaus Province, the westernmost province in the Commonwealth, is characterized by rugged topography. The sedimentary rocks are chiefly flat-lying to gently folded sandstone, siltstone, shale, conglomerate, and coal.

B. Geology and Radon

Although radon is a site-specific problem, several generalities can be made in regard to its occurrence and geological setting. Because of the known presence of uranium-bearing minerals in some of the rocks that compose the Piedmont and Blue Ridge, these provinces are more "suspect" than the Coastal Plain, the Valley and Ridge, and the Appalachian Plateaus. Although limited statewide radon data are available, the presence or suspected presence of uranium concentrations in the Piedmont and the Blue Ridge would lead one to expect higher radon concentrations in these two areas.

1. Uranium Occurrences in the Piedmont and Blue Ridge Provinces

The Piedmont and Blue Ridge provinces contain favorable environments for concentrations of uranium-bearing minerals. These environments are major cataclastic zones (shear zones) favorable for vein-type occurrences, and the low-rank metasediments and metavolcanics that lie near the margin of igneous plutons and are favorable for allogenic occurrences (Baillieul and Daddazio, 1982). Occurrences of uranium and thorium are reported in many counties, including Albemarle, Amelia, Bedford, Culpeper, Henry, Grayson, Nelson, and Rappahannock (Baillieul and Daddazio, 1982; Grauch and Zarinski, 1976).

The world class uranium deposit of Marline Uranium Corporation in Pittsylvania County (Swanson Uranium Deposit) occurs in a major fault (shear or cataclastic) zone, the Chatham fault. Analysis of the aeroradiometric data indicates anomalously high levels of radioactivity along the fault, which could reflect the presence of uranium.

Anomalously high levels of radioactivity over a large portion of Powhatan County was detected by an aeroradiometric survey in 1974 (VDMR, 1974). Detailed geologic investigations near Powhatan indicate high uranium and thorium occurrences (Krason et al., in preparation). Similar aeroradiometric patterns occur in many areas of the Piedmont and they too should be suspect.

Measurements of radioactivity taken over the aureoles of metasedimentary rocks (baked zone, hornfels) adjacent to diabase intrusive rocks in the Culpeper basin are high as opposed to the low readings over the intrusive diabase (Leavy et al., 1982). Daniels (1980) reports that areas immediately adjoining baked zones in Fairfax County have higher radiometric values than the intrusive rocks. He suggests that the thermal effects of the diabase intrusion may have caused an enrichment of radionuclides mobilized from rocks closer to the hot diabase.

2. Uranium Occurrences in the Valley and Ridge and Appalachian Plateaus Provinces

In sedimentary rocks, such as sandstone, limestone, and noncarbonaceous shale, most of the radionuclides are in the detrital particles. Generally, with the exception of black carbonaceous shale and the arkosic sandstone, sedimentary rocks are low in uranium and in overall radioactivity. The Valley and Ridge and Appalachian Plateaus fall into this sedimentary rock group.

However, uranium enrichment in black shale results from the affinity of organic matter for uranium. Black shale occurs throughout many areas in these provinces. This affinity occurs because uranium is transported as an ion in oxidizing groundwater until, in the case of black shales, it encounters a reducing environment. The black shales originated in and remain a reducing environment. Stow (1955) states that several areas in these provinces should be further investigated for uranium. His "suspect" lithologies are mainly sandstone units. The areas to be investigated are quite extensive.

3. <u>Uranium Occurrences in the Coastal Plain Province</u>
The Coastal Plain Province should have the fewest problem areas in regard to radon generation from uranium. However, the presence of uranium-bearing phosphate and heavy minerals (monazite and zircon) could be significant. Radon greater than 4pCi/l has been reported in the province.

C. <u>Radon in Groundwater</u>
Although radon in Virginia's groundwater is unlikely to be a major contributor to the overall radon gas problem, elevated levels in the groundwater supply can add to the total amount of the gas present in the home. As a general rule, the radon in groundwater will reflect the type of rock through which it passes. The Virginia Division of Mineral Resources has performed a few analyses and correlated the results with rock type. As expected, higher values are present in water from rocks that contain uranium-bearing minerals and lower values are found in water from rocks that do not contain these minerals. The highest value was 6,133 pCi/l in granodiorite and a low value of 27 pCi/l in metabasalt.

The results of additional analyses of 63 water samples were reported in a U.S. Department of Energy News Release of January 16, 1981. The samples were from an area in central Virginia (Gordonsville 15-minute quadrangle; Piedmont Province). The values reported ranged from 10,635 pCi/l to 0.00 pCi/l. The same news release reported on 51 water samples from the Culpeper basin (Mesozoic-age rocks). The values reported ranged from 1,576 pCi/l to 1pCi/l. Correlation with rock types was not reported.

Baillieul and Dexter (1982) state that radon values in groundwater from the Hylas zone and the adjacent Richmond basin are anomalously high and may indicate nearby uranium-enriched source rocks. They also state that pegamites, protomylonite, and granite could be a source of uranium in the groundwater. Based on the data, they considered the Richmond basin to be a favorable environment for uranium concentration in sandstones.

D. The National Uranium Resources Evaluation (NURE) Program

The NURE program funded the acquisition of thousands of miles of aeroradiometric data over Virginia (using flight-line intervals of approximately five miles). The results of the surveys indicate hundreds of first-priority uranium anomalies throughout all of Virginia's physiographic provinces. Many of these anomalies have been suggested as possible uranium prospects based on anomaly characteristics and geologic location.

E. The Virginia Division of Mineral Resources Program

The Virginia Division of Mineral Resources acquired aeroradiometric spectrometer data during 1974 - 1981. This data was obtained over a large area of the Piedmont and Blue Ridge provinces and over a small area in the Ridge and Valley Province. The data is available as contour maps showing the total count of radioactivity along one-half mile flight lines. Anomalous areas were indicated as to the major radioactive element uranium, thorium and/or potassium. Profiles for each flight line are available for most surveys. The maps are available at scales of 1/62,500 and 1/250,000. The profiles are available at a scale of 1/62,500. These data are valuable in a regional context in order to identify areas of potential problems.

IV. SUMMARY OF DATA ON INDOOR RADON LEVELS IN VIRGINIA

A. VDH Study

The Virginia Department of Health conducted a study of indoor radon accumulation in homes in Virginia in 1986-1987. The purpose of this study was to determine the extent to which radon poses a health hazard in Virginia. No attempt was made to characterize either the annual average concentration of radon in particular homes or the extent of the radon problem within a particular locality. Using a systematic stratified sample of VDH employees, 725 homes throughout the state were tested for radon progeny in the air. Initial screening was performed in the lowest livable area of the home with a continuous working level meter for a two hour test period. The homes were tested under "worst case" or "closed house" conditions.

Table 1 shows the distribution of radon levels in Virginia homes given the assumption that the VDH study population is representative of the total state population. This assumption may or may not be valid. The following figure depicts the results (average

Table 1. Distribution of Radon Levels in Virginia Homes*

Radon in Working Levels	or picocuries/L**	Virginia Population	% of Total
0.000 - 0.0009	0.0 - 0.19	578,149	10.1
0.001 - 0.0019	0.2 - 0.39	1,078,499	18.9
0.002 - 0.0039	0.4 - 0.79	1,334,477	23.4
0.004 - 0.0099	0.8 - 1.99	1,434,983	25.1
0.010 - 0.0199	2.0 - 3.99	688,045	12.1
0.020 - 0.0399	4.0 - 7.99	407,246	7.1
0.040 - 0.0999	8.0 - 19.99	159,475	2.8
0.100 - 0.4999	20.0 - 99.99	25,427	0.4
	Total	5,706,301	100.0

* Assumes VDH study population is representative of the total state population.

** EPA Action Level is 0.02 Working Levels or 4 picocuries/L.

concentration in working levels) by Health District. Longer term follow-up testing was provided to those homeowners whose initial screening results indicated levels at or above 0.02 WL. Results from the long term tests are discussed below. The following major conclusions were drawn from the research data (VDH, 1987a):

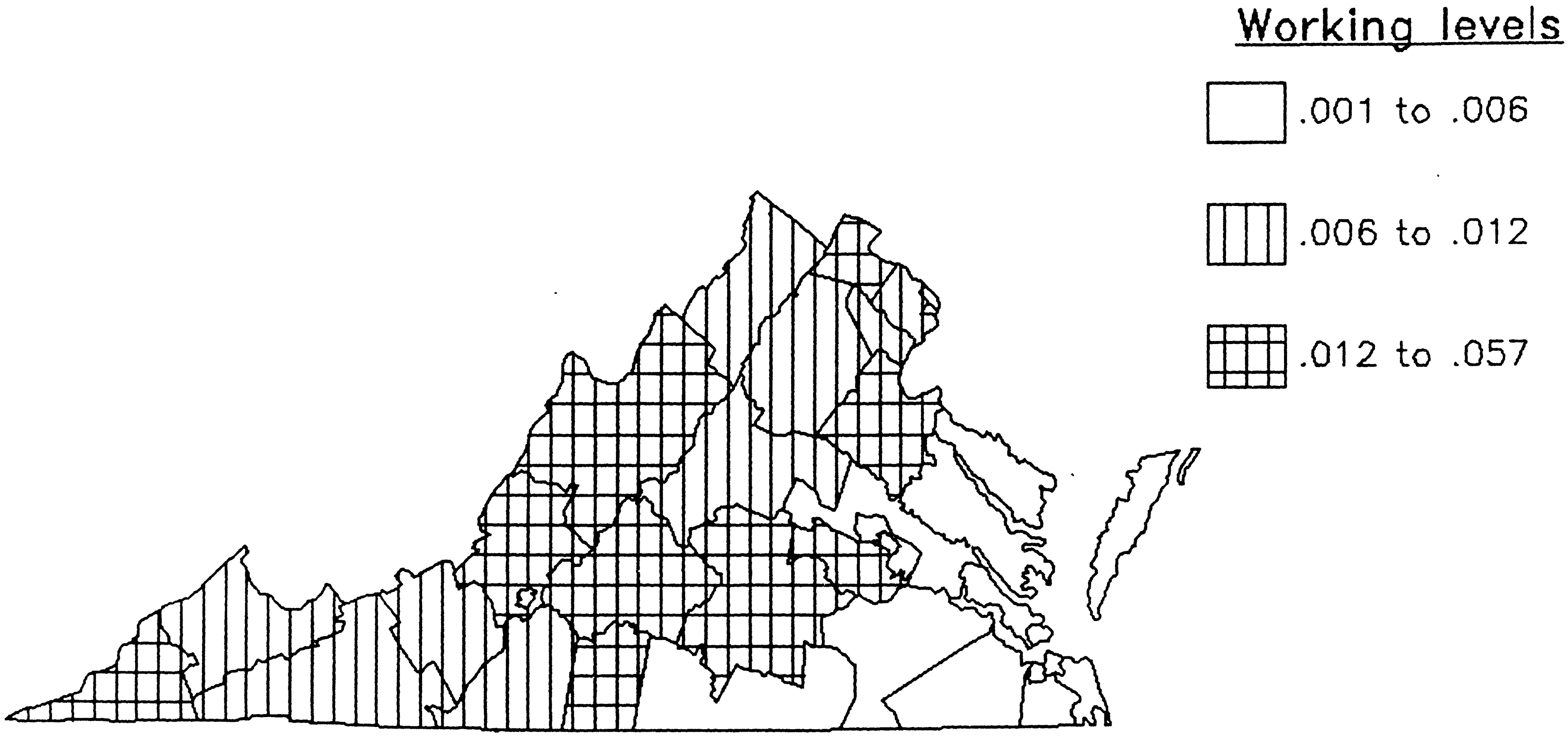
1. The percentage of homes found to be at or above the EPA action level was 19%, 12%, and 1% for homes in the mountain (Blue Ridge and Valley/Ridge), piedmont and tidewater (Coastal Plain) areas, respectively.

2. Homes built over basements were more likely to have elevated radon progeny levels than those built over a concrete slab or a crawl space.

Subsequent to the statewide screening survey described above, confirmatory testing was initiated in 91 homes with screening radon daughter concentrations at or above 0.02 WL (eight homes had levels slightly below 0.02 WL). As of the date of this report, results have been received for 84 homes. Of these, 26 utilized time-averaged working level survey meters (R.A.D. Services Model M-1) placed in the home for a period of five days, and 58 utilized alpha-track detectors

AVERAGE RADON PROGENY BY HEALTH DISTRICT

VDH Employee Survey, Virginia



VDH denotes Virginia Department of Health

(Terradex Track Etch) placed in the home for a period of three months. The mean confirmatory level (0.027 WL) was significantly lower than the mean screening level of 0.045 WL. This finding was not unexpected, since screening tests were conducted under artificial, worst-case (closed house) conditions, whereas confirmatory testing was done under more realistic conditions, although in most cases, measurements were taken in basements, wherever present. Of 76 homes at or above the EPA action level on screening testing, 37 (49%) were below the action level on confirmatory testing. These findings were similar when the analysis was repeated using only the results of the longer term alpha-track detectors (VDH, 1987b).

B. <u>GMU Study</u>

Dr. Douglas Mose, Department of Geology, George Mason University, Fairfax, Virginia, is currently conducting a study on indoor radon accumulation in homes in Virginia and Maryland using the three-month alpha-track method. He has collected data on radon in homes, primarily in Fairfax County, Virginia and Montgomery County, Maryland. His study encompasses about 0.3% of the homes in these two counties and uses the homes of self-selected volunteers. The participants in this study use "open house conditions". They are advised to place the detectors in the basement and each volunteer reports on the placement as the detectors are returned for analysis. Approximately 90% of the participants live in homes having basements and approximately 90% of the participants report testing in the basements of their homes. Preliminary findings include (Mose, 1987):

1. About 30% of the surveyed homes had radon levels above 4 pCi/l in the lowest livable level of the home during the spring tests. About 50% of the surveyed homes had radon levels above 4 pCi/l in the lowest livable level of the home during the winter tests.

2. The geologic material in the area studied seems to correlate with the indoor radon levels. The area of highest indoor radon levels in this study is a major shear zone along the western side of the Piedmont Province.

3. Indoor radon is related to the soil chemistry and soil permeability under the home.

4. Winter indoor radon measurements tend to be about 30% higher than spring measurements at the same

location. (Summer and fall measurements are pending.)

5. Basement radon measurements tend to be about 60% higher than first floor measurements in the same home in the homes of those requesting further testing.

Data for annual average exposures in Dr. Mose's study are currently being compiled. Although he reports a correlation between indoor radon and geologic factors, he also states that levels of radon in a given home cannot be predicted using knowledge of these variables.

C. Fairfax County Study

The Health Department of Fairfax County, Virginia, at the direction of the Fairfax County Board of Supervisors, has begun a survey to determine the level of radon gas in approximately one percent of the homes in the county. The first phase of this survey was done during the winter of 1986-87 and the second phase will continue in the winter of 1987-88. Preliminary findings indicate that 68% of the 1,030 homes tested under "worst case" simulations were found to have radon levels less than 4 pCi/l; 32% of the homes tested were found to have radon levels greater than 4 pCi/l, and 2% had levels of 20 pCi/l or more. Due to the fact that approximately 75% of those homes with levels between 4 pCi/l and 20 pCi/l had levels of less than 10 pCi/l, it is estimated that the annual radon levels in many of these houses will be less than the EPA "action level" of 4 pCi/l. These houses are to be the focus of follow-up testing (FCHD, 1987).

D. Prince William Schools Study

Prince William County also has done air sampling for the detection of radon gas in the public schools of the county. Reported in August of 1987, sampling was done in 53 schools throughout the county. Of those 53 schools, radon levels were found above 3.9 pCi/l in five schools. Schools were tested originally under closed house conditions; however, the follow-up tests done on the five schools with levels over 3.9 pCi/l were done under normal air circulation conditions. The results of the second testing were lower in all cases with only one school testing above 3 pCi/l. School systems in some other localities have similar surveys planned or underway.

E. Terradex Data for Virginia

The database of indoor radon measurements being compiled by Terradex Corporation includes measurements done in the Commonwealth of Virginia. Test results are continuously being added to this database; however, the statistics for a given state change very little after 1000 measurements are made. As of July 1986, the data for 488 measurements in Virginia included the median value of 1.05 pCi/l, the geometric mean of 1.04 pCi/l, and the arithmetic mean of 2.2 pCi/l. Measurements of radon levels above 4 pCi/l comprised 12.9% of the 488 measurements taken (Alter and Oswald, 1987).

V. CURRENT STATE-LEVEL RADON ACTIVITIES IN VIRGINIA

The Virginia Department of Health, Bureau of Radiological Health operates radon activities in the Commonwealth of Virginia. Providing primarily an informational service, the staff of the Bureau of Radiological Health are available to the public and the private sector to answer questions and provide information about the radon exposure problem in Virginia, testing methods, mitigation techniques, and health risks involved. The Bureau, in conjunction with the U.S. EPA, periodically publishes booklets and other literature for the edification of the population. Booklets currently being distributed include: "Indoor Radon", 12,000 printed and distributed; "Radon Reduction Methods: A Homeowner's Guide", 8,000 printed and distributed; "Radon/Radon Progeny Measurement Proficiency Program: Proficiency Report for Virginia", 6,000 distributed; "Radon Reduction in New Construction: An Interim Guide", 100 distributed; "Radon Reduction Techniques for Detached Houses - Technical Guidance", 100 distributed; and "General Remedial Action Details for Radon Gas Mitigation", 100 distributed.

A toll free telephone line also is maintained by the Bureau staff. Since the spring of 1986, Bureau staff has received and responded to 15,000 telephone calls concerning indoor radon.

The Bureau of Radiological Health collected the bulk of the data for the 1986 - 1987 Department of Health Study of Indoor Radon, and is also participating with the EPA in a project designed to evaluate the costs and effectiveness of postconstruction radon mitigation techniques as applied in private sector houses in Virginia.

In this project (called the House Evaluation Program), houses having radon levels of between 10 and 200 pCi/l and being of conventional construction and architectural types are selected and the homeowners are contacted to secure their participation. Mitigation methods are selected and funded by the homeowner after investigators have completed a diagnostic house evaluation which presents a list of mitigation options and recommendations. A post-mitigation evaluation is also provided to determine the effectiveness and costs of the techniques employed. The responsibilities of the state include selecting appropriate houses, drafting a suitable homeowner's agreement, maintaining contact with and briefing the homeowner, and providing the homeowner with a list of contractors from which to select.

The activities being carried out in response to the indoor radon problem in Virginia are being done without the structure of a formal program and with considerable sacrifice of existing radiological health programs. There have been no full time employees (FTEs) allocated and no monies appropriated for a radon program, even though in the past 16 months, $192,000 has been spent by this Bureau in responding to radon through the above activities.

VI. SUMMARY OF RADON ACTIVITIES IN OTHER STATES

The U.S. EPA has collected and assembled information regarding the scope and magnitude of radon programs in the individual states. "Summary of State Radon Programs" describes the activity of the radon programs in the states as of July 1, 1987. According to this report, the status of the program in each state often is determined by the factors contributing to the origin of the program. In the western states, interest in radon developed from studies finding high rates of lung cancer in uranium miners. States having uranium mines and uranium tailing sites began programs to assist citizens living near these areas. While few western states have operational indoor radon programs, they do have the benefit of past experience with measurement techniques. The discovery in 1984 of the highly elevated levels of indoor radon in homes on the Reading Prong geologic formation was the main impetus for the rapid development of the indoor radon programs in the states of Pennsylvania, New Jersey, and New York. In Maine, the stimulus was radon found in well water and in Florida, elevated levels of indoor radon were found in homes built on reclaimed phosphate mining lands. Pennsylvania, New Jersey, New York, Maine, and Florida are the five states having the most advanced indoor radon programs in the United States.

According to the EPA summary, every state has some form of response to indoor radon in its jurisdiction. The EPA has categorized the states into four levels of activity:

Level 1. <u>Information Program</u>: States at this level are seeing the least activity. Generally, they are distributing EPA literature in response to homeowner requests and monitoring activity in other states.

Level 2. Formative Program: In addition to the above activities, these states are developing their own literature for distribution. They are also involved in some measurement activity and are collecting data from measurement firms.

Level 3. Developing Program: States in this level are all involved in state-wide testing programs. Some are reprinting and distributing EPA literature, as well as developing their own. Virginia is in this category.

Level 4. Operational Program: In this level, a radon problem has been uncovered and the states are moving forcefully to correct it. All states in this level have funding for radon programs, some with specific legislative mandate. Each state in this category has sponsored several thousand or more tests.

Of the fifty states, 31 (24%) are in one of the first two levels. The seven states at Level 1. do not see a need to create a fuller program and do not have a clear mandate to develop one. The 24 states at Level 2. acknowledge that a problem could exist in their jurisdiction and are considering program development.

The 14 states at Level 3., with the exceptions of Rhode Island and Colorado, each have some personnel devoted full time to radon. Some have limited funding for radon programs and 9 of the 14 have created task forces to study the problem in their states. Two Level 3. states, including Virginia, are participating in Phase II of the EPA's House Evaluation Program. Seven Level 3. states, including Virginia, have finished or in progress some type of geologic studies (not all are state-sponsored). Maryland and Virginia are the only Level 3. states to have toll-free hotlines.

The five states at Level 4. have radon-specific legislation (with the exception of Maine, where legislative recommendations are expected in 1988). The four states other than Maine have radon program budgets of over one million dollars each and personnel resources of 19 or more in each state. Of the fifty states, the three states in the Reading Prong area (Pennsylvania, New York, and New Jersey) account for 88.5% of the funding and 55.1% of the full time employees allocated for radon-related work. Also, over 86% of the state-sponsored measurements of indoor radon are in Level 4. states.

TABLE 2

CURRENT LEVEL OF STATE RADON PROGRAM DEVELOPMENT

LEVEL 1: INFORMATION PROGRAM

Arkansas	Mississippi	South Dakota
Hawaii	Nevada	Texas
Louisiana		

LEVEL 2: FORMATIVE PROGRAM

Alaska	Minnesota	Ohio
Arizona	Missouri	Oklahoma
California	Montana	Oregon
Delaware	Nebraska	South Carolina
Georgia	New Hampshire	Utah
Idaho	New Mexico	Vermont
Iowa	North Carolina	Washington
Massachusetts	North Dakota	West Virginia

LEVEL 3: DEVELOPING PROGRAM

Alabama	Kansas	Tennessee
Colorado	Kentucky	Virginia
Connecticut	Maryland	Wisconsin
Illinois	Michigan	Wyoming
Indiana	Rhode Island	

LEVEL 4: OPERATIONAL PROGRAM

Florida	New York
Maine*	Pennsylvania
New Jersey	

* Maine's program is Operational for radon in water, but is Developing for radon in air.

SOURCE: Putnam, Hayes & Bartlett, Inc., August 28, 1987.

VII. ASSESSMENT OF THE RADON PROBLEM IN VIRGINIA

Realizing that at the current time, the fall of 1987, the collection of data on indoor radon is ongoing in Virginia as well as nationally, it is the consensus of the Task Force that radon exists in sufficient quantity in the Commonwealth to create an increased risk to some of the residents of Virginia. Based on the data collected in the homes of state residents, the rock types and soil characteristics found throughout much of the state, and the preliminary results of several ongoing research projects, it appears that radon gas is naturally occurring in several areas of the state and that this occurrence could lead to the potential buildup of radon progeny in homes or other structures built in those areas.

The perspective of the Task Force has been one of protection of the public health in regards to indoor radon. All of the homes of Virginians have been considered; the Task Force has not limited its consideration to homes being built or to homes involved in real estate transactions. All areas of the state have been considered. The magnitude of the public health risk associated with low level accumulation of radon progeny over long periods of time is unclear. Although ongoing national and international research is expected to help clarify this issue within the next several years, it is the consensus of this Task Force that some risk does exist and that it could be substantial for some citizens. Therefore, the Commonwealth cannot wait until all questions are answered before preparing for appropriate response to the situation.

The question "what constitutes an appropriate response?" can only be answered by beginning with a public that is well informed. Even though all questions cannot be answered at this point, the information that is available can be disseminated in a manner that is both responsible and expeditious. As current research is completed and analyzed, more information will be accumulated and an appropriate response to indoor radon in Virginia can develop gradually without generating undue alarm. The informed citizen will be better prepared to participate responsibly in the decisions affecting his health and safety.

VIII. POLICY ISSUES AND RECOMMENDATIONS OF THE TASK FORCE

1. **POSITION:** The Virginia Department of Health should continue to provide to the public reliable information based on current scientific research. This Department should be responsible for the coordination of all efforts for the dissemination of information about indoor radon. To the extent feasible, information on radon should be available in all local health offices. The Department should also seek any federal funds which may become available for these purposes.

   RATIONALE: The quality and quantity of information being disseminated at this time is appropriate; however, as public awareness of indoor radon grows, the demand for information will grow also. Currently, information is being provided to the public through the preparation, printing, and dissemination of pamphlets and brochures on radon, its mitigation in existing homes and new construction, and the EPA Measurement Proficiency Program; and through the radon hotline being maintained by the Bureau of Radiological Health, Virginia Department of Health. In the near future, information from the VDH on radon will be made available to building contractors through the National Home Builders' Association and the Home Builders' Association of Virginia. The Virginia Department of Health will also be responsible for the implementation of a training program provided by the EPA for radon mitigators and other interested parties. The training of local health personnel will be the responsibility of the VDH Central office staff. Additional responsibilities undertaken by the Virginia Department of Health will require additional resources.

2. **POSITION:** Because the Virginia Department of Health studies have found the piedmont and mountain (Blue Ridge and Valley/Ridge) areas of the Commonwealth to be at greater risk of indoor radon exposure, the Task Force encourages persons living in or purchasing homes in the piedmont and mountain (Blue Ridge and Valley/Ridge) regions of the Commonwealth to avail themselves of information concerning the sources of radon, the factors influencing radon concentrations in homes, the procedures for measuring radon accumulation, and the techniques for reducing indoor radon and to test their homes. They are also encouraged to contact the Virginia Department of Health for a list, prepared

by the EPA, of radon detection companies which have demonstrated proficiency in measuring radon gas and/or radon progeny levels by participating in the EPA Radon Measurement Proficiency Program.

RATIONALE: Studies correlating the accumulation of radon with geologic identifiers have determined that the piedmont and the mountain (Blue Ridge and Valley/Ridge) regions of the Commonwealth of Virginia are especially susceptible to elevated radon concentrations. The U.S. EPA has initiated a program by which testing companies may submit their testing methods for validation. Proficiency of a company's detector operations and the quality of their data management are evaluated. The EPA produces a list, available through the Virginia Department of Health, of all companies which have successfully completed the EPA program.

3. **POSITION:** Because the Virginia Department of Health studies have shown the tidewater (Coastal Plain) area of the Commonwealth to be at lesser risk of indoor radon exposure, those occupants of homes in the tidewater (Coastal Plain) area of the Commonwealth who are concerned about the presence and the possible health effects of indoor radon should have their homes tested.

   RATIONALE: Although radon accumulation can be predicted for a region given the geologic parameters, each neighborhood/home is so site-specific, and individual factors so varied, that only testing can determine the actual presence, absence, or accumulation of radon and radon progeny even in low risk areas, such as the tidewater (Coastal Plain) region.

4. **POSITION:** The Task Force encourages members of radon-related industries to take responsibility for becoming (and remaining) informed about this topic through contact with the EPA and other sources of ongoing research. In addition, accurate state-of-the-art information on radon and radon mitigation techniques should be provided by the Virginia Departments of Health (VDH) and Housing and Community Development (DHCD) to builders, realtors, architects, and building engineers statewide, through appropriate trade organizations.

RATIONALE: Organizations such as the Home Builders Association of Virginia, the Virginia Association of Realtors, and the National Association of Home Builders have expressed interest in the ongoing research on indoor radon and in the work of this Task Force. It is to their benefit, as well as the benefit of the citizens of the Commonwealth, that accurate information be disseminated as efficiently as possible since only knowledgeable individuals should conduct radon testing or radon mitigation procedures.

5. **POSITION:** The Virginia Department of Health should continue to pursue the results and evaluate the progress of ongoing radon research, especially epidemiologic research designed to better quantify the risks associated with typical home exposures. Results of studies on the correlations between geologic formations and radon occurrence also need to be monitored. At the beginning of the 1990 - 1992 biennium the Virginia Department of Health will provide the General Assembly with an update of the data available on indoor radon in Virginia and formally advise the General Assembly on any need for either changes in policy or Virginia-specific studies to be funded by the Commonwealth.

   RATIONALE: Current decisions about radon are based on extrapolations of data gathered from the analysis of the effects of radon and radon progeny on miners who experienced high exposures over long time periods. Epidemiologic studies on the effects of low doses of radon in homes are underway in several locations with results expected over the next five years. Data collection and analysis of this type can be expected to require hundreds of thousands of dollars, five to ten years, and manpower sufficient to survey thousands of participants.

6. **POSITION:** The Department of Housing and Community Development should pursue and evaluate all new developments in the area of home construction techniques designed to minimize radon exposure or facilitate radon mitigation in order to determine the advisability of future changes to the Virginia Uniform Statewide Building Code. All pertinent information should be disseminated to building inspectors, building engineers, architects, and builders, statewide.

RATIONALE: The National Association of Home Builders' National Research Center, in conjunction with the U.S. EPA, the state of New Jersey, and the New Jersey Homebuilders Association, is building 100 to 300 homes to test cost-effective prevention and/or mitigation techniques. It is in the best interests of the builders and home buyers of the Commonwealth that they and state building inspectors have immediate access to the results of this research. In addition, The Department of Housing and Community Development actively participates in the model code program of the Building Officials and Code Administrators International (BOCA). This program provides extensive testimony from expert speakers and lobbyists on topics of national concern so that model building code specifications may be drafted and recommended to the states. Due to the evolving nature of the research findings and high confidence in the BOCA program, no mandatory mitigation code changes are recommended at this time.

7. **POSITION:** At this time (1987), the Task Force does not recommend a government mandate for radon testing at the time of real estate transactions, but acknowledges the rights of the lender or the buyer to request such a test. This position will need to be continuously reevaluated as more is learned about radon in Virginia.

RATIONALE: Results of radon testing will vary substantially with the method used, the time of the year, the prevailing weather conditions during the test, and the type of ventilation being employed by the home occupants during the test. Unsupervised testing is open to manipulation by the seller. Long term testing provides the most accurate results, but is the most impractical. There is no consensus among the scientific community as to an allowable level of indoor radon; no standards have yet been determined. Government mandated testing may substantially increase the costs associated with real estate transactions and some sales may be prevented inappropriately. The presence or absence of radon is only one factor to be considered by a potential buyer of real estate; mandating a test would give undue weight to this issue. Currently, there are few companies prepared to meet the demand for this service should it be mandated. As of 9/1/87, the EPA list of testing companies includes 12 Virginia companies (including the Hechinger chain), only 2 of which (including Hechinger's) are outside of the Northern Virginia area.

8. **POSITION:** At this time (1987), the Task Force does not recommend that radon testing firms or radon mitigation firms be licensed specifically for radon-related activities. (Licensing of construction, architectural design, and engineering activities, in general, already exists.) The Department of Commerce should monitor the need for such licensing in the future, based on reports from consumers, trade organizations, the Departments of Health, Agriculture and Consumer Services, and Housing and Community Development. At a fixed date, the Department of Commerce should report its findings to the Governor and the General Assembly.

RATIONALE: The fields of radon testing and radon mitigation and/or prevention are comparatively new. At this time, there is little evidence that inferior quality testing or mitigation services is a problem of such magnitude that licensing is warranted. Since the spring of 1986, the Bureau of Radiological Health (VDH) has received approximately 15,000 telephone calls concerning indoor radon. Of those calls, approximately 30 have included complaints about companies which do radon testing or radon reduction. The grievances ranged from concerns about poor workmanship and high prices to complaints about the methods used to interpret results of tests done by various radon testing companies.

The rights and responsibilities of the homeowner in making decisions related to the testing for or mitigation of radon accumulation should not be undermined by the undue involvement of state government. Research on the behavior od radon gas indoors and the most effective and cost-effective methods for correcting radon problems is still underway. There are few companies in these two fields at this time. The current state of the research prevents adequate quality control of either methods or protocols in these fields. Conversely, the display of a state license has the potential for creating a public perception of quality guaranteed by the state when that is not currently possible, and risks hindering the development of new and innovative techniques.

Although the Task Force does not recommend licensing at this time, members recognize that those offering or conducting testing have an obligation to be fully informed with respect to both recent developments in the field and state-of-the-art recommendations by authorities. There is also an obligation (which appropriate government agencies should reinforce in the information disseminated to the public) to not misrepresent the significance of either existing licenses in Virginia (e.g. construction) or out-of-state radon-related licenses when dealing with the citizens of the Commonwealth.

9. **POSITION:** In the face of constantly accumulating data, the Virginia Department of Health should review all assessments, policies, and recommendations of this Task Force and report all findings to the General Assembly in 1990. This task should be accomplished by drawing on the expertise of all agencies currently represented on the Task Force and the Department of Commerce.

RATIONALE: Within the next several years, research on indoor radon and related topics is expected to grow. As studies currently underway are finished, new data will require the reassessment of the positions adopted by the existing Task Force.

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