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# Perspectives on the Studying Cancer Risk in Populations Living near Nuclear Power Facilities

Notes for a Presentation to the Nuclear and Radiation Studies Board of the National Academies[1]

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Chairman Meserve and members of the Board, I appreciate this opportunity to present some perspectives on the study and make some recommendations regarding the approaches you might take in addressing the task before you. There is intense interest in this study and I am glad that you are seeking public input and engaging in a broader public discussion at the outset. I hope that you will be able to chart a course for more thorough and scientifically sound – and potentially less controversial – studies of the health risks to neighbors of industrial facilities, including nuclear power facilities.

I use the phrase "chart a course" advisedly, since I do not think that a single study that seeks to provide a *reliable* "yes" or "no" answer to the general question of cancer risk of living near nuclear power plants is scientifically feasible at the present time. Given the state of the data and the confounding factors there will be ample legitimate basis for parties that do not like either answer to throw the answer into substantial doubt.

It will be therefore be more helpful if the Nuclear and Radiation Studies Board addressed the data requirements and analytical approaches to understanding cancer risks (and more generally health risks) of living near nuclear power facilities and, more generally, industrial facilities.

## A. The terms "near" and "nuclear power facilities"

The very title of the study invites questions about the implicit assumptions and the framework of the study. For instance, if the term "near" means drawing a circle around a nuclear power plant,

[1] Arjun Makhijani did not read these notes at the meeting. Rather these notes form much, but not all, of the basis for what he said. Hence, the oral presentation and these notes are partially complementary.

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much of the battle for a sound study is already lost. The problem is made even worse if, as was done in the 1990 National Cancer Institute study, the term "near" means the "counties that encompass or are near nuclear facilities."[3] For instance, for air emissions of radionuclides, such definitions ignore prevailing wind patterns. For discharges to the water, for instance, of tritium, they ignore the difference between downstream and upstream populations. Meteorological factors are also important for tritium, since tritiated water vapor is emitted by nuclear power reactors. Rainouts of radioactive water are highly weather dependent. In other words, if the term "near" is not carefully defined, the connection between radiation dose – the presumed causative factor – and cancer – the presumed outcome – is already lost or so obscured as to be irretrievable. Defining "near" to take such factors into account is an essential first step to a credible effort.

The term "nuclear power facilities" might at first sight seem less problematic than the term "near." But it is not. At the present time, it is not scientifically sensible to try to come up with a general answer to a general question about the risk of living near nuclear power plants for a host of reasons, including the following:

1. Routine emissions and discharges of radionuclides from nuclear power plants vary a great deal. For instance, the liquid discharges of tritium from Davis Besse in 2005 were 0.46 curies per megawatt, while the discharges from Beaver Valley 1 and 2 were more than three times as large in the same year 1.48 curies per megawatt.[4] All three reactors are PWRs. Moreover, there is a difference between pressurized water and boiling water reactor tritium discharges.
2. Many reactors have tritium leaks. The amounts of such leaks vary and the implications for radiation dose to the surrounding population are not well understood. Indeed, systematic measurements of tritium and other radionuclides in private wells are not required.
3. Reactors routinely discharge tritiated water vapor to the air. These releases vary even more. For instance, in 2004, the Byron 1 and Byron 2 units released 1 and 2 curies of tritium to the air. In contrast, the Palo Verde 1, 2, and 3 units released 672, 479, and 972 curies respectively.[5] Hence, the air discharges of tritium were 700 times greater from the Palo Verde nuclear power plant than from the Byron nuclear power plant. The lowest releases reported were zero (below the detection limit) for Turkey Point 4. All reactors in these examples are PWRs. The variation among BWRs is just as great. The emissions also vary a great deal from year to year and even from one quarter to the next. There are few measurements of the tritium content of rainwater and there is little understanding of the effect of tritium releases for contamination of private wells. As you know, non-public drinking water sources are not covered by safe drinking water regulations for radionuclides. Further, the NRC does not require measurements of tritium in private

[3] Seymour Jablon, Zdenek Hrubec, John D. Boice, and B. J. Stone, *Cancer in Populations Living Near Nuclear Facilities*, (NIH Publication No. 90-874), National Cancer Institute, Bethesda, MD, July 1990, page xi.
[4] See the compilation of routine liquid tritium releases from all U.S. nuclear power reactors for 2005 at http://www.ieer.org/sdafiles/16-1/tritium_releases_liquid_2005.pdf.
[5] See the compilation of routine gaseous tritium releases from all U.S. nuclear power reactors for 2004 at http://www.ieer.org/sdafiles/16-1/tritium_releases_gaseous_2004.pdf.

water wells, which could be an important data gap, particularly for nuclear plants in rural areas.

4. The cumulative impact of routine discharges and emissions of tritium on drinking and irrigation water sources is not well understood and in many cases unknown. The data for developing such an understanding are scant. This is especially so in rural areas, where private wells are often used for drinking and irrigation water and there a few if any data available. In the case of irrigation, organically bound tritium, with its higher dose conversion factor per unit of intake, might become important.
5. The sources of drinking water vary from one nuclear power plant vicinity to another. For instance, communities downstream from the Braidwood, Illinois, plant use the surface water into which the plant discharges tritium for their drinking water supply. This is also the case with plant Vogtle, where the problem is compounded by significant tritium discharges from the Savannah River Site (SRS). In fact, the Savannah River is measurably contaminated with tritium all the way to the Atlantic Ocean more than 100 miles downstream. There is documented contamination of groundwater wells with tritium in the vicinity of Plant Vogtle and SRS.[6]

I will not go into the reliability of the measurements of tritium at this stage except to say that routine tritium discharges are periodic. Their effect on drinking water therefore depends on the precise times of the discharges in relation to the intakes into public water systems downstream. At the present time, the state of knowledge of the source terms in drinking water related to nuclear power plants leaves a lot to be desired.

While some of the problems of variation among nuclear plants are overcome by studying the effect of single plants over time, this does not address issues related to the variations of radiation releases over time and changes in pathways, such as sources of drinking water. Moreover, given the data gaps created by a lack of thorough monitoring requirements, it is difficult to see how such a longitudinal study could be reliably done.

## B. Confounding factors

Studies that attempt to assess the link between one type of facility and a health outcome such as cancer are implicitly oriented towards a regulatory point of view. Regulations on emissions and exposures from industrial facilities attempt to limit such emissions and hence exposures of their neighbors to specific pollutants. But they do not address the public health issue that is implicitly sought to be addressed: what is the health impact of such facilities? One of the central differences between the regulatory and public health approaches is that individuals are subject to

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[6] Arjun Makhijani and Michele Boyd, *Nuclear Dumps by the Riverside: Threats to the Savannah River from Radioactive Contamination at the Savannah River Site*, Institute for Energy and Environmental Research, Takoma Park, Maryland, 2004, at http://www.ieer.org/reports/srs/fullrpt.pdf. This study only deals with SRS. The gaseous releases of tritium, which could affect groundwater via rainfall, from Vogtle 1 and 2 in 2004 were 61 and 4 curies respectively. It is unknown whether Vogtle releases have affected groundwater downwind, since the NRC does not require measurements of tritium in private offsite wells.

a variety of environmental exposures. For instance, the Braidwood, Illinois, plant also has a refinery near it. Refineries emit carcinogens, such as benzene and formaldehyde, as well as other chemical pollutants. The combined effects of chemicals and radiation are ill understood.

In studying the variation in cancers at a particular location over time, it is not only necessary to know what other facilities existed prior to and after commissioning of nuclear facilities, but also the emissions of carcinogens over time from other facilities, which also vary over time. Exposure pathways may also vary over time. It is at least necessary to know those pathways and how hazardous materials may or may not interact with radiation exposures over time to change the risk of certain health outcomes, including cancer.

In this context, it is especially important to consider fetal and childhood exposures. Fetal exposures to strontium-90 in the first trimester, for instance, may have a deleterious effect on the initial stages of the formation of the immune system. This may be compounded by exposures to chemicals that disrupt hormonal systems. In other words, there are a variety of potential synergistic effects that could be at play that may vary over time at a single location as well as from one plant to another.

Differences can also be expected between plants in rural, non-industrial areas, those in rural industrial areas, and those in urban or semi-urban areas. In the first instance, exposure assessments are complicated by the likely presence of large diffuse sources of exposure. Such exposures may not only be environmental. Some are likely to be occupational. A farmer using pesticides, a worker in a chemical factory or refinery is not just any neighbor of a nuclear power plant, but one who has had specific occupational exposures. These exposures vary over time. Some may have cumulative effects. Some chemicals may affect family members of the workers, via contamination of clothes and vehicles, while others may not.

The admitted difficulty of taking such factors into account cannot be occasion for ignoring them. Some problems with longitudinal studies over an appropriate period of time can be overcome by comparative studies between nuclear power plants – Vermont Yankee, Braidwood, Plant Vogtle, and Indian Point might present interesting contrasts. But the extraction of factors attributable to nuclear power plants alone must first take into account the presence of these other complicating factors. Race and diet are among such factors. I once heard a scientist cite the lower cancer rate in Denver to the higher cancer rate in Washington, D.C., which has a lower background radiation rate as evidence that a few tens of millirem of radiation per year do not cause an increase in cancer. He completely ignored the fact that, in contrast to Denver, Washington, D.C., has a majority African American population, which generally has a higher mortality rate from cancer relative to Whites and Hispanics (who together constitute a huge majority in Denver) quite apart from radiation exposure and independent of location.

I might cite a couple of other issues that need addressing. The changes in the rates of occurrence of chronic hepatitis B and C as well as the incidence of HIV-positive populations change the susceptibility to cancer and to environmental carcinogens. Similarly, racial and class disparities in smoking have changed over time. In comparing nuclear power plants in different areas, it will also be essential to address underlying differences in radon exposure.

I would also add that it is very important to know the movement of populations in and out of an area in relation to times and amounts of exposure to the carcinogens in areas with nuclear power plants. This especially applies to children and pregnant women.

## C. Recommendations

The state of the knowledge regarding the various exposure and risk factors in the vicinity of nuclear power plants is too poor to conduct a general study of the subject that would yield a reliable conclusion. I therefore strongly recommend that you not do a study that would attempt study with a yes" or "no" answer to the question of whether there is an increased cancer risk of living near a nuclear power facility. At this stage, it is much more important to set forth the framework in which the risk of living near a nuclear facility can be scientifically addressed. In this context, the panel might examine examples of nuclear facilities to illustrate how such a framework might be used in a specific instance.

It will be important to address the following factors in creating the framework:

1. *Definition of "near"*: Clarity about this point is central to a reliable study. For air emissions, the predominant downwind direction is more important than radius. For water associated pathways, the downstream direction, which may extend a hundred miles or more, as is the case with Plant Vogtle in Georgia, is critical for surface water. Rainfall patterns are especially important in rural areas, since they may be associated with groundwater contamination, as I have mentioned already. Detailed illustrations using, say, ten nuclear power plants would provide a basis from structuring a future study that could provide a sounder basis for conclusions.
2. *Exposure to other carcinogens and presence of factors enabling cancer*: It is essential to consider exposures over time to chemical carcinogens and to other factors that change over time and from one plant to another prior to drawing any general conclusions about the cancer risk of living near nuclear facilities. That risk may vary greatly from one plant to the next depending on such factors. The variety of factors that contribute to the risk and how they may be sorted out in comparative studies between plants and in longitudinal studies at particular locations should be laid out in some detail. Again, illustrating these factors using specific examples is very important. In this regard, I would recommend including the Braidwood plant in the list.
3. *Focus on the vulnerable who are at risk:* There are specific populations near nuclear power plants who are at risk of greater doses for a given level of releases of radioactivity and at greater risk per unit of dose. Generally (though not always) those at greatest risk are children, especially female children. Fetal exposure creating later vulnerability to cancer as well as non-cancer diseases after birth, for instance via compromise of the immune system during the time of its development, should be explicitly considered. I strongly recommend that the panel examine issues such as tritium dose during the first several weeks of pregnancy, where the ICRP model of equating uterine wall dose to fetal dose is clearly wrong. A recognition of the problem and how it ought to be addressed would be very helpful in getting some progress on the science with regard to the most ubiquitous radionuclide associated with nuclear power plant releases to the environment.

4. *Identify the data gaps:* The monitoring of the emissions and discharges from nuclear power plants leaves a lot to be desired. I have already noted gaps relating to monitoring of rainwater and private wells. Equally important, there is little independent verification of the data and of the times of discharges. The latter is important because sampling is not continuous but rather batch sampling. How can the public be confident that water samples were taken when tritiated water is periodically discharged or if the samples were taken before the time of discharge? NRC inspections do not routinely physically confirm the time and representativeness of sampling. In an industry that has rightly been buffeted by controversies, such as those related to tritium leaks and the failure to disclose them to the affected public in a timely fashion, a much more rigorous and independent system of confirmatory monitoring is needed. I have long advocated that affected communities have funds put in escrow by their industrial neighbors so that they can carry out their own monitoring in a fully transparent fashion. This should extend not only to nuclear power plants but to all industrial nuclear facilities and to other industries that have toxic discharges in the same areas. There is a lack of systematic data from which a public environmental health picture, rather than a picture of pollution due to single facilities, can be derived. The panel should make detailed recommendations as to the sets of data that would be needed and identify a few nuclear power facilities that would exemplify the various situations and types of data that should be collected.
5. *Environmental Justice:* Plants are not randomly located. Water is a major consideration for nuclear power plants, but it is also a major factor for many other industries and for agriculture, both of which are often major pollution sources. In this regard, I would highly recommend that you address issues downstream of the Plant Vogtle, where food sources, surface water and groundwater have been affected by a variety of sources, including the Savannah River Site. The contaminants not only include radionuclides discharges from SRS and Plant Vogtle, but also other sources of exposure such as mercury in the fish (possibly associated with SRS). Issues of subsistence fishing and diets are very important in the African American as well as some portions of the White communities along the river. The issue of specific subsistence diets and their potential contamination should be explored.
6. *Create a framework for future work:* This panel should create a framework for future work on this issue, including data requirements (as noted above) as well as scientific research requirements. It should also identify frameworks, such as the one adopted in the 1990 study, that are not useful for studies of health effects in neighboring communities. The panel should specify how baseline information should be created as well as a process for future longitudinal studies. It should also address how other factors such as exposure to chemicals, variations in dietary and smoking patterns, and demographics of populations near nuclear power plants might affect the structure of the studies and data requirements.