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TO: U. S. Nuclear Regulatory Commission

FROM: Dr. Marvin Goldman

RE: Recent reports of Dr. Ernest Sternglass regarding radioactivity and health statistics around nuclear facilities in Connecticut.

I was asked to serve as a consultant to the Nuclear Regulatory Commission in this matter and to review and comment upon two reports by Dr. Ernest Sternglass. One is "Strontium-90 Levels in the Milk and Diet near Connecticut Nuclear Power Plants," dated October 27, 1977, and the other appears to be testimony dated February 10, 1978 for a Congressional seminar and is titled "Cancer Mortality Changes Around Nuclear Facilities in Connecticut." Although I am Director of a large radiobiology laboratory at the University of California, the views expressed herein are entirely my own and in no way imply any endorsement or assessment by the University of California or the Federal agencies who support the Laboratory's research.

For the past 27 years I have been engaged in radiobiologic research related to the dosimetry, metabolism and pathology of radionuclides. In particular, a major effort involves studies of radiostrontium and its effects.

Dr. Sternglass alleges that levels of strontium-90 (physical half-life of about 28 years) and cesium-137 (physical half-life of about 30 years) around Haddam Neck and Millstone Point nuclear power plants have been increasing markedly as a result of plant emissions and that these levels pose a "serious threat to human health."

I do not agree with these conclusions. In reviewing the information available to me I conclude quite the contrary. There are several reasons that prompt me to seriously question the validity of Dr. Sternglass' conclusions.

One central factor relates to the well known fact that Sr-90 and Cs-137 are long-lived fission products resulting from the fissioning of fertile elements such as U-235 and Pu-239. Furthermore, it is also well documented that as a result of atmospheric weapons testing (especially some 15 years ago) that the entire land surface of our planet is, to a variable and frequently measured degree, contaminated with low levels of these (and some other) radionuclides. It is also known that when uranium-235 is fissioned, a host of radionuclides of varying half-lives are generated. This is true of both weapons related fissioning and of nuclear fuels in an operating reactor. One additional fact that

Dr. Sternglass seems to have not taken into account is that recent fission product mixtures will contain short lived radionuclides as well as long-lived radionuclides. The fraction of short-lived radionuclides will decline with time after fissioning and at late times only the long-lived species may be detected in environmental samples. This ability to "date" the radioactivity, or at least confirm it is of recent origin is an important and relatively "fool proof tool."

That Sr and Cs both exist in freshly produced fission products in the form of several isotopes is fortuitous and significant. Generally speaking, considerably more "short-lived" Sr-89 (half-life ~50 days) is produced and to a limited extent released than the longer-lived Sr-90. In terms of relative activity, depending on sampling time, about 5 μCi of Sr-89 might be released for each μCi of Sr-90. Thus even correcting for the decay of radioactivity from "release" to incorporation into the food chain (e.g., milk and other locally produced food stuffs), there must be some Sr-89 present in foodstuffs with Sr-90 of recent origin. The nuclear plants do record the annual totals of both strontium isotopes released and do record the levels in their periodic environmental samples. If this is true, my question is where is the Sr-89? The methodology seems to be sufficiently sensitive to have picked this up following some Chinese atmospheric weapons tests; both Sr-89 and Sr-90 (e.g., 10/5/76 samples of milk which also showed 8 day I-131) were measured.

Furthermore, the alkali earth element cesium is represented by shorter-lived isotopes, particularly the 2.1 year half-life Cs-134. This isotope is released along with the Cs-137 from nuclear reactors in very small quantities (e.g., 1972 Millstone 16.4 Ci Cs-137 plus 8.8 Ci Cs-134). The activity ratios are similar - about the same number of microcuries of each isotope released annually. Since their respective decay emissions are sufficiently different, any detector sensitive enough to identify one can distinguish it from the other - their gamma ray and beta particle energies are different. Thus, I must question the conclusion that the Cs-137 measured in food stuffs was recently released from the nuclear plant in question. If so, where was the Cs-134? There are no pathways to man which separate these two isotopes of the same element. The element cesium will behave like cesium whether it is Cs-137 or Cs-134. The element strontium will behave like strontium whether it is Sr-90 or Sr-89!

In light of the frequent sampling schedules, it is not possible for the short-lived radionuclides to have decayed to non-detectable levels relative to those measured for the longer-lived isotope. Thus, I am forced to conclude that the only explanation for the data shown is that whatever the nuclear plants released was completely masked by the "background" level of Sr-90 and Cs-137 from fairly old atmospheric deposits, i.e., earlier weapons tests.

The Sr-90 and Cs-137 shown in national monitoring data varies from place to place and with time. In food stuffs, some of the variation is related to the degree of fresh foliar deposition on vegetation and cattle forage as well as root uptake from soil deposits. In addition, the local rainfall pattern may "wash on or off" varying amounts of atmospheric fallout on vegetation surfaces, as well as leaching more deeply into the soil that which was deposited on the surface. Globally, millions of dollars have been spent on studying and quantifying these phenomena and their variations. Depending on how one calculates a mean or average value, individual samples may vary by ten fold in repeated sampling

(compare milk Cs-137 in April vs. May 1976 for U. S. cities). The time trends and specific levels have shown me no significant levels which I feel can be attributed to plant releases. On the contrary, the data strongly indicate that the Sr-90 and Cs-137 measured in food pathways samples are almost all, if not entirely, the result of atmospheric weapons test fallout.

A fatal flaw in Dr. Sternglass' analyses is the manner of selection of data. One cannot select a particular sample as meaningful unless the other accompanying radionuclides are all present and the environmental pathway monitoring is consistent. Thus, for milk to contain nuclear plant Sr-90 and Cs-137, it must also have the other nuclides, Cs-134 and Sr-89 (and I-131 I might add). These findings would have to be confirmed by air and liquid samples and the plant monitors would also have to have shown "down stream" increases. I do not find support for these requirements and conclude that the local measurements are reflections of the local temporal weapons fallout situation.

Another problem of apparent misinterpretation of data relates to the reporting of cancer death rates. Connecticut probably has one of the best state tumor registries in the country and I would imagine that the State officials may have their own analyses of the trends of cancer mortality. I reviewed the general statistics on cancer published annually by the American Cancer Society in its "Cancer Facts and Figures." For example, it was of interest to note that in the United States, overall cancer mortality has steadily risen from about 160 per hundred thousand in 1970 to about 170 per hundred thousand in 1975. The ACS published annual Connecticut rates which are generally in agreement with these values. I did not check on the State registry as I wished to determine whether the State was following a different trend than the Nation. The data for both Connecticut and the U. S. show increases which are largely influenced by the increases in both sexes of lung cancer related to cigarette smoking.

If Sr-90 was indeed increasing, and it does not appear to be the case, its deposition in the body would incur an increased dose to bone and marrow. Strontium is an alkaline earth element which concentrates in skeletal mineral as does calcium, about one thousand fold greater than in other tissues. Extending this hypothetical situation further, one might have expected an increase in bone cancer and leukemia were serious skeletal and marrow irradiation resultant from radionuclide burdens. There is no data in support of this. I calculate that between 1 and 3 mrem per year is absorbed by adults and children respectively from milk containing a constant picocurie of strontium-90 per liter. If I accept a milk concentration of about 10 pCi ^{90}Sr/liter, this would account for about 10-30 mrem per year to bone and about 3-10 mrem per year to marrow. This value is close to that which we all receive from the traces of radium present in our drinking water.

What health effects might result from skeletal irradiation associated with Sr-90? The National Academy of Sciences estimates that about 0.2 bone cancer deaths per year would be expected per population of one million per rem absorbed. This would translate in a Connecticut population of about 3 million to 0.6 bone cancer deaths per year per rem and also to 0.6 cases times 0.03 rem (30 mrem) or 0.018 cases per year attributable to the Sr-90 skeletal dose. Using these conservative estimates, one would predict about 1 such death every fifty years consequent to a 30 mrem bone dose added to the State 50 year total of 1000 to 2000 deaths from this disease (I estimate a bone cancer death rate of about 1

per 100,000 per year in Connecticut; i.e., about 30-40 per year). There are other ways of calculating radiation cancer risks, but I included this example to put the risk per absorbed dose question in perspective and in a form which is frequently used by experts in this field. It is not possible for Sr-90 body burdens derived by ingestion to induce cancers in other organs to the exclusion of bone and marrow since the radioelement concentrates so preferentially in skeletal mineral.

In conclusion, I have not found support for the contention that the Connecticut nuclear plants have released sufficient radionuclides (Sr-89, 90 and Cs-137, 134) to have caused significant radiation exposure of the population; such exposures are a minute fraction of those attributed to atmospheric nuclear weapons tests. Furthermore, the radiation doses associated with Sr-90 (from all sources) are very significantly below those associated with observable changes in cancer risk. As a final note, it is generally accepted by the National Academy of Sciences that bone cancer risks from prior radiation would be accompanied by a latent period of about 15 years, and not six years. I can only conclude that the variations in health statistics presented by Dr. Sternglass, if correct, are associated with events totally unrelated to the operation of the nuclear power plants in Connecticut and that there is no evidence to support the allegation that these plants have posed a "serious threat to human health."

MG:pw