To: Dollins, NRR

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AUTHOR:	Jerry Brown
AFFILIATION:	FL
ADDRESSEE:	Nils Diaz
SUBJECT:	Enclosed Final Report of Research on the So FLorida Baby Teeth and Cancer Case Study....
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April 16, 2003

Mr. Nils J. Diaz
Chair
United States Nuclear Regulatory Commission
11555 Rockville Pike
Rockville, MD 20852-2738

Dear Mr. Diaz:

Enclosed please find the Final Report of Research on the South Florida Baby Teeth and Cancer Case Study, entitled "Environmental Radiation from Nuclear Reactors and Childhood Cancer in Southeast Florida."

The Radiation and Public Health Project carried out the study, under a grant from the Health Foundation of South Florida.

If you have any questions or comments, please direct them to:

Ernest J. Sternglass, Ph.D.
Chief Scientist
Radiation and Public Health Project
4601 5th Avenue, Suite 824
Pittsburgh, PA 15213
Ph: (412) 681-6251
Email: MSSEJS@aol.com

We hope this Study will lead to a dialogue among all parties concerned with the public health and safety of the citizens of Florida and the United States.

Sincerely,

Jerry Brown, Ph.D.
Research Associate

Cc: E. J. Sternglass

Enclosures

Cancer Prevention Coalition

UIC SCHOOL OF PUBLIC HEALTH • 2121 W TAYLOR ST • CHICAGO, IL 60612 • FAX (312) 996-1374 • WWW.PREVENTCANCER.COM • EPSTEIN@UIC.EDU

March 26, 2003

Statement on Baby Teeth Study

I have been following the research of the Radiation and Public Health Project's baby teeth study for the past four years. It is, therefore, with great interest that I have reviewed RPHP's April 2003 Final Report of Research on The South Florida Baby Teeth and Cancer Case Study, entitled "Environmental Radiation from Nuclear Reactors and Childhood Cancer in Southeast Florida."

The findings and conclusions of this Report are consistent with both the experimental and epidemiological evidence identifying radioactive emissions as a major risk factor for cancer. Furthermore, such evidence has been substantiated by other scientists in the United States, besides Europe. Such evidence has been documented in the Cancer Prevention Coalition's February 2003 report, "The Stop Cancer Before It Starts Campaign. How to Win the Losing War Against Cancer;" this has been endorsed by over 100 scientific experts on cancer prevention and public policy, and representatives of consumer, environmental, labor, and citizen activist groups (www.preventcancer.com).

The latest Baby Teeth Study Report provides strong evidence that "exposure to radioactive releases from nuclear reactors is a significant factor in increasing childhood cancer rates and other adverse health effects in southeast Florida." In addition, the Report uniquely demonstrates that radioactivity levels are significantly higher in the teeth of children with cancer than in the teeth of healthy control children.

Given prior evidence of the relationship between childhood cancer and radioactive emissions from 103 aging nuclear power plants in the U.S., and the well-established biological risks of radioactive Strontium-90, it is now critical to recognize that radioactive emissions from commercial nuclear power plants pose a grave threat to public health in southeast Florida, and throughout the nation.

Sincerely,

Samuel S. Epstein, M.D.
Professor Emeritus of Environmental and Occupational Medicine,
University of Illinois at Chicago School of Public Health
Chairman, Cancer Prevention Coalition
phone 312-996-2297

International Leading Authority on the Causes and Prevention of Cancer

Samuel S. Epstein, M.D. is professor emeritus of Environmental and Occupational Medicine at the University of Illinois School of Public Health, and Chairman of the Cancer Prevention Coalition. He has published some 260 peer reviewed articles, and authored or co-authored 10 books including: the prize-winning 1978 **The Politics of Cancer**; the 1995 **Safe Shopper's Bible**; the 1998 **Breast Cancer Prevention Program**; the 1998 **The Politics of Cancer, Revisited**; the 2001 **GOT (Genetically Engineered) MILK! The Monsanto rBGH/BST Milk Wars Handbook**; and the 2001 **Unreasonable Risk. How to Avoid Cancer from Cosmetics and Personal Care Products: The Neways Story.**

Dr. Epstein is an internationally recognized authority on avoidable causes of cancer, particularly unknowing exposures to industrial carcinogens in air, water, the workplace, and consumer products--food, cosmetics and toiletries, and household products including pesticides--besides carcinogenic prescription drugs.

Dr. Epstein's past public policy activities include: consultant to the U.S. Senate Committee on Public Works; drafting Congressional legislation; frequently invited Congressional testimony; membership of key federal committees including EPA's Health Effects Advisory Committee, and the Department of Labor's Advisory Committee on the Regulation of Occupational Carcinogens; and key expert on banning of hazardous products and pesticides including DDT, Aldrin and Chlordane. He is the leading international expert on cancer risks of petrochemicals and of consumer products including: rBGH milk; meat from cattle implanted with sex hormones in feedlots, on which he has testified for the E.C. at January 1997 WTO hearings; and irradiated food. In 1998, he presented "Legislative Proposals for Reversing the Cancer Epidemic" to the Swedish Parliament, and in 1999 to the U.K. All Parliamentary Cancer Group. He is also the leading critic of the cancer establishment, the National Cancer Institute (NCI) and American Cancer Society (ACS), for fixation on damage control--screening, diagnosis and treatment, and genetic research--with indifference for cancer prevention, which for the ACS extends to hostility. This mindset is compounded by conflicts of interest with the cancer drug industry, and also with the petrochemical and other industries in the case of the ACS.

His past professional society involvement includes: founder of the Environmental Mutagen Society; President of the Society for Occupational and Environmental Health; President of the Rachel Carson Council; and advisor to environmental, citizen activist and organized labor groups.

His numerous honors include: the 1969 Society of Toxicology Achievement Award; the 1977 National Wildlife Federation Conservancy Award; the 1989 Environmental Justice Award; the 1998 Right Livelihood Award ("Alternative Nobel Prize") for international contributions to cancer prevention; the 1999 Bioneers Award; and the 2000 Project Censored Award ("Alternative Pulitzer Prize" for investigative journalism) for an article critiquing the American Cancer Society. Dr. Epstein has extensive media experience with: numerous regional and national radio programs, including NPR; major TV programs, including Sixty Minutes, Face the Nation, Meet the Press, McNeil/Lehrer, Donohue, Good Morning America, and the Today Show; Canadian, European, Australian and Japanese TV; and numerous editorials and letters to leading national newspapers.

ENVIRONMENTAL RADIATION FROM NUCLEAR REACTORS AND CHILDHOOD CANCER IN SOUTHEAST FLORIDA

FINAL REPORT OF RESEARCH ON

THE SOUTH FLORIDA BABY TEETH AND CANCER CASE STUDY

To the

Health Foundation of South Florida

By the

Radiation and Public Health Project

Miami, Florida
April 9, 2003

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ACKNOWLEDGEMENTS

The Radiation and Public Health Project (RPHP) wishes to acknowledge the following people and foundations, which have made this study possible.

The basic funding for the South Florida Baby Teeth and Cancer Case Study was provided under Grant No. 99-311 from the Health Foundation of South Florida. Health Foundation of South Florida, a not-for-profit grantmaking foundation, is dedicated to expanding access to affordable, quality health care and providing funding that directly benefits the health and well being of underserved individuals in Broward, Miami-Dade and Monroe Counties. Since its inception in 1993, the Foundation has awarded more than $42 million in grants and direct program support.

The Alex and Agnes O. McIntosh Foundation provided additional funding for the South Florida Baby Teeth Study.

Lexie and Robert Potamkin of the Potamkin Charitable Trust provided funding for the study of radiation levels in South Florida water samples.

David Friedson, Barbara Garrett, and Applica, Inc., have provided sustaining funding for the national baby teeth study.

Lee Klein, Chairman and CEO, and Toby Bogorff, Vice President, of the Children's Cancer Caring Center at Cleveland Clinic Florida, were instrumental in introducing RPHP to families of children with cancer and to pediatric oncologists, who were able to provide the baby teeth of children diagnosed with cancer.

A special thank you to Julie Brown, M.A., RPHP Florida Resource Director, whose community outreach efforts have been essential to the success of the South Florida baby teeth study over the past five years.

Marion Levien provided invaluable editorial assistance in reviewing the manuscript for this Report.

RPHP is an independent not-for-profit research organization, established by scientists and physicians to investigate the links between environmental radiation, cancer and public health.

For further information on RPHP and the baby teeth study, please visit our web site at www.radiation.org, or contact: Joseph J. Mangano, National Coordinator, RPHP, at (718) 857-9825 or at Odiejoe@aol.com.

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ABSTRACT

During 2001 and 2002, the Radiation and Public Health Project, Inc. (RPHP) carried out a South Florida baby teeth study and an initial study of radiation levels in the teeth of children without cancer ("healthy teeth") and of children diagnosed with cancer ("cancer teeth").

The major findings of this study are:

- From 1986-89 to 1994-97, there was a 37% rise in the average levels of radioactive Strontium-90 (Sr-90) in southeast Florida baby teeth. This rise reverses a long-term downward trend in Sr-90 levels that has occurred since the mid-1960s, beginning after the atmospheric testing of nuclear weapons was banned.

- This temporal trend of increasing levels of radioactive Sr-90 was found in 485 Florida teeth tested, 95% of which came from six southeast Florida counties (Miami-Dade, Broward, Palm Beach, Martin, St. Lucie and Indian River).

- When compared with baby teeth collected from other Florida counties, the highest levels of Sr-90 were found in the counties closest to the Turkey Point and St. Lucie nuclear power plants.

- The average levels of Sr-90 found in the 17 cancer teeth were 85% higher than the radiation levels found in the 311 non-cancer teeth collected from children born in the same years and in the same counties.

- Recent measurements of high energy beta activity, characteristic of Sr-90 in southeast Florida water samples, indicate that the highest levels occur within 20 miles of the Turkey Point and St. Lucie nuclear power plants, ruling out the fallout from past nuclear tests as the principal source of radiation in Florida drinking water and baby teeth.

The major conclusions of this study are:

- Radiation emissions from nuclear power plants are the predominant cause of rising Sr-90 levels in southeast Florida baby teeth.

- Radiation levels are significantly higher in the teeth of children with cancer than in the teeth of children without cancer.

- There is now substantial evidence that exposure to radioactive releases from nuclear reactors is a significant causal factor of increasing childhood cancer rates and of other adverse health effects in southeast Florida.

EXECUTIVE SUMMARY

Operations at the four nuclear reactors in southeast Florida (Turkey Point units 3 and 4 in Miami-Dade County and St. Lucie units 1 and 2 in St. Lucie County) have added considerable radioactivity to the local environment, raising concerns of whether local residents have been harmed and whether this environmental radiation is related to reported increases in childhood cancer. Under a grant from the Health Foundation of South Florida, the Radiation and Public Health Project (RPHP) research group has investigated this issue, and has documented facts that suggest such harm is occurring. A number of these past findings have already been published in peer-reviewed medical journals. The current findings of the South Florida baby teeth and cancer case study are presented in this Report ("Florida Report").

Radioactivity – Emissions and Environmental Levels

- Official data show that the Turkey Point and St. Lucie nuclear power plants have emitted large quantities of radioactive chemicals into the atmosphere, including such highly toxic elements as Iodine-131 and Strontium-90.

- By 1987, from the time they began operations, these two nuclear plants had officially reported cumulative emissions into the air of "I-131 and Particulates" of 10.3 trillion picoCuries. By comparison, the Three Mile Island accident of 1979 reported releases equal to 14.2 trillion picoCuries.

- The level of radioactivity in Miami-Dade County rainwater rose from a minimum in 1987-88 to a plateau in 1990-93, and then rose again by some 60% in the last half of the 1990s, as reported by the U.S. Environmental Protection Agency.

- Since all atmospheric bomb testing ended in 1980, and releases from underground testing ended in 1992-93, the persistence of high beta activity in precipitation, as well as in drinking water near the Turkey Point and St. Lucie nuclear plants, suggests that the aging, local nuclear reactors have been the predominant recent source of radioactivity in the environment in southeastern Florida.

- This is consistent with the findings of a strong correlation between the increasing percent of operating capacity of all U.S. nuclear reactors and the increasing concentration of Strontium-90 found in baby teeth.

Radioactivity in Drinking Water

- Recent RPHP measurements of beta radioactivity characteristic of Sr-90 in 19 samples of drinking water in the southeast Florida counties (from Miami-Dade County to Indian River County) showed the highest levels within 5-20 miles of the Turkey Point and St. Lucie nuclear plants, and subsequently dropping off with distance from the reactors, clearly ruling out past nuclear weapons tests as the source of Sr-90 in the drinking water or in deciduous baby teeth in recent years. (*See Map 1.*)

- At the same time, water filtered by reverse osmosis showed no significant beta radioactivity, confirming that reverse osmosis systems, known to filter out heavy elements such as Sr-90, can remove most of the radioactivity from drinking water.

Cancer Rates in Southeast Florida

- Between the early 1950s and the late 1980s, breast cancer mortality rose significantly in the counties near the Turkey Point and St. Lucie reactors (up 26% near Turkey Point, up 55% near St. Lucie, compared to a 1% U.S. increase).

- From the early 1980s to the late 1990s, cancer incidence in children under 10 rose 35.2% in five southeast Florida counties, compared to a 10.8% rise in the U.S. Children are especially sensitive to the carcinogenic effects of radioactivity. These five southeast Florida counties are: Miami-Dade, Broward, Palm Beach, Martin, and St. Lucie.

- From the early 1980s to the late 1990s, an enormous 325.3% increase in childhood cancer took place in St. Lucie County, increasing the rate in this area to more than double the national average.

- In the 1990s, the cancer death rate in young adults age 15-34 in the five southeast Florida counties (from Miami-Dade County to St. Lucie County) has risen, in contrast to a decline in the U.S. Increases were particularly large for breast cancer and blood cancers, each especially sensitive to radioactivity.

- In Miami-Dade County, well after the last atmospheric bomb tests, the rate of new cases of childhood cancer was highly correlated with rises and declines of beta radioactivity levels in precipitation, as measured by the U.S. Environmental Protection Agency (EPA).

- Following the end of both atmospheric and underground bomb tests that released Sr-90 and other man-made radioactivity into the environment by 1993, childhood cancer incidence remained at high rates in St. Lucie County, but declined sharply in Charlotte County, located more than 80 miles to the West. Both St. Lucie and Charlotte are small rural counties with similar demographic and precipitation patterns.

Radioactivity in Florida Baby Teeth - In-Body Levels of Sr-90

- As of November 2002, 437 individual teeth have been measured for their Strontium-90 concentration in these five southeast Florida counties. When 24 teeth for Indian River County are added, then these six southeast Florida counties account for 461 baby teeth, or 95% of all Florida baby teeth measured to date for children carried by their mothers in Florida during pregnancy.

- Concentrations of radioactive Strontium-90 in 250 Miami-Dade County baby teeth tested by RPHP have been rising since the early 1980s, rather than declining. The current level is equal to that in the late 1950s, when the U.S., the U.K., and the Soviet Union conducted large-scale nuclear weapons tests in the atmosphere. Due to its high annual rainfall, Florida received high levels of radioactivity from bomb test fallout.

- A comparison of Sr-90 levels in 461 baby teeth from the six southeast Florida coastal counties (from Dade north to Indian River) was made with 24 teeth from 12 other Florida counties, which are more than 40 miles away from any nuclear power plant (i.e., to the west and northwest). This comparison shows that the six counties nearest the Turkey Point and St. Lucie reactors have a significant 44% higher concentration of Sr-90 than do the more distant counties upwind to the west.

- From a low average Strontium-90 concentration of 2.23 picoCuries per gram Calcium (pCi/gCa) in 1982, two years after the last atmospheric test by China, the levels rose to a high of 5.29 (pCi/gCa) by 1995 in southeast Florida. This highly significant rise of 137% makes it impossible to ascribe the current levels of Strontium-90 found in Florida teeth to past atmospheric tests.

- Strong evidence indicating that releases of fission products from the local nuclear plants play a dominant role in the recent rise of childhood leukemia and other types of cancer in the seven southeast Florida counties is the fact that out of 17 teeth from children diagnosed in these counties with some form of cancer between 1981 - 1996, 14 were found to have Strontium-90 levels above the average for those without cancer. Furthermore, 11 out of the 14 cancer teeth have significantly higher Sr-90 levels. On average, Sr-90 levels in the cancer teeth were 85% higher, or nearly double, those found in non-cancer teeth.

Health Effects of Nuclear Reactors

- In 1983-84, when the Turkey Point reactors were mostly closed for steam generator repairs and replacement, infant deaths in Broward and Dade Counties fell 19.1%, compared to only 6.4% in the U.S

- In 1983-84, the first two years that the St. Lucie 2 reactor operated and monitored airborne release of radioactivity rose, infant deaths in St. Lucie County rose 35.3%.

- These findings are consistent with the large declines in infant deaths after shutdown, near eight-out-of- eight U.S. reactors that closed since 1987.

- Further support for the adverse health effects of releases from nuclear power plants comes from a study of cancer incidence for children 0-4 living within 30 miles of 14 eastern U.S. power plants, for which cancer incidence data is available. In the areas around14-out-of-14 reactors studied, the incidence of childhood cancer was higher than the national childhood cancer rate, with the highest rates occurring around the St. Lucie and Turkey Point nuclear power plants in southeast Florida.

Discussion and Conclusions

- Radiation emissions from the Turkey Point and St. Lucie nuclear power plants are the primary cause of rising Sr-90 levels in southeast Florida baby teeth, which is highest in the counties near the plants.

- Radiation levels are significantly higher in the teeth of children with cancer than in the teeth of children without cancer.

- There is now substantial evidence that exposure to radioactive releases from nuclear reactors is a significant causal factor of increasing childhood cancer rates in southeast Florida and of other adverse affects on human health.

- This conclusion of a causal link between man-made environmental radiation and increased levels of childhood leukemia and other forms of cancer, in both children and adults, is further supported by the findings of the European Committee on Radiation Risk (ECRR) formed by independent scientists in 1997. The Executive Summary of the ECRR report, *2003 Recommendations of the European Committee on Radiation Risk: The Health Effects of Ionising Radiation Exposure at Low Doses for Radiation Protection Purposes*, released in early 2003, states:

> The committee concludes that the present cancer epidemic is a consequence of exposures to global atmospheric weapons fallout in the period 1959-63 and that more recent releases of radioisotopes to the environment from the operation of the nuclear fuel cycle will result in significant increases in cancer and other types of ill health.
>
> Using both the ECRR's new model and that of the ICRP [International Committee on Radiological Protection] the committee calculates the total number of deaths resulting from the nuclear project since 1945....The ECRR model predicts 61,600,000 deaths from cancer, 1,600,000 infant deaths and 1,900,000 foetal deaths.

Recommendations

- The recent evidence suggesting that radioactive chemicals emitted from Turkey Point and St. Lucie are one cause of rising cancer rates in southeast Florida is significant and merits more detailed study by medical and scientific researchers and by local, state, and federal officials responsible for public health.

- In particular, since the baby teeth study has shown the importance of obtaining measurements of the levels of in-body Strontium-90 radioactivity, further studies of the relation between these levels in deciduous teeth, cancer and other chronic diseases that have risen in the past two decades should be undertaken.

- Such studies should be continued, especially in southeast Florida, where the largest number of teeth of children with cancer and without cancer have been tested on a year by year basis, during a time period when there have been no nuclear tests of any kind.

- Because the present studies using Sr-90 in deciduous teeth as a measure of actual radiation have revealed that the radiation doses to the general public from nuclear plant releases and their adverse effects on human health are much greater than anticipated (based on the earlier studies of adults exposed to short bursts of high external radiation), the entire subject of very low dose internal exposure to radioactive chemicals should be extensively re-studied and re-evaluated in the United Sates, as has recently been done by the European Committee on Radiation Risk.

- Information on the radiation-cancer link should be considered in federal policies regulating the operation of nuclear reactors, in southeast Florida and across the U.S.

- Information on the radiation-cancer link should be considered by the U.S. Nuclear Regulatory Commission in its environmental review of utility applications to renew and extend the licenses of aging nuclear power plants in Florida and across the U.S.

- The serious nature of the evidence for unexpectedly large effects of small, continuous internal exposure to beta particles emitted by bone-seeking radioactive chemicals produced by nuclear fission should lead to Congressional hearings as to why the NRC no longer requires the measurement of Strontium-90 beta activity in environmental samples of food, drinking water and milk around nuclear plants. In light of rising levels of childhood cancer rates and of Strontium-90 in baby teeth, such hearings should also address the questions of resuming the monthly measurements of radioactivity in pasteurized milk by the U.S. Environmental Protection Agency that ended in 1990, and of resuming the measurement of Sr-90 in human bones and teeth carried out by U.S. government agencies until 1982.

ENVIRONMENTAL RADIATION FROM NUCLEAR REACTORS AND CHILDHOOD CANCER IN SOUTHEAST FLORIDA

I. INTRODUCTION AND BACKGROUND

General History of Reactors. After the discovery of fission that led to the Hiroshima and Nagasaki bombs in August 1945, scientists and government officials looked for alternative uses of man-made radioactive chemicals. President Eisenhower made his "Atoms for Peace" speech to the United Nations on December 8, 1953, suggesting that among other uses atomic power could generate electricity. Congress passed the Atomic Energy Act in 1954, which allowed private companies to build nuclear power plants and ordered the federal Atomic Energy Commission to provide technical assistance.

The Shippingport reactor near Pittsburgh became the first nuclear power reactor to begin operations, in December 1957. Currently, 103 reactors are licensed by the federal government to produce electricity. Since the late 1980s, nuclear power has generated about 20% of the electricity consumed in the U.S.

Health Effects of Radioactivity. Much consideration has been given to health effects of a large-scale meltdown of a reactor's core (where electricity is produced) and/or its spent fuel pools (where radioactive waste is stored). The discussion has been particularly serious since the terrorist attacks of September 11, 2001. Such a major meltdown at a reactor near a large city would constitute the worst environmental catastrophe in U.S. history, comparable to the aftermath of the Chernobyl accident in 1986.

However, nuclear reactors pose health concerns other than major meltdowns. To produce electricity, each reactor must emit relatively low-dose amounts of airborne and liquid radioactivity. This radioactivity represents over 100 different isotopes only produced in reactors and atomic bombs, including Strontium-89, Strontium-90, Cesium-137, and Iodine-131. Internal doses to humans occur as a result of inhalation or ingestion from food or water.

Each of these chemicals has a special biochemical action; iodine seeks out the thyroid gland, strontium concentrates in the bone and teeth (like calcium), and cesium is distributed throughout the soft tissues. All are carcinogenic. Each decays at varying rates; for example, iodine-131 has a half-life of eight days, and remains in the body only a few weeks. Strontium-90 has a half-life of 28.7 years, and thus remains in bone and teeth for many years – with a biological half-life of about two years in young children and five to ten years in adults.

These chemicals are different from "background" radiation found in nature in cosmic rays and the earth's surface. External sources, such as cosmic rays and gamma rays from radioactive uranium and radium in the soil, do not concentrate in specific organs, as do Iodine-131 in the thyroid gland or Strontium-90 in bone. This is also the case for internal doses due to naturally occurring Tritium and Potassium-40, which go to all soft-tissue.

Because no nuclear reactor in the U.S. has been ordered since 1978, the current crop of 103 reactors is aging, which presents additional health concerns. As reactors age, its parts are more likely to corrode and malfunction, raising the possibility of increased levels of environmental radioactivity. For example, in March 2002 officials noticed that corrosion in the Davis-Besse

reactor in Ohio had worn down a steel lid from six inches to three-eighths of an inch. Moreover, since the mid-1980s, the reactors have been operated at an increasing percent of maximum capacity, with decreasing time for maintenance, inspection and repair. As Figure 1 indicates, increased reactor operating capacity is directly correlated with the recent rise of Sr-90 in baby teeth during the 1990s.

Lack of Studies Comparing Low-Level Radioactivity with Disease Rates. Currently, federal regulators require plant operators to submit annual reports of emissions and environmental (air, water, milk, soil) levels of certain types of radioactivity. If these levels fall below federally defined "permissible limits" they are judged to be "safe."

However, in recent years, environmental samples have only been measured for their concentration of gamma ray emitting elements, but not for those elements that only emit beta rays or energetic electrons (such as Sr-90), which produce high internal doses, but cannot be as readily detected as gamma emitters. Furthermore, the Nuclear Regulatory Commission, the utilities that operate nuclear plants, and the state health departments do not conduct studies evaluating the health risks associated with in-body levels of radioactivity in areas around nuclear reactors.

For decades, scientists have documented harm from relatively low-dose exposures to radiation previously presumed to be safe. In the 1950s, British physician Alice Stewart found that pelvic X-rays to pregnant women nearly doubled the risk that the child would die from cancer by age 10. In 1997, the National Cancer Institute estimated that up to 212,000 Americans developed thyroid cancer after ingesting fallout from aboveground nuclear weapons tests in Nevada. In 2000, the U.S. Department of Energy acknowledged that thousands of workers in atomic weapons plants developed cancer and other diseases in excess of the expected rate.

Disease rates in persons living near nuclear power reactors have been studied in dozens of medical journal articles. For example, at least 12 studies have demonstrated high rates of childhood cancer near separate nuclear plants in the United Kingdom. In the U.S., very few studies have been done on childhood cancer near nuclear plants; and these were performed decades ago, were small in scale, and yielded mixed results. Moreover, no study has ever been done involving in-body radioactivity measurements of persons living near U.S. nuclear plants. Thus, much remains to be learned on the health effects of nuclear reactor emissions.

RPHP Baby Tooth Study - A Pioneering Effort. In 1996, the Radiation and Public Health Project (RPHP) initiated the first-ever study of in-body radioactivity near U.S. nuclear plants. Popularly known as the "Tooth Fairy Project," the study involved the collection of discarded baby teeth, and performing laboratory testing for levels of radioactive Sr-90. RPHP is a New York-based non-profit group of scientists and health professionals dedicated to researching the link between low-dose radiation exposures and disease. Since 1994, group members have published 17 articles in professional medical/scientific journals on this topic.

The RPHP baby teeth study is not without scientific precedent. It is based on an earlier effort to measure Sr-90 in baby teeth due to nuclear weapons testing. A 1958-70 effort in St. Louis collected over 300,000 baby teeth and measured them for Sr-90. The St. Louis baby teeth study showed that because of fallout from atomic bomb testing in Nevada, children born in 1964 had about 50 times greater concentrations of Sr-90 than did children born in 1950. It also found that in-body levels of Sr-90 decreased by about 50% from 1964 to 1969, after the Partial Test Ban Treaty signed by President Kennedy and Premier Khrushchev relegated all testing to underground sites.

In recent years, there have been at least four studies of Sr-90 from nuclear reactor emissions in baby teeth outside of the U.S. Three of these addressed fallout from the Chernobyl accident in Greece, Germany, and the Ukraine, while the other examined releases from the Sellafield plant in western England. However, none of these compared the Sr-90 levels to disease patterns.

Because of the knowledge gap from lack of prior research, the RPHP baby tooth study set the following goals:

1. To measure patterns of Sr-90 concentrations in baby teeth near U.S. nuclear reactors.

2. To compare Sr-90 patterns with those of cancer and other diseases.

To date, RPHP has collected about 3900 baby teeth, of which laboratory results of Sr-90 levels are available for about 3400. Most of these teeth are from children born since the mid-1980s living close to one or more nuclear reactors.

RPHP researchers have already published three medical journal articles on preliminary results. (28-30) The three principal findings are:

1. Current Sr-90 levels in children are similar to St. Louis children born in the late 1950s, during the time of aboveground bomb testing.

2. Instead of declining, Sr-90 levels began to rise again in the late 1980s, in parallel with the average energy generated by U.S. nuclear power plants, suggesting that nuclear reactors are now the principal source of Sr-90 found in the human body.

3. In Suffolk County, NY, where over 500 teeth have been tested, the recent trend in Sr-90 is highly correlated with the trend in childhood leukemia and cancer, suggesting a cause-and-effect relationship.

U. S. Nuclear Power Plants. Nuclear power reactors have been operating in the U.S. since 1957. Each of the 103 reactors currently operating in the U.S. (at 65 commercial nuclear power facilities) emits radioactive chemicals into the air and water, from federally permitted routine operations and from accidents. This radioactivity is inhaled and also enters the food chain mainly through precipitation, and is consumed by humans, largely by drinking milk and water. Most emissions involve chemicals that are not found in nature, but are produced only by atomic bomb explosions and nuclear reactor operations.

Of the 103 nuclear reactors, four are located in southeast Florida. The Turkey Point unit 3 and 4 reactors are situated in southeast Miami-Dade County, approximately 25 miles south of Miami. The St. Lucie 1 and 2 are about 120 miles to the north, in southeast St. Lucie County, approximately 40 miles north of West Palm Beach. The Turkey Point reactors began operating in 1972 and 1973, respectively, while the St. Lucie reactors started in 1976 and 1983, respectively. (*See Map 1*).

Built to help the area meet its demand for electricity, the reactors have had a spotty record of safety and health concerns. Turkey Point nuclear units 3 & 4 began to experience problematic and unmonitored leaks in steam generators within two years after they started operations. As a result, the nuclear plant was closed for much of 1982 and 1983, while the steam generators were being replaced. In 1978, Florida Power and Light Co., the operator of Turkey Point, was

the first of 13 utilities to file a lawsuit against Westinghouse, which manufactured the parts and had promised a reliable operating life of the steam generators. The suit was later settled.

The replacement of the steam generators at Turkey Point 3 & 4 was completed in April 1982 and May 1983, respectively. The replacement of the steam generators at St. Lucie 1, which were manufactured by Combustion Engineering, was completed in January 1998.

II. RADIOACTIVITY

1. Radioactive Releases Into the Environment

Utilities operating nuclear power plants are required to send annual reports on radioactive releases to the federal government. Both Turkey Point and St. Lucie have reported the emission of substantial amounts (10.3 Curies, equal to 10.3 trillion picoCuries) of radioactivity into the air from 1970-87, in the form of "Iodine and Particulates" that include Sr-90.[1] About two-thirds of this total (6.69 trillion) is from Turkey Point. (1) These totals do not include rapidly decaying radioactive chemicals (half-life of under eight days) or unmonitored releases from steam generator corrosion.

By comparison, the Three Mile Island accident in March 1979 released 14.20 trillion picoCuries of Iodine-131 and particulates into the atmosphere. Thus, reported releases from the four southeast Florida reactors are about three-fourths of that during the Three Mile Island accident.

2. Dietary Levels of Radioactivity

These releases, in the form of molecules or tiny particles, are returned to earth in precipitation and enter the drinking water, milk, and food. The federally mandated program to measure radioactivity in the diet was started by the Eisenhower administration in 1957, during the time of large-scale atomic bomb testing above the Nevada desert. However, the program of measuring and publishing the monthly levels of radioactive fission products (such as Iodine-131, Cesium-137, Strontium-90 and Barium-140) in pasteurized milk by the U.S. Environmental Protection Agency (EPA), in cities across the nation was ended in 1990, except for a single measurement of Strontium-90 in milk once a year.

Levels of radioactivity in the Miami area are of particular interest. With a yearly average rainfall of 79 inches, the region is the wettest of all densely populated areas in the continental U.S. For two decades, the EPA has measured the amount of radioactive beta emitting particles in precipitation in Miami. In the 1980s, following the last atmospheric bomb test worldwide (China, 1980) levels of radioactivity in rainwater were falling, to a low of 1.49 picoCuries per liter (pCi/l) in the period 1979-80. But the levels rose again to a peak of 3.62 pCi/l for the years 1981-83, when the Turkey Point plant reported a large peak of airborne releases of "Iodine and Particulates." Another low point of beta activity in rainwater of 0.63 pCi/l occurred in 1988-90, which was followed by a 62% rise to a high of 1.11 pCi/l in the period 1998-2000, even though there have been no nuclear tests of any type since 1993. (2)

This recent rise in rainwater beta activity measured by the EPA in Miami-Dade County can therefore only be explained by renewed large releases from the Turkey Point nuclear plant, with some possible contribution from the St. Lucie plant, approximately 120 miles to the north, which required the replacement of its steam generators in 1997-98. Moreover, the high beta

[1] A Curie is a unity of radioactivity equivalent to 3.70×10^{10} disintegrations per second.

activity recently measured by RPHP in drinking water near the two nuclear plants is consistent with the comparable levels measured by the EPA in the rainwater.

No atomic bombs have been tested above ground in the U.S. since 1962 and below ground since 1992, and nuclear waste is buried and has not yet entered the food chain. The last atmospheric test by any nation took place in China in 1980, and the last Chinese underground test in 1993. Thus, the only source of bone-seeking, man-made radioactive chemicals today are nuclear power plants, research reactors, or nuclear fuel and nuclear weapons production facilities.

3. Radioactivity Levels in the Body

In the 1950s and 1960s, the St. Louis Committee for Nuclear Information tested about 325,000 baby teeth for a study of levels of radioactive Strontium-90 (Sr-90) at birth. Sr-90 is one of dozens of radioactive chemicals found only in atomic bomb tests and nuclear reactor emissions. It is like calcium, seeking out bone and teeth, and resides in the body for many years (half-life of 28.7 years), making it possible to test in-body levels. Sr-90 impairs cells in the bone and bone marrow (in which the immune system defenses are built) making it a risk factor for all cancers.

The physical half-life of Sr-90 is 28.7 years, with a biological half-life in the bone of adults of 5-10 years, and in young children of about 2 years. This makes it possible to test in-body levels of Sr-90 by measuring it in the newly developing teeth, where it remains fixed after the first few years of life as a marker of exposure to fission products at birth. Sr-90 mutates or kills cells in the bone and bone marrow, where the white cells of the immune system originate that normally destroy cancer cells wherever they form in the body, making it a risk factor for all types of cancer and other diseases involving the immune system, including infectious and auto-immune diseases such as diabetes.

Furthermore, Sr-90 decays into the radioactive element Yttrium-90, which has different chemical properties and concentrates particularly strongly in the hormone producing soft tissue organs such as the breasts, the pituitary gland, and the pancreas where insulin is produced, thus leading to Type I diabetes found to be rising in children in recent years. Moreover, Yttrium-90 concentrates also in the male and female reproductive glands, the testes and the ovary, so that genetic damage is produced that affects future generations. It has also been found to concentrate in the lung in laboratory experiments, so that the ingestion of Sr-90 in the milk and drinking water can be a cause of both asthma, emphysema and lung cancer. (For *a more detailed discussion of the toxicity of Strontium-90, see Appendix 4*)

The St. Louis group found that for children born in 1964, the year after above-ground bomb testing ended, the average Sr-90 level was 50 times greater than for those born in 1950, just before Nevada testing began. After 1964, Sr-90 averages declined sharply until the federal government discontinued the study in 1970.

As shown in Figure 2, recent measurements of Sr-90 in 2,089 baby teeth by RPHP for teeth of children born since 1954 across the U.S. (mainly in California, Florida, New York, New Jersey, and Pennsylvania) clearly documents the rise during the period of bomb testing to a peak in 1962-65. This rise was followed by a sharp decline of Sr-90 levels during the late 1960s, that ended in the 1970s when fallout from large hydrogen bombs detonated in the atmosphere by France and especially by China reached the U.S. Figure 2 also shows that there was only a very small decline of Sr-90 in 1970-73 through 1974-77 period, when the first large nuclear reactors, such as Turkey Point, which had large radiation releases, came on line. As a

result, by the mid-1970s the levels of Sr-90 were twice as large as projected after the end of bomb testing, based on the initial rate of decline from the 1962-65 peak.

The difference between actual vs. projected levels of Sr-90 became even larger in 1978-81, after the Three Mile Island accident occurred in 1979. Therefore, by 1982-85, when massive venting from underground explosions in Nevada during the so-called Star Wars tests occurred and the number of large reactors coming on line increased sharply, the data show that there was no further decline of Sr-90 at all, despite the end of all atmospheric testing in 1980. Following a small decline in Sr-90 in 1986-89 with the end of the venting of Star Wars tests in Nevada, there has been a renewed and continuous rise in Sr-90 during the 1990s. None of these 1990s increases could be attributed to either above or underground nuclear tests, especially after 1993 when all underground tests by the U.S., China, France and the Soviet Union had ended.

Government officials also maintained a small program of testing Sr-90 in bones of deceased adults in New York and San Francisco. This program was also discontinued in 1982 (3), just as Sr-90 levels failed to continue their decline since the end of atmospheric nuclear weapons testing in 1963 and had begun to increase again due to the expansion of commercial nuclear power. Since then, the U.S. has been without a systematic state or federal government program for testing radioactivity levels in human bodies. This is unfortunate, because this in body testing provides the best indicator of the presence in humans of Sr-90, which is also a marker for exposure to other radioactive isotopes.

Figures 3 shows the average Sr-90 levels by state, based on 2,089 teeth tested as of October 2002, for the states of California, Florida, New Jersey, New York, Pennsylvania, plus all "Other" states. The data for these named states are comprised mainly of teeth from areas near nuclear power plants.

In Figure 3, the measured levels of Sr-90 are shown by state for four periods: 1982-85, 1986-89, 1990-93 and 1994-97. For each of these periods, at least 12 teeth were available, except for Pennsylvania where only 6 teeth were available in the 1982-85 period so that only the data for the three later periods are represented.

In all cases where baby teeth data are available, there was a decline in Sr-90 between 1982-85 and 1986-89 just as seen for all states combined in Figure 2. Furthermore, in all states there was then a continuous rise in the three succeeding periods, or between 1982-85 and 1994-97, as well as in the remaining scattered "Other" areas across the United States. Moreover, the levels in the most recent years have begun to approach the levels seen during the period 1954-

Since nearly one-quarter of all of the baby teeth Sr-90 levels reported in Figures 2 and 3 come from southeast Florida (485 Florida teeth out of 2,089 total U.S. teeth), there is no doubt that the Florida baby teeth study can serve as a bellwether for the nation as a whole in the effort to understand the reason for puzzling rises in childhood cancer and other chronic diseases since the early 1980s.

4. Beta Radiation Levels in Florida Water

In order to test the hypothesis that contamination of the drinking water by releases from the nuclear reactors in Miami-Dade and St. Lucie counties is a major contributing factor in the rise of Sr-90 and childhood cancer rates since the early 1980s, RPHP collected a series of drinking water samples at various distances from the two plants. These samples were analyzed for the presence of Sr-90 radioactivity in the form of high-energy beta activity, characteristic of the electrons emitted from the nuclei of the Sr-90 atom, as well as from its daughter product Yttirum-90. By only counting high-energy electrons, one can eliminate naturally occurring tritium (a form of hydrogen).

This analysis of the presence of high-energy beta radiation from Sr-90 in drinking water is important, because such analysis is not currently being done, neither by the utility that operates the nuclear plants nor by the State of Florida Department of Health. Because Sr-90 emits only electrons that have a short range of only a few millimeters in tissue and does not emit gamma rays, the existing measurements techniques of environmental samples by the operators of the nuclear plants and the Florida DOH are limited in that they can detect the presence of penetrating gamma rays but cannot detect Sr-90.

In the early years of nuclear power prior to the early 1980s, the NRC required specific measurements of Sr-90 beta activity in environmental samples. In fact, such measurements showed the presence of Sr-90 around nuclear plants with peak levels similar to those measured during the height of nuclear weapons testing, declining with distance away from the plant in a series of dairy farms. This is clearly illustrated by Sr-90 data collected around the Millstone plant in Connecticut. (5) (6)

Figure 4 shows the results for the analysis of drinking water samples taken within 20 miles of the Turkey Point and St. Lucie nuclear power plants, as well as in areas more than 20 miles from any nuclear reactor in southeast Florida. The latter includes samples from Broward and Palm Beach counties located between the two nuclear plants, as well as from Indian River and Okeechobee counties to the north and northwest of the St. Lucie reactor.

In addition, it was decided to test water that has been filtered by reverse osmosis in these areas, both near the nuclear plants and more than 20 miles away. Reverse osmosis is reported to remove more than 98% of Sr-90 and other heavy beta emitters, because their molecules are larger than those of the water molecules and, therefore, cannot pass through the RO filters.

Inspection of Figure 4 shows that, as predicted, the levels of beta activity in the water samples was greatest in the water samples within 20 miles of the Turkey Point (located in Miami-Dade County) and St. Lucie (located in St. Lucie County) nuclear plants, while much lower beta activity readings were obtained from water samples from the more distant intermediate counties. Five water samples were collected from within 20 miles of each reactor, while a total of six samples were collected from the intermediate counties.

Moreover, the three samples of water filtered by reverse osmosis showed an average of only 0.06 picoCuries per liter (pCi/l), which represents essentially zero activity within the limits of

the measurement uncertainty of ±0.14 pCi/l of water. The beta activity in these RO filtered water samples was more than 18 times less than the activity in the unfiltered water samples collected near the St. Lucie nuclear plant, and more than 19 times less than for those around the Turkey Point nuclear plant.

Furthermore, the beta activity average of 0.46pCi/l for the more distant counties, although 7.7 times higher than the filtered samples, was significantly lower than those collected near the plants, which were some two and a half times higher at 1.19 for Turkey Point and 1.13 pCi/l for St. Lucie, respectively. The differences between the level in Palm Beach county and the counties nearest the two reactors are statistically significant with sigma, or uncertainty values, of more than 2, corresponding to a probability that they are purely accidental of less than 5%.

This pattern bears a striking resemblance to that for the most recent childhood cancers for the 0-4 year age group shown in Figure 5, where the rates for the counties where the two reactors are located are seen to be far higher than for Palm Beach County in the 1996-98 period, when the releases from the last underground tests in 1992 and 1993 could no longer have a significant effect on the incidence of cancer in children under five years old.

It is seen that both the St. Lucie and Miami-Dade County cancer incidence are higher than that for Palm Beach County, whose center is some 60 miles away from either of the southeast Florida nuclear plants. However, St. Lucie County has a higher cancer incidence than Miami-Dade County, by about 60%, because most of the population in the county lives within 10 miles of the St. Lucie nuclear plant located on Hutchinson Island, whereas only a small fraction of the population in Miami-Dade County lives close to the Turkey Point nuclear plant, located near Homestead some 25 miles south of Miami.

It appears that the distribution of high energy beta activity in the water samples, with the highest radioactivity near the reactors, together with the patterns of rising Sr-90 in the deciduous teeth and the pattern of cancer incidence, make an extremely strong case that the rising Sr-90 found in the teeth of children born in southeast Florida in the period from 1986-89 to 1994-97 cannot be due to nuclear weapons tests or the 1986 Chernobyl reactor accident. Therefore, rising Sr-90 levels in southeast Florida baby teeth are primarily due to emissions from the local Turkey Point and St. Lucie nuclear reactors.

III. CANCER RATES IN SOUTHEAST FLORIDA

1. Introduction

Since the atomic era began in the 1940s, scientists have been studying the effects of exposures to man-made radiation produced by the detonation of nuclear weapons. Elevated levels of illness and death among the survivors exposed in Hiroshima and Nagasaki are attributed to the flash of gamma rays and neutrons. Other studies were done following the fallout from bomb tests in Nevada, the South Pacific, and the former Soviet Union, as well as from the 1986 accident at the Chernobyl nuclear power plant. Most of these studies were recently summarized in the European Committee on Radiation Risk publication, *2003 Recommendations of the European Committee on Radiation Risk: The Health Effects of Ionising Radiation Exposure at Low Doses for Radiation Projection Purposes.* (7)

In addition, researchers have addressed effects of relatively low doses of radioactivity produced by medical X-ray examinations. The first to scientifically document hazards of low-dose exposures was Alice Stewart, a British physician. In the 1950s, Stewart showed that a

pelvic X-ray examination to a pregnant woman, involving only two or three X-ray films, doubled the chance that the baby would die of cancer before age 10. (8)

Studies of low-dose exposures have addressed many diseases, but often focus on cancer in children. Radioactive chemicals are known to be more harmful to the young, particularly the developing fetus and infant. Body growth and cell division is most rapid early in life, and thus a damaged cell is most likely to cause harm.

The federal government does no systematic tracking of health patterns for persons living near nuclear plants. The only known federal study on cancer near nuclear reactors was a 1990 effort prepared by the National Cancer Institute (NCI), at the request of U.S. Senator Edward M. Kennedy. (9) NCI concluded there was no cancer risk from reactors. However, this conclusion is flawed, due to the NCI's highly controversial designation of counties near reactors as "unexposed controls." Since a majority of the "control counties" were located either adjacent to or within 50-100 miles of the "study counties," most of the control counties were also significantly exposed to airborne emissions and, therefore, do not represent valid controls. (10) Since 1990, the federal government conducted no published studies on the health effects of reactor operations.

RPHP has performed additional research on cancer near nuclear reactors. The book, *The Enemy Within*, written by Jay M. Gould and RPHP research associates, found that women living within 100 miles of nuclear reactors are at the greatest risk of dying of breast cancer. (10) These findings are highly reliable, since they are based on NCI data on all white women who died of breast cancer, available for every U.S. county, in every year between 1950 and 1989. These *epidemiological* findings of a strong correlation between proximity to reactors and breast cancer mortality promoted RPHP to undertake the baby tooth study, designed to gather *clinical* evidence of the presence of environmental radiation in children's teeth, and thus also in the bones and diet of the mother when she was pregnant.

Regarding southeast Florida, from the early 1950s to the late 1980s, age-adjusted breast cancer mortality near Turkey Point (Broward, Collier, Dade, Monroe, and Palm Beach counties) rose 26%, while the rise near St. Lucie (Brevard, Indian River, Okeechobee, Osceola, and St. Lucie counties) was 55%. The U.S. average increased only 1% in this period. (10)

2. Cancer in Southeast Florida – Children

In the late 1990s, a rise in childhood cancer incidence occurred in the five most populous counties in southeast Florida (Broward, Dade, Martin, Palm Beach, and St. Lucie), which account for nearly 95% of the baby teeth obtained and measured in this Report.

The 1996-98 cancer rate age 0-9 in the southeast Florida region is 35.2% higher than in 1981-83, compared to a 10.8% increase in the U.S., a statistically significant difference. This indicates that the rate of childhood cancer in southeast Florida grew more than three times faster than the national average. The 1996-98 rate of 20.64 per 100,000 is 32.3% higher than the U.S. average of 15.6 per 100,000.

Table 1
Trends in Cancer Incidence, Children Age 0-9
Five Southeast Florida Counties *

Years	Age 0-9 Cancer Cases	Population	Cases per 100,000 Pop.	% Change
1981-83	191	1,250,648	15.27	
1996-98	408	1,976,508	20.64	**+35.2% (p <.01)**
				+10.8% in U.S.

Sources: Florida Cancer Data System; National Cancer Institute,
SEER Cancer Statistics Review, 1973-97.
* Five southeast Florida counties are: Dade, Broward, Palm Beach, Martin and St. Lucie.

In St. Lucie County, cancer incidence under age 10 rose 325.3% from the early 1980s to the late 1990s. The 1996-98 St. Lucie rate of 40.79 cancer cases per 100,000 population (30 cases) is more than double the U.S. figure of 15.6. (More recent data for the age group 0-4 in St. Lucie and Charlotte Counties are discussed in Section IV.)

3. Cancer in Southeast Florida - Young Adults

During the 1990s, cancer deaths for persons age 15-34 in southeast Florida rose, even though national rates fell. Radiation-sensitive cancers rose especially quickly, including breast cancer and cancers of the blood forming organs and bone marrow (leukemia, lymphoma, Hodgkin's Disease, multiple myeloma) that are susceptible to bone-seeking chemicals such as Strontium-90. In addition, deaths from pneumonia, a condition that depends on a strong immune response to overcome, increased. Differences between local and U.S. trends are all statistically significant.

Table 2
Trends in Cancer and Pneumonia Mortality, Persons Age 15-34
Five Southeast Florida Counties

Years	Age 15-34 Cancer Cases	Population	Deaths per 100,000 Pop.	% Change
All Cancers Combined (codes 140.0-239.9)				
1981-89	1027	10,497,150	9.78	
1990-98	1197	11,263,382	10.63	+ **8.7%** (p<.001)
				- 5.0% in U.S.
Female Breast Cancer (codes 174.0-174.9)				
1981-89	90	5,292,483	1.70	
1990-98	111	5,662,217	1.96	**+15.3%** (p <.07)
				- 10.2% in U.S.
Blood-related Cancers (codes 200.0-208.9)				
1981-89	314	10,497,150	2.99	
1990-98	388	11,263,382	3.45	**+15.4%** (p <.01)
				- 5.3% in U.S.

Pneumonia (codes 480.0-486.9)

1981-89	134	10,497,150	1.28	
1990-98	172	11,263,382	1.53	**+19.5%** ($p < .04$) - 5.2% in U.S.

Source: National Center for Health Statistics, www.cdc.gov, data and statistics, CDC Wonder

IV. THE LINK BETWEEN SR-90 IN FLORIDA BABY TEETH AND CANCER RISK

1. Background

The St. Louis study was designed to measure the increased burden of radioactivity in the body from atomic bomb testing, and did not examine the cancer risk of this radioactivity. However, the rise in Sr-90 levels in teeth corresponded to a rise in cancer incidence in children under five years old in the 1950s and early 1960s, as documented in the cancer incidence records of the State of Connecticut. (11) In the late 1960s, after above ground testing ended, both Sr-90 in teeth and childhood cancer declined.

The concern about the rise of Sr-90 in the milk and the teeth of children during the late 1950s due to bomb testing contributed to President Kennedy's decision to sign the historic Partial Test Ban Treaty with the former Soviet Union and Great Britain in the summer of 1963. At that time, the Kennedy White House asked Dr. Ernest Sternglass, now chief scientist of RPHP, to testify before a Congressional committee on the potential rise in childhood cancer due to nuclear weapons testing. These health effects had been described by Sternglass in a paper published in the journal Science in June of 1963 (12). Thus, Sternglass's paper and testimony appear to have played a role in the U.S. Senate's ratification of the historic treaty, which prohibited above ground and under water nuclear weapons tests.

Initial results of RPHP's baby teeth study have been published in three peer-reviewed medical journals. (13) (14) (15) In Suffolk County NY, which contributed over 500 teeth to the study, an increase in Sr-90 averages was followed by an increase in childhood cancer - and a drop in Sr-90 was followed by lower childhood cancer rates (see Figure 6). Thus, RPHP has found the same pattern in Monmouth-Ocean Counties, N.J. and Westchester, N.Y., both located near nuclear reactors. In addition, average Sr-90 levels in deciduous teeth increased significantly after the opening of the Diablo Canyon plant in California in the mid-1980s, followed by a rise in local childhood cancer death rates in the 1990s.

2. Environmental Radioactivity and Childhood Cancer in Southeast Florida

The U.S. Environmental Protection Agency has reported levels of "gross beta", or radioactive chemicals that emit beta particles, such as those produced by Sr-90, in Miami precipitation for more than a decade. RPHP discovered that trends in these levels are closely correlated with similar trends in cancer incidence for Miami-Dade County children under five just three years later. Again, RPHP has discovered a strong correlation between radioactivity in the Miami environment and local childhood cancer (see Figure 7).

3. Sr-90 in Florida Baby Teeth

As shown in Table 3, the six contiguous southeast Florida counties, bordering on the Atlantic coast and nearest the two nuclear plants, have an average Sr-90 concentration of 3.61 ± 0.15 pCi/l, compared with 2.51 ± 0.52 for the group of 12 other Florida counties, which are not on the Atlantic coast and more than 50 miles from any reactor. This represents a significant excess in the "study counties" of 44% over the more distant "control counties," with a probability that

this difference is accidental of less than 0.05. The six southeast Florida counties are: Miami-Dade, Broward, Palm Beach, Martin, St. Lucie and Indian River, for which a total of 461 teeth have been tested for Sr-90 (*see Map 1*).

Individually, each and every one of these six most highly exposed southeast Florida counties have Sr-90 levels in the teeth of their children that exceeds the average concentration in the less exposed and more distant counties as a group. Among the southeast Florida counties, St. Lucie and Palm Beach show the largest excess at the statistically significant level of $P< 0.05$, with an excess of 62% for St. Lucie and 64% for Palm Beach, respectively. This pattern is consistent with the findings for Westchester County, New York, and its neighboring two counties, which are the counties closest to the Indian Point nuclear plant located just north of New York City. Here, the counties located closest to the Indian Point plant showed excess Sr-90 levels relative to the more distant counties and to the state of New York as a whole. These finding were documented in a baby teeth study officially commissioned by the Westchester County Legislature in the state of New York. (4)

Table 3

Sr-90 in Baby Teeth in18 Florida Counties for Children Born in 1981-96, Six Southeast Florida Study Counties and Twelve Control Counties (In picoCuries per gram Calcium for teeth tested as of 11/02)

(A) Six Southeast Florida Counties
On Atlantic Coast and within 50 Miles from Turkey Point or St. Lucie Reactors

County	Miles From Turkey Pt.*	Number of teeth	Sr-90 pCi/gCa	Miles from St. Lucie *
Miami-Dade	25	250	3.45 ± 0.22	105
Broward	50	65	3.46 ± 0.43	90
Palm Beach	90	49	4.12 ± 0.59	50
Martin	115	13	3.81 ± 1.06	20
St. Lucie	130	60	4.08 ± 0.53	8
Indian River	165	24	3.32 ± 0.68	25
	Total of 461 teeth		**3.61 ±0.17 (Weighted average)**	

(B) Twelve Other Florida Counties
More than 50 Miles from any Reactor and not on the Atlantic Coast

County	Miles from Turkey Pt.*	Number of teeth	Sr-90 pCi/gCa
Monroe	50	2	1.89 ± 1.43
Collier	80	1	1.57 ± 0.70
Lee	130	2	2.49 ± 1.83
Charlotte	150	1	1.22 ± 0.70
De Soto	160	1	2.48 ± 0.70
Sarasota	185	1	5.61 ± 0.70
Manatee	195	1	2.41 ± 0.70
Osceola	195	1	3.13 ± 0.70
Orange	225	4	2.26 ± 1.24
Hillsborough	225	3	3.17 ± 1.87
Pasco	250	4	2.85 ± 1.50
Alachua	325	3	1.72 ± 1.07
	Total of 24 teeth		**2.51±0.52 (Weighted Average)**

Notes: Individual teeth measurements have an uncertainty of ± 0.7 pCi/gCa.
The difference of the (A) and (B) averages is significant at $p < 0.05$.
* Approximate distance from reactor to population center of the county.

4. Sr-90 and Childhood Cancer Risk in Southeast Florida

During this study, RPHP was able to collect 17 teeth from children, born in six counties of southeastern Florida between 1981 and 1996, who were diagnosed with cancer. For these same birth years and counties, RPHP was also able to collect 311 teeth from children without cancer. Based on these teeth samples, it became possible to test whether Strontium-90 levels were higher in children diagnosed with cancer than children without cancer. The counties are Dade, Broward, Palm Beach, Martin, St. Lucie and Indian River.

As can be seen from an inspection of Table 4 and Figure 8, in this period there were 10 years when one or more teeth from children were available for Strontium-90 determination who were born the same year but who were diagnosed with some form of leukemia or cancer. For these years, we were able to obtain an average of some 31 teeth from children who were born in southeastern Florida and who were not reported to have been so diagnosed and could therefore provide a comparison. Thus, it was possible to determine whether children diagnosed with cancer in a given year had a significantly greater concentration of Sr-90 in their teeth at birth than the average child born in the same year in the same area of Florida not subsequently diagnosed with cancer.

Since the individual teeth were measured with a very high accuracy of ±0.7 pCi/gCa, or with an average percent accuracy of ±20% comparable to the average ±22% percent accuracy with which the yearly Sr-90 levels in the non-cancer teeth could be established, it was possible to determine how frequently the cancer teeth were significantly higher in Sr-90 concentrations than the non-cancer teeth for the same birth-year. The high accuracy of individual teeth measurements results from the long period of counting beta particles in a high efficiency scintillation detector, and the high accuracy in the averages for the non-cancer teeth results from the large number of teeth available for most years, on average 31, for which the percent uncertainty is given by the inverse square root of the number multiplied by 100.

As shown in Table 4 and Figure 8, the average concentration of Sr-90 in the cancer teeth was higher than in the non-cancer teeth in 8 out of 10 years, and both rose from the early 1980s to their highest levels in the period 1994-96, involving 14 teeth from children diagnosed with some form of malignancy out of a total of 17.

Overall, the Sr-90 concentration in the 17 teeth from children diagnosed with some form of cancer was close to double the amount of Sr-90 per gram calcium found in the 311 teeth from children not diagnosed for leukemia or cancer, namely higher by 3.04± 0.30 pCi/gCa, or by 85±10%.

As shown in the last column of Table 4, for 11 out of the 17 teeth of children with some form of cancer the excess Sr-90 percentage was more than twice the percent standard deviation, ranging from 2.2 to 29, the highest concentration measured being 22.96±0.7 pCi/gCa. Thus, the probability that the excess Sr-90 in any of these 11 cancer case teeth is accidental is less than 5 out of 100. Since these 11 cases are independent tests, the combined probability that the excess levels of Sr-90 in the teeth of children diagnosed with cancer is due to chance is less than 0.05 multiplied by itself 11 times.

Taken in combination with all the other epidemiological and clinical evidence, this result provides extremely strong support for the hypothesis that the recent rise in childhood leukemia

and cancer of all types in southeast Florida is causally related to the rising levels of Sr-90 and other fission products released from the local nuclear plants.

This is consistent with a recently published study in Suffolk County, Long Island, an area surrounded by nuclear plants in Connecticut, New Jersey and New York. (11) The study found that a single picoCurie per gram calcium in recent baby teeth is associated with nearly a doubled risk of childhood cancer; and is, therefore, about three times as serious as the Strontium-90 in baby teeth measured in the early 1960s in St. Louis, that originated from high altitude H-bomb tests, when fallout came down from the stratosphere over a period of years. The reason for the increased risk per picoCurie of Sr-90 near nuclear plants as compared with high altitude H-bomb tests is that many short-lived radioactive isotopes such as Strontium-89 with a half-life of 50 days, Barium-140 with a half-life 12.8 days along with Iodine-133 with a half-life of only 21 hours can be inhaled following repeated routine batch-releases or leakages from corroding steam generators, pipes and valves, since winds carry the airborne emissions to nearby towns and large cities in a matter of only a few hours.

The evidence that surprisingly small concentrations of Sr-90 in baby teeth released from nuclear reactors appear to provide a radiation dose sufficient to increase the risk of developing some form of childhood cancer is consistent with earlier findings going back more than 30 years. The first indication that very small doses of radiation can produce leukemia and cancer was the discovery by Dr. Alice Stewart at Oxford University in the mid-1950s that just three diagnostic X-rays to the abdomen of a pregnant woman just before delivery doubled the risk that the child would develop leukemia or another type of cancer before age 10. By 1970, she and her statistician George Kneale had discovered that women who had abdominal X-rays in the first three months of pregnancy had a ten to fifteen times greater risk that the child they were carrying would develop cancer. This implied that a very small dose -- of the order of the annual dose due to natural background in the range of 60 to 100 millirads -- doubled the risk of a child developing some form of cancer.

These doses are also comparable with the dose of 42 mrad per year -- due to external background gamma radiation in the range of 57 to 92 mrad/yr -- found by Hatch and Susser (16) to double the incidence of childhood cancer in the area with the highest annual dose within a 10-mile radius of the Three Mile island nuclear plant for the years 1975-85, both for the age groups 0-4 and 0-14.

During the years of atmospheric bomb testing, there was great concern over the possible effects of nuclear fallout containing Sr-90, and calculations were made to determine how large a dose to the bones and bone marrow would result from the ingestion and inhalation of this known carcinogen.

Thus, the 1972 report of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) Volume I, Paragraph 205 gave the result that 1 picoCurie of Sr-90 per gram Calcium (pCi/gCa) produced a dose of 4.5 millirads (mrad) per year, and 1.95 mrad per year for the cells lining the walls of bone cavities containing the bone marrow where the cells of the blood and immune system are born.

This means that alone from Sr-90, the radiation doses for children diagnosed with cancer in southeast Florida with concentrations of Sr-90 ranging from 4.23 to 22.96 pCi/gCa in their baby teeth represent doses between 19.04 and 103.32 mrad per year to their bones, comparable to the doubling dose for children exposed to X-rays in the first three months of intra-uterine development.

The radiation doses to the bones of the children diagnosed with cancer in southeast Florida must be compared with the present maximum allowable dose to any organ of individuals in the general population due to nuclear reactor releases according to present NRC regulations of 15 mrad or mrem per year (17), where mrad and mrem are equivalent units of absorbed radiation in the case of X-rays and fission products such as Sr-90.

However, Sr-90 is not the only radioactive element whose radiation affects the bone and bone marrow when the exposure is due to the fission of uranium or plutonium. As shown in Table 45 in Volume I of the 1972 UNSCEAR report cited above, the total dose from all such elements combined to the bone lining cells and the bone marrow, both external and internal in origin due to fallout from nuclear testing up to 1971, was 3 to 4 times the internal dose from Sr-90 alone.

Since the reported radioactive elements released from nuclear reactors contain most of those found in bomb fallout, this means that when a single pCi/gCa of Sr-90 is found in the teeth of a newborn child, the dose to the crucial cells in the inner lining of the bone and the marrow (where the white cells of the immune system are located) will be in the range of 5-8 mrad. As a result, even the doses to the general population in Florida and other states where the baby teeth in recent decades have ranged between 3 and 5 pCi/gCa of Sr-90 as shown in Figure 3 represent radiation doses of the order of 15 to 40 mrad per year. This applies to both the newborn and their mothers at the time the child is born, explaining the continuing rise in childhood malignancies (18) and many forms of adult cancer incidence such as breast cancer (6) in the past two decades both in Florida and the nation as a whole, due to a reduced ability of the immune system to control the multiplication of cancer cells anywhere in the body as discussed in Appendix 4.

Yet another piece of evidence tying the recent rise in childhood cancer to the releases of Sr-90 and other fission products comes from the most recent data for the incidence in children 0-4 years old that has become available from the Florida Cancer Statistics System for the years 1981 to 2000 (C). This allows one to compare the change in newly diagnosed cases in St. Lucie where the entire population lives within 30 miles of the nuclear plant on Hutchinson Island with a similarly small county directly upwind more than 80 miles to the west, namely Charlotte County. The two counties presently have populations within a factor of two, similar population growth since 1981 and they also have comparable annual rainfall, which brings down 90% of radioactive fallout.

One can now compare the reported incidence of newly diagnosed cancer cases in these two counties during the period 1981-1996, when fission products from atmospheric bomb tests and from the venting of underground tests in Nevada, the Soviet Union and China that ended in 1993 were present in both St. Lucie and Charlotte, with the incidence in these counties during 1997-2000 when fresh fission products existed only in St. Lucie due to the releases from the local nuclear plant.

The results are as follows: In the period 1981-96, Charlotte had a rate of 18.0±4.5 and St. Lucie a rate of 24.3±6.1, just 35% higher, consistent with a contribution due to early releases from the St. Lucie nuclear reactors. But in the years 1997-2000, Charlotte's rate declined to 4.6±4.6, while that for St. Lucie rose to 31.1±8.3, reaching a level 576% higher than in Charlotte. This is a statistically highly significant difference of nearly three standard deviations, consistent with the fact that very large releases occurred in the previous years from defective steam generators that required extensive repairs in 1997 and 1998.

This finding adds further support to the RPHP conclusion that the childhood cancer cluster, investigated by the Florida Department of Health in St. Lucie County was indeed related to the releases from the nuclear plant and not to other carcinogens in the environment. The comprehensive Florida DOH study of 561 chemical carcinogens, carried out during 1997-99, eliminated these other environmental carcinogens as possible causal factors of the St. Lucie County cancer cluster. (19)

The importance of this peak in the incidence rate involving 8 new cases in a single year is especially clear when this rate is compared with the low of only 16.6±7.4, corresponding to an average of only 1.3 cases per year diagnosed in St. Lucie County in the period 1981-84. That was shortly after Unit 1 went on line in 1976 so that corrosion in the steam generators could not have had a serious effect on the releases, and before the start of Unit 2 in 1983 could have resulted in a significant rise in the incidence of leukemia and other cancers in children.

Table 4

COMPARISON OF STRONTIUM-90 IN TEETH OF CHILDREN DIAGNOSED WITH CANCER AND IN TEETH OF NON-CANCER CHILDREN IN SIX SOUTHEAST FLORIDA COUNTIES FOR THE PERIOD 1981-96

(Sr-90 in picoCuries per gram Calcium. The measurement uncertainty is ± 0.7 pCi/gCa)

Birth Year	Number of Non-Cancer Teeth	Average Sr-90 in Non-Cancer Teeth	Sr-90 in Cancer Teeth	Excess Sr-90 in Cancer Teeth	Standard Deviation %	Ratio of Column (5) to Column (6)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1981	9	3.24 ±33%	4.23 ± 17%	+ 31%	±45%	+0.7
1984	25	3.29 ±20%	4.61 ± 15%	+ 40%	±25%	+1.6
	---	-------	5.03 ± 14%	+ 53%	±24%	+2.2
1986	15	2.57 ±26%	5.39 ± 13%	+110%	±29%	+3.8
1987	28	3.15 ±19%	5.20 ± 14%	+ 68%	±24%	+2.8
1988	29	3.02 ±19%	8.29 ± 8%	+175%	±21%	+8.3
1990	69	3.13 ±12%	1.47 ± 48%	- 54%	±49%	-1.1
1991	41	3.51 ±16%	5.15 ± 14%	+47%	±21%	+2.2
1994	58	3.82 ±13%	0.68 ±103%	- 82%	±104%	-0.8
	---	-----	6.32 ± 11%	+ 65%	±17%	+3.8
1995	31	3.68 ±18%	6.60 ± 11%	+ 79%	±21%	+3.8
	---	-----	7.34 ± 10%	+ 99%	±21%	+4.7
	---	-----	11.53 ± 6%	+213%	±19%	+11.2
	---	-----	4.57 ± 15%	+ 24%	±23%	+1.0
	---	-----	22.96 ± 3%	+524%	±18%	+29.0
1996	6	3.72 ±40%	2.17 ± 32%	- 42%	±51%	- 1.2
	---	-----	7.28 ± 10%	+ 96%	±41%	+2.3
Average	31.1	3.36 ±22%	6.40 ±20% *	+ 85% *	±33% *	+4.4 *

Notes: (a) Averages in columns (4), (5), (6) and (7) for cancer case teeth data are marked "*", while the other averages in columns (1) and (2) are for the non-cancer teeth data.

(b) Total number of non-cancer teeth = 311.

V. HEALTH EFFECTS OF NUCLEAR REACTORS

1. Background

In April 2000, RPHP also published findings that in downwind areas within 40 miles of five closed nuclear power plants, infant deaths dropped sharply in the first two years after closing. (15) Since the article was published, this list has been expanded to eight plants - all showing a relatively rapid and, in most cases, dramatic improvement in infant mortality.

Table 5
Change in Deaths, Infants Age <1 Year
Counties Downwind of Closed Nuclear Plants
Two Years Before Closing vs. Two Years After Closing*

Reactor	Year Closed	% Change
Permanently Closed		
LaCrosse WI	1987	-15.4%
Rancho Seco CA	1989	-16.0%
Fort St. Vrain CO	1989	-15.4%
Trojan OR	1992	-17.9%
Big Rock Point MI	1997	-42.4%
Maine Yankee ME	1997	- 9.3%
Temporarily Closed		
Pilgrim MA	1986	-24.3%
Millstone/ Haddam Neck CT	1995	-17.4%
TOTAL 8 REACTORS		**-17.4% ($p<0.05$)**
U.S. AVERAGE, 1986-98		**- 6.4%**

* For example, LaCrosse compares 1986-87 with 1988-89
Millstone 1 and Haddam Neck permanently closed, Millstone 2 and 3 temporarily closed

Source: National Center for Health Statistics, www.cdc.gov, data and statistics, CDC Wonder

In the most populated area near a closed reactor (the Sacramento CA region near Rancho Seco), immediate plunges were also shown for fetal deaths over 20 weeks gestation; deaths in children age 1-4; and infant deaths from birth defects, the risk of which has long been known to be increased by radiation exposure.

2. Health Effects of Closing Turkey Point Reactors

A few years after Turkey Point started operations in 1972, the nuclear plant began to have problems with steam generator corrosion, which lead to unmonitored leaks of radiation. During part of 1981-82 and the first half of 1983, Turkey Point units 3 & 4 were closed, one after the other alternatively, to replace the steam generators. During 1983-84, after the steam generators had been replaced and radioactive exposures to fetuses and infants were greatly reduced, infant mortality in Dade and Broward Counties fell 19.1% from the previous two years, significantly more than the 6.4% national drop. These findings are consistent with research on the eight other closed reactors, as shown in Table 5.

Table 6
Changes in Infant Mortality <1 Year
Dade and Broward Counties
Before and After Temporary Closing of Turkey Point

Years	Deaths <1 Yr.	Live Births	Deaths/1000	% Change
1981-82 (before)	988	74,160	13.32	
1983-84 (after)	859	79,687	10.78	- **19.1%** (p <.01) - 6.4% in U.S.

Source: National Center for Health Statistics, www.cdc.gov, data and statistics, CDC Wonder

Furthermore, the rate of infant deaths due to birth defects in Broward and Dade plunged 21.7% when Turkey Point's steam generators were being repaired, compared to a national decline of only 3.6% (difference significant at p <.06). Radiation exposure to the fetus is known to increase the risk of birth defects, underweight births and all causes of death before age one.

3. Health Effects of Opening St. Lucie 2

The St. Lucie 2 reactor started operations on June 2, 1983. During the first two years that Unit 2 operated (1983-84), the infant mortality rate in St. Lucie County rose 35.3%, compared to a 6.4% decline nationwide, a significant difference.

Table 7
Changes in Infant Mortality <1 Year
St. Lucie County
Before and After Startup of St. Lucie 2 Reactor

Years	Deaths <1 Yr.	Live Births	Deaths per 1000 Pop.	% Change
1981-82 (before start)	43	3247	13.24	
1983-84 (after start)	61	3406	17.91	+ **35.3%** (p <.05) - 6.4% in U.S.

Source: National Center for Health Statistics, www.cdc.gov, data and statistics, CDC Wonder.

4. Childhood Cancer Near 14 Nuclear Power Plants

Further support for the serious adverse effect of releases from nuclear plants on the health of children comes from a study, authored by RPHP research associate Joseph Mangano, of cancer rates in counties near 14 nuclear power plants in the U.S., for which data on cancer rates are available (20). As indicated in Table 8, the incidence of cancer diagnosed in children less than five years of age during the period 1988-97 was higher than the national rate near 14-out-of-14 nuclear plants in the study. The rate for all 49 counties (less than 30 miles from a nuclear plant) combined was 22.51 per 100,000, or 11.4% greater than the U.S. average of 20.20 (p <.0002). The smallest excess was near the Salem/Hope Creek complex in southwestern New Jersey/Delaware (+0.7%), while the largest occurred near both the Turkey Point and St. Lucie facilities in Florida (+29.1%).

Table 8
Cancer Incidence Near 14 Nuclear Plants
Persons Age 0-4 Years, Eastern United States, 1988-97

Plant	Cases per 100,000 Age 0-4	Percent Above/Below U.S. Incidence Age 0-4
U.S.	20.20	-------
Beaver Valley	20.74 (253)	+ 2.7
Brookhaven	23.30 (207)	+15.3
Crystal River	22.35 (57)	+10.6
Indian Point	22.94 (169)	+13.6
Limerick	20.87 (322)	+ 3.3
Millstone	20.71 (117)	+ 2.5
Oyster Creek	24.82 (179)	+22.9
Peach Bottom/ Three Mile Is.	22.01 (213)	+ 9.0
Pilgrim	22.95 (77)	+13.6
St. Lucie	**26.08 (45)**	**+29.1**
Salem/Hope Cr	20.35 (133)	+ 0.7
Seabrook	21.50 (163)	+ 6.4
Susquehanna	21.25 (80)	+ 5.2
Turkey Point	**26.07 (396)**	**+29.1**
TOTAL	**22.51 (2411)**	**+11.4** p< 0002

Source: State Cancer Registries

VI. DISCUSSION AND CONCLUSIONS

Minimizing adverse health effects of emissions from nuclear power reactors is an important element in any effective strategy to prevent disease and death. Studies show that radioactivity from nuclear plants is getting into the environment and human body, and there is now strong evidence that it is hurting the health of Americans, especially the health of the children on which the future of our nation depends.

Because of the need to minimize risk and prevent disease, RPHP has initiated a national study of Strontium-90 in baby teeth, with the goal of collecting and testing several thousand teeth and correlating radioactivity levels found in these teeth with cancer risk. A study of in-body radioactivity levels in persons living near nuclear reactors is the most effective means of studying whether radioactivity emitted from nuclear reactors is affecting cancer levels in the U.S. To date, there have been no such studies by the U.S. government, state health departments, nuclear utilities, or other private researchers of the relationship between in-body levels of radiation and public health around nuclear reactors.

After reviewing the initial findings of the Baby Teeth Study in 1999, Dr. Victor W. Sidel, past president of the American Public Health Association, and Dr. H. Jack Geiger, past president of Physicians for Social Responsibility, stated:

> *"If the levels of Strontium-90 in children's teeth and the variations in levels by geographic area reported in this study are validated by appropriate repetition, these findings would appear to justify intensive follow-up and continuing large-scale surveillance. Given the biological risk associated with body burdens of even small amounts of long-lived radioactive Strontium-90, it would be prudent to regard these findings as suggestive of a potential threat to human health."*

Southeast Florida typifies the recent rise of Sr-90 levels in the nation, and has above average rates of childhood cancer, especially within thirty miles of its nuclear plants. There is now significant evidence that children diagnosed with cancer have higher Strontium-90 levels in their bodies than children without cancer. This is consistent with the discovery by Dr. Alice Stewart that very low doses from a few diagnostic X-rays of the mother during pregnancy lead to an excess risk of childhood leukemia and cancer.

It therefore appears that the combined data patterns of the highest beta activity in water samples near the Turkey Point and St. Lucie nuclear plants, of rising Sr-90 in the deciduous teeth, and of increasing cancer incidence make an extremely strong case that the rising Sr-90 found in the teeth of children born in the late 1980s and early 1990s cannot be due to the atmospheric tests that ended in 1980, or the venting of all underground bomb tests that ended in 1993.

Furthermore, it appears that recent rises in the childhood cancer incidence in Florida and the rest of the U.S. are causally related to internal exposures to radioactive fission products. The adverse health effects related to cancer and all diseases related to the human immune system and hormonal system have been underestimated by factors of hundreds to thousands of times, as recently concluded by the European Committee on Radiation Risk. (7)

Since the levels of Sr-90 in the teeth have kept rising throughout the 1990s from their lowest values in the early 1980s long after the end of all atmospheric tests in 1980 and more than five years after the arrival of the Chernobyl fallout in 1986, it is no longer possible to regard Chernobyl or atmospheric bomb tests as significant sources of Sr-90. Even the known venting from underground nuclear bomb testing in Nevada ended in 1992, and in China by 1993, making it impossible to regard the very high levels of Sr-90 in both teeth with cancer and without cancer, found for children born in the late 1990s, as due to underground tests.

Taken together with the fact discussed in the present report that the highest levels of Sr-90 beta activity in drinking water were found nearest to the location of the two nuclear plants in southeast Florida, there can no longer be any reasonable doubt that nuclear reactors are now the major source of fission products in the environment.

Thus, it appears that a significant cause, or contributing cause, of the two decade long rise in childhood cancer (including leukemia, brain cancer, and other cancers) since the early 1980s are the bone-seeking nuclear fission products such as Sr-90, which are presently only released into the environment by commercial nuclear reactors in the United States, both in the course of accidents and during routine operations within presently permitted limits.

The finding that children diagnosed with cancer have higher Sr-90 concentrations in their teeth at birth than children without cancer points to environmental radiation from nuclear reactors as the principal cause of the mysterious cluster of brain and other cancers diagnosed among infants and children in St. Lucie County. This cancer cluster was documented by the Florida Department of Health (FDOH) in 1997 and subsequently studied by both state and federal health researchers, who eliminated chemical carcinogens as a possible cause of the increasing incidence of childhood cancers in St. Lucie County. During 1997-1999, the Department of Health conducted a comprehensive study of 561 chemicals known or suspected carcinogens and concluded that "based on comparisons to state and federal standards and toxicological publications, none of these chemicals represents a health threat or is associated with neuroblastoma or other childhood cancers." (19)

But the FDOH study did not include a study of nuclear fission products in environmental samples or in the deciduous teeth of children, such as Sr-90, that are chemically similar to calcium and seek out bone, irradiating the bone marrow where the red cells of the blood and the white cells of the immune system originate. Particularly serious is the damage to the immune and hormonal system as well as to the developing brain in the sensitive embryo, fetus and infant, often acting synergistically with other environmental toxins as Rachel Carson warned forty years ago in *Silent Spring* (1962).

This conclusion of a causal link between man-made environmental radiation and increased levels of childhood leukemia and other forms of cancer is further supported by the findings of the European Committee on Radiation Risk (ECRR) formed by independent scientists in 1997. The Executive Summary of the ECRR, entitled "The Health Effects of Ionizing Radiation Exposure at Low Doses for Radiation Protection Purposes," and released in early 2003, states:

> The committee concludes that the present cancer epidemic is a consequence of exposures to global atmospheric weapons fallout in the period 1959-63 and that more recent releases of radioisotopes to the environment from the operation of the nuclear fuel cycle will result in significant increases in cancer and other types of ill health.
>
> Using both the ECRR's new model and that of the ICRP [International Committee on Radiological Protection] the committee calculates the total number of deaths resulting from the nuclear project since 1945....The ECRR model predicts 61,600,000 deaths from cancer, 1,600,000 infant deaths and 1,900,000 foetal deaths. (7)

VII. RECOMMENDATIONS

- The recent evidence suggesting that radioactive chemicals emitted from Turkey Point and St. Lucie are one cause of rising cancer rates in southeast Florida is significant and merits more detailed study by medical and scientific researchers and by local, state, and federal officials responsible for public health.

- In particular, since the baby teeth study has shown the importance of obtaining measurements of the levels of in-body Strontium-90 radioactivity, further studies of the relation between these levels in deciduous teeth, cancer and other chronic diseases that have risen in the past two decades should be undertaken.

- Such studies should be continued, especially in southeast Florida, where the largest number of teeth of children with cancer and without cancer have been tested on a year by year basis, during a time period when there have been no nuclear tests of any kind.

- Because the present studies using Sr-90 in deciduous teeth as a measure of actual radiation have revealed that the radiation doses to the general public from nuclear plant releases and their adverse effects on human health are much greater than anticipated (based on the earlier studies of adults exposed to short bursts of high external radiation), the entire subject of very low dose internal exposure to radioactive chemicals should be extensively re-studied and re-evaluated in the United Sates, as has recently been done by the European Committee on Radiation Risk.

- Information on the radiation-cancer link should be considered in federal policies regulating the operation of nuclear reactors, in southeast Florida and across the U.S.

- Information on the radiation-cancer link should be considered by the U.S. Nuclear Regulatory Commission in its environmental review of utility applications to renew and extend the licenses of aging nuclear power plants in Florida and across the U.S.

- The serious nature of the evidence for unexpectedly large effects of small, continuous internal exposure to beta particles emitted by bone-seeking radioactive chemicals produced by nuclear fission should lead to Congressional hearings as to why the NRC no longer requires the measurement of Strontium-90 beta activity in environmental samples of food, drinking water and milk around nuclear plants. In light of rising levels of childhood cancer rates and of Strontium-90 in baby teeth, such hearings should also address the questions of resuming the monthly measurements of radioactivity in pasteurized milk by the U.S. Environmental Protection Agency that ended in 1990, and of resuming the measurement of Sr-90 in human bones and teeth carried out by U.S. government agencies until 1982.

NOTES

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APPENDIX 1
STUDY HISTORY AND METHODOLOGY

STUDY HISTORY

This study was funded by Health Foundation of South Florida, Grant No. 99-311. The purpose of the grant was to complete a South Florida baby teeth study and cancer case study of radiation levels in the teeth of children without cancer and of children with cancer. The grant was awarded in August 2001. The research was conducted throughout the balance of 2001 and during 2002.

STUDY METHODOLOGY

A. Collecting Baby Teeth: RPHP attempted to obtain a random, representative sample of teeth from persons living in South Florida. Using a computerized listing of all households in southeast Florida counties with at least one child age 6 to 17, RPHP mailed 15,000 letters signed by actor Alec Baldwin to these households. Households were randomly selected for each zip code in the county. RPHP subcontracted the services of a national marketing and mailing list company to select the households, and enlisted the services of Florida mailing services company to print, fold, stamp, and mail letters. Most of the teeth studies in this report are from the mailings, even though other teeth have been obtained from parents who have otherwise heard about the study.

Since the beginning of the South Florida baby teeth study, which was initiated prior to the Health Foundation grant, RPHP has, as of December 21, 2002, received a total of 775 baby teeth from Florida. For the purposes of this study, a total of 485 baby teeth from 18 counties in Florida have been tested for Sr-90 levels. Of that total, 461 came from the six southeast Florida counties of Miami-Dade, Broward, Palm Beach, Martin, St. Lucie and Indian River.

Collecting Teeth of Children with Cancer: The collection of the teeth of children with cancer ("cancer teeth") presented a challenge for several reasons. First, to the best of our knowledge, the specific collection and testing of cancer teeth has never been attempted before in a research project. Second, RPHP could not use mailing list services to obtain the names of parents in South Florida, whose children had been diagnosed with cancer, because such medical information is confidential and not available to mailing list or marketing companies.

In order to address this fieldwork issue, RPHP approached parents, parent support organizations, and pediatric oncologists to request their support in identifying children diagnosed with cancer and distributing a cover letter and baby teeth envelope to their parents, requesting that they participate in the project. For the purpose of this study, teeth were requested from parents with children diagnosed with cancer, who are currently under treatment, recently finished with treatment, long-term survivors, or who have passed away.

In this effort, RPHP received the collaboration of the Children's Cancer Caring Center, Inc., of Ft. Lauderdale, FL, a non-profit organization that has been providing care and financial assistance to children cancer patients for the past 37 years, most recently through the Cleveland Clinic of Florida. Also collaborating with the study are pediatric hematologist/oncologists at several hospital in southeast Florida.

Through this study, RPHP has, as of January 24, 2003, received 35 cancer teeth from parents residing in Florida, of which 25 were from mothers who lived in Florida during pregnancy. At the time this report was prepared, 17 out of the 25 Florida cancer teeth, from mothers who lived in Florida during pregnancy had been tested for Sr-90 by an independent lab. Because much of the Sr-90 uptake in baby teeth occurs during pregnancy and early infancy, these 17 teeth represent the most meaningful data for the comparative study. The results of those Sr-90 measurements are presented in this Report

B. Testing Teeth. RPHP measures the amount of Strontium-90 in each baby tooth by contracting with Radiation Environmental Management Systems, Inc., (REMS) an laboratory in Waterloo, Ontario, Canada, that specializes in environmental and radiation analysis. REMS is under the direction of Hari Sharma, PhD, a senior radio chemist with decades of experience in the field. RPHP sends teeth to the laboratory in batches, and teeth are tested individually using a scintillation counter. All lab personnel are "blinded" about all information concerning each tooth (that is, they know nothing about what state it comes from, how old the child is, if the child is healthy or has cancer, etc). This "blinding" helps assure objectivity to the results.

The laboratory measures the concentration of Sr-90. Specifically, it calculates the picoCuries of Sr-90 per gram of calcium in each tooth. The strontium-to-calcium ratio has been used in the St. Louis study in the 1960s and all other recent baby tooth studies.

The laboratory returns results to RPHP, where staff converts the ratio to that at birth, using the Sr-90 half-life of 28.7 years. For example, if the lab determines the tooth had 3.00 picoCuries of Sr-90 per gram of calcium, and the person was 28.7 years old, the ratio at birth would be 6.00 (half of the Sr-90 would have decayed in 28.7 years). RPHP automates the results, and produces summary reports.

The Sr-90/Ca ratio for a single tooth is not a precise number because a typical baby tooth is small in mass. In fact, only the most modern machines can test individual teeth with any precision; the St. Louis study only tested batches of teeth. The standard error for each tooth is plus or minus 0.7 picoCuries. Thus, there is a 95% chance that the "actual" amount of Sr-90 in a tooth with a ratio of 6.00 is between 4.60 and 7.40 (plus or minus twice the standard error). Obviously, when using large numbers of teeth, the measurement error for the average level becomes much smaller, by the inverse square root of the number of teeth.

When a large number of teeth from a given area and year are averaged, the dominant uncertainty is due to the finite number, and percent uncertainty is given by 1000 times the inverse square root of the number of teeth in the group. To this must be added the uncertainty of individual tooth measurements, using the square root of the squares of the two sources of uncertainty.

C. Change in Counter, Technique. After June 2000, when RPHP had Sr-90 results for 1335 teeth, it made two upgrades to its testing procedures. First, it leased and began using a new machine, the 1220-003 Quantulus Ultra Low-Level Liquid Scintillation Spectrometer. Made by the Perkin-Elmer Company of Massachusetts, this new model is considered to be one of the most sophisticated counters in the field. Introduced in 1995, only about 15 to 20 are in use in the United States. This counter is located on the premises of REMS, Inc.

Also, the method of removing organic material from the teeth was changed by treating them with hydrogen peroxide prior to grinding them into powder. This proved to be more effective in allowing light produced in the liquid scintillation fluid by the beta particles emitted by the

Sr-90 and its daughter product, Yttrium-90, to reach the photo multipliers, partly by shifting the spectrum of the light emitted by the scintillation fluid to some degree. As a result of these counter and teeth cleaning enhancements, the efficiency of detecting the very low radioactivity in single teeth was increased by over a factor of two, improving the quality of the data.

All of the Florida healthy and cancer teeth analyzed in this report were tested for Sr-90 using this same Quantulus scintillation counter and cleaning technique. Based on the data produced by this analysis, RPHP was able to measure the differences in the Sr-90 concentrations between teeth from individuals such as those born in different Florida counties in a given year, differences in successive birth years in a given area, and differences between children with cancer and children without cancer.

D. Inter-laboratory comparisons to assess consistency. RPHP set up a method to test the same teeth for Sr-90 in different laboratories, to assure that results produced by the REMS lab were consistent and accurate. The Perkin-Elmer Company staff recommended several users of the same model scintillation counter that RPHP was employing. RPHP selected Michael P. Neary, PhD, of the University of Georgia Center for Applied Isotope Studies for this test. Dr. Neary, an experienced radiochemist, operates three of the 15-20 units in the U.S., and was perhaps the first American to use them when he purchased them in the mid-1990s.

RPHP sent Dr. Sharma two batches of teeth to test. They contained 10 teeth each from persons born in St. Louis (from in the original 1958-70 study mentioned earlier). One batch were 1954 births, and the other were 1959 births. Again, Drs. Sharma and Neary were blinded and had no information other than that they were baby teeth.

1.Inter-laboratory Consistency. Dr. Sharma dried teeth in the two batches and ground them into a powder. He tested Sr-90 levels for the 10 teeth from 1954 on the counter used in the RPHP tooth study. When he completed work, he sent the entire batch to Dr. Neary. Dr. Neary could only test the Sr-90 level of the dissolved solution of teeth, not the crushed powder, but this should not alter the results.

The findings from each test of the 1954 teeth are as follows:

Inter-Laboratory Comparability, St. Louis Teeth, 1954 Births

Tester	Sr-90 Level*	Std. Error	Confidence Interval+
Sharma	1.77	+/- 0.31	1.15 - 2.39
Neary	2.13	+/- 0.31	1.51 - 2.75

* Average picoCuries of Strontium-90 per gram of calcium
+ Average Sr-90 level plus or minus two times the standard error, i.e. there is a 95% certainty that the actual value falls between these two values.

While there is some variation between each set of readings, there is substantial overlap between each confidence interval, therefore indicating that measurements are largely consistent between labs. It is clear that with a small sample (10 teeth), results will vary somewhat, which is why RPHP collected hundreds of teeth from Florida before presenting data as anything more than preliminary.

2.Consistency Between Years. A second reliability test was performed by Dr. Sharma. Prior results from the St. Louis study indicated that average 1959 Sr-90 levels were considerably higher than those for 1954. Dr. Sharma split his two samples of 10 teeth each into two "sub-batches," and calculated Sr-90 levels separately.

The following results were obtained:

Batch	Avg. Sr-90*	% 1959 Over 1954	Std. Error	Confidence Interval
#1 - 1954	1.66		+/- 0.27	1.12 - 2.20
- 1959	3.28	+98%	+/- 0.36	2.56 - 4.00
#2 - 1954	1.77		+/- 0.31	1.15 - 2.39
-1959	3.36	+90%	+/- 0.37	2.64 - 4.10

* Average picoCuries of Strontium-90 per gram of calcium

In the two tests, the excess of 1959 averages are slightly less than double that of 1954 (98% and 90%). Confidence levels do not overlap, meaning it is very likely the "true" values of the 1959 results exceed those for 1954. Thus, the RPHP results are also largely consistent with those found in the St. Louis study in the 1960s.

E. Do Sr-90 Levels Represent Current or Past Emissions? Some have suggested that the Sr-90 detected in the RPHP study represents no new emissions from nuclear reactors, but instead represents leftover fallout from atmospheric atomic bomb tests in Nevada from 1951-62. Large-scale atmospheric testing ended in 1963, and the last aboveground test worldwide was done in China in 1980. Underground tests by the U.S. ended in 1992, and those by China in 1993. There are no other sources of Sr-90 other than from the fission of Uranium and Plutonium in bomb tests or reactor emissions.

There are numerous reasons why the great majority of Sr-90 detected in baby teeth of today's children represents emissions from nuclear reactors, not old bomb test fallout.

1. Physical/Biological Half-Life. A fetus takes up Sr-90 in its tooth buds from the mother's bone stores and from the mother's diet (delivered to the fetus through the placenta) during pregnancy. During early infancy, Sr-90 is taken up from the diet, whether the baby is bottle-fed or breast-fed.

The biological half-life of Sr-90 in the body is about two years for children and 5-10 years for adults. Thus, the bones of the mothers of tooth donors (many of whom were at least 25 at delivery) have little Sr-90 from atmospheric bomb tests remaining in their bone by now.

The physical half-life of Sr-90 is about 28.7 years. But Sr-90, that rained into reservoirs (drinking water) 40-50 years ago, has long sunk into the sediment. Similarly, Sr-90 that rained onto grass, which cows graze on, has long ago penetrated into the soil, or has run off into rivers and the ocean.

Thus, it is logical that little Sr-90 from 1950s and 1960s bomb tests remains in mother's bodies or in the environment, and most of the current Sr-90 represents emissions from nuclear reactors. Several data sources support this.

2. Sr-90 in Bone, Teeth Leveling or Rising. There is a precedent for reactor emissions causing rises in Sr-90. In southern Germany, 280 baby teeth from children born before and after the Chernobyl accident were analyzed. The change from 0.81 to 7.56 picoCuries of Sr-90 per gram calcium, nearly a ten-fold increase, was observed for children born 1983-85 and 1987, following a period of rapid decline with a half-life of about 2 years.

The St. Louis baby tooth study also examined Sr-90 levels in the mandibles (jaw bone) of dead fetuses. Similar to baby teeth, a large increase was observed in the early 1960s, during the height of atmospheric bomb testing. However, after large-scale testing ended following the Test Ban Treaty, average Sr-90 levels fell by about half from 1964-69, when only China and France conducted atmospheric tests. No further data are available because federal government support for the study ceased in 1970.

In the late 1960s, only half-dozen small nuclear reactors were in operation, and underground bomb tests emitted less radiation into the atmosphere. If the trend of the 1960s had continued, about 95% less Sr-90 should have been present in the body at birth by the early 1980s. But RPHP found otherwise. In the first 1335 teeth (using the "old" counter and technique), the average Sr-90 level fell nearly in half from 1974-76 to 1983-85. For persons born since 1985, however, there was no further decline. As the data below indicate, using the new technique/counter, the rapid decline stopped at the same time, and has actually increased 35.6% from 1980-82 to 1995-97. Furthermore, Sr-90 levels have increased by 57% between the low point of 2.98 in 1986-88 and the high point of 4.68, a highly significant rise of more than 5 standard deviations ($p < 0.0001$).

There can be no explanation for this reversal other than an increase in a current source of radioactivity. This source must be nuclear reactors, because fallout from the Chernobyl accident arrived in the U.S. in May 1986 and all venting from underground tests ended in 1993. Since the early 1980s, the number of operating reactors has risen from about 70 to just over 100. Moreover, since the mid-1980s, plants are closed less frequently for inspections, maintenance, and repairs, and the number of gigawatt-hours of electricity produced by these reactors tripled during this time.

Average Sr-90 Concentration, By Birth Year, U.S., New Technique/Counter

Birth Yr	No. Teeth	Avg. Sr-90*	Total Teeth: 2,084
1951-73	82	7.04	
1974-76	29	5.36	
1977-79	41	4.78	
1980-82	77	3.45	
1983-85	141	3.87	
1986-88	350	2.98	
1989-91	578	3.25	
1992-94	649	3.85	
1995-97	137	4.68	

% Change, 1980-82 to 1995-97, +35.6%
% Change, 1986-88 to 1995-97, +57.0%

Note: Most teeth are from states of CA, CT, FL, NJ, NY, and PA
* Average picoCuries of Strontium-90 per gram of calcium

3. Philippine Teeth Considerably Lower. RPHP collected several dozen teeth from persons born in the Philippine Islands. This area has never had a nuclear reactor (for weapons, power, or research). It may have received fallout from Chinese atmospheric bomb tests, and the venting of underground tests by the U.S., the U.S.S.R., and China. But these underground bomb tests were far fewer than U.S. atmospheric bomb tests, and they all ended by 1993.. Thus, if emissions from some reactors around the globe are contributing to current Sr-90 levels, then Philippine teeth should contain less of this chemical than American teeth.

Thirteen (13) teeth of children born in 1991 and 1992 (9 and 4, respectively), were tested. The average Sr-90 concentration at birth was 2.04 (using the new technique/counter). The average for teeth of American children born those years was 3.44, making Philippine teeth about 41% lower than U.S. teeth. Again, reactors appear to be a major source of current Sr-90 levels (note that some Sr-90 may also exist in Philippine teeth due to imported food products from affected areas).

4. California Teeth Rise After Reactor Opening. RPHP collected 34 teeth from San Luis Obispo County CA, the location of the Diablo Canyon 1 and 2 reactors, which started operations in 1984 and 1985. The average Sr-90 concentration for children born after the reactors opened was 49.6% greater than those born before.

5. Other Reports Indicate Current Rates Should Be Near Zero. One of the recent Sr-90 tooth studies mentioned earlier by Greek researchers contained a chart summarizing trends in Sr-90 in deciduous (baby) teeth from various European nations and the Soviet Union. The chart shows that, from a level of about 0.27 picoCuries of Sr-90 per gram of calcium in 1951, a peak of 6.75 was reached in 1964, similar to the U.S. trend. By 1975, the average level had slumped to about 0.81 (three times the 1951 average) and was still declining.

At three times the 1951 average, the 1975 U.S. Sr-90 level should have been about 0.6 (0.2 times three) picoCuries Sr-90 per gram calcium. But the actual levels found by RPHP were 4.95 (12 teeth, respectively, using new technique/method).

6. Short-Lived Radioactive Chemicals Found In Local Eggshells. In 2001, a high school student from Rockland County presented an innovative idea for the baby teeth study. RPHP could not measure levels of short-lived radioactive chemicals in baby teeth. Many of these, such as Strontium-89, with a physical half-life of 50 days, or Barium-140, with a half-life of 12.8 days, are produced only in nuclear reactors and bomb tests. By the time the child lost a baby tooth, at least five years after birth, the short-lived particles had disappeared.

The student's idea was to test chicken eggshells for short-lived radioactivity. She collected several local specimens soon after they were hatched, and rushed them to the REMS laboratory, which tested for Barium-140 (Appendix 3). These preliminary tests found several picoCuries of Ba-140, which because of its rapid half-life could only have come from a nuclear reactor, probably the nearby Indian Point.

7. Drinking Water Measured in 2002 in Southeast Florida. Results showed the highest levels of current beta activity within 20 miles of the Turkey Point and St. Lucie reactors and that the beta activity dropped off significantly in samples collected in an intermediate county, at distances greater than 20 miles away from these reactors.

APPENDIX 2
NEW METHOD USED TO TREAT TEETH PRIOR TO TESTING FOR STRONTIUM-90 (BEGUN IN JUNE 2000)

Water-washed teeth were treated with 30 per cent hydrogen peroxide for a period of 24 hours to ensure that organic material adhering to teeth was oxidized. Teeth were then scrubbed with a hard brush for removing oxidized organic material and the fillings. Teeth are then dried at 110 degrees Celsius (centigrade) and then ground in a ball mill. It is very important to remove any filling because if left behind inside a tooth, they tend to give colored solution or dissolution in a mineral acid. The presence of colored solution reduces the efficiency of counting.

APPENDIX 3
METHOD USED TO CALCULATE BARIUM-140 CONCENTRATIONS FROM CHICKEN EGGSHELLS IN ROCKLAND COUNTY, NY

Dry eggshells were digested in nitric and hydrochloric acids. Barium chloride solution as carrier was added to the digested eggshells. Barium chloride monohydrate was then precipitated by adding an ice-cold solution of a mixture of ether and concentrated hydrochloric acid. The slurry was centrifuged and precipitate dissolved in water. To the resulting solution, five milligrams of ferric chloride was added and ferric hydroxide precipitated by adding ammonium hydroxide, for scavenging trace impurities of other fission products. Clear solution was obtained by centrifugation and ferric hydroxide precipitate was discarded. One more cycle was repeated and activity due to Ba-140 (half life 12.8 days) present in the purified barium chloride solution was assayed with the help of liquid scintillation spectrometer. Several picoCuries of Ba-140 were seen in the eggshell specimens. La-140, the daughter product of Ba-140, was also identified by its characteristic beta particles. We intend measuring Ba-140 in eggshells from various locations.

Note: Information for all appendices from Hari D. Sharma, PhD, President of REMS Laboratories, Waterloo, Ontario, Canada.

APPENDIX 4
STRONTIUM-90 AND HUMAN HEALTH

Strontium-90 is considered to be one of the most hazardous bone-seeking elements created in the fission of uranium or plutonium, because of its long half life of 28 years and because it resembles calcium so closely. By masquerading as calcium needed to form bone and teeth, it is readily taken up and concentrates in bone. In a pregnant woman, the Strontium-90 that has accumulated in the bone, together with that in her diet, is transported with calcium into the rapidly dividing cells of the embryo and fetus, where it can either kill or mutate them by the emission of high-energy electrons or beta particles. When Strontium-90 lodges near the bone marrow, where stem-cells form blood and immune system cells, there is an increased risk of leukemia, many other forms of cancer and autoimmune diseases, especially in newborn infants and elderly adults whose immune system functions are weak.[2]

[2] Stokke, T., Oftedal P., and Pappas A. Effects of Small Doses of Strontium-90 on the Rat Bone Marrow. Acta Radiologica 7 321, 1968. The authors found that extremely small radiation doses by Strontium-90 in laboratory animals comparable to that from a month or two from natural background sources produced significant declines in the

In early developmental stages of both humans, fish and other wildlife, when cells rapidly reproduce, damage to the genes is not efficiently repaired, so that if the cell survives and divides a defect is multiplied. Thus cellular damage can lead to a greater risk of leukemia or cancer in the newborn than in the mother, typically by anywhere from ten to a hundred times as great, depending on the stage of development. Moreover, many studies have shown that there is also an increased risk of premature birth, low birth weight and birth defects. The damage, which often does not become apparent until many years later, is known to involve the developing immune, hormonal and central nervous systems. In recent years, it has also been found that such conditions as obesity, diabetes, high blood pressure, heart disease and stroke can be the delayed result of the damage during development in the womb, leading to a higher death rate, particularly for individuals of abnormally low or abnormally high birth weight.

Especially serious is damage to different parts of the developing brain such as the prefrontal cortex, which can result in dyslexia, autism, and reduced cognitive ability. The reason is that neurons communicate by sending out calcium ions, so that Strontium-90 and Strontium-89 can be substituted for calcium, with devastating results due to the enormous energy with which electrons or beta rays are ejected from the nucleus in the course of the radioactive transformation from Strontiun-90 to Yttrium-90, destroying neurons in the process.

Part of the reason why Strontium-90 is so damaging is that radioactive Yttrium-90, which has different chemical properties than Strontium-90, concentrates in the hormone producing soft-tissue glandular organs such as the pituitary gland, the pancreas, the thyroid, the male and female reproductive organs, and the female breasts. Thus, key hormones such as estrogen and testosterone can be affected both during early development and later in life, when they play a major role in breast and prostate cancer, as well as in reduced fertility, premature births, sexual development and sexual orientation.

Another reason is that protracted exposures over periods of days, months or years were discovered by Petkau to be much more damaging biologically than the same dose received in short diagnostic medical exposures or flashes from a nuclear bomb explosion by factors of hundreds to thousands of times.[3] This is due to the greater efficiency of free-radical oxygen molecules in puncturing cell-membranes, when they are produced one-by one and do not become deactivated by colliding with each other in the dense cluster produced during short X-

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number of bone -marrow cells. This weakens the immune system and thus allows cancer cells anywhere in the body to proliferate more rapidly, and also causes infectious diseases to take a greater toll.

[3] Petkau, A. Effect of Na-22 on a Phospholipid Membrane, Health Physics, 22: 239,1972; Protection of Acholeplasma laidlawii B by superoxide dismutase, Int. J. Radiation Biology, 26: 421-426, 1974; Protection and Repair of Irradiated Membranes, in Free Radicals, Aging, and Degenerative Diseases, 481-508 (Alan R. Liss, Inc., 1986). These articles describe the discovery that protracted radiation exposures such as occur from inhaled or ingested fission products accumulating in bone or other organs are hundreds to thousands of times as damaging as the same dose given in a short burst, such as diagnostic X-rays or the flash from a nuclear bomb. This is due to the action of free-radicals such as negatively charged oxygen molecules, whose efficiency in puncturing cell membranes and thus killing cells increases greatly as the radiation dose per unit of time decreases. This is unlike the case of direct damage to the DNA in very short diagnostic or therapeutic X-ray exposures and the flash of a nuclear detonation, where repair mechanisms are able to reduce the DNA damage to healthy tissue and the free radicals produced in high concentrations deactivate each other before most of them can reach cell membranes.

ray or gamma ray exposures. Thus, chronic exposures to Strontium-90 can produce cancer, immune system and respiratory damage such as asthma at very low doses. Moreover, it has been found in laboratory studies that Yttrium-90 also concentrates in the lung, so that the ingestion of Strontium-90 can cause lung cancer.

In addition to the Strontium-90 dose to the human body or organ, Sr-90 is also an indicator of, or marker for, other radiation doses received from the many shorter-lived fission products that are produced together with Strontium-90 and released from nuclear reactors both in liquid and airborne effluents that do not rise high into the atmosphere. Elements such as Iodine-131, with an 8 day half-life and others with even shorter half-lives, can produce many times the radiation dose of Strontium-90, just as occurred during the early period of A-bomb testing in Nevada when the fallout came down in a matter of hours.

A recently published study in Suffolk County, Long Island, surrounded by nuclear plants in Connecticut, New Jersey and New York, shows that a single picoCurie per gram calcium in recent baby teeth is associated with nearly a doubled risk of childhood cancer; and is, therefore, about three times as serious as the Strontium-90 in baby teeth measured in the early 1960s in St. Louis, that originated from high altitude H-bomb tests, when fallout came down from the stratosphere over a period of years.[4] The reason for the increased risk per picoCurie of Sr-90 near nuclear plants as compared with high altitude H-bomb tests is that many short-lived radioactive isotopes such as Strontium-89 with a half-life of 50 days, Barium-140 with a half-life 12.8 days along with Iodine-133 with a half-life of only 21 hours can be inhaled following repeated routine batch-releases or leakages from corroding steam generators, pipes and valves, since winds carry the airborne emissions to nearby towns and large cities in a matter of only a few hours.

[4] Gould, J.M. et al. Strontium-90 in Deciduous Teeth as a Factor in Early Childhood Cancer. International Journal of Health Services, 30: 515-539, 2000. This article describes findings of a high correlation between rising and declining Sr-90 concentrations in children and the number of newly reported leukemia and cancer rates in Suffolk County, Long Island, and higher cancer rates downwind from nuclear reactors than in distant areas, similar to what was found at the time of large-scale nuclear weapons testing in the atmosphere in the 1950s and early 1960s.

Map 1
Southern Florida by County with Major Southeast Florida Cities and Location of Turkey Point and St. Lucie Nuclear Power Plants

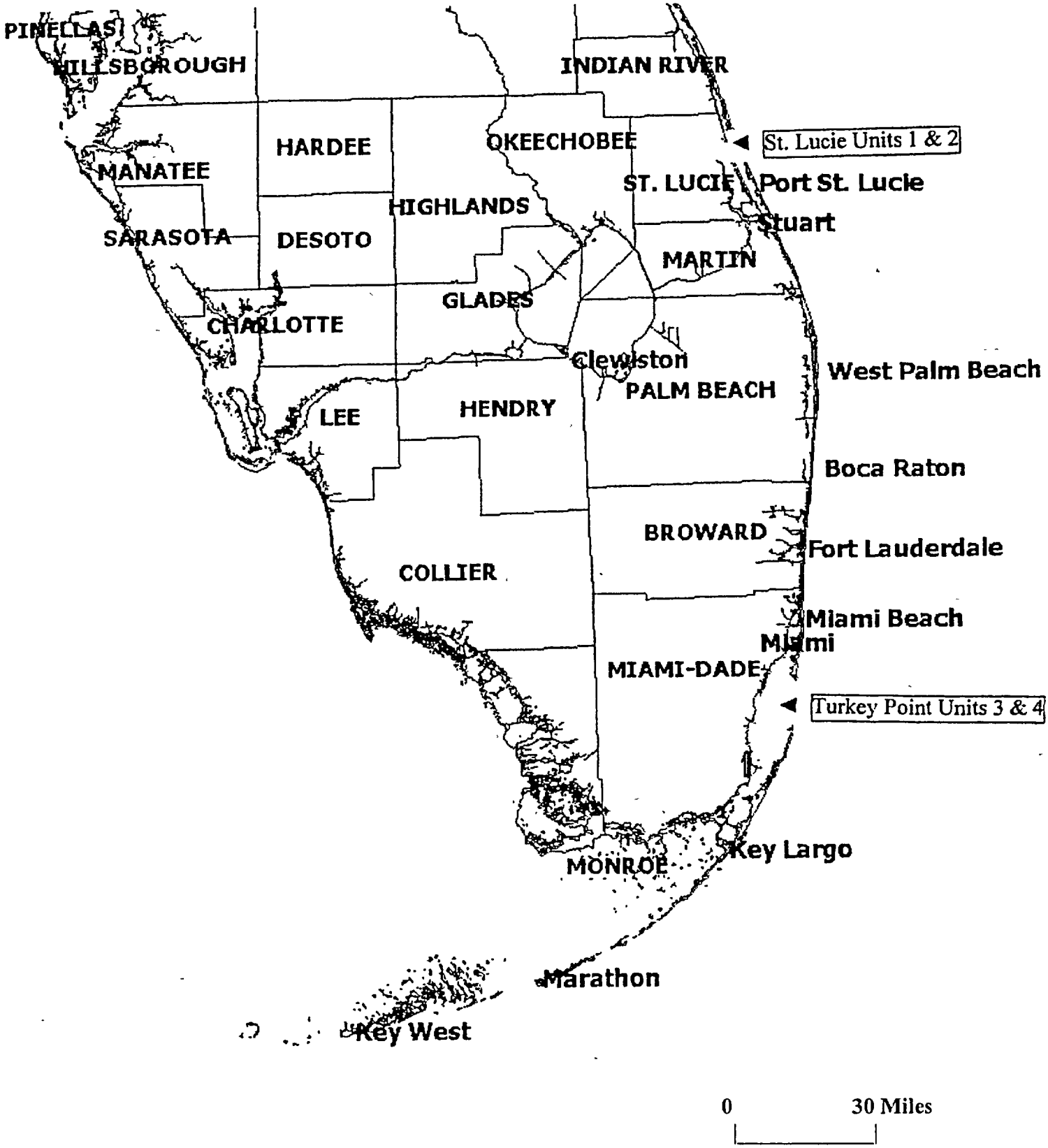
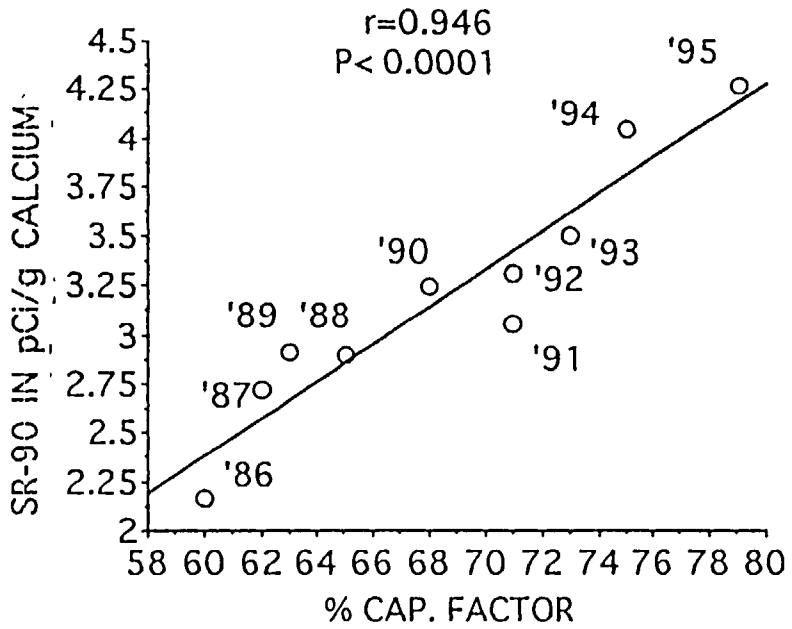


Fig. 1

AVERAGE SR-90 IN BABY TEETH IN THE U.S. VS. AVERAGE ANNUAL PERCENT OPERATING FACTOR OF U.S. NUCLEAR REACTORS 1986-95

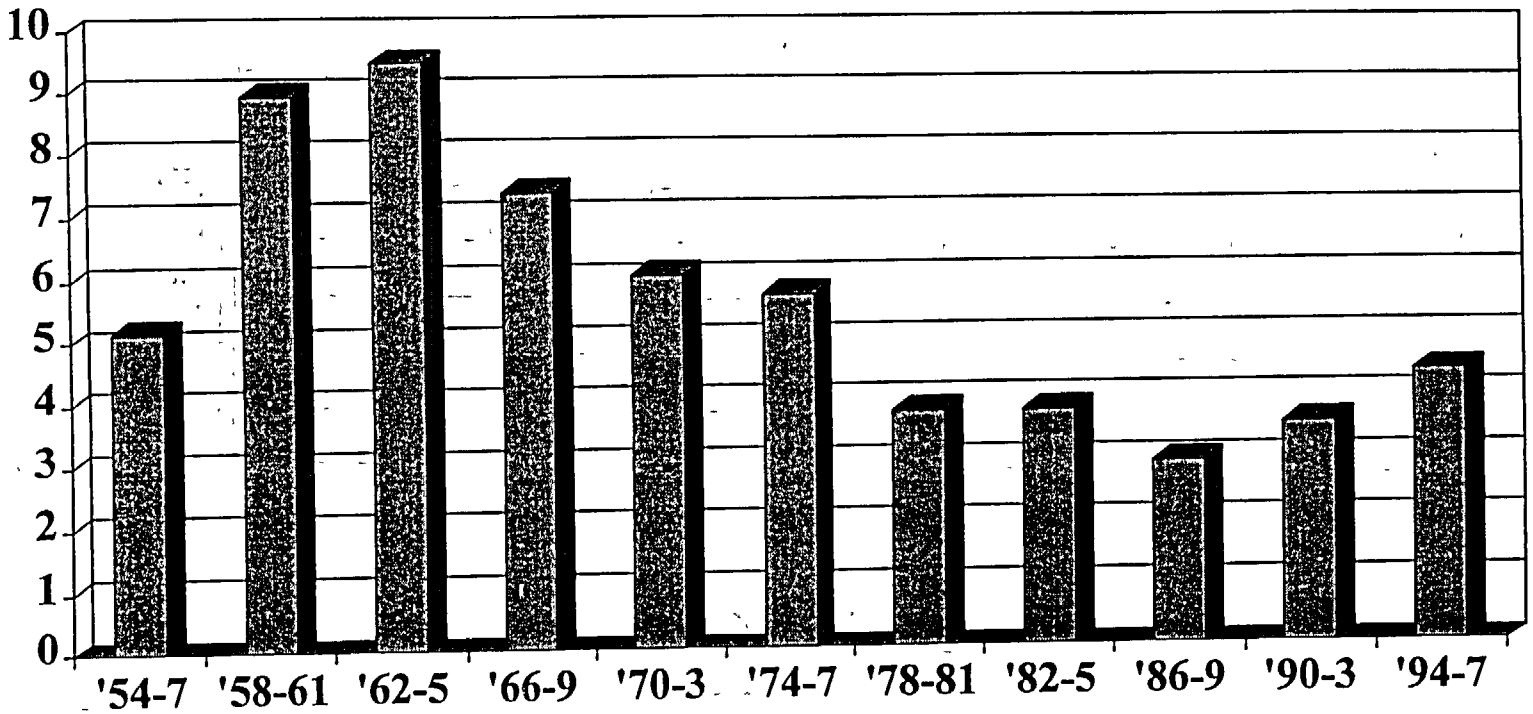


Source of data for the percent operating factor : NRC NUREG1350, Volume. 12,Table 7, 2000. Strontium-90 measurements by REMS, Inc. by year of birth for 1277 deciduous teeth collected by the Radiation and Public Health Project in picoCuries per gram Calcium. Correlation coefficient r =0.946. Probabilty of an accidental correlation P by t -test is less than 1 in 10,000.

Fig. 2

AVERAGE SR90 IN BABY TEETH, U.S.

MOSTLY CA, FL, NJ, NY, PA

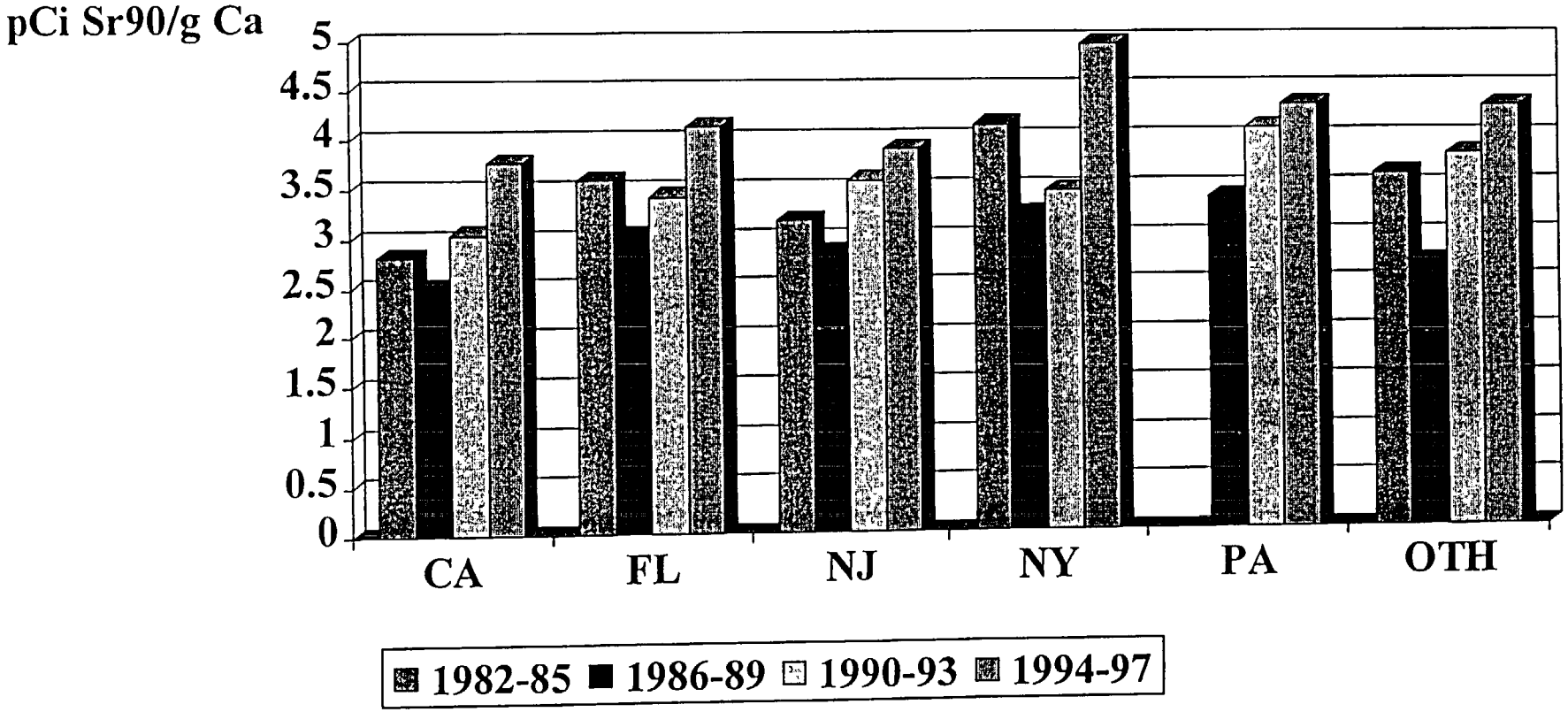


Source: Radiation and Public Health Project, based on 2089 baby teeth. Years represent years of birth.

Fig. 3

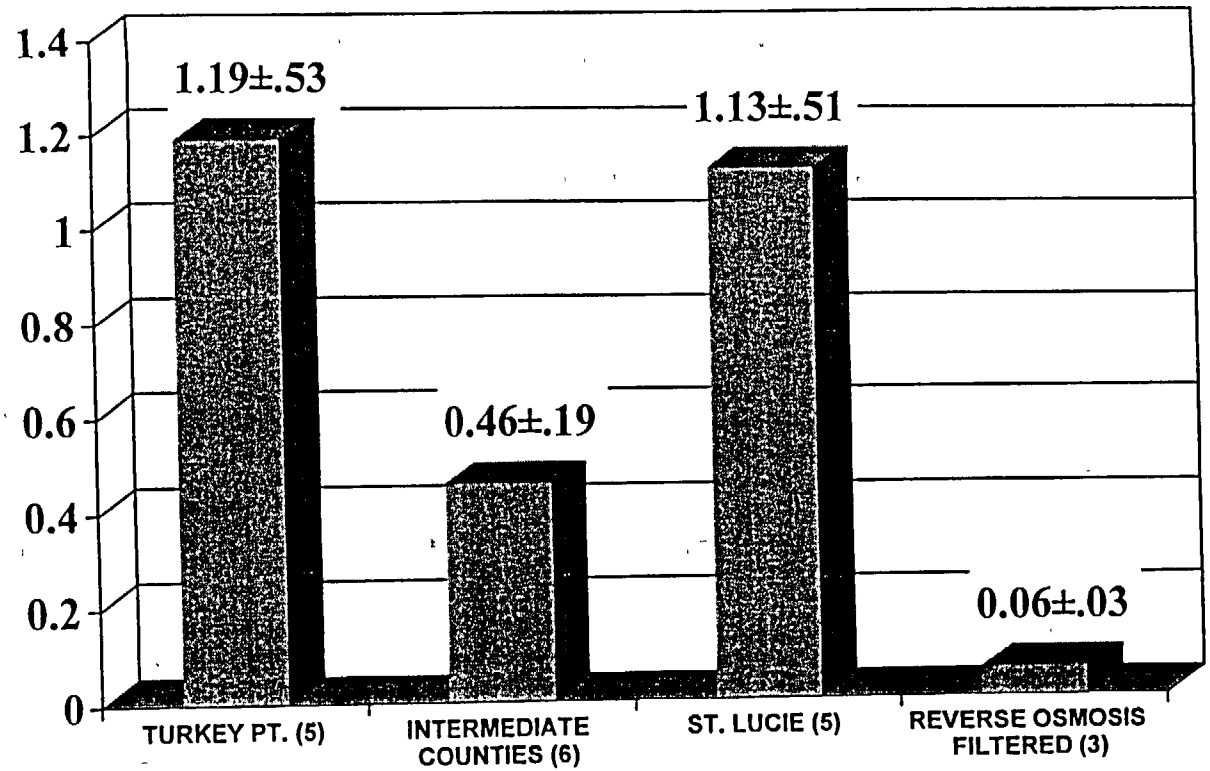
AVERAGE SR90 IN BABY TEETH

by State, 1982-1997



Source: Radiation and Public Health Project, based on 2089 baby teeth. Years represent birth years.

Fig. 4

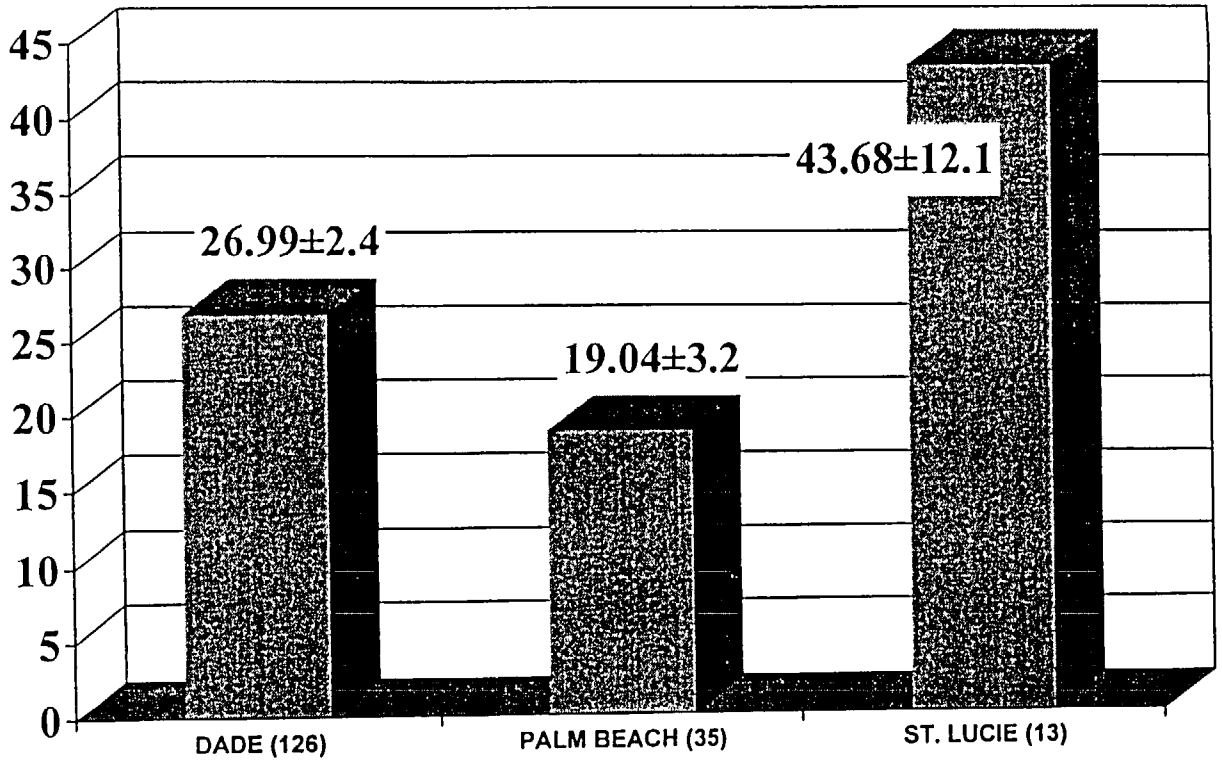


High Energy Beta Activity* in Drinking Water in Southeast Florida, 2002

*Beta Activity in Picocuries Per Liter

Source: Five water samples within 20 miles of the Turkey Pt. And Port St. Lucie Nuclear Plants; six water samples more than 40 miles away; and three samples of reverse osmosis filterd water.

Fig. 5

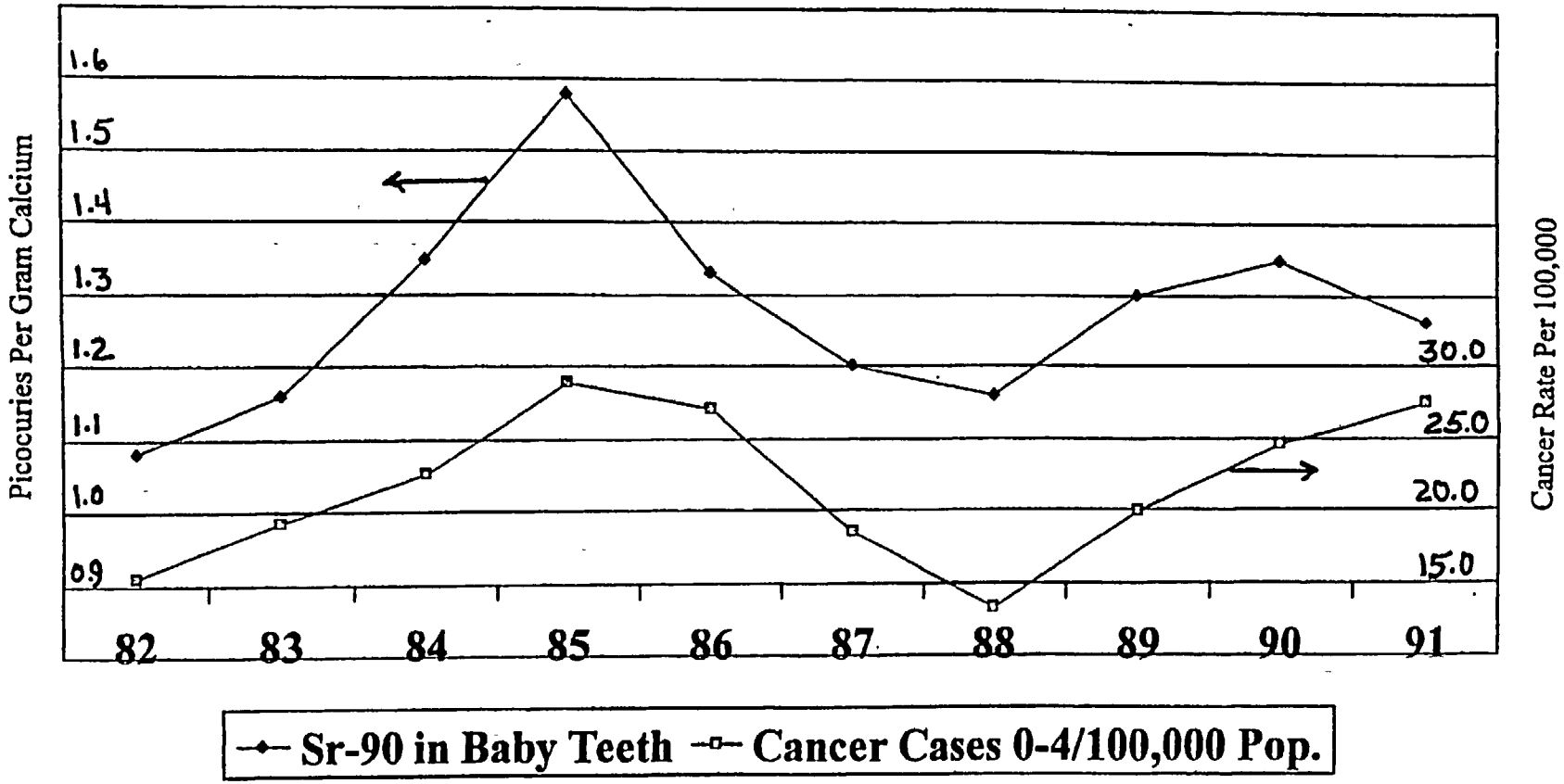


0-4 Year Leukemia and Cancer Incidence in Dade, Palm Beach, and St. Lucie, 1996-98 Averages

Source: Florida Cancer Data System

Fig. 6. Sr-90 in Baby Teeth vs. Cancer 0-4 Suffolk County, NY, 1982-1991

Four Year Lag (Sr-90 = 1982-91, Cancer = 1986-95)



Source: Radiation and Public Health Project. Based on 488 baby teeth, persons born 1981-92, and 262 cancer cases 0-4 diagnosed 1985-96. Uses three year moving averages.

Fig. 7. DADE CTY BETA AND CANCER O-4 YEARS
3 YEAR MOVING AVERAGES, 3 YEAR LAG

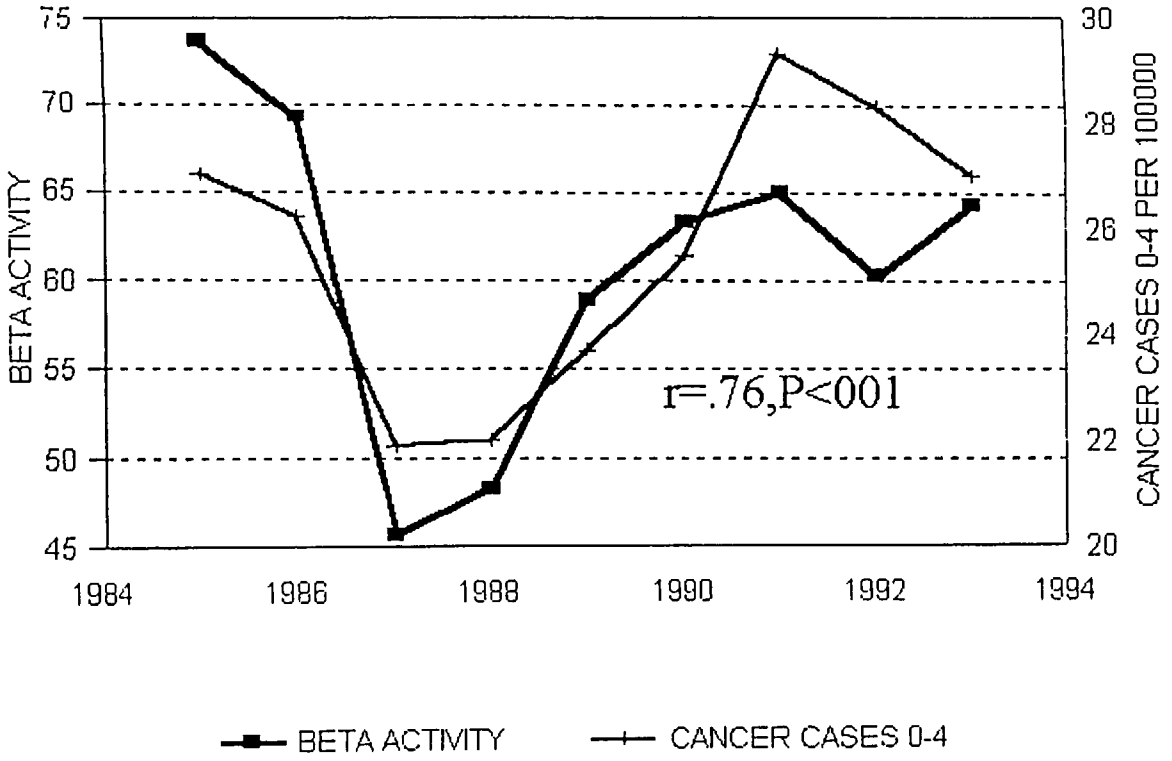
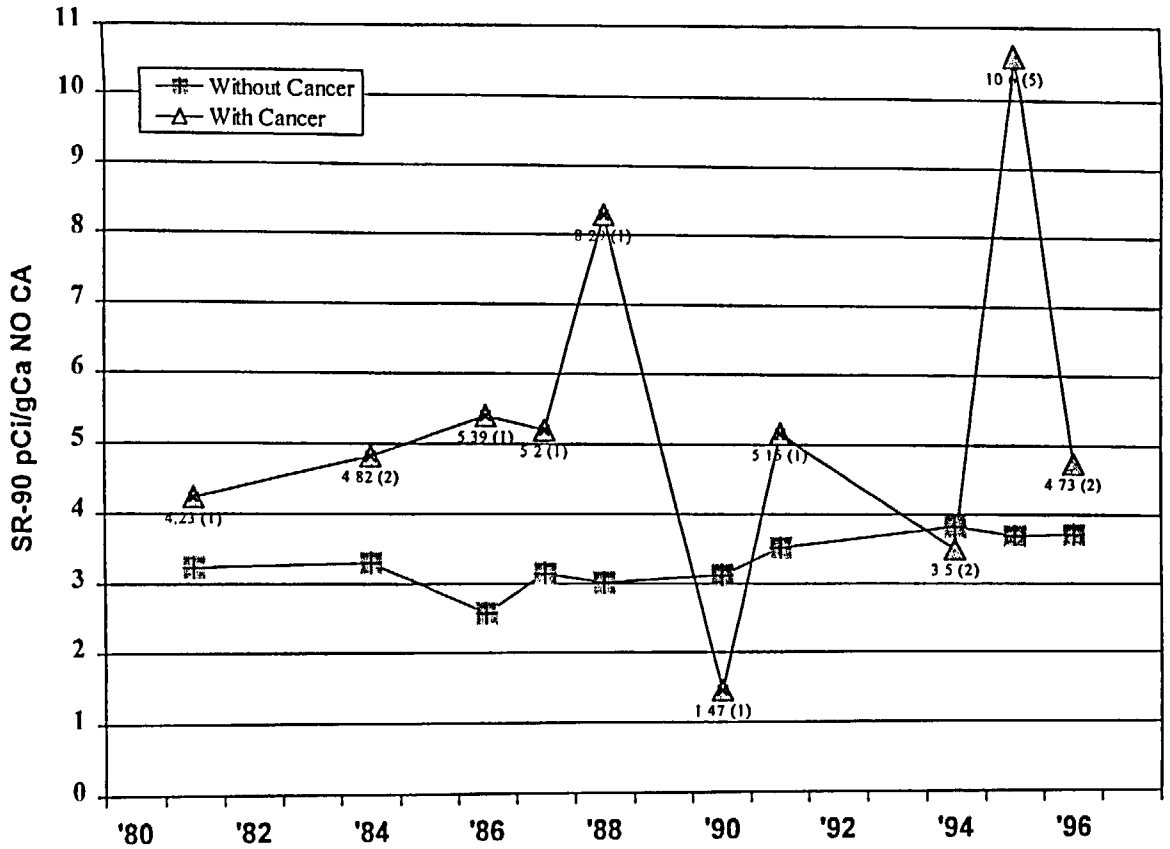


Fig. 8



SR-90 pCi/gCa in Teeth of Southeast Florida Children With and Without Diagnosed Cancer

Dade, Monroe, Broward, Palm Beach, Martin, St. Lucie and Indian River Counties. (Number of Cancer Teeth in brackets)