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PATTERNS OF RADIOACTIVE EMISSIONS AND HEALTH TRENDS NEAR THE SHEARON HARRIS NUCLEAR REACTOR

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Introduction and Operating Capacity. The Shearon Harris nuclear power reactor is located in New Hill NC, in southwestern Wake County, about 20 miles from Raleigh. On April 29, 1971, Carolina Power and Light announced plans to build three reactors at the site, but two were cancelled several years later. On January 3, 1987, Shearon achieved initial criticality (began producing radioactivity), and on May 2, 1987 it began commercial operations (reached full capacity and began selling electricity). (Source: U.S. Nuclear Regulatory Commission, www.nrc.gov).

Although Shearon Harris has operated for more than 20 years, it is the 17th newest of the 104 reactors in the United States.

Through 1998, Shearon Harris was closed 16% of the time due to various mechanical problems and routine maintenance. But from 1999 to mid-2005, it was closed only 6% of the time. (Source: U.S. Nuclear Regulatory Commission, www.nrc.gov).

Radioactivity Produced in Reactors. All nuclear power plants operate by splitting uranium-235 atoms, which produces high heat that is transformed into electrical power. The process of splitting, known as fission, also produces over 100 chemicals not found in nature. These chemicals are the same cocktail produced in atomic bombs used in Japan in World War II, and in bomb tests worldwide (the U.S. conducted over 1100 such tests in Nevada and the South Pacific from 1946 to 1992).

Each fission product is radioactive. When it enters the body through breathing and the food chain, it kills and injures healthy cells, which can lead to cancer and other immune-related diseases. Each chemical, called isotopes, affects the body differently. Iodine-131 attaches to the thyroid gland. Strontium-90 seeks out the bone. Cesium-137 disperses throughout the soft tissues.

Each isotope decays at a different rate. Some decay quickly, and disappear within days or even hours. But others decay much more slowly. Strontium-90 has a half life of 29 years, while that of plutonium-239 is 24,000 years. Thus, some of these chemicals will reside in the body for a lifetime. These chemicals decay into "daughter products" of which some are also radioactive, before finally becoming non-radioactive, or stable.

The fetus, infant, and child are especially susceptible to the damage caused by fission products. In 2003, the U.S. Environmental Protection Agency estimated the health risks to infants under age two are 10 times greater than those to adults.

Radioactive Emissions. While most fission products are contained within a reactor and stored as high-level waste, all reactors must release radioactivity into the air and water in order to operate. Some of these are routine ongoing emissions, some are accidental, and

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some are scheduled (such as during refueling, which must be performed approximately every 18 months).

The U.S. Nuclear Regulatory Commission sets annual emission limits for reactors, and requires utilities to measure and report them. Shearon Harris has complied with regulatory limits in each year of its operation. While emission levels are relatively low, there is considerable variation over time. Annual airborne releases of all radioactive isotopes with a half life over eight days – and thus, most likely to enter the food chain – ranged from 2 to 816 millicuries during the first seven years that Shearon Harris operated (see below).

ANNUAL AIRBORNE RELEASES OF RADIOACTIVITY
SHEARON HARRIS NUCLEAR REACTOR, 1987-1993

Year	I-131 and Effluents
1987	4
1988	46
1989	2
1990	77
1991	47
1992	816
1993	181

I-131 and Effluents= radioactive chemicals with a half life >8 days in millicuries (one-millionth of a curie).

Source: Tichler J, Doty K, Lucadamo K. Radioactive Materials Released from Nuclear Power Plants. Upton NY: Brookhaven National Laboratory, compiled for the U.S. Nuclear Regulatory Commission. NUREG/CR-2907. Annual Reports (comparative reports ceased after 1993).

Local Environmental Levels of Radioactivity. The NRC also places limits on levels of radioactivity in the environment, i.e. the air, water, soil, and vegetation, near nuclear plants. Utilities are required to measure such levels and report them to the NRC.

While radioactivity levels near Shearon Harris are all below regulatory limits, there is considerable variation over time. One example of this variation occurred in 2004 in drinking water at two locations 6.2 and 17.2 miles from the reactor. Levels of "gross beta," which constitutes all radioactive chemicals that emit beta particles (others emit alpha particles or gamma rays), were measured each month.

Levels steadily increased until by September they had doubled those detected in March, before leveling off. Moreover, the 2004 average for the two sites of 4.95 and 4.82 are nearly double the U.S. average of 3.01. At a site on the Shearon Harris grounds, the concentration of tritium (radioactive heavy hydrogen) in drinking water tripled during this time (see below).

There is some variation in each measurement. But such consistent data near Shearon Harris strongly suggests that releases from the plant travel a distance of at least 17 miles, and are entering the local environment, and human bodies.

MONTHLY GROSS BETA ACTIVITY IN DRINKING WATER, 2004
TWO LOCATIONS NEAR HARRIS NUCLEAR PLANT

	Picocuries gross beta per liter	
Date	Location 38	Location 40
January 12	4.19	3.47
February 9	4.74	4.18
March 11	**3.38**	**2.77**
April 12	5.08	5.18
May 13	4.85	3.49
June 13	5.12	5.02
July 12	5.59	6.07
August 16	6.66	6.62
September 13	**7.00**	**5.77 (more than double March)**
October 11	4.84	5.52
November 11	5.12	5.81
December 13	2.82	3.91
Yearly average	4.95	4.82
U.S. avg, 78 stations 2003		3.01

Location 38 is Cape Fear plant intake, 6.2 miles from Harris
Location 40 is in Lillington on the Cape Fear River, 17.2 miles from Harris

Sources: Radiological Environmental Operating Amended Report, 2004, September 23, 2005, www.nrc.gov (local data). Environmental Radiation Data, U.S. Environmental Protection Agency, Montgomery AL, Volumes 112 and 116, www.epa.gov/narel, Environmental Radiation Data (U.S. data).

MONTHLY TRITIUM IN DRINKING WATER, 2004
WATER TREATMENT BUILDING AT HARRIS NUCLEAR PLANT (location 51)

Date	Picocuries Tritium per liter
January 12	2200
February 9	2250
March 11	**1850**
April 12	1890
May 13	2160
June 13	3580
July 12	**5150 (nearly triple March)**
August 16	4610
September 13	4520
October 11	5400
November 11	5120
December 13	5240

Source: Radiological Environmental Operating Amended Report, 2004, September 23, 2005, www.nrc.gov

Changes in Local Disease and Death Rates. In 1990, the U.S. National Cancer Institute published the only national study examining changes in cancer before and after startup of nuclear plants. Because the study was restricted only to nuclear plants operating before 1982, no data near the Shearon Harris plant was included. Thus, there have been no studies by government or independent researchers on health patterns near the plant.

The NCI report typically defined the area near nuclear reactors as the one or two most proximate counties, often within 30 miles. A logical selection of counties to study near Shearon Harris would include Durham and Wake Counties, as residents of both live within 30 miles of the plant. Prevailing local winds from the southwest also mean that Durham and Wake Counties are downwind, and most likely to be exposed to releases.

The two counties have a growing population of over 1 million, a fourfold increase since the late 1950s. The area has a poverty rate that is somewhat below the state and nation; an above-average household income level; and a highly-educated population (see below). These demographic factors, plus the availability of world class medical care in the Triangle area, suggest no obvious health risk for local residents.

POPULATION OF DURHAM AND WAKE COUNTIES, 1950-2006

Year	Durham	Wake	Total
1950	101,639	136,450	238,089
1960	111,995	169,082	281,077
1970	132,681	228,453	361,134
1980	152,785	301,327	454,112
1990	181,835	423,380	605,215
2000	223,314	627,846	851,160
2006 (est)	246,896	786,522	1,033,418

Source: U.S. Census Bureau, www.census.gov, Your Gateway to 2000 Census, State/County Quick Facts.

SELECTED DEMOGRAPHIC CHARACTERISTICS
DURHAM AND WAKE COUNTIES vs. N.C. AND U.S.

Characteristic	Durham	Wake	N.C.	U.S.
2000 % Foreign Born	10.9	9.7	5.3	11.1
2000 % HS grad, age 25+	83.0	89.3	78.1	80.4
2000 % Coll grad, age 25+	40.1	43.9	22.5	24.4
2004 % below poverty	14.9	9.2	13.8	12.7
2004 Median H'hold Inc.	44048	57846	40863	44334

Source: U.S. Census Bureau, www.census.gov, Your Gateway to 2000 Census, State/County Quick Facts.

Infant Deaths. While all humans are affected by radiation exposure, those most susceptible are the very young, especially the developing fetus, whose cells are duplicating at a very rapid rate. Deaths to infants, especially those that occur shortly after birth, are often a result of problems during pregnancy. The number of deaths to

infants in the first month of life from 1986 to 1987 rose in the two-county area from 69 to 97, an increase of 34% compared to a 2% increase for the rest of North Carolina and a 4% decline nationally (see below). Because Shearon Harris began producing radioactivity on January 3, 1987, this can be considered as an initial before-and-after startup comparison.

NEONATAL MORTALITY RATE (DEATHS UNDER 28 DAYS)
DURHAM AND WAKE COUNTY vs. OTHER N.C. AND U.S., 1986-1987

	Deaths < 28 days		Live Births		Deaths/1000		
Area	1986	1987	1986	1987	1986	1987	% Ch Rate
Durham County	20	25	2526	2664	7.92	9.38	+19
Wake County	49	72	5389	5669	9.09	12.70	+40
2 counties	69	97	7915	8333	8.72	11.64	**+34**
Other NC	622	658	82339	85168	7.55	7.73	**+ 2**
U.S.	25212	24627	3756547	3809394	6.71	6.46	**- 4**

Difference in rate change between two counties and U.S. significant at p<.04.
Source: National Center for Health Statistics, http://wonder.cdc.gov, underlying cause of death.

Childhood Cancer. Perhaps the most-studied disease near nuclear plants is childhood cancer. As far back as the late 1950s, Dr. Alice Stewart demonstrated that as little as one pelvic X-ray to a pregnant woman nearly doubled the chance the child would die of cancer by age ten. (Stewart A et al. A survey of childhood malignancies. British Medical Journal 1958;i:1495-1508). Because Stewart identified children under age ten, and because the National Cancer Institute used the same age group as a category in its 1990 study, cancer in Durham and Wake County children under age ten can be analyzed.

For analyses of potential causes, using incidence of cancer is often more helpful than mortality, as advances in diagnosis and treatment allow most children afflicted with cancer to survive. But no incidence data exists in North Carolina before 1990, thereby preventing any before-and-after comparison near Shearon Harris. Current (1990-2003) data show Wake and Durham children have an incidence rate 10% above other North Carolina counties, based on 241 cases diagnosed (see below). No comparable data exists for the 50 states.

CANCER INCIDENCE RATE, CHILDREN AGE 0-9, 1990-2003
DURHAM AND WAKE COUNTY vs. OTHER NORTH CAROLINA

Area	Cases	Avg. Population	Cases/1000	% +/- Other NC
Durham County	66	28,971	16.27	+14
Wake County	175	80,328	15.56	+ 9
Total 2 Counties	241	109,299	15.75	**+10**
Other NC	1862	931,724	14.27	---

Source: North Carolina State Cancer Registry, from special request, 2007.

Even though there are many fewer childhood cancer deaths than cases, the existence of a historical data base makes it possible to analyze rates before and after the startup of Shearon Harris. From 1979-1987 to 1988-2004, **the Durham/Wake childhood cancer mortality rate rose 51%, compared to a decline of 29% elsewhere in the state and nation** (see below). With a total of 71 local deaths after Shearon Harris startup, the increase is statistically significant. Before startup, the local rate was well below state and national standards, but now it exceeds other North Carolina by 31% and the U.S. by 20%.

CANCER MORTALITY RATE, CHILDREN AGE 0-9
DURHAM AND WAKE COUNTY vs. OTHER NC AND US, 1979-1987 to 1988-2004

	Cancer Deaths 0-9		Pop. 0-9		Deaths/100000		
Area	1979-87	1988-04	1979-87	1988-04	1979-87	1988-04	% Ch Rate
Durham County	5	24	188199	485984	2.66	4.94	+86
Wake County	10	47	393400	1339445	2.54	3.51	+38
2 counties	15	71	581599	1825429	2.58	3.89	**+51**
Other NC	295	465	7040684	15.7 m	4.19	2.96	**- 29**
U.S.	13931	21316	305.4 m	657.8 m	4.56	3.24	**- 29**

Difference in rate change between two counties and other NC/U.S. significant at p<.0001.
Source: National Center for Health Statistics, http://wonder.cdc.gov, underlying cause of death. ICD-9 codes include 140.0-239.9 (1979-1998). ICD-10 codes include C00-D48.9 (1999-2004).

The 20 most populated U.S. counties account for about 19% of the U.S. total. Every one of these counties experienced a reduction in childhood cancer mortality (between 19% and 44%). In the period 1988-2004, the Durham/Wake rate was greater than that for each of the 20 counties (see below and appendix).

CANCER MORTALITY RATE, CHILDREN AGE 0-9
DURHAM AND WAKE COUNTY vs. 20 MOST POPULATED U.S. COUNTIES

Area	1988-2004 Deaths 0-9	1988-2004 Avg. Pop. 0-9	Deaths/100,000	% +/- U.S.
Durham/Wake NC	71	107,378	3.89	**+20**
Other NC	465	923,636	2.96	**- 9**
TOTAL 20 COS	4,387	7,624,289	3.38	**+ 4**
TOTAL U.S.	21,316	38,696,270	3.24	-----

	Deaths/100,000 (Deaths)		
Area	1979-1987	1988-2004	% Ch Rate
Durham/Wake NC	2.58 (15)	3.89 (71)	**+51**
Other NC	4.19 (295)	2.96 (465)	**- 29**
TOTAL 20 COS	4.82 (2624)	3.38 (4387)	**- 30**
TOTAL U.S.	4.56 (13931)	3.24 (21316)	**- 29**

Source: National Center for Health Statistics, http://wonder.cdc.gov, underlying cause of death. ICD-10 codes include C00-D48.9.

Cancer in Adults. Most U.S. states did not have a reliable cancer incidence registry until about 1990. In recent years, the federal government has attempted to produce comparative incidence data for all states. The web site for the U.S. Centers for Disease Control and Prevention now makes available 1999-2002 incidence data for 38 states (including North Carolina) plus the District of Columbia, accounting for about 85% of the total U.S. population. It also includes data for 55 Metropolitan Statistical Areas (MSAs), including Raleigh/Cary, which includes Franklin, Johnston, and Wake Counties (Wake accounts for about 80% of the population in this group).

While incidence cannot be compared before and after Shearon Harris startup, it is possible to examine how current rates in the Raleigh/Cary area compare to the rest of the state. For all cancers, the Raleigh/Cary incidence rate is 1% lower (includes all persons, adjusted for age). But for most radiation-sensitive cancers, incidence is higher, including thyroid cancer which is sensitive to radioactive iodine, (+27%). Other cancers of the bone and blood forming organs, sensitive to bone-seeking elements such as strontium, also exceed rates for the rest of the state (see below). This pattern should be considered unusual in an area where the rate of most cancers is similar to the state.

CANCER INCIDENCE RATE, SELECTED CANCERS, 1999-2002
RALEIGH/CARY METROPOLITAN STATISTICAL AREA vs. OTHER NC

	Raleigh/Cary MSA		Other North Carolina		% Ral/Cary
Cancer	Cases	Cases/100,000	Cases	Cases/100,000	+/- Oth NC
All	8030	423.7	94,935	428.4	- 1
Cancers Most Sensitive to Radiation					
Bone/joint	22	0.98	177	0.80	**+23**
Breast (F)	1458	132.3	14,790	121.5	**+ 9**
Hodgkin's	68	2.7	551	2.5	**+11**
Leukemia	200	10.3	2,066	9.4	**+ 9**
Myeloma	82	4.6	1,074	4.9	**- 6**
Non-Hodgkins	347	17.6	3,719	15.5	**+15**
Thyroid	145	6.1	1,062	4.8	**+27**
Other Most Common Cancers					
Lung	1097	61.6	15,284	68.9	- 11
Prostate (M)	1194	157.0	14,749	153.1	+ 3
Colon	562	32.2	7,771	35.5	- 9
Bladder	297	17.4	4,024	18.3	- 5
Melanoma	308	14.2	3,083	13.9	+ 2
Kidney/renal	215	11.2	2,689	12.1	- 7

Raleigh/Cary Metropolitan Statistical Area includes Franklin, Johnston, and Wake Counties. Estimated 2006 population for this area is 994,551 (Franklin = 55,886, Johnston = 152,143, Wake = 786,522).

Source: U.S. Centers for Disease Control and Prevention (http://wonder.cdc.gov, National Association of Cancer Registries). Data not reported for the year 2000. Rates adjusted to 2000 U.S. standard population.

Trends in mortality for all ages can also be measured. The National Cancer Institute study compared local death rates near nuclear plants to U.S. rates every five years, using the Standard Mortality Ratio (SMR), or local versus national. The following shows five year trends in SMR for Durham/Wake vs. the U.S. The local rate before Shearon Harris began operating was slightly above the U.S. (SMR over 1.00), and slightly below the U.S. after startup (SMR below 1.00).

CANCER MORTALITY RATE, ALL CANCERS, FIVE-YEAR PERIODS
DURHAM/WAKE COUNTIES vs. U.S., 1979-2004

Period	Wake/Durham Rate/100,000 (Cases)	U.S. Rate/100,000	SMR
1979-83	213.3 (3525)	210.3	1.014
1984-88	220.2 (4221)	214.6	1.026
1989-93	218.0 (4915)	217.4	1.003
1994-98	209.0 (5630)	209.4	0.998
1999-03	194.0 (6021)	200.6	0.967
2004	187.6 (1294)	190.4	0.985

Source: National Center for Health Statistics, http://wonder.cdc.gov, underlying cause of death. ICD-9 codes include 140.0-239.9 (1979-98), ICD-10 codes include C00-D48.9 (1999-04).

Discussion. The data presented in this report document a wide variation over time in radioactive emissions from Shearon Harris into the environment, and similar wide variations in the environmental concentrations of this radioactivity near the plant, and at least as far as 17 miles away. It also shows an unexpected 51% rise in child cancer mortality in Wake and Durham Counties after the reactor began operating, compared to a 29% decrease in the state and nation, as well as elevated local incidence levels of several radiosensitive cancers.

While one cannot automatically conclude there is a cause-and-effect link between Shearon Harris emissions and local cancer rates, questions are raised by the data. The fact that no studies of local cancer rates near the plant have been conducted in its two decades of operation calls strongly for health officials to undertake such studies. These will provide important information on the operating performance of Shearon Harris, especially as federal officials consider proposals to extend the license of the existing reactor for 20 additional years to 2047 and to build two new reactors at the site are.

U.S. COUNTIES WITH LARGEST POPULATIONS (as of July 1, 2003)

1. Los Angeles CA	9,871,506	11. Wayne MI	2,028,778
2. Cook IL	5.351,552	12. San Bernardino CA	1,859,678
3. Harris TX	3,596,086	13. Riverside CA	1,782,650
4. Maricopa AZ	3,389,260	14. King WA	1,761,411
5. Orange CA	2,957,766	15. Santa Clara CA	1,678,421
6. San Diego CA	2,930,886	16. Clark NV	1,576,541
7. Kings NY	2,472,523	17. New York NY	1,564,798
8. Dallas TX	2,284,096	18. Tarrant TX	1,559,148
9. Miami-Dade FL	2,253,362	19. Philadelphia PA	1,479,331
10. Queens NY	2,225,486	20. Middlesex MA	1,471,724
TOTAL	54,095,003 (19% of U.S.)		

Source: U.S. Census Bureau, www.census.gov, your gateway to the 2000 census, State/County quick facts.

CANCER MORTALITY RATE, CHILDREN AGE 0-9, 1988-2004
DURHAM AND WAKE COUNTY vs. 20 MOST POPULATED U.S. COUNTIES

County	Deaths 0-9	Avg. Pop. 0-9	Deaths/100,000	% +/- U.S.
Durham/Wake NC	71	107,378	3.89	**+20**
Other NC	465	923,636	2.96	**- 9**
Los Angeles CA	985	1,515,515	3.82	+18
New York NY	100	154,683	3.80	+17
King WA	129	210,449	3.61	+11
Kings NY	223	371,405	3.53	+ 9
Harris TX	318	536,172	3.49	+ 8
Santa Clara CA	138	236,469	3.43	+ 6
San Diego CA	238	407,864	3.43	+ 6
Philadelphia PA	125	219,135	3.36	+ 4
Cook IL	442	781,868	3.33	+ 3
Orange CA	234	417,257	3.30	+ 2
Dallas TX	190	339,365	3.29	+ 2
Riverside CA	136	244,659	3.27	+ 1
Wayne MI	181	327,966	3.25	+ 0
Maricopa AZ	235	425,188	3.25	+ 0
Middlesex MA	95	181,698	3.08	- 5
San Bernardino CA	149	298,661	2.93	- 10
Miami Dade FL	149	298,727	2.93	- 10
Tarrant TX	107	218,162	2.89	- 11
Queens NY	132	269,367	2.88	- 11
Clark NV	81	168,979	2.82	- 13
TOTAL 20 COS	4387	7,624,289	3.38	**+ 4**
TOTAL U.S.	21,316	38,696,270	3.24	-----

Source: National Center for Health Statistics, http://wonder.cdc.gov, underlying cause of death. ICD-10 codes include C00-D48.9.

CHANGE IN CANCER MORTALITY RATE, CHILDREN AGE 0-9
DURHAM AND WAKE COUNTY vs. 20 MOST POPULATED U.S. COUNTIES
1979-1987 to 1988-2004

	Deaths/100,000 (Deaths)		
County	1979-1987	1988-2004	% Ch Rate
Durham/Wake NC	2.58 (15)	3.89 (71)	**+51**
Other NC	4.19 (295)	2.96 (465)	**- 29**
Los Angeles CA	4.69 (504)	3.82 (985)	- 19
New York NY	5.57 (69)	3.80 (100)	- 32
King WA	4.50 (69)	3.61 (129)	- 20
Kings NY	4.85 (150)	3.53 (223)	- 27
Harris TX	5.21 (210)	3.49 (318)	- 33
Santa Clara CA	5.52 (96)	3.43 (138)	- 38
San Diego CA	5.13 (133)	3.43 (238)	- 33
Philadelphia PA	4.28 (85)	3.36 (125)	- 21
Cook IL	4.23 (291)	3.33 (442)	- 21
Orange CA	4.93 (130)	3.30 (234)	- 33
Dallas TX	4.68 (113)	3.29 (190)	- 30
Riverside CA	4.70 (52)	3.27 (136)	- 30
Wayne MI	4.63 (141)	3.25 (181)	- 30
Maricopa AZ	5.71 (132)	3.25 (235)	- 43
Middlesex MA	4.77 (69)	3.08 (95)	- 35
San Bernardino CA	5.48 (87)	2.93 (149)	- 28
Miami Dade FL	5.19 (102)	2.93 (149)	- 44
Tarrant TX	4.15 (58)	2.89 (107)	- 30
Queens NY	5.12 (104)	2.88 (132)	- 44
Clark NV	4.17 (29)	2.82 (81)	- 32
TOTAL 20 COS	4.82 (2624)	3.38 (4387)	**- 30**
TOTAL U.S.	4.56 (13931)	3.24 (21316)	**- 29**

Source: National Center for Health Statistics, http://wonder.cdc.gov, underlying cause of death. ICD-10 codes include C00-D48.9.