Surveillance2006

Vermont Yankee Nuclear Power Station

Report on Public Health Monitoring
June 15, 2007

VERMONT
DEPARTMENT OF HEALTH
Agency of Human Services

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Executive Summary

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This 2006 Vermont Yankee Nuclear Power Station Surveillance Report is the most recent such report. Similar reports have been compiled annually by the Vermont Department of Health since 1971. Over the years the annual report has expanded from a small number of surveys in 1971 to the 1,300 different measurements of the air, water, milk, soil, vegetation, sediment and fish the Vermont Department of Health obtained in 2006.

Environmental surveillance helps verify that Vermont Yankee is operating in compliance with Department of Health regulations designed to protect the health and safety of Vermonters. Should measurements indicate a lack of compliance, the station is notified, an investigation is undertaken to determine if the measurements are accurate, and, if so, remedial actions are taken to prevent recurrence. Overall, the Department of Health found no issues of non-compliance in its environmental surveillance of Vermont Yankee in 2006.

Particular interest was generated in 2005 when Vermont Yankee was notified that Department of Health quarterly and annual limits on direct gamma radiation at the site boundary may have been exceeded in 2004. Using past interpretations of uncertainty as precedent, the Vermont Department of Health now considers those measurements to have been compliant. A similar situation exists for 2006. For both 2004 and 2006, site boundary direct gamma radiation doses were less than the State's interpretation of the limit of 20 plus or minus 5 milllirem per year, where plus or minus 5 millirem accounts for the dosimeter uncertainty.

As important as they are for indicating compliance, the samples and measurements taken over the course of 2006 may also be taken as evidence that no significant adverse health effects from radiological exposures are likely from the operation of Vermont Yankee Nuclear Power Station. To test this hypothesis, the Vermont Department of Health has for the first time in this report published statistics regarding specific health outcomes for people who live near the Station. In particular, cancer incidence and cancer mortality rates in the communities around Vermont Yankee were found not to differ significantly from those in the rest of Windham County, Vermont or the United States.

A summary table of environmental surveillance results is found in the Introduction section, and detailed presentations of the sampling methods and data are also included in this report. The sampling and measurements reported here are sometimes complex, and we invite all who read this report to contact the radiological health staff at the Vermont Department of Health to answer any questions they may have.

Introduction

Environmental surveillance of Vermont Yankee Nuclear Power Station is important. This report profiles the radiological conditions around Vermont Yankee Nuclear Power Station using samples and measurements in the communities surrounding the station. In reviewing the data tabulated here, you will find comparisons of some 2006 results to long-term historical trends. Generally, these comparisons show no significant increased radiological exposures due to Vermont Yankee Nuclear Power Station operations.

You may also find results that are compared to background levels. Background levels, in this case, are the levels of radioactivity in the air, water and earthen materials not attributable to Vermont Yankee Nuclear Power Station. Measurements above background may generally be attributed to the station, other uses of radioactivity in the measurement area, and changing meteorological conditions. The report also includes maps that show the locations where samples are collected or where measurements are made.

Some samples and measurements are being collected or made continuously. Other samples are taken periodically. All of the samples are analyzed by the Vermont Department of Health Laboratory in Burlington, Vermont. You will find the results of all of these samples and measurements in this report:

- The direct gamma radiation emanations as measured continuously at dozens of thermoluminescent dosimeter (TLD) sites.
- The amount of radioactive particulates and radioactive iodine that may be found in the air as collected with numerous continuous air samplers.
- Water from wells and waterways surrounding the plant and milk from local dairy farms that are sampled every month to determine the amount of natural and man-made radioactivity within them.

- Various wild and cultivated vegetation, river bed sediments, fish and soils that are sampled at least twice annually, and analyzed for man-made and naturally occurring radioactivity.

2006 was notable for three reasons. First, Vermont Yankee was authorized to increase reactor power by 20 percent. With the Extended Power Uprate, Vermont Yankee Nuclear Power Station increased its potential to impact offsite public doses. Offsite public doses may be affected by increased direct gamma radiation, increased discharges into ground and surface water, and increased emissions of particulates, gases and vapors from the plant stack and other sources. With the Extended Power Uprate, Vermont Yankee estimates direct gamma radiation alone could increase by as much as 26 percent.

The second important development was installation of a turbine shield at Vermont Yankee Nuclear Power Station in May 2006. This shield was designed to decrease gamma radiation levels from the high pressure turbine and at the site boundary by 30 percent. Vermont Department of Health measurements before and after installation of the turbine shield appear to support the premise that the turbine shield negates the increased direct gamma radiation levels of the Extended Power Uprate.

The third major development was the work conducted by Oak Ridge Associated Universities. Oak Ridge Associated Universities was hired by the Department of Health as a third party expert to evaluate Department of Health and Vermont Yankee determinations of direct gamma radiation dose at the Vermont Yankee Nuclear Power Station site boundary. Oak Ridge Associated Universities' contract was the result of a 2005 impasse over Department of Health direct gamma radiation measurements at the Station site boundary. Vermont Department of Health measurement results for the fourth quarter of 2004, and for the year 2004 in its entirety, were in excess of the 10 millirem per quarter and 20 millirem per year Department of Health limits. Vermont Yankee held that their measurements and supporting calculations proved otherwise.

Oak Ridge Associated Universities completed their assessment and draft final report at the end of January 2007. They concluded that Vermont Yankee had not exceeded the Department of Health quarterly and annual limits in 2004. Oak Ridge Associated Universities went on to recommend many ways that both the Department of Health and Vermont Yankee could improve measurements of direct gamma radiation and the assessment of compliance to the Vermont Department of Health regulations on direct gamma radiation. Some of those recommendations were incorporated in Department of Health methods for 2006; others will be incorporated for 2007 and subsequent years. The 188-page Oak Ridge Associated Universities report is available at the Vermont Department of Health web site at http://healthvermont.gov/enviro/rad/documents/013107Site%20BoundaryEvaluation.pdf

In addition to providing an assessment of the impacts of Vermont Yankee Nuclear Power Station operations on public health, the samples, measurements and equipment used in the Vermont Department of Health environmental surveillance program help establish baseline values of radioactivity in the region around the Station. These baselines help us recognize measurements outside the expected range, and allow comparisons when conditions warrant them. The surveillance equipment pre-positioned in this region may also be useful in emergency responses. In the event of an unexpected release from the Station, the Department of Health air samplers and thermoluminescent dosimeters may help us determine the extent of human exposure and contamination of our environment.

This report should also depict the extent of capabilities at the Vermont Department of Health Laboratory. Vermonters are served well by the staff and other resources there that allow the Health Department conduct rather rigorous testing. All radiological analyses of the laboratory are subject to high levels of quality control as tested both from within the lab, and by outside organizations.

For this year, some changes have been made in the report. These are most evident in the maps, tables and graphs. In addition, the entire report is published at the Vermont

Department of Health web site, http://healthvermont.gov Also, new this year, we are publishing the first statistics regarding health outcomes in the vicinity of Vermont Yankee Nuclear Power Station. Should you have questions about the content, please call the Vermont Department of Health Radiological Health Program at 802-865-7730.

Program Results Summary

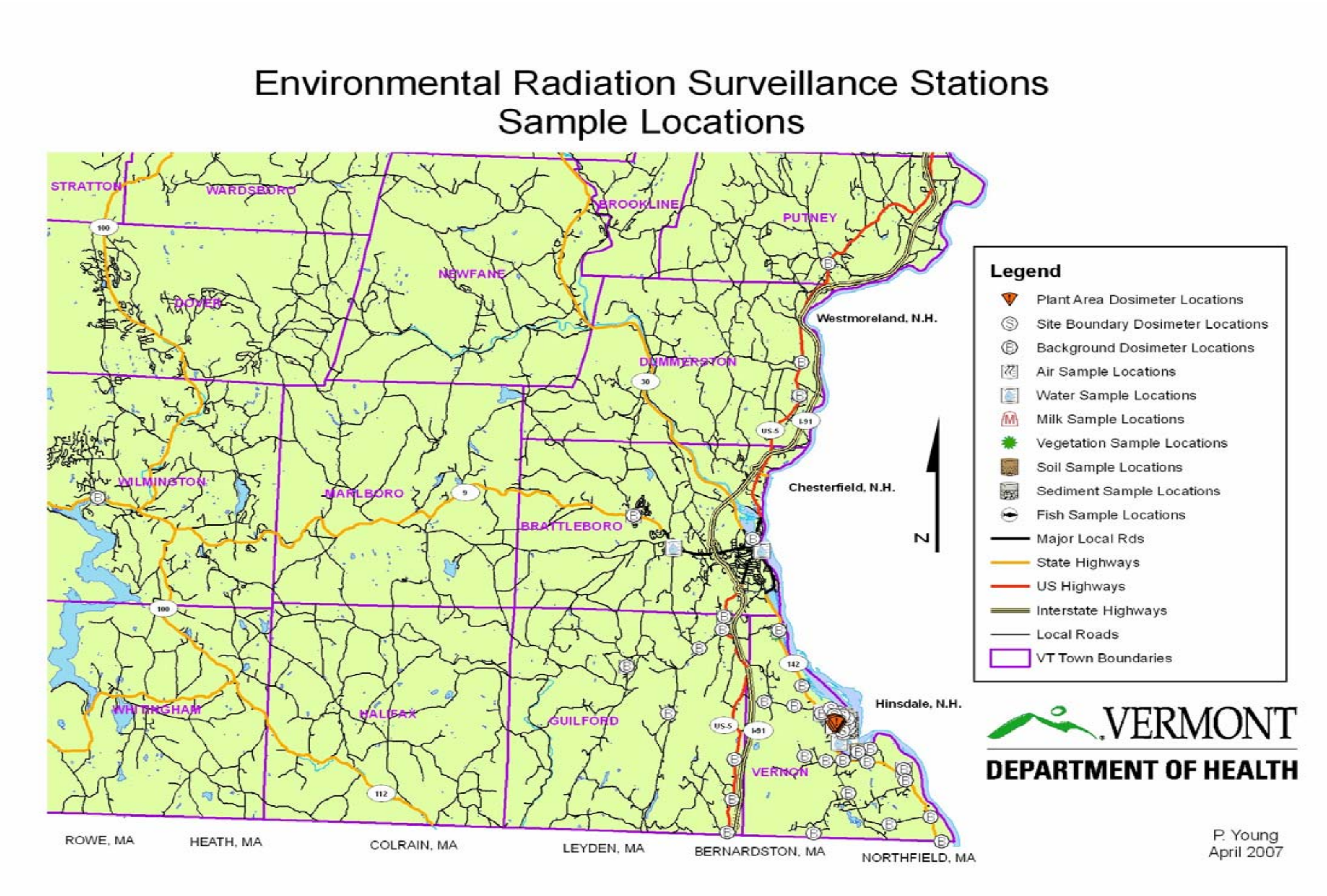
The number of samples and analyses in the Vermont Department of Health environmental surveillance program for the Vermont Yankee Nuclear Power Station is indicative of a significant investment in evaluating compliance to Department of Health regulations and protecting public health. Table 1 indicates the number of sample types, measurement or sample collection locations, samples, analyses and general results for each sample. Maps 1 and 2 display the specific locations of the sampling. More detailed discussion about the sample results comprises the bulk of this report.

With each discussion are tables that show the results and map location identification numbers. Some maps are more easily viewed on the Vermont Department of Health web site, where they can be enlarged. This is especially true of Map 1, where all the sample locations and types are depicted, but the printed version does not show them as clearly as the individual maps for the different sample types later in the report. You can view this report and all of the maps at http://healthvermont.gov/

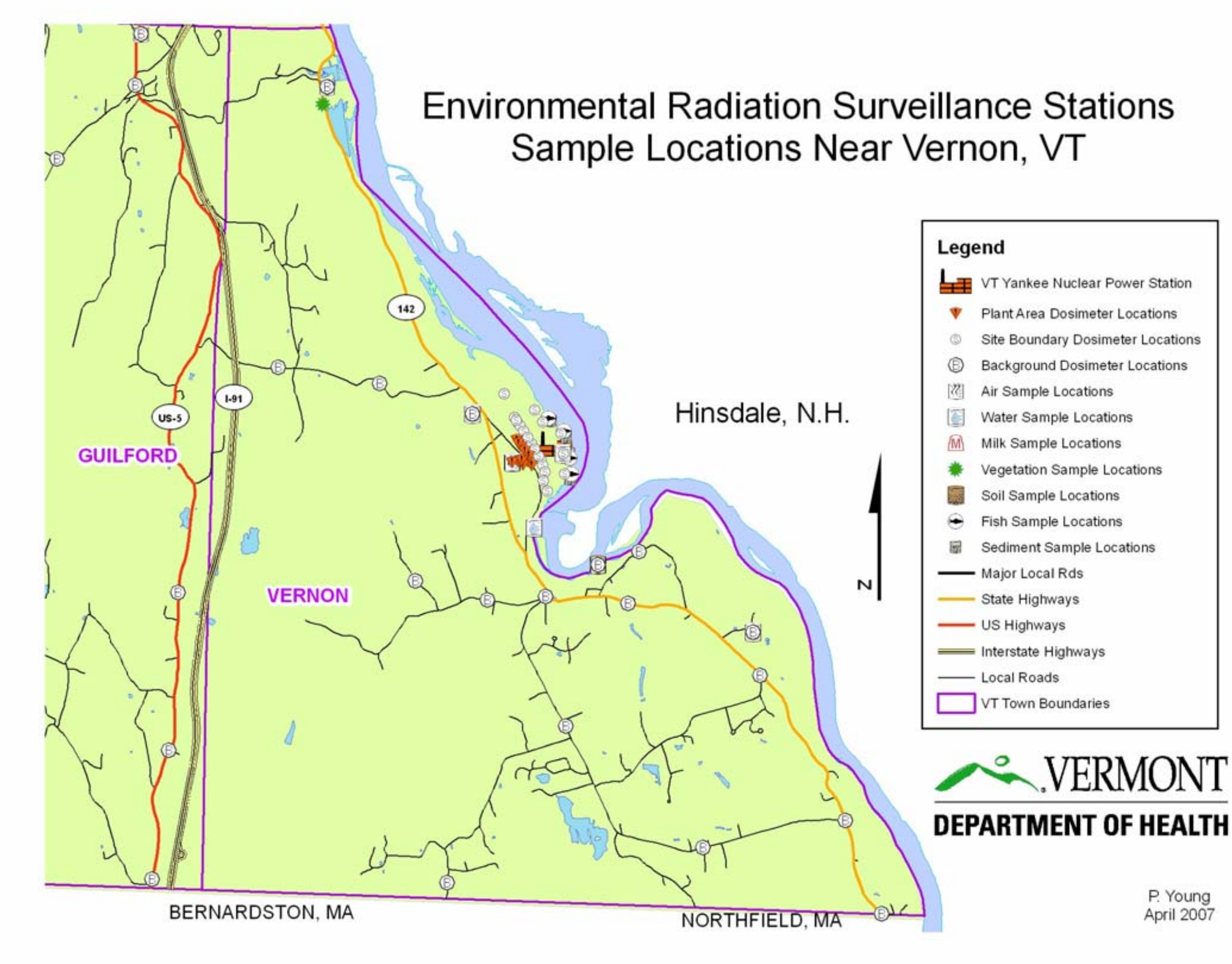
Table 1. Summary of 2006 Samples, Analyses and Results

Sample Type	Locations	No. Samples	Analysis Type	Results
Direct Gamma Radiation	71	284	Thermoluminescent Dosimeters	Less than limits plus 25% uncertainty including at site boundary bordered by land
Air Particulates, Gases, Vapors	9	106	Total Alpha Radioactivity	Within historical range; mean results near VYNPS similar to those further from VYNPS
		106	Total Beta Radioactivity	Within historical range; mean results near VYNPS similar to those further from VYNPS
		4	Total Gamma Radioactivity	All detected gamma radioactivity of natural origin
		106	Iodine-131 Radioactivity	All samples less than lower limit of detection, 0.02 pCi/m^3
		106	Total Gamma Radioactivity	All detected gamma radioactivity of natural origin
Water	6	118	Total Alpha Radioactivity	Within historical range; mean results near VYNPS similar to those further from VYNPS
		118	Total Beta Radioactivity	Within historical range; mean results near VYNPS similar to those further from VYNPS
		118	Tritium Radioactivity	All samples less than lower limit of detection of 300 pCi/l
		118	Total Gamma Radioactivity	All detected gamma radioactivity of natural origin
Milk	2	24	Iodine-131 Radioactivity	All samples less than lower limits of detection, 2.26 pCi/l
		24	Total Gamma Radioactivity	All detected gamma radioactivity of natural origin
Vegetation	5	13	Total Gamma Radioactivity	All detected gamma radioactivity of natural origin or Chernobyl and nuclear weapons testing
Soil	5	16	Total Gamma Radioactivity	All detected gamma radioactivity of natural origin or Chernobyl and nuclear weapons testing
River Sediments	20	35	Total Gamma Radioactivity	All detected gamma radioactivity of natural origin or Chernobyl and nuclear weapons testing
Fish	4	4	Total Gamma Radioactivity	All detected gamma radioactivity of natural origin
Totals	122	1300		

Map 1. All Samples, All Locations



Map 2. All Samples in Vernon, Vermont



Ionizing Radiation Risks

The radiations to which people may be exposed as a result of Vermont Yankee Nuclear Power Station operations are called ionizing radiations. According to the International Agency for Research on Cancer, ionizing radiation is a known human carcinogen. Cancer may result from exposure to ionizing radiation because the energy absorbed may directly or indirectly damage the DNA of human cells. DNA damage is a general requirement of carcinogenesis.

It has been clearly demonstrated that at high doses, generally in excess of 10 rem or 10,000 millirem (1 rem = 10,000 millirem), people exposed have a higher risk of cancer than people exposed to lower doses. As with other carcinogens, it is impossible to prove that low doses are without risk. With radiation exposure, it is assumed that no dose is without risk. Still, at very low doses such as those reported here, the risk of developing cancer is considered very low, if it exists at all.

The risk management approach used for public health protection with carcinogenic agents is precautionary. In the field of radiation protection, this precautionary approach is called the ALARA principle. Every reasonable effort must be made to maintain exposures and doses *As Low As Reasonably Achievable*. The Vermont Department of Health regulations not only require that exposures to ionizing radiation be less than specific limits, but also that users of ionizing radiation - in all forms of industry, medicine and education - maintain exposures ALARA. More about ionizing radiation risk may be found at these websites:

The National Academies of Science:
http://books.nap.edu/openbook.php?isbn=030909156X

The Health Physics Society: http://hps.org/documents/risk_ps010-1.pdf

The International Agency for Research on Cancer, their complete series of monographs on carcinogenic agents: http://monographs.iarc.fr/ENG/Monographs/allmonos90.php

Beginning with this Surveillance 2006 Report on Public Health Monitoring, the Vermont Department of Health is presenting information about certain health outcomes in the vicinity of Vermont Yankee. While environmental sampling is important in determining compliance with regulations, assessments of the health of people living near the Power Station helps us understand the actual health impacts. Working with the Department of Health Cancer Registry and the Department of Health Vital Records Office, some initial information about the health of people in Windham County and in the six towns nearest Vermont Yankee Nuclear Power Station is being presented.

Considering the primary concern about chronic low level exposure to ionizing radiation is cancer, the first health outcomes being summarized are cancer incidence (new cancer cases diagnosed) and cancer mortality (people dying from cancer). Later reports may present investigations of other health outcomes.

Cancer is, unfortunately, very common. Roughly one out of every two men and one out of every three women will develop cancer in their lifetime.

The source of the information in Table 2 is the Vermont Department of Health Cancer Registry. It was updated as of January 2007. The incidence rates are for all cancers, for invasive thyroid cancers, for leukemia and for childhood cancers for the years 1994 - 2003. More information about cancer rates in Vermont may be found at: http://healthvermont.gov/pubs/cancerpubs/cancer_in_vermont.aspx

The data in Table 2 indicate that, for all cancer types combined, the rate of cancer incidence in the six towns near Vermont Yankee Nuclear Power Station (Brattleboro, Dummerston, Guilford, Halifax, Marlboro and Vernon) is lower as compared to the rest of Vermont and the United States as a whole. No statistical differences are seen in incidence rates for thyroid cancer, leukemia, and childhood cancers among the different geographic areas.

Thyroid cancers and leukemia are of particular interest because increased risk may be associated with excess radiation exposure. There is no evidence of excessive radiation exposure in these geographic areas, but the focus on these kinds of cancers remains useful. Pediatric cancers are important because radiation health effects are generally more likely when individuals are exposed prenatally or at an early age. The embryo or fetus is most radiosensitive.

Table 2. Cancer Incidence Rates Near VYNPS, in Vermont and in U.S.

Vermont and U.S. Cancer Incidence, All Sites, Males and Females, 1994 – 2003
(Urinary Bladder Includes Malignant and In Situ)

	Rate	Lower CI	Upper CI	Avg cases per year
U.S White	488.8	487.9	489.8	
Vermont	490.1	484.5	495.7	2,996
Windham County	472.9	453.6	492.9	227
VYNPS Nearby Towns	434.2	407.2	462.7	98

Rates are per 100,000 and age-adjusted to the 2000 U.S. Std Population (18 age groups - Census P25-1130) standard; Confidence intervals (CI) are 95% for rates.

Vermont and U.S. Cancer Incidence, Invasive Thyroid Cancer, Males and Females, 1994 - 2003

	Rate	Lower CI	Upper CI	Avg cases per year
U.S White	7.7	7.6	7.8	
Vermont	6.6	6.0	7.3	41
Windham County	5.4	3.5	8.1	3
VYNPS Nearby Towns	5.1	2.5	9.4	1

Rates are per 100,000 and age-adjusted to the 2000 U.S. Std Population (18 age groups - Census P25-1130) standard; Confidence intervals (CI) are 95% for rates.

Vermont and U.S. Cancer Incidence, Leukemia, Males and Females, 1994 - 2003

	Rate	Lower CI	Upper CI	Avg cases per year
U.S White	13.4	13.3	13.6	
Vermont	13.0	12.1	13.9	78
Windham County	12.9	9.9	16.7	6
VYNPS Nearby Towns	9.1	5.6	14.3	2

Rates are per 100,000 and age-adjusted to the 2000 U.S. Std Population (18 age groups - Census P25-1130) standard; Confidence intervals (CI) are 95% for rates.

Vermont and U.S. Cancer Incidence, Pediatric Cancers (<Age 20),
Males and Females, 1994 - 2003 (Urinary Bladder Includes Malignant and In Situ)

	Rate	Lower CI	Upper CI	Avg cases per year
U.S White	17.3	16.9	17.6	
Vermont	16.6	14.7	18.7	28
Windham County	14.7	8.6	23.7	2
VYNPS Nearby Towns	Rates are only presented when the number of cases is at least 6.			

Rates are per 100,000 and age-adjusted to the 2000 U.S. Std Population (18 age groups - Census P25-1130) standard; Confidence intervals (CI) are 95% for rates.

In Table 3, mortality rates from cancer in Windham County as a whole and the six towns near Vermont Yankee Nuclear Power Station are presented for the years 1994 - 2003. The data in this table indicate there are no statistical differences in the death rates from malignant neoplasms, leukemia, thyroid cancer and pediatric cancer among the six towns near Vermont Yankee and Windham County as a whole. These data are from the Department's Health Vital Statistics System, last updated in January 2007.

It is important to note that in several cases, cancer incidence and cancer mortality rates in the United States, Vermont, Windham County and the six towns near Vermont Yankee Nuclear Power Station are not statistically different. So characterizations that one population is at more risk or at less risk as compared to another are not valid. It is clear, however, that for the years 1994 – 2003 cancer mortality rates in the towns of Brattleboro, Dummerston, Guilford, Halifax, Marlboro and Vernon are not different than those for Windham County as a whole.

To understand the numbers reported in Tables 2 and 3, examining an example from each table may help. From the first set of numbers at the top of Table 2, you can see that the incidence rate for all cancers in the U.S. white male and female population is about 489 cases per 100,000 persons. Statistically speaking, we are 95 percent confident (not due to chance alone) that this rate exists in the range of 487.9 to 489.9 cases per 100,000 persons. In the six towns near Vermont Yankee, the all cancer incidence rate is 434 cases per 100,000 persons. We are 95 percent confident that the actual rate is between 407.2 cases and 462.7 cases per 100,000 persons. At the reported confidence intervals, these differences are statistically significant. After adjusting for age and population size, people in the six towns near Vermont Yankee Nuclear Power Station were diagnosed with fewer cancers between 1994 and 2003 than Vermont and the U.S.

From the second collection of rates in Table 3, it initially appears that deaths from leukemia in the six towns nearer Vermont Yankee may be higher than in Windham County as a whole. However, this difference is not statistically significant. In Windham

County, the death rate from leukemia was 7.60 deaths per 100,000 persons, while the death rate from leukemia in the six towns near Vermont Yankee was 8.33 deaths per 100,000 persons. We are 95 percent confident that these rates fall between 5.31 and 10.77 deaths per 100,000 persons in Windham County, and between 4.98 and 13.56 deaths per 100,000 persons in the six towns. With these confidence intervals, as they are called, the two leukemia death rates are not statistically different.

One other caution about the use of these data: the numbers of cancer cases and the number of cancer deaths in the six towns near Vermont Yankee are small. Making predictions for larger populations is better done with larger numbers of cases, which may be recorded over longer periods of time. This is an objective at the Vermont Department of Health – to annually update these figures to help reconcile the differences between perceived risks for developing cancer and the actual experience of cancer diagnoses in the community.

Table 3. Cancer Mortality Rates in Windham County and Towns Near VYNPS

Counts of Deaths and Age-Adjusted Mortality Rates for Selected Cancers, 1994-2003

ALL AGES	**Malignant Neoplasms (all sites)**		
	# Deaths	**Rates(1)**	**95% CI**
Brattleboro, Dummerston, Guilford Halifax, Marlboro, Vernon	505	217.52	(198.77, 237.98)
Windham County	1019	210.62	(197.85, 224.20)

ALL AGES	**Leukemia**		
	# Deaths	**Rates(1)**	**95% CI**
Brattleboro, Dummerston, Guilford Halifax, Marlboro, Vernon	19	8.33	(4.98, 13.56)
Windham County	36	7.60	(5.31, 10.77)

ALL AGES	**Thyroid Cancer**		
	# Deaths	**Rates(1)**	**95% CI**
Brattleboro, Dummerston, Guilford Halifax, Marlboro, Vernon	*	0.44	(0.00, 3.22)
Windham County	*	0.70	(0.14, 2.34)

AGES 0-19	**Malignant Neoplasms (all sites)**		
	# Deaths	**Rates(1)**	**95% CI**
Brattleboro, Dummerston, Guilford Halifax, Marlboro, Vernon	*	2.18	(0.00, 15.87)
Windham County	*	3.40	(0.83, 10.20)

Rates are per 100,000 persons

(1) Rates are age-adjusted to US 2000 Standard Population

* Less than 5 deaths reported.

Source: VT Department of Health Vital Statistics System

Surveillance Methods

The types of surveys and analyses performed by the Department of Health deserve some description relative to their role in protecting public health.

Direct Gamma Radiation

The Vermont Department of Health currently uses thermoluminescent dosimeters (TLDs) to monitor direct gamma radiation. Direct gamma radiation is the energy emanating from the Vermont Yankee Nuclear Power Station systems and components. Direct gamma radiation is not a contaminant that collects on surfaces like particles, gases or vapors released from a facility might. Direct gamma radiation is energy that the body is affected by only when a person is located in an area where gamma radiation exists. Everyone is continuously exposed to direct gamma radiation from natural and human-made sources.

Department of Health thermoluminescent dosimeters are installed all the way around the Vermont Yankee site fence line, along its site boundary and in the publicly occupied spaces around the station to identify the amount of public exposure that may be associated with operations at the Station. Additional Department of Health thermoluminescent dosimeters are installed throughout the towns of Vernon and Guilford, and in locations in Brattleboro, Dummerston, Putney and Wilmington to establish what the background levels of direct gamma radiation are, in the absence of the Vermont Yankee Nuclear Power Station.

The gamma radiation measured by the Department of Health thermoluminescent dosimeters is an electromagnetic wave similar to X-rays. Gamma radiation passes through your skin and may pass through your entire body. The radiation delivers ionizing radiation dose to the tissues with which it interacts.

With a thermoluminescent dosimeter, the gamma radiation interacts with and changes the physical composition of the materials in the thermoluminescent dosimeter. When the thermoluminescent dosimeter is removed from its monitoring location and sent to a laboratory for analysis, the physical changes in the thermoluminescent dosimeter are reversed. When this occurs, light is emitted, and the amount of light measured in the process is directly proportional to the amount of ionizing radiation energy absorbed in the thermoluminescent dosimeter. This is considered representative of the dose a person would receive at the specific location if that person remained in that location 24 hours a day every day of the monitoring period.

Typical gamma radiation emitting radioactive materials include the potassium-40 inside our own bodies, the beryllium-7 in most earthen materials and the nitrogen-16 in reactor coolant water at a nuclear power plant. Other important reactor-generated gamma radiation emitters include the solids cobalt-60 and cesium-137, the vapor iodine-131 and the gases krypton-88 and xenon-133.

Personnel thermoluminescent dosimeters, like those worn by workers in nuclear power plants and in medical and research facilities, are calibrated to provide a measure of biological dose for the wearer. Dose is the amount of an agent to which you are exposed that actually affects you. The dose is recorded in units called millirem.

On the other hand, environmental thermoluminescent dosimeters, including those reported on in this document, are not calibrated to provide direct measures of dose in millirem. Environmental thermoluminescent dosimeters are only calibrated to provide a measure of exposure. These thermoluminescent dosimeter exposures are recorded in milliroentgen. Historically, the Vermont Department of Health has considered the amount of radiation exposure measured in milliroentgen to be equal to the amount of biological dose equivalent in millirem. Both personnel and environmental thermoluminescent dosimeters are used to measure beta and gamma radiation exposure.

The remaining sample types are used to determine the amount of radioactivity, or radioactive contamination, in the media being sampled. Identifying the quantities and types of radioactive materials in the environment helps us predict how much may end up in our bodies from the air we breathe and in the water and food we eat.

Air Monitoring

The Vermont Department of Health uses continuously operating air samplers to monitor the air near Vermont Yankee Nuclear Power Station in Vernon, as well as air in the nearby towns of Guilford, Brattleboro, Dummerston and Wilmington. The air samples allow us to evaluate the amount of three different kinds of radiation to which people may be exposed in the air they breathe. These are alpha, beta and gamma radiation.

Alpha and beta radiation are similar to gamma radiation in that the health risk associated with each is carcinogenesis from damage to DNA. Alpha and beta radiation differ from gamma radiation because they are particle forms of radiation energy, and gamma radiation is an electromagnetic wave of energy. While electromagnetic waves like gamma radiation travel great distances and through most materials, particle radiations like alpha and beta radiation travel relatively short distances and are completely stopped by simple materials.

Alpha particle radiation is the most biologically hazardous form of ionizing radiation. For equal amounts of alpha, beta and gamma radiation energy, alpha particle radiation may cause roughly 20 times more tissue damage. Radon gas and its radioactive decay daughter products emit alpha, beta and gamma radiation. It is the alpha radiation that leads to so much concern about lung cancer.

Fortunately, alpha radiation cannot penetrate the simplest of materials. For example, a sheet of paper can completely stop an alpha particle, as can the dead layer of skin that covers the outer surface of the skin of our bodies. Thus, the only way alpha particles may actually harm us is if radioactive material that emits alpha radiation is inhaled, ingested or otherwise taken into the body.

Most alpha-emitting radioactive materials are heavy metals like human-made americium-241 and plutonium-239 or naturally-occurring uranium-234 or thorium-232. Radon-222 is unusual because it is a radioactive gas. It is this characteristic that also adds to our exposures to, and risks from, radon. Radon gas seeps from the earth's crust and accumulates in buildings and other structures, unlike solids like uranium and thorium that are trapped in soil and rock.

Beta particle radiations also have predictable ranges through materials and are stopped by simple materials. Most beta particle radiations are stopped by plastics and simple construction materials. The dead layer of skin on the outside of our bodies is not always capable of protecting the living skin beneath it. Most beta particle radiation can cause skin dose.

Still, beta particles do not penetrate the living skin more than a few millimeters, so our internal organs are only affected by beta particle radiation if we inhale or ingest beta particle emitting radioactive materials. Once taken into the body, and like alpha particle radiation, the beta particle radiation may damage the tissues of our internal organs. This is why monitoring of the air, water and food chain is so important in an environmental surveillance program.

Materials that emit beta particle radiation include the naturally-occurring carbon-14 in all living things, as well as hydrogen-3 (also known as tritium), which may be both human-made or of natural origin. Strontium-90 is a beta particle radiation emitting radioactive material. It is a product of the fission process that may be found in nuclear reactor coolant water.

Radioactive materials that emit alpha, beta or gamma radiation behave chemically just like non-radioactive materials. For example, radioactive hydrogen in water goes everywhere water (a compound of two atoms of hydrogen and one atom of oxygen) goes in our bodies, radioactive iodine goes to the thyroid gland like non-radioactive iodine does, and radioactive strontium goes to the bone just like non-radioactive strontium does.

Alpha and beta particle radiation in radioactive materials in the air is determined by drawing air through a glass fiber filter. Radioactive materials are trapped on the filter and the filter is counted on a gas flow proportional counter in the Vermont Department of Health Laboratory. All radiological analyses of the laboratory are subject to high levels of quality control as tested both from within the lab, and by outside organizations.

Gamma radiation is also monitored in the air samples the Vermont Department of Health takes each month. Specifically, a charcoal cartridge is positioned in the air sampler immediately downstream from the glass fiber filter described above. While the glass fiber filter traps particulate forms of radioactive materials, the charcoal cartridge traps molecules of gas and vapors. One particular radioactive material of interest existing in a vaporous form especially likely to be trapped by the charcoal cartridge is iodine-131.

Iodine-131 is a vapor at temperatures above room temperature. It is created during the fission of nuclear reactor fuel. Leaks in fuel rod cladding allow the iodine-131 into the reactor coolant, the water that runs through the reactor core, and other plant components and systems. The iodine-131 vapor may be trapped by plant ventilation system charcoal beds, but some may also be released from the plant stack. Iodine-131 is not generally found in the environment except where used in medicine and produced by nuclear facilities.

Iodine-131 that is inhaled, like other isotopes of iodine that may also be released, travels through the bloodstream to the thyroid gland in a person’s neck. That which is not taken up by the thyroid gland is soon excreted from the body with other waste fluids. If a person’s thyroid gland is saturated with iodine, most of the iodine-131 taken into the body passes straight from the bloodstream to the urine for elimination. This is the benefit afforded to those who take potassium iodide. If one takes a sufficient dose of potassium iodide, about 130 milligrams (mg) for an adult and 65 mg for children between the ages of 3 and 18, radioactive iodine-131 will not be taken up into the thyroid, and risks of thyroid cancer will be reduced significantly.

More about potassium iodide availability and use around the Vermont Yankee Nuclear Power Station may be found at: http://healthvermont.gov/enviro/rad/KI_program.aspx

In addition to analyzing the charcoal cartridges for radioactive iodine-131, both the charcoal cartridges and the air filters are analyzed for most other gamma radiation emitting radioactive materials. Hence, the Vermont Department of Health looks for nearly every radioactive material that may be emitted from the Vermont Yankee Nuclear Power Station and found in air.

Gamma radiation is analyzed by gamma spectroscopy. Gamma spectroscopy relies on the unique energy signatures of radioactive materials that emit gamma radiation. These unique gamma radiation energies are analyzed to identify the specific radioactive materials in the sample. Gamma spectroscopy can also determine the amount of radioactivity in the sample by measuring the amount of gamma radiation energy emitted by the sample. Gamma spectroscopy is performed by the Vermont Department of Health Laboratory under relatively ideal conditions.

Water Monitoring

Groundwater and surface water around the Vermont Yankee Nuclear Power Station is monitored with methods similar to those for air. Water is collected from wells that supply water to two Vernon farms and to the Vernon Elementary School. Samples are also taken from the Brattleboro municipal water supply. Surface water is sampled from the Connecticut River near the plant discharge, downstream of Vernon Dam and in Brattleboro. Water monitoring results are presented below.

Water samples are collected monthly by the Vermont Department of Health and by an environmental monitoring contractor. All of the samples are analyzed by the Vermont Department of Health Laboratory through various methods. The Vermont Department of Health Laboratory analyzes all water samples for total alpha radioactivity and total beta radioactivity. It also analyzes for all gamma radiation-emitting radioactive materials through gamma spectroscopy. Finally, all of these water samples are analyzed specifically for tritium (hydrogen-3).

Monitoring of the Inputs to the Food Chain

Given that direct gamma radiation that may contribute to public ionizing radiation dose is monitored, and that radioactive materials in the air we breathe and in the water we drink are measured, the remaining pathway for public exposure from Vermont Yankee Nuclear Power Station is the food we consume. To evaluate the food chain and inputs to it, the Vermont Department of Health takes samples from the soil within which plants grow and obtain nutrients and water, from sediments that support fish and other aquatic species in waterways, from wild and cultivated vegetation, from fish, and from cow's raw milk.

Every soil, sediment, vegetation, fish and milk sample is evaluated for gamma radiation emitting radioactive materials, while raw cow's milk is also specifically analyzed for iodine-131.

Direct Gamma Radiation Results

Direct gamma radiation is what we call the electromagnetic energy that is emitted from the reactor and turbine systems at Vermont Yankee Nuclear Power Station. Like light from a bulb, this energy is emitted in all directions from certain station components and operations. Like light, this direct gamma radiation is reduced in intensity with increasing distance. Also like light, it scatters and reflects off of nearby materials. Some direct gamma radiation actually reflects from the atmosphere above the station back to earth. This is called skyshine.

The Vermont Department of Health direct gamma radiation measurements also account for any gamma radiation exposures from gases, vapors and particles in the air. This includes gamma radiation exposures from gases like krypton-88 and xenon-133 that might be released from the Vermont Yankee Nuclear Power Station plant stack, as well as particulates and vapors, including radioactive iodine. These exposures are likely very small, especially as compared to the direct gamma radiation and scattered and skyshine radiation from plant components, systems and operations.

Direct gamma radiation can contribute to public exposures outside the site boundary of the station. The Vermont Department of Health limits direct gamma radiation doses for members of the public. The limit is expressed in millirem, a unit that accounts for both the amount of radiation energy absorbed and the potential biological effects of that radiation energy absorption. The unit millirem quantifies what is called the biological dose equivalent. The Vermont Department of Health regulations for radiological health can be found at http://healthvermont.gov/regs/radio_health.pdf

The biological dose equivalent allowed annually for a member of the general public from direct gamma radiation emitted from Vermont Yankee Nuclear Power Station is limited to 5 millirem. Because it is impossible to verify that the biological dose equivalent to every single person exposed throughout the year is less than 5 millirem, the regulations provide for measurements of the site boundary dose as an acceptable alternative for verifying compliance. This makes sense, since measurements of the actual dose at a location along the site boundary may be readily obtained. Specifically, the regulations limit the calculated biological dose equivalent at the site boundary to 20 millirem per year. There is a further, separate limit of no more than 10 millirem per calendar quarter.

It is important to note that the Vermont Department of Health regulations for site boundary direct gamma radiation dose pertain only to that portion of the site boundary bordered by land. thermoluminescent dosimeter locations DR42, DR43, DR44, DR45, DR46 and DR47 in Table 5 below are on the site boundary along the Connecticut River. Also note that the thermoluminescent dosimeter results in Tables 5, 6 and 7 below are in units of milliroentgen. The unit milliroentgen (mR) is a unit of exposure, and environmental thermoluminescent dosimeters only record exposure.

When evaluating compliance to Vermont Department of Health regulations, measurements of exposure are taken. These measurements record exposures in units of milliroentgen (mR). This is true whether we are evaluating compliance with the use of medical X-rays or whether we are evaluating compliance at Vermont Yankee Nuclear Power Station.

Biological dose equivalent, measured in millirem, accounts for the amount of ionizing radiation exposure that actually leads to biological dose. In reality, the biological dose equivalent that results from a given exposure to gamma radiation is not equal to the exposure in milliroentgen (mR). This is like heat. You may be exposed to 110 degrees of thermal energy, but your tissues do not all warm to 110 degrees. In the Vermont Department of Health regulations, however, biological dose equivalents in millirem are defined to be equal to the exposures in milliroentgen (mR).

Three methods may generally be used to determine the direct gamma radiation exposures at the site boundary. The first is by using instruments that add up the total radiation exposure over some extended time interval like a calendar quarter or a year. This method results in exposures in units of milliroentgen (mR). The Vermont Department of Health thermoluminescent dosimeters (TLDs) are exposed at the site boundary for a calendar quarter and the total dose for that timeframe is determined. Summing the measurements for the four calendar quarters allows comparison to the annual limit.

The second method uses instruments that indicate the exposure rate at a given time. This results in exposure rates in units of milliroentgen per hour. If you multiply the milliroentgen per hour times the number of hours in a calendar quarter or year, you can compare the result to the Vermont Department of Health limits. A survey meter measures the exposure rate in milliroentgen per hour. One type of accurate survey meter is an ion chamber. The Department of Health has recorded site boundary doses this way over the years, but has not generally used those measurements to determine compliance. The Department also uses ion chambers to evaluate compliance to limits for users of x-rays in medical and industrial facilities. Staff at the Vermont Yankee Nuclear Power Station use ion chambers to measure site boundary dose, in addition to using thermoluminescent dosimeters.

A third method is to use characteristics of the source of exposure and values for distance, time and other aspects of the situation to calculate the quarterly or annual exposure. The Vermont Department of Health has done this frequently over the years too, but generally, not for determining compliance to limits at the Vermont Yankee Nuclear Power Station site boundary. For example, the Vermont Department of Health may calculate possible doses from samples of radioactivity found in the environment or in work places.

In this surveillance report, we present direct gamma radiation doses using only thermoluminescent dosimeters. Past reports have only presented thermoluminescent dosimeter, or other dosimeter, results. Future reports will present the results from thermoluminescent dosimeters, ion chambers and calculations.

To determine the direct gamma radiation exposure attributable only to Vermont Yankee Nuclear Power Station, background radiation must be subtracted from measurements. The 71 thermoluminescent dosimeters the Vermont Department of Health deploys in its environmental surveillance program record what are called gross measurements. Gross measurements of gamma radiation include exposures from all natural and man-made sources of radiation where the thermoluminescent dosimeter is physically located.

Gross gamma radiation measurements include exposures from radon gas in the air; from naturally-occurring radioactive materials in the soil, water and vegetation; from radioactive materials in building materials; from contaminants deposited as a result of above-ground nuclear weapons testing; from passing vehicles containing radioactive materials; from people who have varying amounts of natural and human-made radioactive materials within their bodies, and from the direct and scattered gamma radiation from the systems, components and operations at Vermont Yankee Nuclear Power Station.

For thermoluminescent dosimeter measurements, the Vermont Department of Health uses the results of thermoluminescent dosimeter measurements at 34 locations unlikely to be affected by Vermont Yankee Nuclear Power Station. These 34 thermoluminescent dosimeters are located as far west as Wilmington, as far north as Putney, and as far south as the Vermont/Massachusetts state line in Guilford and Vernon.

Beginning this year, each quarter’s average (or mean) dose to these 34 thermoluminescent dosimeters is calculated to estimate background radiation. Past determinations of background gamma radiation were from the mean of two thermoluminescent dosimeter stations, one in Putney and one Wilmington. This change from the past was implemented because the calculated mean background is more accurate when 34 measurements are used than when only two measurements are used to calculate the mean. The mean background exposures are reported in Table 4.

The exposures reported in Tables 5, 6 and 7 for comparison to the annual limit are the net thermoluminescent dosimeter results – the gross thermoluminescent dosimeter reading minus the mean background radiation.

Background gamma radiation levels for the four quarters of 2006 are presented in summary in Table 4 at the 95 percent confidence level. These results, as well as the complete results in Tables 5, 6 and 7, are provided in units of gamma radiation exposure, milliroentgen (mR), for technical accuracy.

Table 4. 2006 Mean Direct Gamma Radiation Background

Calendar Quarter	Mean Background and Error at the 95% Confidence Level
January 1 to March 31	18.3 mR ± 2.5 mR
April 1 to June 30	20.3 mR ± 3.1 mR
July 1 to September 30	21.4 mR ± 3.2 mR
October 1 to December 31	22.0 mR ± 3.1 mR
Calendar Year 2006	82.1 mR ± 6.0 mR

These quarterly background levels provide an important context for interpretation of the direct gamma radiation levels and limits. The sum of these mean quarterly direct gamma radiation background levels is 82.1 mR. The Vermont Department of Health limit for direct gamma radiation, 20 millirems per year, is approximately one-fourth the direct gamma radiation dose people receive from natural background radiation, excluding the doses received from radon gas and its daughter products. Another thing these results point out is the effect of uncertainty. The uncertainty of each quarterly background exposure measurement is between 14 and 16 percent of the measurement.

All dosimeter measurements over time, and survey meter measurements at a given time, are estimates. They are best estimates, but these measurements are subject to error or uncertainty. It is appropriate when reporting measurements, then, to also report the amount of uncertainty. Uncertainty results from variability in what is being measured, in the measurement devices, and in the persons doing the measurements. The uncertainty in what is being measured – radioactivity - may be accounted for statistically; the uncertainty in measurement instruments can be determined readily in a laboratory; the uncertainty in human performance during measurement, can be reasonably estimated.

Uncertainty can be minimized, too. For example, the amount of uncertainty in the background measurements the Vermont Department of Health uses is greater when two dosimeters are used to calculate the mean background, as compared to when the mean background is calculated from 34 background thermoluminescent dosimeter measurements. Generally, the greater the number in the sample size, the more accurate statistics like the mean and standard deviation will be. The same is true of time. The longer you collect measurements, the more likely it is that the measurement accurately characterizes the condition. For example, it may be better to characterize background radiation using 10 years worth of measurements than to use the measurements for a three-month calendar quarter.

In the three tables below are the results of Vermont Department of Health thermoluminescent dosimeter measurements of direct gamma radiation at the Vermont Yankee Nuclear Power Station site boundary (Table 5), in the immediate area around the station (Table 6) and, to establish a background radiation level, in parts of Windham County distant from the station (Table 7).

Table 5 lists the results for 2006 for what we call the site boundary. It must be noted, that in 12 locations the thermoluminescent dosimeter is on the fence that surrounds the station, but not actually at the site boundary. These 12 fenceline dosimeters, DR-53, VY Parking Lot, VY Parking Lot #2, DR-51, DR-07, DR-49, T01, T02, T03, T04, T05 and T06 are all located more than 350 feet closer to the station's sources of direct gamma radiation than the actual site boundary.

Because the fenceline was originally more coincident with the actual site boundary, the fenceline has been used to assess compliance to the Vermont Department of Health limits for direct gamma radiation. This may be appropriate, too, because the land between the fence line and the actual site boundary (primarily open fields and some limited patches of trees) is not restricted from public access.

From Table 5, there are two dosimeters that measured direct gamma radiation exposure in excess of the 20 millirem per year limit, given the regulation-defined equivalence of milliroentgen (mR) of exposure and millirem of biological dose equivalent. These dosimeters are VY Parking Lot at 21.6 + 1.7 mR and VY Parking Lot #2 at 20.3 + 1.5 mR. Both dosimeters are at the same location on the Vermont Yankee Nuclear Power Station fenceline. Like all the other results in Tables 5 6 and 7 below, these values were arrived at using the mean exposure from the 34 background dosimeters in Table 7. Also, the error for the annual results is the total propagated error at the 95 percent confidence level.

Since the early 1970s, the Department of Health has informed the operators of Vermont Yankee, as well as elected and staff members of Vermont State government, that a possible 25 percent error in site boundary direct gamma radiation measurements of dose was accounted for by allowing annual doses of 20 millirem + 5 millirem. Since the 2006 site boundary direct gamma radiation levels measured by the Department of Health were less than 25 millirem, the Department does not deem the direct gamma radiation levels at the Vermont Yankee Nuclear Power Station to be out of compliance with its regulations for the year 2006.

Note also that numerous site boundary dose measurements for 2006 are incomplete. In mid-February 2006, the Department of Health added 29 more thermoluminescent dosimeters to its deployment of dosimeters on the fenceline and on the actual site boundary.

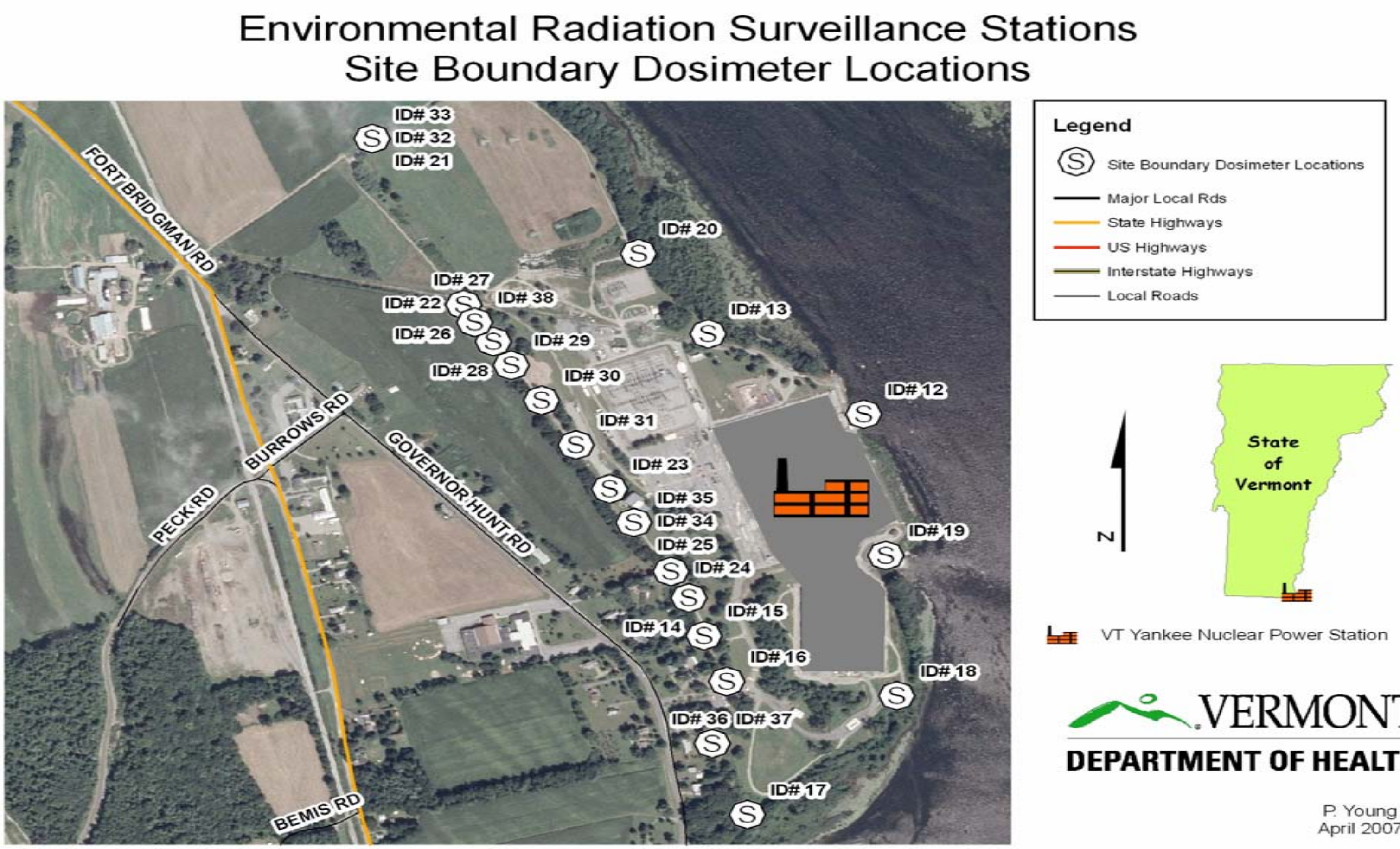
Maps 3, 4, 5 and 6 depict the physical locations of the site boundary, plant area and background dosimeters, respectively. The ID numbers on the maps may be matched to the locations in Tables 5, 6 and 7.

Table 5. 2006 Net VYNPS Site Boundary TLD Results for 2006

Location Site Boundary Dosimeters	Map ID No.	QTR1 Net mR	Error mR	QTR 2 Net mR	Error mR	QTR 3 Net mR	Error mR	QTR 4 Net mR	Error mR	2006 Net mR	Error mR
VDH T01*	26	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	1.1
VDH T02*	27	0.0	2.3	0.7	0.0	0.0	1.1	1.3	1.1	2.0	2.7
VDH T03*	28	0.0	1.1	1.0	1.1	0.0	0.0	2.3	2.3	3.3	2.8
VDH T04*	29	0.0	0.0	1.3	1.1	0.0	1.1	1.0	2.0	2.3	2.5
VDH T05*	30	0.0	5.7	1.7	0.0	2.2	3.0	1.0	2.0	4.9	6.2
VDH T06*	31	0.0	1.1	3.7	2.0	0.6	0.0	4.6	2.3	8.9	3.2
VDH DR07*	14	0.0	1.1	2.3	1.1	1.2	1.1	3.0	2.0	6.5	2.7
VDH DR08*	15	0.0	1.1	4.3	1.1	3.2	1.1	4.6	1.1	12.2	2.2
VDH DR41*	16	0.0	0.0	1.2	1.4	0.0	1.1	1.3	2.3	2.5	2.9
VY Southwest Fence	36	0.1	1.1	1.0	2.3	0.0	0.0	0.0	1.1	1.1	2.8
VY Southwest Fence #2	37	0.0	1.1	0.7	2.0	0.0	0.0	0.0	1.1	0.7	2.5
VDH DR42*	17	0.0	0.0	0.3	1.1	1.2	1.1	0.3	1.1	1.9	1.9
VDH DR43*	18	0.0	0.0	2.2	1.4	0.0	1.1	2.3	1.1	4.5	2.1
VDH DR44*	19	0.0	1.1	4.0	1.1	4.9	4.1	4.6	1.1	13.5	2.8
VDH DR45*	12	5.4	3.0	11.0	1.1	9.2	2.3	14.0	2.0	39.6	4.0
VDH DR46*	13	0.0	2.0	5.7	2.0	3.6	2.0	5.6	1.1	14.9	3.3
VDH DR47*	20	0.0	1.1	1.7	0.0	1.6	2.0	3.0	2.0	6.2	2.7
VDH DR48*	21	0.0	1.1	1.0	1.1	0.0	1.1	1.3	1.1	2.3	2.2
VY North Fence	32	0.2	1.4	2.7	0.0	0.2	1.1	1.0	0.0	4.1	1.7
VY North Fence #2	33	0.0	0.0	3.0	1.1	0.0	1.1	2.0	0.0	5.0	1.6
VDH DR49*	22	0.0	1.1	0.0	1.1	0.0	3.0	0.0	1.1	0.0	2.6
VDH DR51*	23	0.0	0.0	4.3	1.1	2.6	0.0	5.3	1.1	12.2	1.6
VDH DR52*	24	0.0	1.1	5.7	0.0	4.2	2.3	6.6	1.1	16.5	2.2
VY Parking Lot	**34**	**5.4**	**1.1**	**8.0**	**2.3**	**3.6**	**2.0**	**4.6**	**1.1**	**21.6**	**3.1**
VY Parking Lot #2	**11**	**4.4**	**1.1**	**5.7**	**0.0**	**3.9**	**1.1**	**6.3**	**2.3**	**20.3**	**2.7**
VDH DR53*	25	0.0	1.1	7.3	1.1	4.6	0.0	6.6	1.1	18.5	2.0

*Installed Mid-February

Map 3


Environmental Radiation Surveillance Stations
Site Boundary Dosimeter Locations
Legend
Site Boundary Dosimeter Locations
Major Local Rds
State Highways
US Highways
Interstate Highways
Local Roads
FORT BRIDGMAN RD
BURROWS RD
GOVERNOR HUNT RD
PECK RD
BEMIS RD
ID# 33
ID# 32
ID# 21
ID# 20
ID# 27
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ID# 38
ID# 13
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ID# 12
ID# 31
ID# 23
ID# 35
ID# 34
ID# 25
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State of Vermont
VT Yankee Nuclear Power Station
VERMONT
DEPARTMENT OF HEALTH
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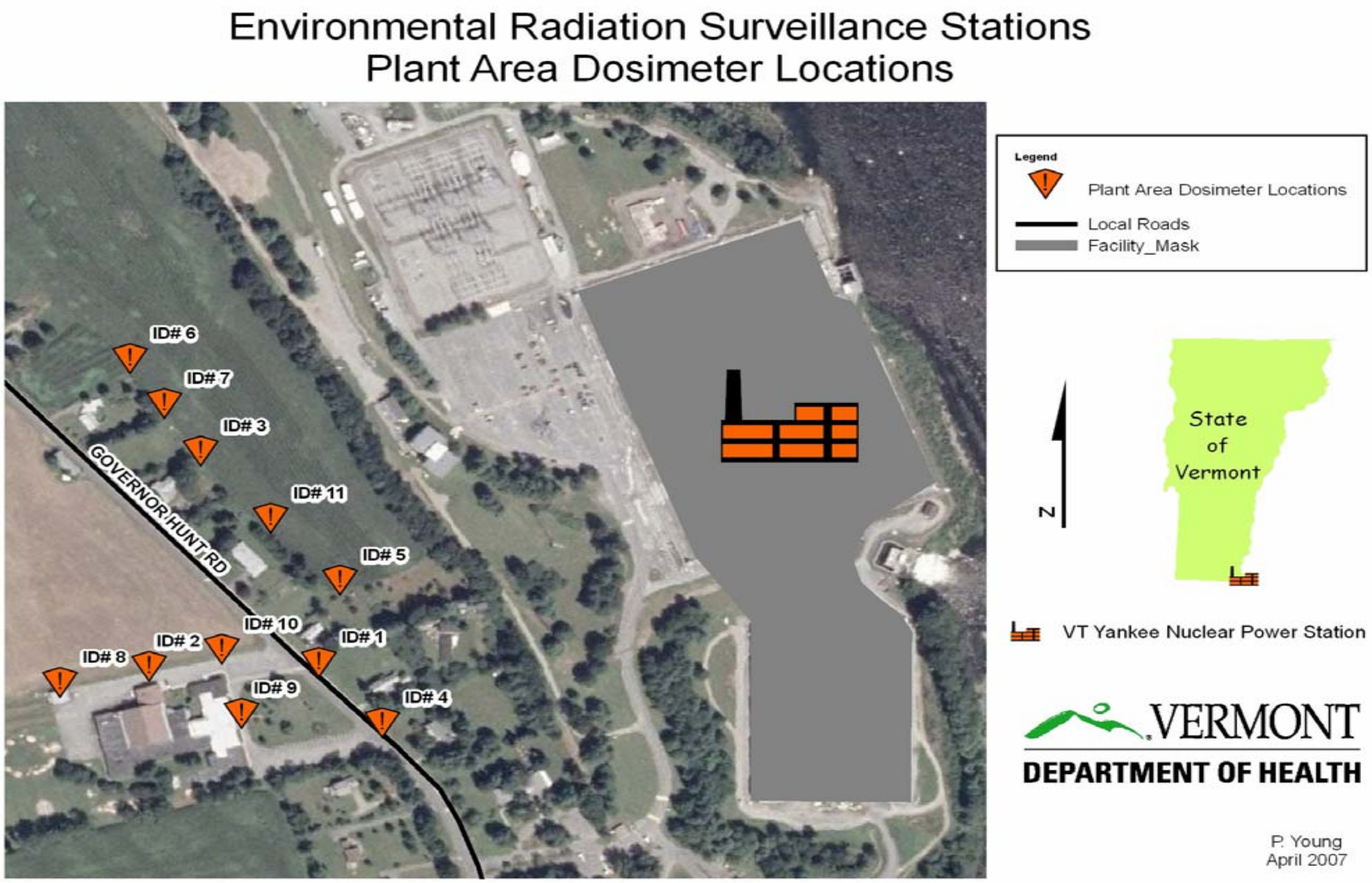
April 2007

Table 6. 2006 VYNPS Plant Area TLD Results

Location Plant Area Dosimeters	Map ID No.	QTR 1 Net mR	QTR 1 Error mR	QTR 2 Net mR	QTR 2 Error mR	QTR 3 Net mR	QTR 3 Error mR	QTR 4 Net mR	QTR 4 Error mR	2006 Net mR	2006 Error mR
VDH T07A*	6	0.0	0.0	2.7	2.0	1.6	2.0	1.6	1.1	5.9	2.7
VDH T07B*	7	0.0	2.0	2.3	3.0	4.9	2.3	2.3	1.1	9.5	4.0
VDH DR51A*	3	0.0	1.1	3.3	1.1	4.6	0.0	2.3	1.1	10.2	2.0
VY PARKING LOT A*	11	0.0	1.1	4.3	1.1	4.9	1.1	3.0	2.0	12.2	2.7
VDH DR53A*	5	0.0	1.1	3.7	2.0	6.6	0.0	4.0	0.0	14.2	2.3
Gov Hunt Road # 39*	1	1.4	1.1	3.0	1.1	1.9	1.1	2.0	2.0	8.3	2.7
Vernon School Nurse's Office	9	4.1	1.1	2.3	1.1	2.2	1.1	3.3	1.1	11.9	2.2
VDH DR06*	2	0.0	0.0	0.7	0.0	0.0	1.1	0.0	2.3	0.7	2.5
Vernon School Air Station	8	0.0	0.0	0.0	1.1	1.9	1.1	0.0	1.1	1.9	1.9
VDH DR52A*	4	1.4	1.1	1.7	0.0	0.9	1.1	1.3	1.1	5.3	1.9
Vernon School Pole	10	0.0	1.1	3.2	1.4	3.9	2.3	3.0	2.0	10.0	3.1
*Installed Mid-February											

Map 4


Environmental Radiation Surveillance Stations
Plant Area Dosimeter Locations
Legend
Plant Area Dosimeter Locations
Local Roads
Facility_Mask
ID# 6
ID# 7
ID# 3
ID# 11
ID# 5
ID# 10
ID# 1
ID# 2
ID# 8
ID# 9
ID# 4
GOVERNOR HUNT RD
N
State of Vermont
VT Yankee Nuclear Power Station
VERMONT
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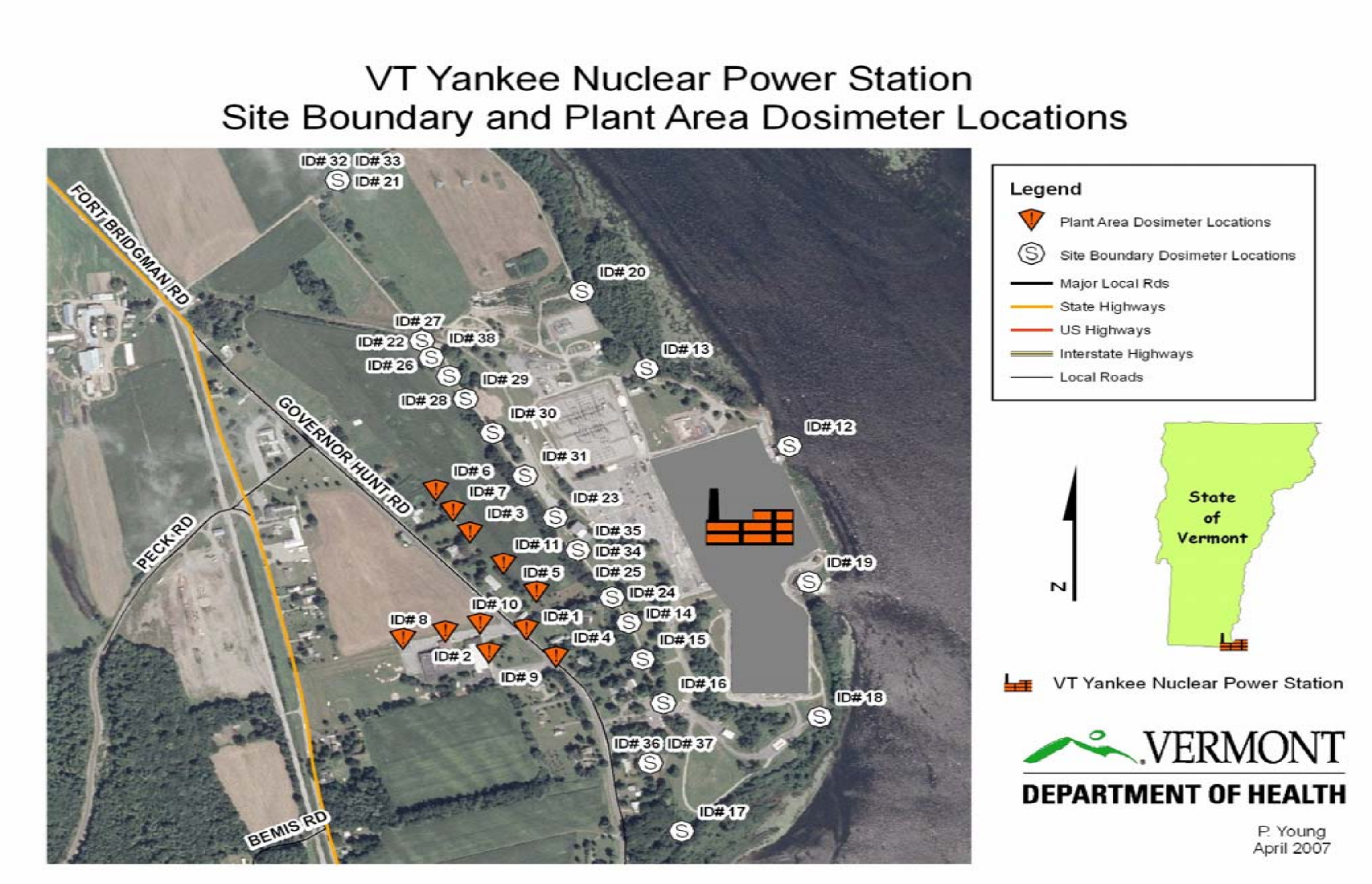
Map 5


VT Yankee Nuclear Power Station
Site Boundary and Plant Area Dosimeter Locations
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GOVERNOR HUNT RD
PECK RD
BEMIS RD
ID# 32 ID# 33
ID# 21
ID# 20
ID# 27
ID# 22
ID# 38
ID# 26
ID# 13
ID# 29
ID# 28
ID# 30
ID# 12
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ID# 1
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ID# 15
ID# 2
ID# 9
ID# 16
ID# 18
ID# 36 ID# 37
ID# 17
Legend
Plant Area Dosimeter Locations
Site Boundary Dosimeter Locations
Major Local Rds
State Highways
US Highways
Interstate Highways
Local Roads
N
State of Vermont
VT Yankee Nuclear Power Station
VERMONT
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April 2007

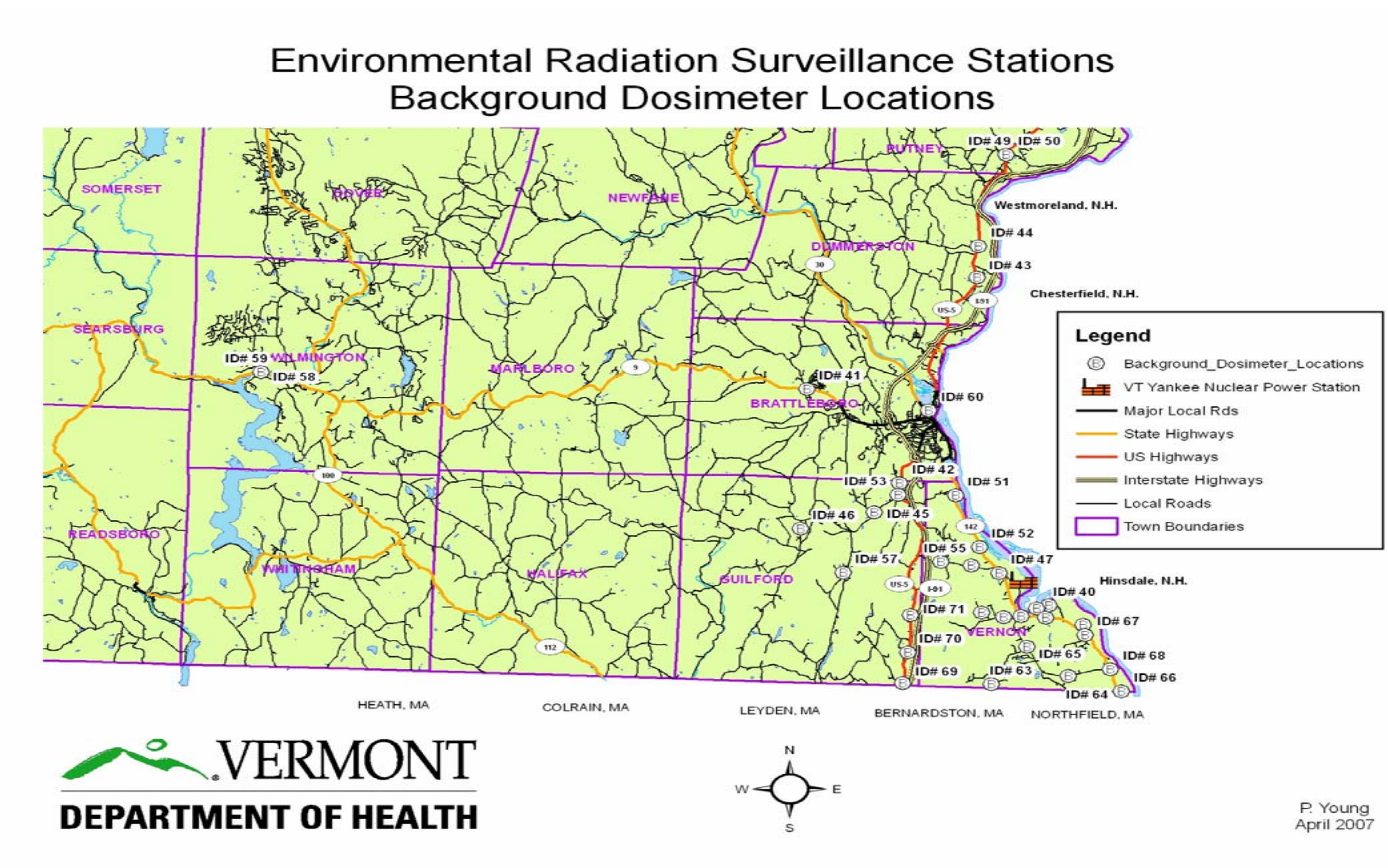
Table 7. 2006 VYNPS Background TLD Results

Location Background Dosimeters	Map ID No.	QTR 1 Net mR	Error Net mR	QTR 2 Net mR	Error mR	QTR 3 Net mR	Error mR	QTR 4 Net mR	Error mR	2006 Net mR	Error mR
Putney Town Clerk's Office	50	0.1	1.1	0.0	1.1	0.0	1.1	0.0	1.1	0.1	2.2
Putney Pole	49	0.4	1.1	1.3	1.1	0.0	0.0	1.3	1.1	3.0	2.0
Dummerston School	44	1.1	1.1	0.2	1.4	0.9	1.1	1.0	2.0	3.1	2.9
Dummerston IFO	43	0.4	1.1	0.0	1.1	1.9	1.1	0.6	2.3	2.9	3.0
Windham County Court	60	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	1.1
Renaud Brothers	51	0.1	1.1	1.7	2.0	0.0	1.4	0.0	2.0	1.7	3.2
Rt 142 North of Trans Lines	52	0.7	2.0	0.3	1.1	0.0	1.1	0.6	1.1	1.7	2.7
Tyler Hill Road	54	0.0	1.1	1.7	3.4	0.0	1.1	0.6	1.1	2.3	3.9
Miller Farm	47	0.0	1.1	0.0	0.0	0.6	0.0	0.0	1.1	0.6	1.6
142 & Pond Road North	39	1.1	2.3	0.0	0.0	0.0	3.0	0.6	3.0	1.7	4.1
Fairman Road	62	0.0	1.1	1.0	1.1	1.6	2.0	0.0	2.0	2.6	2.9
West Road & Edgewood	72	0.0	0.0	0.0	1.1	0.6	2.0	0.0	1.1	0.6	2.1
Vernon Fire Station	56	3.4	4.5	1.3	1.1	2.2	2.3	0.3	1.1	7.3	5.0
Power Line River Crossing	48	0.4	1.1	0.3	2.3	1.6	0.0	0.3	1.1	2.6	2.8
A&M/Smead, Stebbins Rd	40	0.1	1.1	0.0	1.1	1.6	0.0	0.0	2.3	1.6	2.8
Blodgett Farm	61	0.0	1.1	1.7	0.0	0.0	2.0	0.6	1.1	2.3	2.1
Rt 142 & Newtron Rd	67	0.0	2.0	0.0	1.1	0.0	1.1	0.0	1.1	0.0	2.7
Rt 142 & Pond Rd South	68	1.1	1.1	0.3	1.1	0.0	0.0	0.0	2.0	1.4	2.5
Rt 142 & Depot Street	66	0.0	1.1	0.3	1.1	0.6	0.0	0.3	1.1	1.2	2.0
Pond Rd & Houghton	64	0.0	2.3	0.0	1.1	0.2	1.1	0.6	1.1	0.9	3.0
Pond Rd at Vernon Recreation	65	0.0	2.0	0.0	2.0	0.0	1.1	0.0	1.1	0.0	3.2
Huckle Hill Rd.VT Line	63	2.1	2.3	2.7	2.0	2.1	1.4	3.6	2.3	10.4	3.9
Route 5 & Wolosko Rd	69	1.7	2.0	1.2	1.4	3.9	1.1	1.0	0.0	7.8	2.6
Rt 5 & Andrews Cemetary	70	0.0	0.0	0.7	0.0	1.9	2.3	0.0	2.0	2.6	2.5

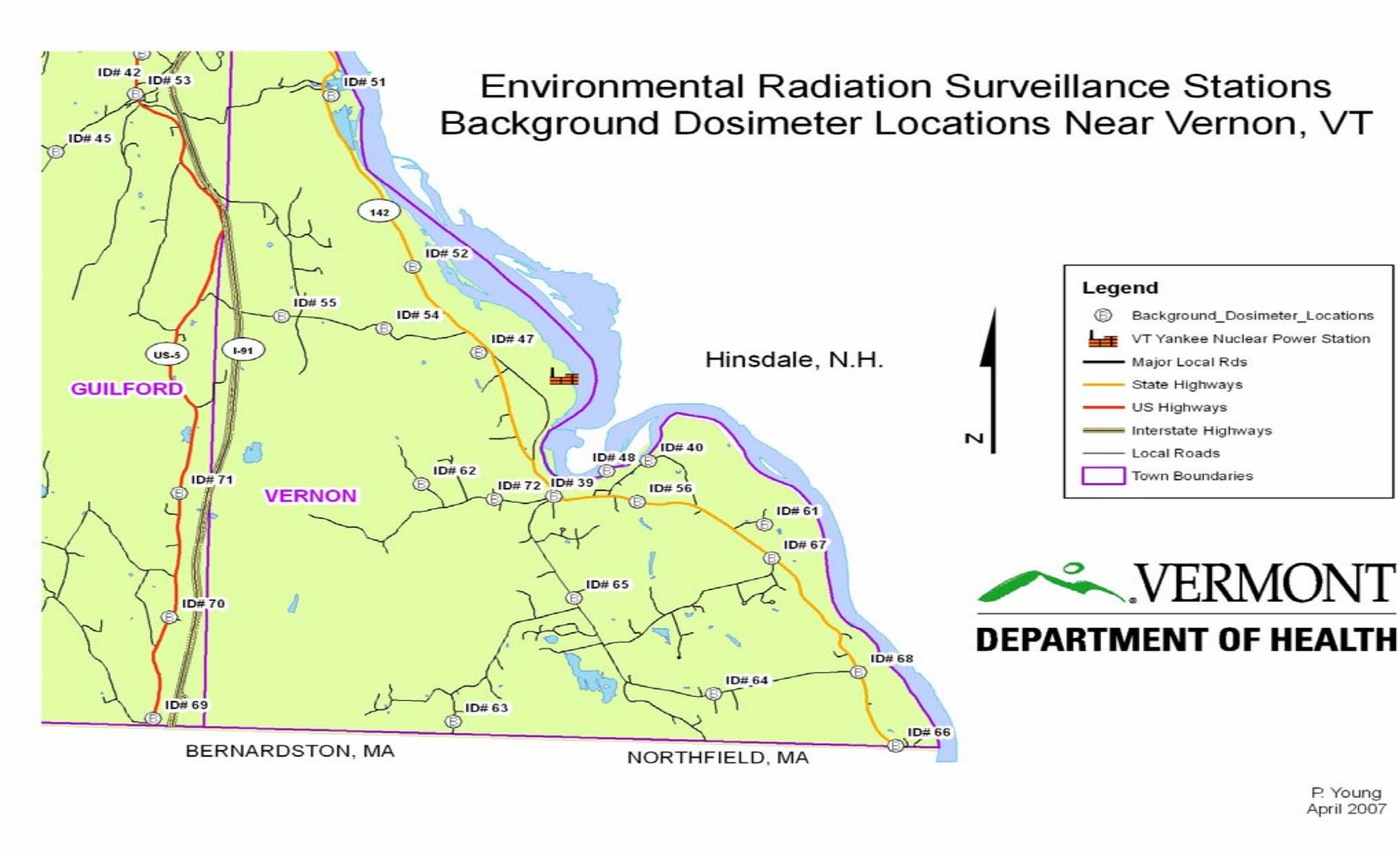
Table 7. 2006 VYNPS Background TLD Results (continued)

Location Background Dosimeters	Map ID No.	QTR 1 Net mR	Error Net mR	QTR 2 Net mR	Error mR	QTR 3 Net mR	Error mR	QTR 4 Net mR	Error mR	2006 Net mR	Error mR
Rt 5 & Tkaczyk Farm Rd	71	0.0	1.1	0.7	0.0	1.6	0.0	0.3	1.1	2.5	1.6
Tyler Rd & Franklin Rd	55	0.1	1.1	0.7	2.0	0.0	1.1	3.6	1.1	4.4	2.7
D&E Tree, Rt 5, Guilford	42	0.0	1.1	0.0	1.1	0.0	2.0	0.0	2.0	0.0	2.9
Rt 5 & Guilford Ctr Rd	53	0.0	1.1	1.3	1.1	0.9	1.1	1.3	1.1	3.5	2.2
Guilford Ctr Rd & Tater Rd	45	0.0	1.1	0.0	1.1	0.0	0.0	1.0	2.0	1.0	2.5
Weatherhead Hollow Rd	57	0.0	2.0	0.0	1.1	0.0	1.1	0.0	2.0	0.0	3.2
Guilford Town Garage	46	1.4	2.3	0.3	1.1	0.9	1.1	2.0	0.0	4.6	2.7
West Brattleboro SP	41	0.0	0.0	0.0	1.1	0.0	1.1	0.0	1.1	0.0	1.9
Wilmington AOT Pole	58	0.4	1.1	0.3	1.1	0.0	1.1	0.0	0.0	0.7	1.9
Wilmington AOT Air Station	59	2.4	1.1	1.7	2.0	0.0	1.1	0.0	1.1	4.1	2.7

Map 6


Environmental Radiation Surveillance Stations
Background Dosimeter Locations
Legend
Background_Dosimeter_Locations
VT Yankee Nuclear Power Station
Major Local Rds
State Highways
US Highways
Interstate Highways
Local Roads
Town Boundaries
SOMERSET
DOVER
NEWFANE
PUTNEY
DUMMERSTON
SEARSBURG
WILMINGTON
MARLBORO
BRATTLEBORO
READSBORO
WHITINGHAM
HALIFAX
GUILFORD
VERNON
Westmoreland, N.H.
Chesterfield, N.H.
Hinsdale, N.H.
HEATH, MA
COLRAIN, MA
LEYDEN, MA
BERNARDSTON, MA
NORTHFIELD, MA
ID# 49
ID# 50
ID# 44
ID# 43
ID# 59
ID# 58
ID# 41
ID# 60
ID# 42
ID# 53
ID# 51
ID# 46
ID# 45
ID# 52
ID# 57
ID# 55
ID# 47
ID# 40
ID# 71
ID# 67
ID# 70
ID# 65
ID# 68
ID# 69
ID# 63
ID# 66
ID# 64
N
W
E
S
VERMONT
DEPARTMENT OF HEALTH
P. Young
April 2007

Map 7


Environmental Radiation Surveillance Stations
Background Dosimeter Locations Near Vernon, VT
Hinsdale, N.H.
GUILFORD
VERNON
BERNARDSTON, MA
NORTHFIELD, MA
ID# 42
ID# 53
ID# 45
ID# 51
ID# 52
ID# 55
ID# 54
ID# 47
ID# 48
ID# 40
ID# 62
ID# 72
ID# 39
ID# 56
ID# 71
ID# 61
ID# 67
ID# 65
ID# 70
ID# 68
ID# 64
ID# 69
ID# 63
ID# 66
142
US-5
I-91
N
Legend
Background_Dosimeter_Locations
VT Yankee Nuclear Power Station
Major Local Rds
State Highways
US Highways
Interstate Highways
Local Roads
Town Boundaries
VERMONT
DEPARTMENT OF HEALTH
P. Young
April 2007