Surveillance*2007*

Vermont Yankee Nuclear Power Station

Report on Public Health Monitoring
June 30, 2008

VERMONT
DEPARTMENT OF HEALTH
Agency of Human Services

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Table of Contents

Executive Summary

This 2007 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 more than 1,300 different measurements of the air, water, milk, soil, vegetation, sediment and fish the Vermont Department of Health obtained for this current report.

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 2007.

Direct gamma radiation measurements taken by the Department of Health deserve special comment. Department dosimeters measure direct gamma radiation levels in the environment. Some of the radiation energy to which we are exposed is not absorbed by the body. In fact, for radiation energy levels such as those near Vermont Yankee, the human body absorbs about 60 percent of it as radiation dose. In 2007, Oak Ridge Associated Universities recommended that the Department of Health convert radiation exposure as measured by the dosimeters to biological dose using this factor of 60 percent. Using this recommended exposure to dose conversion factor, the Vermont Department of Health limits were not exceeded in 2007. More discussion of this is provided in the Direct Gamma Radiation chapter.

The many samples and measurements of the environment around Vermont Yankee provide evidence that no significant adverse health effects from radiological exposures are likely from the operation of the Station. To further investigate this, we publish statistics regarding specific potential adverse health effects for people who live near the Station in this report. These statistics show that cancer incidence and cancer mortality rates in the communities around Vermont Yankee did not differ significantly from those in the rest of Windham County or Vermont as a whole.

A summary table of environmental surveillance results is found in the Introduction chapter, and detailed presentations of the sampling methods and data are in the rest of the report. The information is 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 using samples and measurements in the communities surrounding the station. In reviewing the data tabulated here, you will find comparisons of some 2007 results to long-term historical trends. With the exception of direct gamma radiation as measured at the site boundary, these comparisons show no significant increased radiological exposures due to Vermont Yankee Nuclear Power Station operations.

As documented in the Oak Ridge Associated Universities Report of January 2007, past Vermont Department of Health reports of direct gamma radiation doses at the Vermont Yankee site boundary or fence line have been overstated by reporting the dosimeter measurement without applying an exposure to dose equivalent conversion factor. This is important to note given that exposures and calculated doses around Vermont Yankee have increased as a result of Extended Power Uprate and corrosion control practices. The Department concurs with the Oak Ridge Associated Universities Report recommendation and applies the recommended conversion factor to the 2007 exposure data as part of its analysis of direct gamma radiation at the site boundary or fence line.

This Report also contains 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. Some background measurements were obtained in Windham County, while others were obtained in other parts of Vermont. Measurements around Vermont Yankee that are significantly above the normal range of background may generally be attributed to the station, other uses of radioactivity in the measurement area, and/or changing meteorological conditions. The report also includes maps that show the locations where samples are collected or where measurements are made.

All of the measurements in this report are presented at the 95 percent confidence level. This means we are 95 percent certain (not due to chance alone) that the results lie within two standard deviations on either side of the mean. The mean is the reported result, usually found in the tables next to the location identifier, and the uncertainty, often called the error, is the plus or minus factor associated with that result. The error is usually found in the column immediately next to the mean result in the tables.

Some samples and measurements are being collected or made continuously. Other samples are taken periodically. With one exception, all of the samples are analyzed by the Vermont Department of Health Laboratory in Burlington, Vermont. Measurements of direct gamma radiation exposures using thermoluminescent dosimeters are analyzed by National Voluntary Laboratory Accreditation Program vendors. 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 and identity 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 and identity 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.

With regard to environmental surveillance, 2007 was notable for two reasons. First, it was the first full year within which Vermont Yankee operated in Extended Power Uprate. Second, it was the first year within which many improvements were fully incorporated into the Vermont Department of Health monitoring of direct gamma radiation exposures and public doses at Vermont Yankee.

The Effects of Extended Power Uprate

Extended Power Uprate, operating the reactor, turbine and generator systems at 120 percent of originally licensed levels, was initiated in early 2006. It was known that operating the plant at Extended Power Uprate would increase direct gamma radiation levels everywhere on and near the plant site. Before Extended Power Uprate was authorized by the United States Nuclear Regulatory Commission and the Vermont Pubic Service Board, it was calculated that radiation levels would increase 26 percent with Extended Power Uprate. After operating at Extended Power Uprate for a full year, it was determined that actual increases for the year 2007 were about 30 percent.

So, why did a 20 percent increase in power increase direct gamma radiation levels by more than an equal 20 percent? One reason is the simple fact that predictions, no matter how thoroughly made, are rarely equal to actual results. Another answer to this question is found in Vermont Yankee's reactor coolant water chemistry. Specifically, like other nuclear power plants, Vermont Yankee injects hydrogen into and adds noble metals to the reactor coolant system to help prevent corrosion in plant systems and components. The operators of Vermont Yankee Nuclear Power Station began injecting hydrogen and adding noble metals into the reactor coolant system after the 2001 refueling outage. Hydrogen injection prevents corrosion by scavenging oxygen from the reactor coolant. Oxygen is essential to corrosion. The addition of noble metals into the reactor coolant inhibits corrosion by forming a protective layer on the inside of reactor coolant components with metals that resist corrosion. Noble metals include gold, silver, tantalum and palladium.

A side effect of hydrogen injection and noble metals chemistry in a nuclear reactor is increased radiation levels. Nuclear reactor coolant radiochemistry is complicated, and it is unnecessary to go into details here, but the general effect of the two processes is an increased production of nitrogen-16 or ^{16}N. Nitrogen-16 is a radioactive isotope of non-radioactive nitrogen. Nitrogen is a primary element in air, in water that contains air, and

in systems that circulate water through power plants, including reactor coolant water. It may also be formed by a nuclear reaction with oxygen in water. Nitrogen-16 is also the predominant radioactive material contributing to general public doses from Vermont Yankee nuclear operations because it emits very high energy gamma radiations. The energy levels are high enough to cause measurable public doses outside the Vermont Yankee site boundary.

With increased nitrogen-16 production due to hydrogen injection and noble metals chemistry and a 120 percent reactor power increase with Extended Power Uprate, one result was a thirty percent increase in radiation levels at the plant, including at the site boundary, the fence line and other nearby public locations. The effects of Extended Power Uprate, hydrogen injection and noble metals chemistry had never been observed for a full year at Vermont Yankee until 2007. The three factors combined to increase radiation levels significantly over levels measured in previous years. These combined effects will be seen as long as Vermont Yankee operates under these conditions.

Improvements in Vermont Yankee Direct Gamma Radiation Monitoring

The second important development was the incorporation of improvements into the methods for determining public doses from the measured exposures of direct gamma radiation at Vermont Yankee. Some of these improvements were recommendations of the Oak Ridge Associated Universities report published in 2007. This report was written after more than a year of investigation by technical experts working for the Vermont Department of Health. The report, *An Evaluation of Direct Gamma Dose at the Site Boundary of the Vermont Yankee Nuclear Power Station*, may be accessed at the Department of Health web site, at the following web address:

http://healthvermont.gov/enviro/rad/yankee/013107Site%20BoundaryEvaluation.pdf

Even before the Oak Ridge Associated Universities Report, the Vermont Department of Health began improving its direct gamma radiation measurement methods, and some of these were reported in the 2006 Environmental Surveillance Report. For example, in 2006, the Department of Health stopped using just two dosimeter sites to calculate direct gamma radiation background. Instead, background was determined using the mean of 34 different dosimeter sites. These sites are in parts of Windham County unaffected by Vermont Yankee operations, and the Department has been taking measurements of direct gamma radiation there for many years. A general rule in statistics is that your estimate of the true value of the mean (average) for any real population is better estimated with a larger sample size. Thus, the background we calculate using 34 dosimeter sites is more likely closer to the true background than that calculated using two dosimeter locations.

Another effort begun in 2006 was a comparison of different dosimeter vendors. Over eleven months in 2006 and 12 months in 2007, the Vermont Department of Health deployed the dosimeters of two different vendors. Through this process we determined that one dosimeter vendor has preferable qualities as compared to the other and the Department will use only the dosimeters of the selected vendor beginning in 2008. One particular quality we prefer is how the chosen vendor reports only exposures recorded while the dosimeters are in place in the field. The other vendor reports exposures from the time the dosimeters leave their facility. We also prefer the selected vendor's treatment of potential errors in the various steps of dosimeter deployment, retrieval and processing activities. It should be pointed out that the measurements of exposure for 2007 from the selected vendor's dosimeters were higher than those of the vendor.

One other improvement is very important. In prior years, the Vermont Department of Health measurements of site boundary dose were compared to a limit expressed with uncertainty. In particular, past statements by the Department indicated that the annual limit for direct gamma radiation was 20 plus or minus 5 millirem. The Department of Health will no longer use this approach. Uncertainty will not be expressed as part of the

limit, but as a part of the measurements. Beginning in 2008, the Department will use a hard and fast 20 millirem per year as the direct gamma radiation dose limit.

Another improvement incorporated in 2006 before the Oak Ridge Associated Universities Report is in the propagation of error. This is a mathematical process that more accurately accounts for the uncertainty of multiple time-dependent measurements that are added together as is the case for the annual summation of quarterly doses. If you would like further explanation of the propagation of error, please contact our office.

Of the Oak Ridge Associated Universities Report recommendations, the use of a dose conversion factor is among the most significant. As noted above, the Department concurs with this recommendation and in this report is applying the conversion factor in its analysis of the direct gamma radiation exposures at the site boundary. In adopting this recommendation, the Department determined that it is appropriate to also apply the conversion factor in its analysis of all direct gamma or x-ray radiation exposures. Therefore, in addition to Vermont Yankee, the Department is also applying the conversion factor to other entities such as the medical, dental and industrial X-ray registrants whom the Department of Health regulates. In applying the conversion factor, the Department reports exposures to radiation in milliroentgen, and we report biological doses to radiation in millirem. Doses in millirem were calculated using the guidance for energy specific dose conversion factors in *American National Standards Institute Standard ANSI/ANS-6.1.1-1991, Neutron and Gamma-ray Fluence-to-dose factors.*

These dose conversion factors account for the fact that human dose from an agent is not equal to the amount measurable in the environment to which they are exposed. As an example, consider exposure to another form of radiation - heat. If you are exposed to a temperature of 50 degrees Celsius, about 122 degrees Fahrenheit, your actual body temperature does not increase to 50º C. Your dose is like the actual body temperature your body rises to in response to being exposed to 50º C. In particular, your core body temperature may increase only 1º C for every 25º C increase in ambient temperature.

In the same way, when we are exposed to 20 milliroentgen of direct gamma radiation, our actual dose from that exposure is less. For the gamma radiation energies near the Vermont Yankees site boundary, the dose conversion factor is 0.60. Our bodies absorb a dose of about 0.60 millirem for each milliroentgen exposure. To put it another way, 20 milliroentgen of direct gamma radiation exposure leads to approximately 12 millirem of radiation dose. As such, starting with this 2007 report, the thermoluminescent dosimeter measurements of exposure around Vermont Yankee are being converted to dose using this 0.60 conversion factor. At least for this year, we will report both the unconverted exposure and the converted dose.

As mentioned above, the use of a conversion factor is appropriate for all our determinations of dose. In 2007, the Vermont Department of Health also started using the ANSI/ANS-6.1.1-1991 dose conversion factors for its report of occupational and patient doses from exposures to medical and dental x-rays. We will apply these conversion factors in all of our exposure and dose determinations for radiological surveillance activities in the future.

The ANSI/ANS-6.1.1-1991 exposure to dose conversion factor is just one of the many recommendations made in the Oak Ridge Associated Universities Report. Some recommendations will be adopted in our efforts to continually improve our processes. In addition to recommendations to the Vermont Department of Health, the report made recommendations to Vermont Yankee Nuclear Power Station. The station has also begun to implement improvements to its direct gamma radiation exposure assessment processes. One is a new determination of the direct gamma radiation characteristics under Extended Power Uprate and as effected by installation of the new turbine shield. Another is the development of methods to better account for changes in site boundary exposures and doses with low level and high level radioactive waste storage and other operations onsite.

Returning to the report as a whole, 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 also describes valuable expertise and capabilities of the Vermont Department of Health Laboratory and its scientific staff. Vermonters are served well by the staff and other resources there that allow the Health Department to conduct 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.

The entire report is published at the Vermont Department of Health web site www.healthvermont.gov. Should you have questions about the content, please call the Vermont Department of Health Radiological Health Program at 802-865-7730.

Program Results Summary

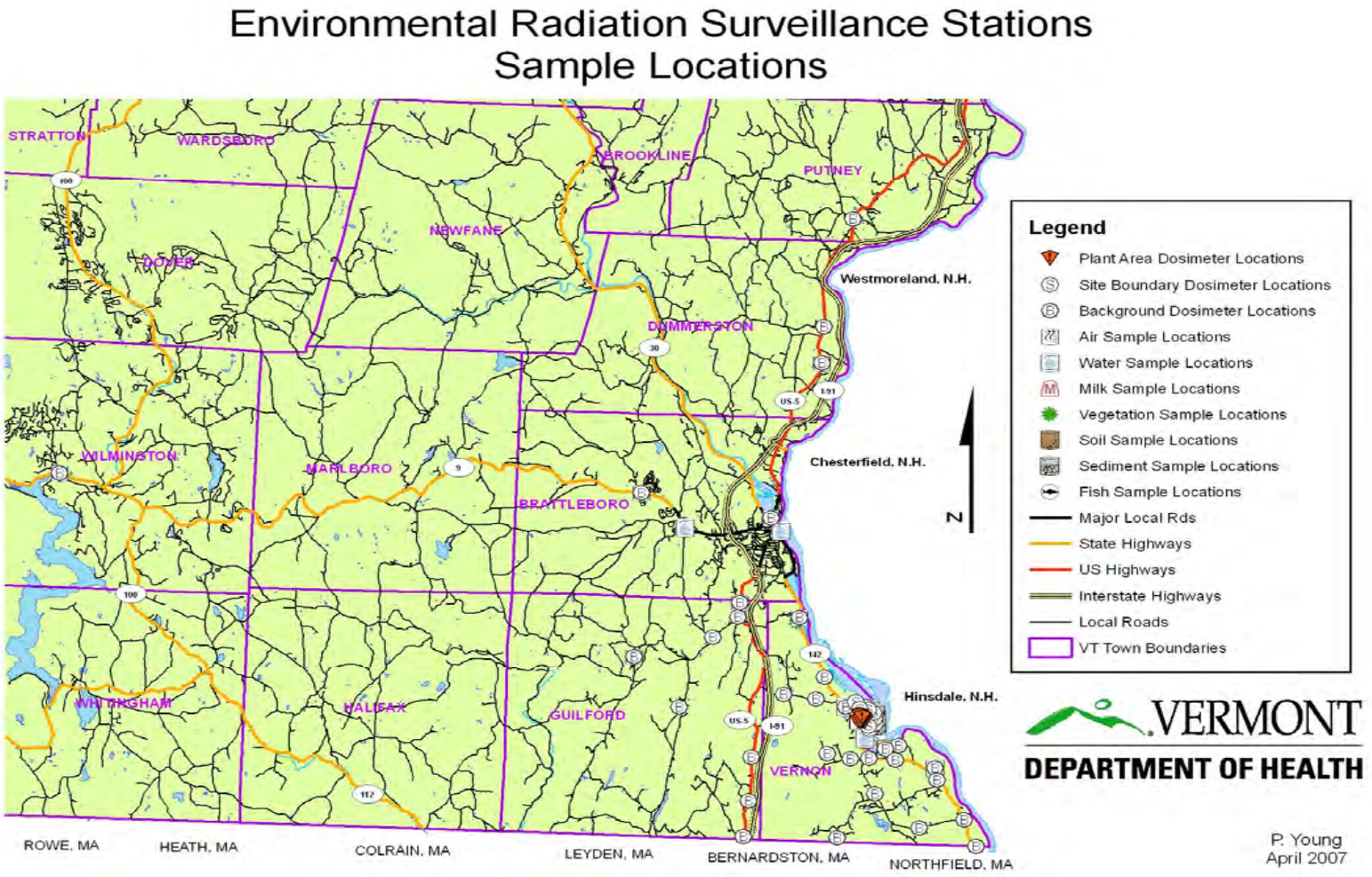
The number of samples and analyses in the Vermont Department of Health environmental surveillance program for the Vermont Yankee Nuclear Power Station is indicative of a significant commitment to evaluating compliance with Department of Health regulations and protecting public health. Table 1 indicates the number of sample types, the number of measurements or sample collection locations, the total number of samples collected, the analysis types and the overall results for each sample type. 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. 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/.

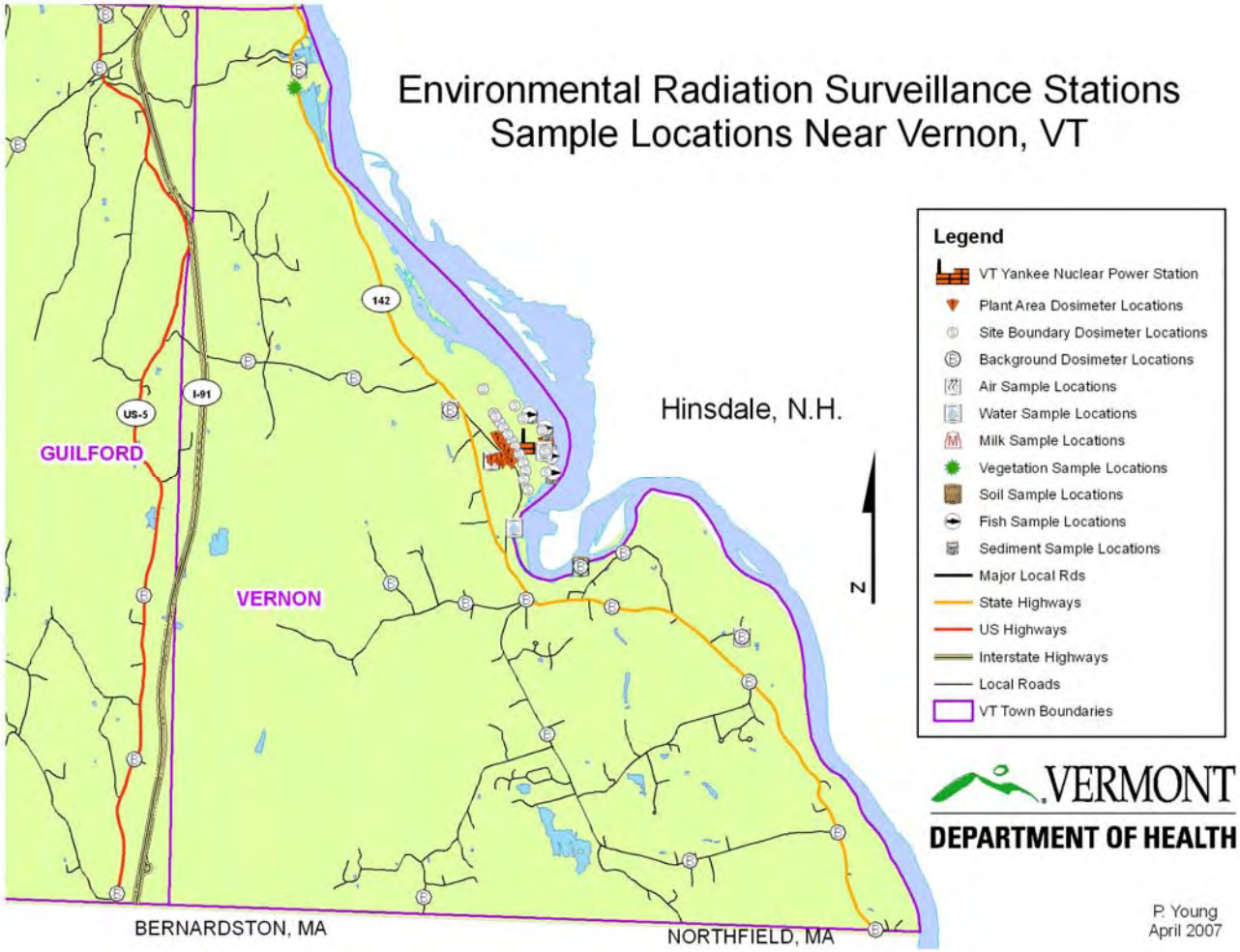
Table 1. Summary of 2007 Samples, Analyses and Results

Sample Type	Locations	Samples	Analysis Type	Results
Direct Gamma Radiation	71	284	Thermoluminescent Dosimeter	Less than the dose limits of 10 millirem per calendar quarter and 20 millirem per calendar year
Air Particulates, Gases,Vapors	9	108	Total Alpha Radioactivity	Within historical range; mean results near VYNPS similar to those further from VYNPS
		108	Total Beta Radioactivity	Within historical range; mean results near VYNPS similar to those further from VYNPS
		108	Iodine-131 Radioactivity	All samples less than lower limit of detection of 0.00 38 pCi/m^3
		108	Total Gamma Radioactivity	All detected gamma radioactivity of natural origin
		4	Total Particulate Gamma Radioactivity	All detected gamma radioactivity of natural origin
Water	13	120	Total Alpha Radioactivity	Within historical range; mean results near VYNPS similar to those further from VYNPS
		120	Total Beta Radioactivity	Within historical range; mean results near VYNPS similar to those further from VYNPS
		120	Tritium Radioactivity	All samples less than the lower limit of detection of 300 pCi/l
		120	Total Gamma Radioactivity	All detected gamma radioactivity of natural origin
		9	Radium-226 Radioactivity	All samples well below EPA action levels of 5 pCi/l
		9	Radium-228 Radioactivity	All samples well below EPA action levels of 5 pCi/l
		6	Uranium Radioactivity	All samples well below VT limit of 20 mg/l
Milk	2	11	Iodine-131 Radioactivity	All samples less than the lower limit of detection of 2.53 pCi/l
		11	Total Gamma Radioactivity	All detected gamma radioactivity of natural origin
Vegetation	11	18	Total Gamma Radioactivity	All of natural, Chernobyl or nuclear weapons testing origin
Soil	14	14	Total Gamma Radioactivity	All of natural, Chernobyl or nuclear weapons testing origin
River Sediments	18	36	Total Gamma Radioactivity	All of natural, Chernobyl or nuclear weapons testing origin
Fish	4	4	Total Gamma Radioactivity	All detected gamma radioactivity of natural origin
Totals	142	1318		

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 = 1,000 millirem), people exposed have a statistically higher risk of cancer as compared to people incurring 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 as low as reasonably achievable. 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

With the Surveillance 2006 Report on Public Health Monitoring published in 2007, the Vermont Department of Health began presenting information about certain health outcomes in the vicinity of Vermont Yankee. Environmental sampling is important in determining compliance with regulations and verifying that radioactivity and radiation exposures remain at or near background levels. 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 presented below.

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 June 5, 2008. The incidence rates are for all cancers, for invasive thyroid cancers, for leukemia and for childhood (pediatric) cancers for the years 1995 - 2004. 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, for invasive thyroid cancer and for leukemia, 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 rates in Windham County, and in the rest of Vermont and the United States white population as a whole. The incidence rates for pediatric cancers in the six towns could not be calculated as there were too few cases (less than 6) over the time period studied. The pediatric cancer incidence rate in Windham County, however, was calculated and it is lower than that in Vermont and the United States white population as a whole. Similar results were seen in the incidence rates in last year's report which covered the five year period 1994 - 2003.

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
DEPARTMENT OF HEALTH

Vermont Cancer Registry

Vermont and U.S. Cancer Incidence, All Sites, Males and Females, 1995 – 2004 (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	101263
Vermont	493.4	487.9	498.9	3078
Windham County	470.3	451.2	490.1	230
Emergency Zone	427.1	400.4	455.4	97

Vermont and U.S. Cancer Incidence, Invasive Thyroid Cancer, Males and Females, 1995-2004

	Rate	Lower CI	Upper CI	Avg. cases per year
U.S. White	8.2	8.0	8.3	1707
Vermont	7.2	6.6	7.9	45
Windham County	6.2	4.2	9.0	3
Emergency Zone	5.5	2.8	10.0	1

Vermont and U.S. Cancer Incidence, Leukemia, Males and Females, 1995-2004

	Rate	Lower CI	Upper CI	Avg. cases per year
U.S. White	13.5	13.3	13.7	2791
Vermont	13.4	12.5	14.4	82
Windham County	14.1	10.9	18.0	7
Emergency Zone	9.7	6.1	15.1	2

Vermont and U.S. Cancer Incidence, Pediatric Cancers (< Age 20), Males and Females, 1995-2004 (Urinary Bladder includes malignant and in situ)

	Rate	Lower CI	Upper CI	Avg. cases per year
U.S. White	17.4	17.1	17.8	966
Vermont	17.6	15.6	19.8	29
Windham County	15.7	9.3	25.0	2
Emergency Zone	--	--	--	--

-- Rates are only presented when the number of cases is greater than 6. All rates are age adjusted to the 2000 U.S. standard population.

In Table 3, mortality rates from cancer in the United States (U.S. white rate), Vermont, Windham County and the six towns near Vermont Yankee Nuclear Power Station are presented for the ten years 1996 - 2005. The Vermont data are from the Vermont Department of Health's Vital Statistics System, last updated in June 2008, and the U.S. data were taken from the Surveillance, Epidemiology, and End Results (SEER) Program at the National Cancer Institute at www.seer.cancer.gov . The data in this table indicate there are no statistical differences in the death rates from malignant neoplasms, leukemia, thyroid cancer and pediatric cancer (ages 0 – 19 malignant neoplasms) among the six towns near Vermont Yankee and Windham County, Vermont and the United States (U.S. white population) as a whole.

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 1996 – 2005 cancer mortality rates in the towns of Brattleboro, Dummerston, Guilford, Halifax, Marlboro and Vernon are not different than those for Windham County, Vermont, or the U.S. white population as a whole. Though the six towns, Windham County and Vermont as a whole have higher mortality rates than the rate for the U.S. white population as a whole, none are statistically higher than the rate for the U.S. white population.

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 489.8 cases per 100,000 persons. In the six towns near Vermont Yankee, the all cancer incidence rate is 427 cases per 100,000 persons. We are 95 percent confident that the actual rate is between 400.4 cases and 455.4 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 1995 and 2004 than Vermont and the U.S.

For an example from the second collection of rates in Table 3, it initially appears that deaths from malignant neoplasms (all sites, all ages) 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 malignant neoplasms was 203.17 deaths per 100,000 persons, while the death rate from malignant neoplasms in the six towns near Vermont Yankee was 211.53 deaths per 100,000 persons. We are 95 percent confident that these rates fall between 190.81 and 216.32 deaths per 100,000 persons in Windham County, and between 193.22 and 231.53 deaths per 100,000 persons in the six towns. Because these confidence intervals overlap, the two malignant neoplasm death rates are not statistically different. The same conclusion is drawn relative to Vermont as a whole – the all sites, all ages cancer mortality rates are not significantly different. Also, the same is true relative to the U.S. white population – the all sites, all ages cancer mortality rates are not significantly different since the confidence intervals overlap.

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

VERMONT RESIDENTS AND U.S. WHITES

ALL AGES	Malignant Neoplasms (all sites)		
	# Deaths	Rates(1)	95% CI
Brattleboro, Dummerston, Guilford, Halifax, Marlboro, Vernon, 1996-2005	502	211.53	(193.22, 231.53)
Windham County, 1996 - 2005	1,015	203.17	(190.81, 216.32)
Vermont, 1996-2005	12,224	193.36	(189.94, 196.84)
U.S. White, 1996-2005	4,769,323	193.24	(193.07, 193.42)
ALL AGES	**Leukemia**		
	# Deaths	**Rates(1)**	**95% CI**
Brattleboro, Dummerston, Guilford, Halifax, Marlboro, Vernon, 1996-2005	19	8.19	(4.90, 13.34)
Windham County, 1996 - 2005	36	7.3	(5.09, 10.37)
Vermont, 1996-2005	481	7.7	(7.03, 8.44)
U.S. White, 1996-2005	190,024	7.72	(7.69, 7.76)
ALL AGES	**Thyroid Cancer**		
	# Deaths	**Rates(1)**	**95% CI**
Brattleboro, Dummerston, Guilford, Halifax, Marlboro, Vernon, 1996-2005	*	0.44	(0.00, 3.20)
Windham County, 1996 - 2005	*	0.5	(0.05, 2.13)
Vermont, 1996-2005	23	0.4	(.26, .60)
U.S. White, 1996-2005	11,403	0.46	(.45, .47)
AGES 0-19	**Malignant Neoplasms (all sites)**		
	# Deaths	**Rates(2)**	**95% CI**
Brattleboro, Dummerston, Guilford, Halifax, Marlboro, Vernon, 1996-2005	*	2.26	(0.00, 16.50)
Windham County, 1996 - 2005	*	1.8	(0.15, 8.09)
Vermont, 1996-2005	39	2.4	(1.70, 3.35)
U.S. White, 1996-2005	17,710	2.82	(2.78, 2.86)

(1) Rates are age-adjusted to the U.S. 2000 standard population per 100,000 persons
(2) U.S. White rate is Crude Rate, not age-adjusted
* Less than 5 deaths reported
Source of Vermont data: VT Department of Health Vital Statistics System
Source of U.S. White data: Surveillance, Epidemiology, and End Results (SEER) Program;
National Cancer Institute - Cancer Statistics Branch

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 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 radiation from 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. As it does pass through your body, the radiation energy 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 to which the thermoluminescent dosimeter was exposed.

While the dosimeter's radiation exposure is directly proportional to the wearer's radiation exposure, the Oak Ridge Report made it clear that the radiation dose the wearer absorbs from this exposure is not equal to the dosimeter exposure. According to the Oak Ridge Report, the human body absorbs about 60 percent of the radiation energy to which it is exposed at the energy levels found near the nuclear power station. As described earlier, the thermoluminescent dosimeter exposure results are converted to human dose prior to being compared to the regulatory dose limits. Because this is the first year doing this for Vermont Yankee, we will show both the exposure values from the thermoluminescent dosimeters and the converted biological dose equivalent.

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 neutron-activated reactor coolant water at a nuclear power plant. Other important reactor-generated gamma radiation emitters include the particulate solids cobalt-60 and cesium-137, vaporous iodine-131 and gaseous 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. The Oak Ridge Report documented that this assumption results in overstating the biological dose equivalent. Following the recommendation of the Oak Ridge Report, the Department of Health now converts the exposures measured by the dosimeters in milliroentgen to biological dose equivalent in millirems using the guidance of nationally recognized standards, in particular, the 0.6 millirem per milliroentgen dose conversion factor of *American National Standards Institute Standard ANSI/ANS-6.1.1-1991, Neutron and Gamma-ray Fluence-to-dose Factors.*

Both personnel and environmental thermoluminescent dosimeters are used to measure beta and gamma radiation exposure. The Vermont Department of Health accounts for exposures from beta radiation with our analyses of beta radiation in water and air samples. This is appropriate because beta radiation, like alpha radiation, contributes to whole body dose essentially only through internal contamination by radioactive materials inhaled or ingested into the body. It is to these kinds of samples we turn next.

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-238 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 also cause skin dose. Risks from beta radiation exposure of the skin are low, on the order of ten times lower than whole body irradiation by gamma rays.

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, 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 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. Obviously, our concern is that radioactive materials in these parts of our bodies may subject our bodies to unnecessary risk. Thus far, in the history of Vermont Yankee surveillance, the Vermont Department of Health has found no significant reactor-produced radioactive contaminants in the environment near the station. Department records indicate that those contaminants that have been identified in past years were small amounts unlikely to be associated with any adverse public health effects. Results this year do not indicate any additional VYNPS-related radioactive contaminants in the environment.

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.

Radioactive materials that emit gamma radiation are 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 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 number of gamma radiation photons emitted by the sample over a given counting time. 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 separate 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 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. All of these water samples are analyzed specifically for tritium (hydrogen-3).

Beginning in 2007, the Vermont Department of Health Laboratory analyzed samples from each of the ground water locations for naturally occurring uranium and radium. These radioactive materials emit alpha, beta and gamma radiation, and have contributed to elevated radiation levels in water samples for decades. The Vermont Department of Health will periodically test these water sources for uranium and radium to keep track of their possible impact on other water sample results.

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. These analyses are via gamma spectroscopy at the Vermont Department of Health Laboratory.

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 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 exposure results in Tables 5a, 6a and 7a below are in units of milliroentgen. The unit milliroentgen (mR) is a unit of exposure, and environmental thermoluminescent dosimeters only record exposure. The calculated dose equivalents are shown in units of millirem in Tables 5b, 6b and 7b. These dose equivalents were calculated using the 0.60 millirem per milliroentgen conversion factor.

When evaluating compliance with Vermont Department of Health regulations, measurements of exposure are taken. These measurements record exposures in units of milliroentgen (mR). The regulations are in units of dose equivalent in millirem. Obtaining dose equivalents in millirem from exposures in milliroentgen requires use of nationally recognized dose conversion factors in accordance with Vermont Department of Health Regulations for Radiation Protection, specifically Section 5-305, Standards. The Department of Health uses the dose conversion factors found in *American National Standards Institute Standard ANSI/ANS-6.1.1-1991, Neutron and Gamma-ray Fluence-to-dose Factors* as recommended in the Oak Ridge Report. The use of such dose conversion factors is done whether we are evaluating compliance for the use of medical X-rays or whether we are evaluating compliance at Vermont Yankee Nuclear Power Station. After calculating the dose equivalents, they are compared to the Vermont Department of Health limits. There are two relevant limits: no more than 10 millirem per calendar quarter and no more than 20 millirem per calendar year. For 2007, neither any quarterly limit nor the annual limit was exceeded.

Background Gamma Radiation

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 measurements at 34 locations unlikely to be affected by Vermont Yankee Nuclear Power Station to establish what the background exposure levels are. 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.

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 and dose equivalents reported in Tables 5a, 5b, 6a, 6b, 7a and 7b 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 2007 are presented in summary in Table 4 at the 95 percent confidence level. These results, as well as the complete results in Tables 5a, 5b, 6a, 6b, 7a and 7b, are provided in units of both gamma radiation exposure, milliroentgen (mR), and in units of biological dose equivalent, millirem (mrem) as converted using the Oak Ridge dose conversion factor, for completeness and for technical accuracy.

Note also that the tables have more columns than last year's direct gamma radiation dose table. In Table 4, there are four columns to the right of the calendar quarter column. These columns allow for comparison of the exposures and calculated doses as calculated using the 0.60 dose conversion factor for two different dosimeter vendors used in 2007. As described earlier, the Department of Health used two different dosimeter vendors for most of 2006 and all of 2007. This was done to compare the qualities of the two vendors for subsequent choice between them. The Vermont Department of Health chose AREVA NP Dosimetry Services to be its dosimetry vendor for 2008 and beyond.

Table 4. Mean Direct Gamma Radiation Background for 2007

	Exposure		Dose Equivalent	
Calendar Quarter of 2007	Mean Background Exposure and Error (mR) at the 95% Confidence Level	Mean Background Exposure and Error (mR) at the 95% Confidence Level	Mean Background Dose Equivalent and Error (mrem) at the 95% Confidence Level	Mean Background Dose Equivalent and Error (mrem) at the 95% Confidence Level
	Vendor 1	AREVA NP	Vendor 1	AREVA NP
January 1 to March 31	20.3 ± 1.8	13.3 ± 2.2	12.2 ± 1.1	8.0 ± 1.3
April 1 to June 30	18.0 ± 3.4	13.9 ± 2.6	10.8 ± 2.1	8.4 ± 1.6
July 1 to September 30	22.6 ± 3.2	14.8 ± 3.1	13.6 ± 1.9	8.9 ± 1.8
October 1 to December 31	21.6 ± 3.3	14.1 ± 2.5	13.0 ± 2.0	8.5 ± 1.5
Calendar Year 2007	82.5 ± 6.0	56.2 ± 5.2	49.5 ± 3.6	33.7 ± 3.1

Uncertainty of Dosimeter Measurements

All dosimeter measurements over 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; and, 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 was greater when only two dosimeters were used to calculate the mean background, as compared to when the mean background is calculated from 34 background thermoluminescent dosimeter

measurements, as was begun in 2006. 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 past, the Vermont Department of Health indicated it would account for uncertainty in the direct gamma radiation measured at the site boundary by allowing up to 25 percent more radiation than the limit. This was seen in expressing the limit as 20 plus or minus 5 millirem. Unlike the new methods for accounting for uncertainty, the plus or minus 5 millirem factor for uncertainty was not accurately calculated. Instead, and from this time onward, the Department of Health will express uncertainty as it is calculated and where it exists in the measurements. Our calculated uncertainty using this approach is actually much less than the 25 percent uncertainty previously accepted.

2007 Direct Gamma Radiation Exposures and Calculated Dose Equivalents

In the six 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 (Tables 5a and 5b), in the immediate area around the station (Tables 6a and 6b) and, to establish a background radiation level, in parts of Windham County distant from the station (Tables 7a and 7b).

Tables 5a and 5b list the results for 2007 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. Four of the 12 are on the east side of the plant on the Connecticut River. The remaining eight fence line dosimeters, DR-53, VY Parking Lot, VY Parking Lot #2, DR-51, DR-07, DR-41, T05 and T06 are all located on the west side of the site 350 feet or more closer to the station's sources of direct gamma

radiation than the actual site boundary. Nevertheless, because the fence line was originally more coincident with the actual site boundary, the fence line 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 5a, there are three Vendor 1 thermoluminescent dosimeters and five AREVA NP dosimeters that measured direct gamma radiation exposure in excess of 20 milliroentgen. Applying the 0.60 millirem per milliroentgen dose conversion factor as recommended in the Oak Ridge Report in Table 5b, you can see that none of the Vendor 1 or AREVA NP thermoluminescent dosimeters exceeded the 20 millirem dose equivalent per year limit., All the exposure results in Table 5a were arrived at by subtracting the mean exposure from the 34 background dosimeters from the net exposure results for each of the site boundary dosimeters. The physical locations of these 34 background dosimeters, and the net results for each of them, are found in Table 7a.

The actual biological dose equivalent results in Table 5b were calculated by multiplying the exposure results in Table 5a by the 0.60 millirem per milliroentgen dose conversion factor appropriate for gamma radiation energies at the site boundary from *American National Standards Institute Standard ANSI/ANS-6.1.1-1991, Neutron and Gamma-ray Fluence-to-dose Factors*. The error for the annual results is the total propagated error at the 95 percent confidence level.

The plant area exposures were arrived at in the same way. The mean background exposure results from the 34 background thermoluminescent dosimeters was subtracted from the net plant area dosimeter measurements. The results are found in Table 6a. The dose equivalents are calculated using the ANSI Standard dose conversion factor and presented in Table 6b.

Note that the exposure and dose equivalent results for the Vernon Elementary School are less than half the exposure and dose equivalent values for the plant's western site boundary or fence line. The Vernon Elementary School measurement locations are listed as Vernon School Nurse, VDH DR06, Vernon School A/S and Vernon School Pole. The Vernon School Nurse measurement site is inside the school, while the other locations are outside the building. The location called Governor Hunt Road #39 is a telephone pole immediately between the plant site boundary and the school.

The net background exposure and dose equivalent results are displayed in Tables 7a and 7b, respectively. Like the results in Tables 5a and 5b, 6a and 6b, these results are net measurements, meaning that the mean of the 34 background dosimeter exposures was subtracted from each of the individual measurements. That is why some of the measurements are close to zero.

Maps 4, 5, 6 and 7 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.

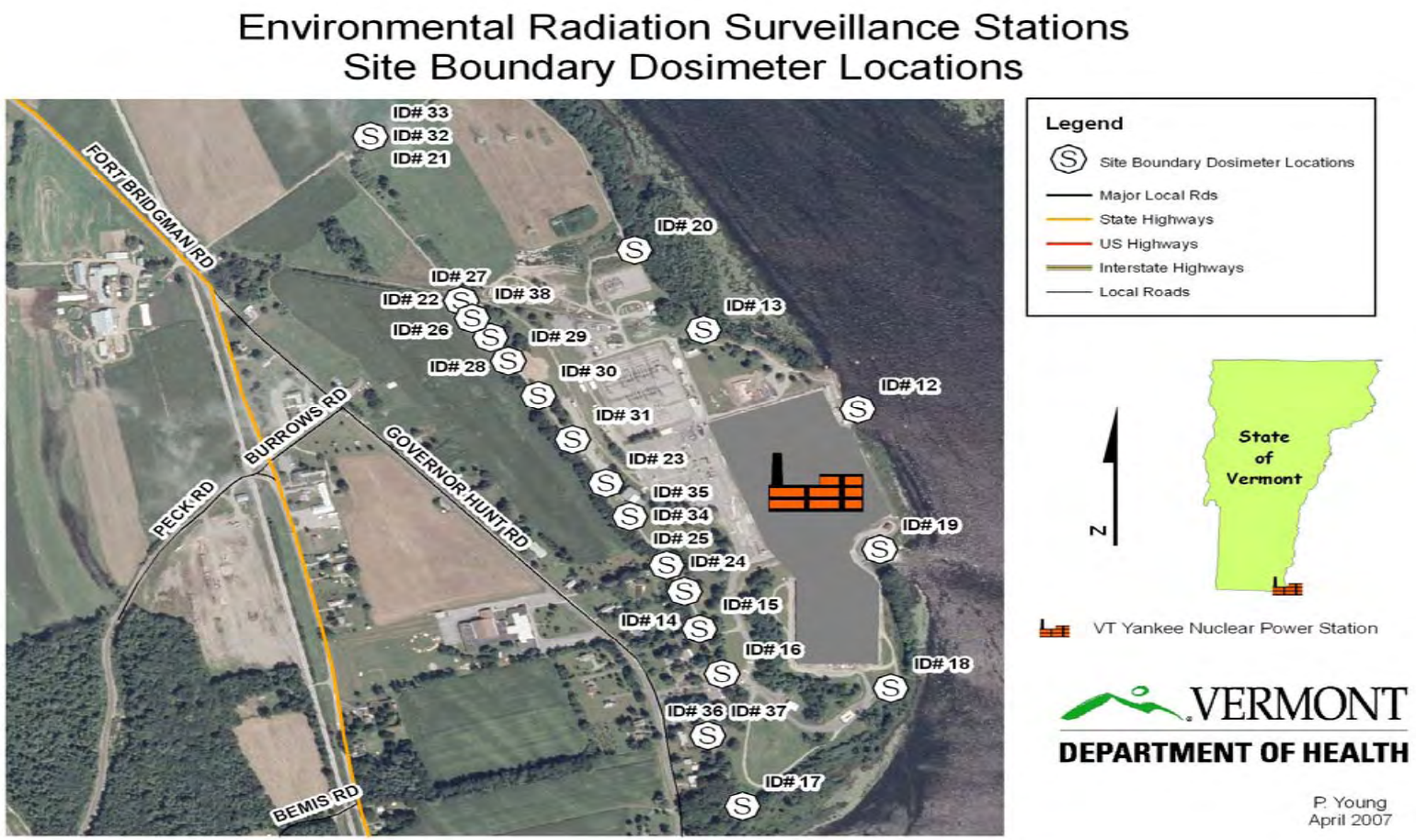
Table 5a. Net VYNPS Site Boundary TLD Exposure Results for 2007 in Milliroentgen

	Vendor 1 TLDs										AREVA, NP TLDs									
Location	Q 1 Net	2 SD Error	Q 2 Net	2 SD Error	Q 3 Net	2 SD Error	Q 4 Net	2 SD Error	2007 Net	2 SD Error	Q 1 Net	2 SD Error	Q 2 Net	2 SD Error	Q 3 Net	2 SD Error	Q 4 Net	2 SD Error	2007 Net	2 SD Error
VDH T01	0.0	0.0	0.4	0.0	1.4	1.1	0.0	1.1	1.7	1.6	0.0	0.0	0.8	0.0	0.6	1.1	0.5	0.0	1.9	1.1
VDH T02	0.0	2.3	2.4	0.0	0.0	1.1	0.0	2.3	2.4	3.4	0.1	2.3	0.6	0.0	1.0	1.1	0.4	1.1	2.1	2.7
VDH T03	0.4	1.1	1.0	1.1	0.0	0.0	0.0	3.0	1.4	3.4	0.0	1.1	0.9	1.1	0.6	0.0	0.9	2.3	2.4	2.8
VDH T04	1.1	0.0	0.0	1.1	1.4	1.1	1.4	0.0	3.8	1.6	1.2	0.0	1.5	1.1	1.5	1.1	0.6	2.0	4.8	2.5
VDH T05	0.1	5.7	1.7	0.0	2.4	3.0	1.4	0.0	5.5	5.9	1.3	5.7	2.6	0.0	2.3	3.0	2.0	2.0	8.3	6.2
VDH T06	0.4	1.1	2.0	2.0	5.4	0.0	3.7	4.1	11.5	4.7	2.2	1.1	2.9	2.0	3.6	0.0	2.3	2.3	10.9	3.2
VDH DR07	1.4	1.1	3.0	1.1	4.0	1.1	4.7	1.1	13.2	2.2	4.0	1.1	4.8	1.1	3.7	1.1	3.7	2.0	16.1	2.7
VDH DR08	2.4	1.1	5.7	1.1	6.4	1.1	5.4	2.0	19.8	2.7	5.7	1.1	5.2	1.1	6.2	1.1	6.3	1.1	23.4	2.2
VDH DR41	0.7	0.0	2.0	1.4	0.4	1.1	0.0	1.1	3.2	2.1	1.7	0.0	1.8	1.4	2.0	1.1	1.3	2.3	6.8	2.9
VY SW Fence	0.0	1.1	0.0	2.3	0.0	0.0	0.0	1.1	0.0	2.8	0.0	1.1	0.1	2.3	0.6	0.0	0.2	1.1	0.8	2.8
VY SW Fence #2	0.0	1.1	0.7	2.0	0.0	0.0	0.0	1.1	0.7	2.5	0.2	1.1	0.6	2.0	0.7	0.0	0.3	1.1	1.8	2.5
VDH DR42	0.0	0.0	0.7	1.1	0.7	1.1	0.0	1.1	1.4	1.9	0.6	0.0	0.6	1.1	1.1	1.1	0.4	1.1	2.7	1.9
VDH DR43	1.4	0.0	2.4	1.4	3.4	1.1	3.4	3.9	10.5	4.3	2.5	0.0	2.8	1.4	2.6	1.1	2.8	1.1	10.6	2.1
VDH DR44	4.4	1.1	5.0	1.1	5.4	4.1	5.0	1.1	19.8	2.8	6.6	1.1	5.7	1.1	6.3	4.1	7.7	1.1	26.3	2.8
VDH DR45	10.7	3.0	17.7	1.1	14.7	2.3	21.0	4.1	64.2	5.4	17.8	3.0	18.4	1.1	19.8	2.3	22.4	2.0	78.4	4.0
VDH DR46	3.7	2.0	4.0	2.0	5.7	2.0	5.0	1.1	18.5	3.3	6.3	2.0	5.6	2.0	7.2	2.0	6.4	1.1	25.5	3.3
VDH DR47	1.1	1.1	2.7	0.0	3.0	2.0	1.7	1.1	8.5	2.1	3.1	1.1	2.8	0.0	5.7	2.0	1.9	2.0	13.5	2.7
VDH DR48	1.4	1.1	2.4	1.1	0.7	1.1	2.7	3.0	7.2	3.6	0.6	1.1	1.6	1.1	1.4	1.1	0.7	1.1	4.3	2.2
VY North Fence	0.2	1.4	1.7	0.0	0.7	1.1	1.4	2.0	4.0	2.6	0.0	1.4	0.8	0.0	1.7	1.1	1.2	0.0	3.7	1.7
VY North Fence #2	0.7	0.0	0.7	1.1	0.0	1.1	0.7	1.1	2.1	1.9	1.0	0.0	1.1	1.1	1.4	1.1	1.2	0.0	4.7	1.6
VDH DR49	0.0	1.1	0.0	1.1	0.0	3.0	0.7	3.0	0.7	3.8	0.0	1.1	0.0	1.1	0.8	3.0	0.0	1.1	0.8	2.6
VDH DR51	3.4	0.0	3.7	1.1	4.4	0.0	5.0	4.1	16.5	4.2	4.1	0.0	5.3	1.1	6.5	0.0	4.6	1.1	20.4	1.6
VDH DR52	4.1	1.1	5.4	0.0	4.4	2.3	5.4	2.8	19.2	3.4	7.2	1.1	6.3	0.0	7.9	2.3	7.6	1.1	29.0	2.2
VY Parking Lot	4.7	1.1	4.4	2.3	5.7	2.0	5.7	4.5	20.5	5.4	5.2	1.1	6.8	2.3	8.8	2.0	5.9	1.1	26.8	3.1
VY Parking Lot #2	4.7	1.1	6.0	0.0	8.0	1.1	6.4	2.0	25.2	2.5	5.0	1.1	7.1	0.0	8.1	1.1	6.8	2.3	27.0	2.7
VDH DR53	4.7	1.1	6.0	1.1	6.4	0.0	5.0	1.1	22.2	2.0	7.1	1.1	7.2	1.1	8.2	0.0	6.7	1.1	29.2	2.0

Table 5b. Net VYNPS Site Boundary Dose Equivalent Results for 2007 in Millirem

	Vendor 1 TLDs										AREVA, NP TLDs									
Location	Q 1 Net	2 SD Error	Q 2 Net	2 SD Error	Q 3 Net	2 SD Error	Q 4 Net	2 SD Error	2007 Net	2 SD Error	Q 1 Net	2 SD Error	Q 2 Net	2 SD Error	Q 3 Net	2 SD Error	Q 4 Net	2 SD Error	2007 Net	2 SD Error
VDH T01	0.0	0.0	0.2	0.0	0.8	0.7	0.0	0.7	1.0	0.9	0.0	0.0	0.5	0.0	0.4	0.7	0.3	0.0	1.2	0.6
VDH T02	0.0	1.4	1.4	0.0	0.0	0.7	0.0	1.4	1.4	2.0	0.1	1.4	0.3	0.0	0.6	0.7	0.3	0.7	1.2	1.6
VDH T03	0.2	0.7	0.6	0.7	0.0	0.0	0.0	1.8	0.9	2.0	0.0	0.7	0.5	0.7	0.4	0.0	0.5	1.4	1.4	1.7
VDH T04	0.6	0.0	0.0	0.7	0.8	0.7	0.8	0.0	2.3	0.9	0.7	0.0	0.9	0.7	0.9	0.7	0.4	1.2	2.9	1.5
VDH T05	0.0	3.4	1.0	0.0	1.4	1.8	0.8	0.0	3.3	3.6	0.8	3.4	1.6	0.0	1.4	1.8	1.2	1.2	5.0	3.7
VDH T06	0.2	0.7	1.2	1.2	3.2	0.0	2.2	2.4	6.9	2.8	1.3	0.7	1.7	1.2	2.2	0.0	1.4	1.4	6.6	1.9
VDH DR07	0.8	0.7	1.8	0.7	2.4	0.7	2.8	0.7	7.9	1.3	2.4	0.7	2.9	0.7	2.2	0.7	2.2	1.2	9.7	1.6
VDH DR08	1.4	0.7	3.4	0.7	3.8	0.7	3.2	1.2	11.9	1.6	3.4	0.7	3.1	0.7	3.7	0.7	3.8	0.7	14.1	1.3
VDH DR41	0.4	0.0	1.2	0.8	0.2	0.7	0.0	0.7	1.9	1.2	1.0	0.0	1.1	0.8	1.2	0.7	0.8	1.4	4.1	1.7
VY SW Fence	0.0	0.7	0.0	1.4	0.0	0.0	0.0	0.7	0.0	1.7	0.0	0.7	0.0	1.4	0.3	0.0	0.1	0.7	0.5	1.7
VY SW Fence #2	0.0	0.7	0.4	1.2	0.0	0.0	0.0	0.7	0.4	1.5	0.1	0.7	0.3	1.2	0.4	0.0	0.2	0.7	1.1	1.5
VDH DR42	0.0	0.0	0.4	0.7	0.4	0.7	0.0	0.7	0.8	1.2	0.4	0.0	0.4	0.7	0.7	0.7	0.3	0.7	1.6	1.2
VDH DR43	0.8	0.0	1.4	0.8	2.0	0.7	2.0	2.4	6.3	2.6	1.5	0.0	1.7	0.8	1.6	0.7	1.7	0.7	6.4	1.2
VDH DR44	2.6	0.7	3.0	0.7	3.2	2.4	3.0	0.7	11.9	1.7	4.0	0.7	3.4	0.7	3.8	2.4	4.6	0.7	15.8	1.7
VDH DR45	6.4	1.8	10.6	0.7	8.8	1.4	12.6	2.4	38.5	3.2	10.7	1.8	11.0	0.7	11.9	1.4	13.5	1.2	47.1	2.4
VDH DR46	2.2	1.2	2.4	1.2	3.4	1.2	3.0	0.7	11.1	2.0	3.8	1.2	3.4	1.2	4.3	1.2	3.8	0.7	15.3	2.0
VDH DR47	0.6	0.7	1.6	0.0	1.8	1.2	1.0	0.7	5.1	1.3	1.9	0.7	1.7	0.0	3.4	1.2	1.2	1.2	8.1	1.6
VDH DR48	0.8	0.7	1.4	0.7	0.4	0.7	1.6	1.8	4.3	2.1	0.4	0.7	0.9	0.7	0.9	0.7	0.4	0.7	2.6	1.3
VY North Fence	0.1	0.8	1.0	0.0	0.4	0.7	0.8	1.2	2.4	1.6	0.0	0.8	0.5	0.0	1.0	0.7	0.7	0.0	2.2	1.0
VY North Fence #2	0.4	0.0	0.4	0.7	0.0	0.7	0.4	0.7	1.3	1.2	0.6	0.0	0.7	0.7	0.8	0.7	0.7	0.0	2.8	0.9
VDH DR49	0.0	0.7	0.0	0.7	0.0	1.8	0.4	1.8	0.4	2.3	0.0	0.7	0.0	0.7	0.5	1.8	0.0	0.7	0.5	1.6
VDH DR51	2.0	0.0	2.2	0.7	2.6	0.0	3.0	2.4	9.9	2.5	2.4	0.0	3.2	0.7	3.9	0.0	2.7	0.7	12.2	1.0
VDH DR52	2.4	0.7	3.2	0.0	2.6	1.4	3.2	1.7	11.5	2.0	4.3	0.7	3.8	0.0	4.7	1.4	4.6	0.7	17.4	1.3
VY Parking Lot	2.8	0.7	2.6	1.4	3.4	1.2	3.4	2.7	12.3	3.2	3.1	0.7	4.1	1.4	5.3	1.2	3.5	0.7	16.1	1.9
VY Parking Lot #2	2.8	0.7	3.6	0.0	4.8	0.7	3.8	1.2	15.1	1.5	3.0	0.7	4.3	0.0	4.8	0.7	4.1	1.4	16.2	1.6
VDH DR53	2.8	0.7	3.6	0.7	3.8	0.0	3.0	0.7	13.3	1.2	4.2	0.7	4.3	0.7	4.9	0.0	4.0	0.7	17.5	1.2

Map 3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ID# 18
ID# 36
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FORT BRIDGMAN RD
BURROWS RD
GOVERNOR HUNT RD
PECK RD
BEMIS RD
Legend
Site Boundary Dosimeter Locations
Major Local Rds
State Highways
US Highways
Interstate Highways
Local Roads
N
State of Vermont
VT Yankee Nuclear Power Station
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April 2007

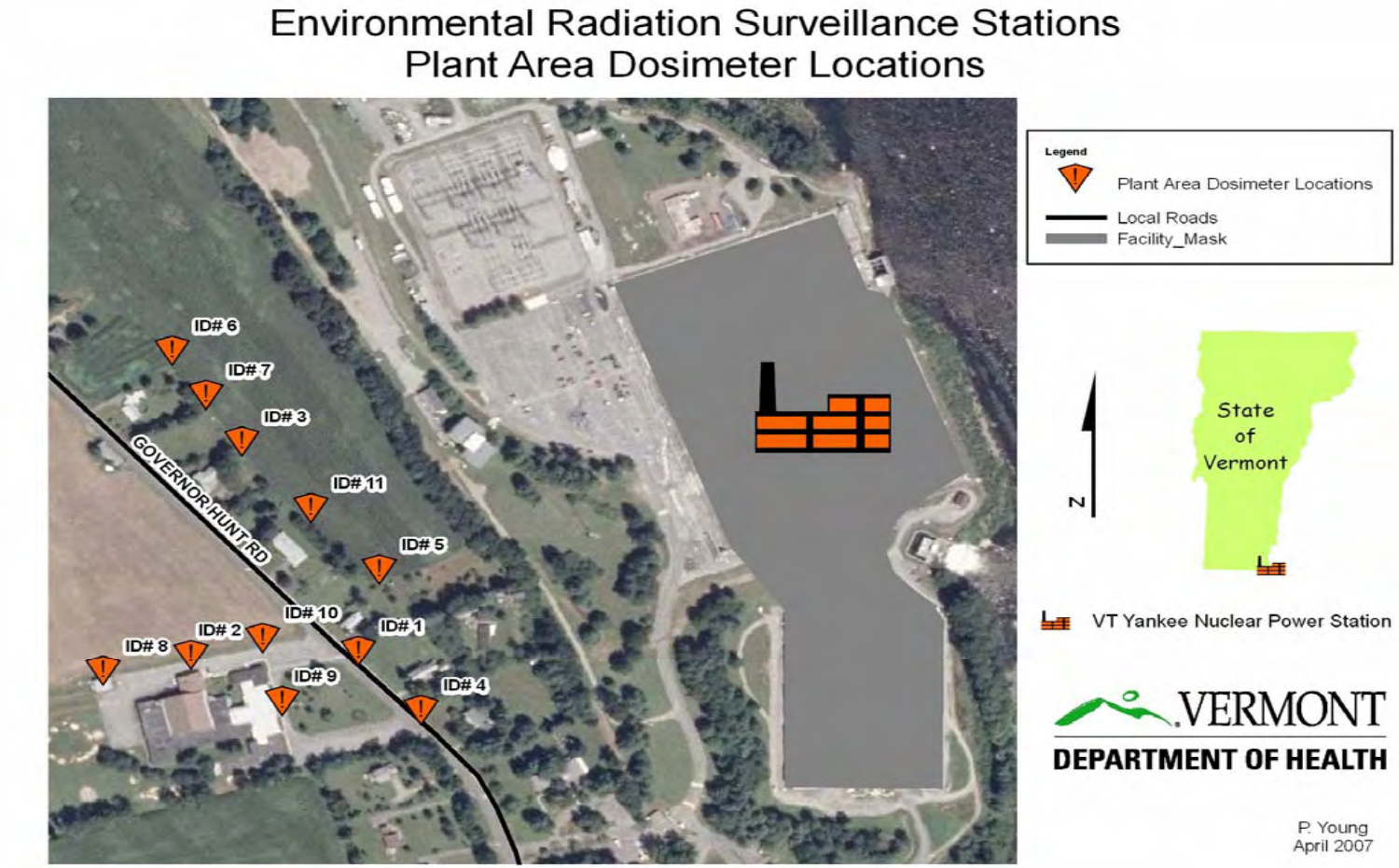
Table 6a. VYNPS Net Plant Area TLD Exposure Results for 2007 in Milliroentgen

	Vendor 1 TLDs										AREVA, NP TLDs									
	Q 1	2 SD	Q 2	2 SD	Q 3	2 SD	Q 4	2 SD	2007	2 SD	Q 1	2 SD	Q 2	2 SD	Q 3	2 SD	Qr4	2 SD	2007	2 SD
Location	Net	Error	Net	Error	Net	Error	Net	Error	Net	Error	Net	Error	Net	Error	Net	Error	Net	Error	Net	Error
VDH T07A	2.4	0.0	2.0	2.0	1.0	2.0	1.4	0.0	6.8	2.4	2.6	0.0	1.9	2.0	2.0	2.0	2.1	1.1	8.6	2.7
VDH T07B	0.0	2.0	2.4	3.0	3.7	2.3	1.4	2.3	7.4	4.5	1.3	2.0	2.0	3.0	1.8	2.3	1.9	1.1	7.1	4.0
VDH DR51A	0.0	1.1	1.7	1.1	2.7	0.0	2.4	2.8	6.8	3.2	2.3	1.1	2.2	1.1	2.6	0.0	2.4	1.1	9.4	2.0
VY PARKING LOT A	2.7	1.1	4.7	1.1	2.4	1.1	3.4	5.2	13.2	5.5	2.7	1.1	3.5	1.1	3.4	1.1	4.1	2.0	13.7	2.7
VDH DR53A	2.1	1.1	3.7	2.0	4.4	0.0	0.0	0.0	10.1	2.3	3.4	1.1	3.9	2.0	5.0	0.0	4.6	0.0	16.9	2.3
Gov Hunt Road # 39	1.4	1.1	2.0	1.1	3.7	1.1	1.4	1.1	8.5	2.2	2.2	1.1	2.1	1.1	3.1	1.1	2.3	2.0	9.5	2.7
Vernon School Nurse	3.1	1.1	2.7	1.1	1.4	1.1	2.4	1.1	9.5	2.2	3.6	1.1	3.1	1.1	2.6	1.1	3.2	1.1	12.5	2.2
VDH DR06	0.0	0.0	1.0	0.0	0.7	1.1	2.4	1.1	4.1	1.6	0.7	0.0	1.1	0.0	1.6	1.1	0.8	2.3	4.3	2.5
Vernon School A/S	0.0	0.0	1.0	1.1	0.7	1.1	0.4	1.1	2.1	1.9	0.6	0.0	0.8	1.1	1.2	1.1	0.9	1.1	3.5	1.9
VSH DR52A	0.7	1.1	0.4	0.0	0.7	1.1	2.4	2.0	4.2	2.5	3.5	1.1	2.7	0.0	3.3	1.1	2.7	1.1	12.3	1.9
Vernon School Pole	1.7	1.1	3.7	1.4	1.7	2.3	2.4	1.1	9.5	2.6	0.6	1.1	0.6	1.4	2.2	2.3	0.7	2.0	4.1	3.1

Table 6b. VYNPS Net Plant Area Dose Equivalent Results for 2007 in Millirem

	Vendor 1 TLDs										AREVA, NP TLDs									
	Q 1	2 SD	Q 2	2 SD	Q 3	2 SD	Q 4	2 SD	2007	2 SD	Q 1	2 SD	Q 2	2 SD	Q 3	2 SD	Q 4	2 SD	2007	2 SD
Location	Net	Error	Net	Error	Net	Error	Net	Error	Net	Error	Net	Error	Net	Error	Net	Error	Net	Error	Net	Error
VDH T07A	1.4	0.0	1.2	1.2	0.6	1.2	0.8	0.0	4.1	1.4	1.6	0.0	1.2	1.2	1.2	1.2	1.2	0.7	5.1	1.6
VDH T07B	0.0	1.2	1.4	1.8	2.2	1.4	0.8	1.4	4.5	2.7	0.8	1.2	1.2	1.8	1.1	1.4	1.2	0.7	4.2	2.4
VDH DR51A	0.0	0.7	1.0	0.7	1.6	0.0	1.4	1.7	4.1	1.9	1.4	0.7	1.3	0.7	1.5	0.0	1.5	0.7	5.7	1.2
VY PARKING LOT A	1.6	0.7	2.8	0.7	1.4	0.7	2.0	3.1	7.9	3.3	1.6	0.7	2.1	0.7	2.0	0.7	2.4	1.2	8.2	1.6
VDH DR53A	1.2	0.7	2.2	1.2	2.6	0.0	0.0	0.0	6.1	1.4	2.0	0.7	2.3	1.2	3.0	0.0	2.8	0.0	10.2	1.4
Gov Hunt Road # 39	0.8	0.7	1.2	0.7	2.2	0.7	0.8	0.7	5.1	1.3	1.3	0.7	1.2	0.7	1.8	0.7	1.4	1.2	5.7	1.6
Vernon School Nurse	1.8	0.7	1.6	0.7	0.8	0.7	1.4	0.7	5.7	1.3	2.2	0.7	1.8	0.7	1.6	0.7	1.9	0.7	7.5	1.3
VDH DR06	0.0	0.0	0.6	0.0	0.4	0.7	1.4	0.7	2.5	0.9	0.4	0.0	0.7	0.0	1.0	0.7	0.5	1.4	2.6	1.5
Vernon School A/S	0.0	0.0	0.6	0.7	0.4	0.7	0.2	0.7	1.3	1.2	0.3	0.0	0.5	0.7	0.7	0.7	0.6	0.7	2.1	1.2
VSH DR52A	0.4	0.7	0.2	0.0	0.4	0.7	1.4	1.2	2.5	1.5	2.1	0.7	1.6	0.0	2.0	0.7	1.6	0.7	7.4	1.2
Vernon School Pole	1.0	0.7	2.2	0.8	1.0	1.4	1.4	0.7	5.7	1.6	0.4	0.7	0.3	0.8	1.3	1.4	0.4	1.2	2.4	1.8

Map 4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ID# 9
ID# 4
GOVERNOR HUNT RD
Legend
Plant Area Dosimeter Locations
Local Roads
Facility_Mask
N
State of Vermont
VT Yankee Nuclear Power Station
VERMONT
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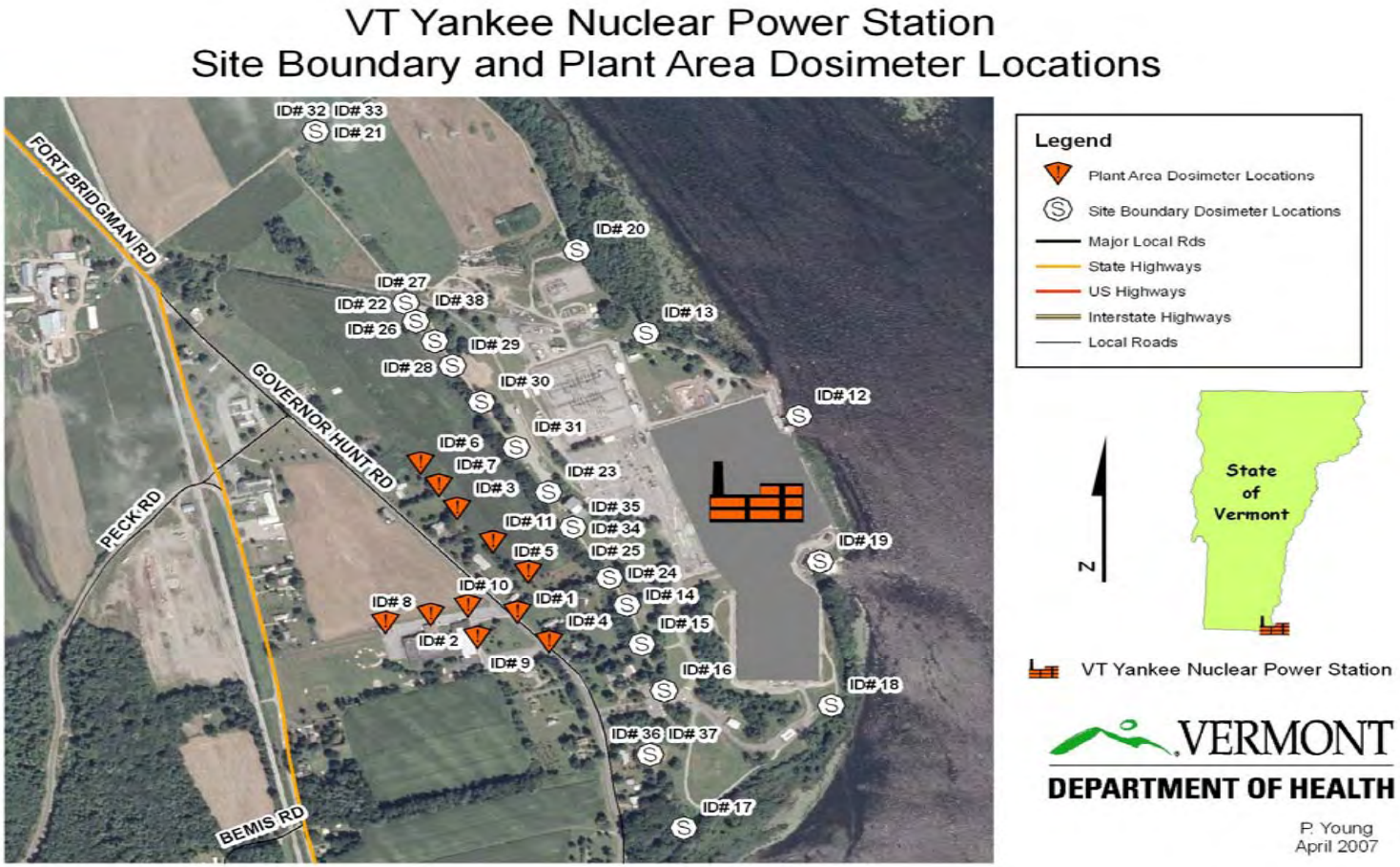
April 2007

Map 5


VT Yankee Nuclear Power Station
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ID# 37
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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

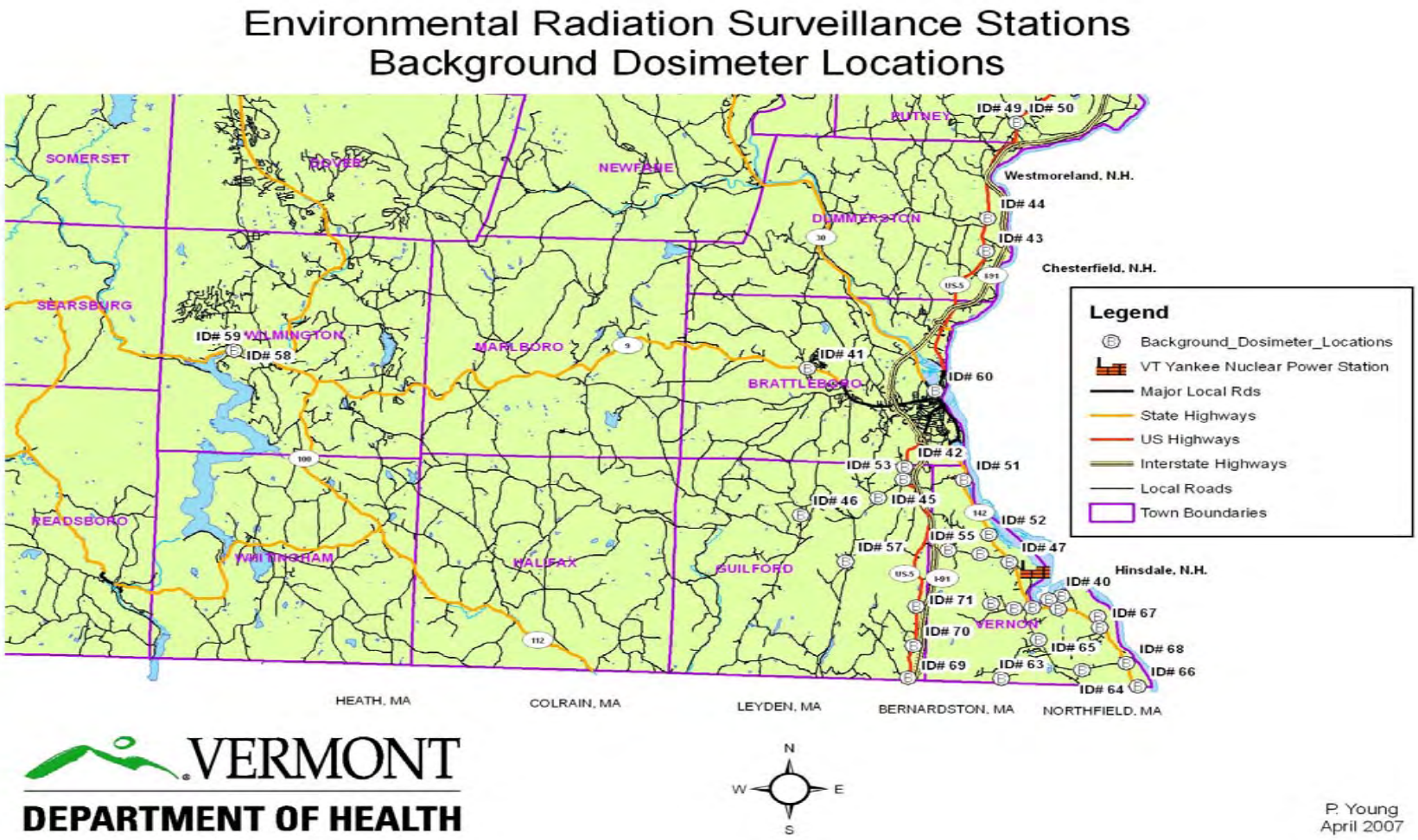
Table 7a Net VYNPS Background TLD Exposure Results for 2007 in Milliroentgen

	Vendor 1 TLDs										AREVA, NP TLDs									
Location	Q 1	Error	Q 2	Error	Q 3	Error	Q 4	Error	2007	Error	Q 1	Error	Q 2	Error	Q 3	Error	Q 4	Error	2007	Error
Putney Town Clerk	0.0	1.1	0.0	1.1	0.0	1.1	0.0	4.5	0.0	4.9	0.0	1.1	0.0	1.1	0.0	1.1	0.0	1.1	0.0	2.2
Putney Pole	0.7	1.1	1.4	1.1	0.7	0.0	0.4	1.1	3.2	2.0	1.2	1.1	0.0	1.1	0.0	0.0	0.9	1.1	2.1	2.0
Dummerston School	0.4	1.1	0.4	1.4	0.4	1.1	0.0		1.1	2.1	0.0	1.1	1.4	1.4	0.8	1.1	0.0	2.0	2.2	2.9
Dummerston IFO	0.7	1.1	0.0	1.1	0.4	1.1	0.4	1.1	1.5	2.3	0.5	1.1	0.5	1.1	1.0	1.1	0.3	2.3	2.4	3.0
Windham County Court	0.0	0.0	0.0	0.0	0.0	1.1	0.0	2.0	0.0	2.3	0.0	0.0	0.4	0.0	0.6	1.1	0.0	0.0	0.9	1.1
Renaud Brothers	0.1	1.1	0.7	2.0	0.4	1.4	1.4	0.0	2.5	2.7	0.2	1.1	0.0	2.0	0.0	1.4	1.9	2.0	2.1	3.2
Rt 142 N Trans Lines	1.7	2.0	0.0	1.1	0.4	1.1	0.4	2.0	2.5	3.2	1.2	2.0	1.3	1.1	1.6	1.1	0.4	1.1	4.4	2.7
Tyler Hill Road	0.4	1.1	1.0	3.4	1.0	1.1	5.4	1.1	7.8	3.9	0.0	1.1	0.0	3.4	0.0	1.1	0.0	1.1	0.0	3.9
Miller Farm	0.1	1.1	0.0	0.0	0.0	0.0	0.0	3.0	0.1	3.2	0.0	1.1	0.0	0.0	0.7	0.0	0.0	1.1	0.7	1.6
142/Pond Road North	0.0	2.3	0.0	0.0	0.0	3.0	0.0	1.1	0.0	3.9	0.0	2.3	0.0	0.0	0.0	3.0	0.0	3.0	0.0	4.1
Fairman Road	0.0	1.1	0.0	1.1	0.0	2.0	0.0	0.0	0.0	2.5	0.0	1.1	0.0	1.1	0.0	2.0	0.0	2.0	0.0	2.9
West Road/Edgewood	0.0	0.0	0.0	1.1	0.0	2.0	0.0	1.1	0.0	2.5	0.0	0.0	0.0	1.1	0.0	2.0	0.0	1.1	0.0	2.1
Vernon Fire Station	0.1	4.5	0.0	1.1	0.0	2.3	0.4	1.1	0.4	5.3	0.0	4.5	0.0	1.1	0.0	2.3	0.0	1.1	0.0	5.0
Power Line R Crsng	0.0	1.1	0.0	2.3	0.4	0.0	0.0	1.1	0.4	2.8	0.3	1.1	0.0	2.3	0.0	0.0	0.1	1.1	0.4	2.8
A&M Auto/Smead	1.4	1.1	0.0	1.1	2.0	0.0	0.4	1.1	3.8	2.0	0.0	1.1	0.5	1.1	0.3	0.0	0.0	2.3	0.7	2.8
Blodgett Farm	0.7	1.1	1.0	0.0	1.0	2.0	0.4	0.0	3.2	2.3	1.4	1.1	0.0	0.0	0.1	2.0	1.1	1.1	2.6	2.1
Rt 142/Newtron Rd	0.0	2.0	0.0	1.1	0.0	1.1	0.0	1.1	0.0	2.8	0.0	2.0	0.3	1.1	0.6	1.1	0.0	1.1	0.9	2.7
Rt 142/Pond Rd S	1.1	1.1	0.0	1.1	0.0	0.0	0.4	1.1	1.4	2.0	0.3	1.1	0.0	1.1	0.0	0.0	0.0	2.0	0.3	2.5
Rt 142/Depot Street	0.4	1.1	0.4	1.1	0.0	0.0	0.4	2.0	1.1	2.5	0.2	1.1	0.0	1.1	0.0	0.0	0.2	1.1	0.4	2.0
Pond Rd/Houghton	0.1	2.3	0.7	1.1	0.7	1.1	0.0	1.1	1.5	3.0	0.2	2.3	0.1	1.1	0.7	1.1	0.0	1.1	1.0	3.0
Pond Rd/Vernon Rec	0.0	2.0	0.0	2.0	0.0	1.1	0.0	1.1	0.0	3.2	0.0	2.0	0.0	2.0	0.2	1.1	0.0	1.1	0.2	3.2
Huckle Hill Rd.VT Line	1.1	2.3	2.0	2.0	4.0	1.4	1.4	1.1	8.5	3.5	2.2	2.3	0.0	2.0	0.0	1.4	2.4	2.3	4.6	3.9
Route 5/Wolosko	1.4	2.0	6.0	1.4	2.7	1.1	2.4	1.1	12.5	2.9	1.7	2.0	3.4	1.4	3.3	1.1	2.3	0.0	10.7	2.6
Rt 5/Andrews Cemetary	0.0	0.0	0.7	0.0	1.7	2.3	1.4	2.0	3.8	3.0	0.0	0.0	2.6	0.0	3.0	2.3	0.9	2.0	6.5	2.5
Rt 5/Tkaczyk Farm Rd	0.1	1.1	0.7	0.0	0.4	0.0	0.0	1.1	1.1	1.6	0.4	1.1	1.0	0.0	0.3	0.0	0.4	1.1	2.2	1.6
Tyler Rd/Franklin Rd	0.0	1.1	2.0	2.0	1.4	1.1	1.4	1.1	4.8	2.8	0.6	1.1	0.7	2.0	0.1	1.1	1.1	1.1	2.6	2.7
D&E Tree, Guilford	0.0	1.1	0.0	1.1	0.0	2.0	0.0	2.3	0.0	3.4	0.0	1.1	0.7	1.1	2.5	2.0	0.0	2.0	3.1	2.9
Rt 5 & Guilford Ctr Rd	0.1	1.1	0.0	1.1	0.0	1.1	0.0	0.0	0.1	2.0	0.1	1.1	0.0	1.1	0.0	1.1	0.0	1.1	0.1	2.2
Guilfor Ctr & Tater Rds	0.0	1.1	0.4	1.1	0.0	0.0	0.0	2.0	0.4	2.5	0.0	1.1	0.0	1.1	0.0	0.0	0.0	2.0	0.0	2.5
Weatherhead Hllw Rd	0.0	2.0	0.0	1.1	0.0	1.1	0.0	2.0	0.0	3.2	0.0	2.0	0.3	1.1	0.0	1.1	0.0	2.0	0.3	3.2
Guilford Town Garage	1.1	2.3	0.7	1.1	0.0	1.1	1.4	1.1	3.2	3.0	1.2	2.3	0.0	1.1	0.0	1.1	0.9	0.0	2.1	2.7
West Brattleboro SP	0.0	0.0	0.0	1.1	0.0	1.1	0.0	1.4	0.0	2.1	0.0	0.0	0.7	1.1	0.0	1.1	0.0	1.1	0.7	1.9
Wilmington AOT Pole	0.0	1.1	0.0	1.1	1.0	1.1	1.4	1.1	2.4	2.3	0.3	1.1	0.0	1.1	0.0	1.1	0.8	0.0	1.1	1.9
Wilmington AOT A/S	1.1	1.1	2.0	2.0	2.4	1.1	2.4	1.1	7.8	2.8	2.1	1.1	0.2	2.0	0.7	1.1	2.8	1.1	5.7	2.7

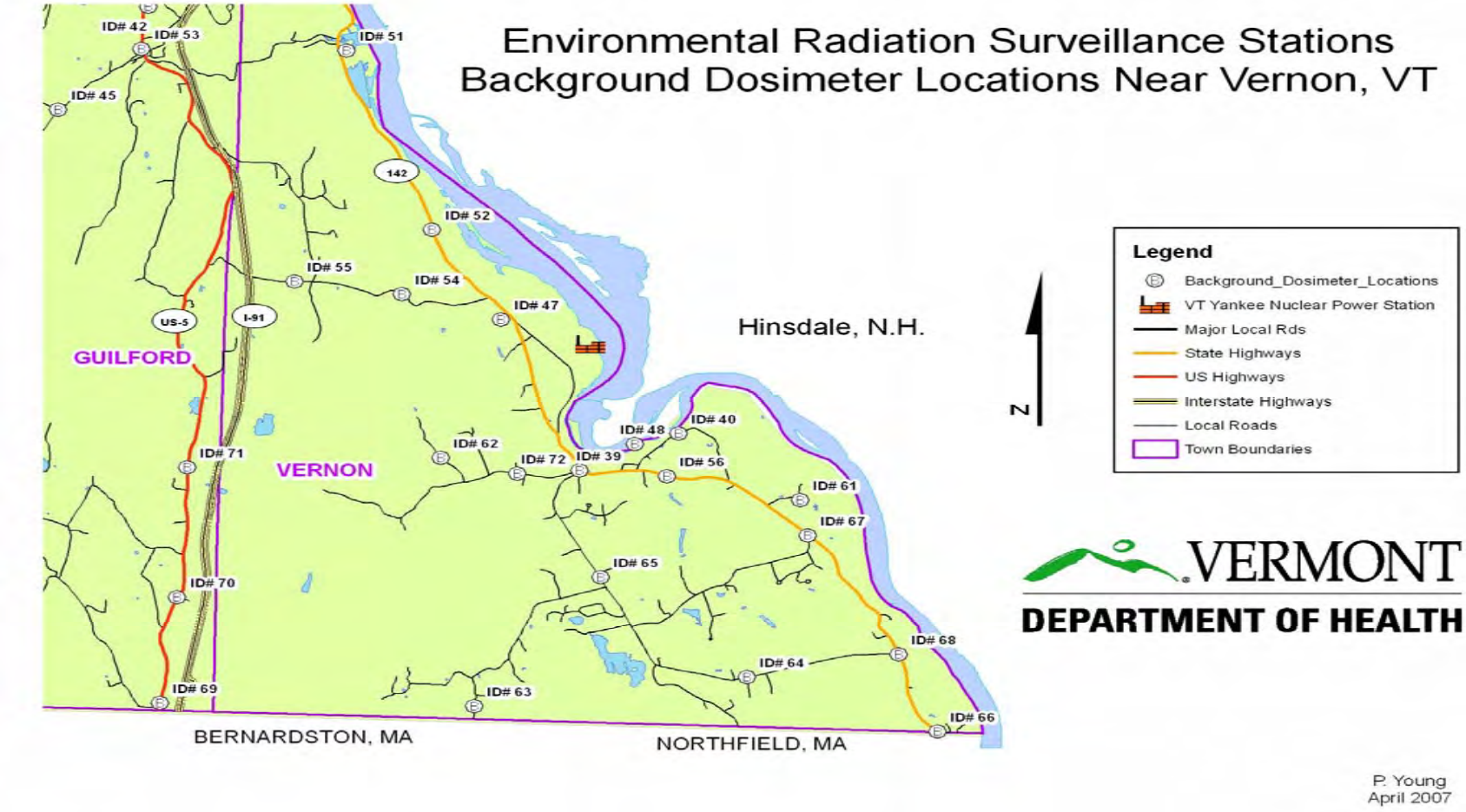
Table7b. VYNPS Net Background Dose Equivalent Results for 2007 in Millirem

	Global Dosimetry TLDs										AREVA, NP TLDs									
Location	Q 1	Error	Q 2	Error	Q 3	Error	Q 4	Error	2007	Error	Q 1	Error	Q 2	Error	Q 3	Error	Q 4	Error	2007	Error
Putney Town Clerk	0.0	0.7	0.0	0.7	0.0	0.7	0.0	2.7	0.0	3.0	0.0	0.7	0.0	0.7	0.0	0.7	0.0	0.7	0.0	1.3
Putney Pole	0.4	0.7	0.0	0.7	0.0	0.0	0.2	0.7	0.7	1.2	0.7	0.7	0.0	0.7	0.0	0.0	0.5	0.7	1.3	1.2
Dummerston School	0.2	0.7	0.8	0.8	0.4	0.7	0.0	0.0	1.5	1.2	0.0	0.7	0.8	0.8	0.5	0.7	0.0	1.2	1.3	1.7
Dummerston IFO	0.4	0.7	0.2	0.7	0.2	0.7	0.2	0.7	1.1	1.3	0.3	0.7	0.3	0.7	0.6	0.7	0.2	1.4	1.4	1.8
Windham County Court	0.0	0.0	0.0	0.0	0.2	0.7	0.0	1.2	0.2	1.3	0.0	0.0	0.2	0.0	0.3	0.7	0.0	0.0	0.6	0.6
Renaud Brothers	0.0	0.7	0.0	1.2	0.0	0.8	0.8	0.0	0.9	1.5	0.1	0.7	0.0	1.2	0.0	0.8	1.2	1.2	1.3	1.9
Rt 142 N Trans Lines	1.0	1.2	0.4	0.7	0.2	0.7	0.2	1.2	1.9	1.9	0.7	1.2	0.8	0.7	0.9	0.7	0.2	0.7	2.7	1.6
Tyler Hill Road	0.2	0.7	0.0	2.0	0.2	0.7	3.2	0.7	3.7	2.3	0.0	0.7	0.0	2.0	0.0	0.7	0.0	0.7	0.0	2.3
Miller Farm	0.0	0.7	0.6	0.0	0.6	0.0	0.0	1.8	1.3	1.9	0.0	0.7	0.0	0.0	0.4	0.0	0.0	0.7	0.4	1.0
142/Pond Road North	0.0	1.4	0.0	0.0	0.0	1.8	0.0	0.7	0.0	1.8	0.0	1.4	0.0	0.0	0.0	1.8	0.0	1.8	0.0	2.5
Fairman Road	0.0	0.7	0.0	0.7	0.0	1.2	0.0	0.0	0.0	1.3	0.0	0.7	0.0	0.7	0.0	1.2	0.0	1.2	0.0	1.7
West Road/Edgewood	0.0	0.0	0.0	0.7	0.0	1.2	0.0	0.7	0.0	1.3	0.0	0.0	0.0	0.7	0.0	1.2	0.0	0.7	0.0	1.3
Vernon Fire Station	0.0	2.7	0.0	0.7	0.0	1.4	0.2	0.7	0.3	3.0	0.0	2.7	0.0	0.7	0.0	1.4	0.0	0.7	0.0	3.0
Power Line R Crsng	0.0	0.7	0.0	1.4	0.0	0.0	0.0	0.7	0.0	1.7	0.2	0.7	0.0	1.4	0.0	0.0	0.0	0.7	0.2	1.7
A&M Auto/Smead	0.8	0.7	0.0	0.7	0.2	0.0	0.2	0.7	1.3	1.2	0.0	0.7	0.3	0.7	0.2	0.0	0.0	1.4	0.4	1.7
Blodgett Farm	0.4	0.7	0.0	0.0	1.2	1.2	0.2	0.0	1.9	1.1	0.9	0.7	0.0	0.0	0.0	1.2	0.6	0.7	1.5	1.3
Rt 142/Newtron Rd	0.0	1.2	0.6	0.7	0.6	0.7	0.0	0.7	1.2	1.6	0.0	1.2	0.2	0.7	0.3	0.7	0.0	0.7	0.5	1.6
Rt 142/Pond Rd S	0.6	0.7	0.0	0.7	0.0	0.0	0.2	0.7	0.9	1.2	0.2	0.7	0.0	0.7	0.0	0.0	0.0	1.2	0.2	1.5
Rt 142/Depot Street	0.2	0.7	0.0	0.7	0.0	0.0	0.2	1.2	0.5	1.5	0.1	0.7	0.0	0.7	0.0	0.0	0.1	0.7	0.3	1.2
Pond Rd/Houghton	0.0	1.4	0.2	0.7	0.0	0.7	0.0	0.7	0.3	1.8	0.1	1.4	0.1	0.7	0.4	0.7	0.0	0.7	0.6	1.8
Pond Rd/Vernon Rec	0.0	1.2	0.4	1.2	0.4	0.7	0.0	0.7	0.8	1.9	0.0	1.2	0.0	1.2	0.1	0.7	0.0	0.7	0.1	1.9
Huckle Hill Rd.VT Line	0.6	1.4	0.0	1.2	0.0	0.8	0.8	0.7	1.5	2.0	1.3	1.4	0.0	1.2	0.0	0.8	1.5	1.4	2.8	2.4
Route 5/Wolosko	0.8	1.2	1.2	0.8	2.4	0.7	1.4	0.7	5.9	1.7	1.0	1.2	2.1	0.8	2.0	0.7	1.4	0.0	6.4	1.6
Rt 5/Andrews Cemetary	0.0	0.0	3.6	0.0	1.6	1.4	0.8	1.2	6.1	1.5	0.0	0.0	1.6	0.0	1.8	1.4	0.5	1.2	3.9	1.5
Rt 5/Tkaczyk Farm Rd	0.0	0.7	0.4	0.0	1.0	0.0	0.0	0.7	1.5	1.0	0.2	0.7	0.6	0.0	0.2	0.0	0.3	0.7	1.3	1.0
Tyler Rd/Franklin Rd	0.0	0.7	0.4	1.2	0.2	0.7	0.8	0.7	1.5	1.6	0.4	0.7	0.4	1.2	0.1	0.7	0.7	0.7	1.5	1.6
D&E Tree, Guilford	0.0	0.7	1.2	0.7	0.8	1.2	0.0	1.4	2.0	1.9	0.0	0.7	0.4	0.7	1.5	1.2	0.0	1.2	1.9	1.7
Rt 5 & Guilford Ctr Rd	0.0	0.7	0.0	0.7	0.0	0.7	0.0	0.0	0.0	1.2	0.1	0.7	0.0	0.7	0.0	0.7	0.0	0.7	0.1	1.3
Guilfor Ctr & Tater Rds	0.0	0.7	0.0	0.7	0.0	0.0	0.0	1.2	0.0	1.5	0.0	0.7	0.0	0.7	0.0	0.0	0.0	1.2	0.0	1.5
Weatherhead Hllw Rd	0.0	1.2	0.2	0.7	0.0	0.7	0.0	1.2	0.2	1.9	0.0	1.2	0.2	0.7	0.0	0.7	0.0	1.2	0.2	1.9
Guilford Town Garage	0.6	1.4	0.0	0.7	0.0	0.7	0.8	0.7	1.5	1.8	0.7	1.4	0.0	0.7	0.0	0.7	0.6	0.0	1.3	1.6
West Brattleboro SP	0.0	0.0	0.4	0.7	0.0	0.7	0.0	0.8	0.4	1.2	0.0	0.0	0.4	0.7	0.0	0.7	0.0	0.7	0.4	1.2
Wilmington AOT Pole	0.0	0.7	0.0	0.7	0.0	0.7	0.8	0.7	0.8	1.3	0.2	0.7	0.0	0.7	0.0	0.7	0.5	0.0	0.7	1.2
Wilmington AOT A/S	0.6	0.7	0.0	1.2	0.6	0.7	1.4	0.7	2.7	1.6	1.3	0.7	0.1	1.2	0.4	0.7	1.7	0.7	3.4	1.6

Map 6


Environmental Radiation Surveillance Stations
Background Dosimeter Locations
SOMERSET
ROYER
NEWFANE
PUTNEY
ID# 49
ID# 50
Westmoreland, N.H.
ID# 44
DUMMERSTON
ID# 43
Chesterfield, N.H.
SEARSBURG
ID# 59
WILMINGTON
ID# 58
MARLBORO
ID# 41
BRATTLEBORO
ID# 60
ID# 42
ID# 53
ID# 51
ID# 46
ID# 45
ID# 52
READSBORO
ID# 55
ID# 57
ID# 47
WHITINGHAM
HALIFAX
GUILFORD
Hinsdale, N.H.
ID# 40
ID# 71
ID# 67
VERNON
ID# 70
ID# 65
ID# 68
ID# 69
ID# 63
ID# 66
ID# 64
HEATH, MA
COLRAIN, MA
LEYDEN, MA
BERNARDSTON, MA
NORTHFIELD, MA
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
N
W
E
S
P. Young
April 2007

Map 7


Environmental Radiation Surveillance Stations
Background Dosimeter Locations Near Vernon, VT
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ID# 53
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ID# 47
US-5
I-91
GUILFORD
Hinsdale, N.H.
ID# 48
ID# 40
ID# 62
ID# 72
ID# 39
ID# 56
ID# 71
VERNON
ID# 61
ID# 67
ID# 65
ID# 70
ID# 68
ID# 64
ID# 69
ID# 63
ID# 66
BERNARDSTON, MA
NORTHFIELD, MA
N
Legend
Background_Dosimeter_Locations
VT Yankee Nuclear Power Station
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