STATE OF VERMONT
BEFORE THE PUBLIC SERVICE BOARD

Docket No. 7600

Investigation into (1) whether Entergy Nuclear Vermont	**)**
Yankee LLC, and Entergy Nuclear Operations, Inc.	**)**
(collectively, "Entergy VY"), should be required to cease	**)**
operations at the Vermont Yankee Nuclear Power Station,	**)**
or take other ameliorative actions, pending completion of	**)**
Repairs to stop releases of radionuclides, radioactive	**)**
materials, and, potentially, other non-radioactive materials	**)**
into the environment; (2) whether good cause exists to modify	**)**
or revoke the 30 V.S.A. 231 Certificate of Public Good issued	**)**
to Entergy VY for any identified violations of Vermont	**)**
statutes or Board orders related to the releases	**)**

CORRECTED DIRECT TESTIMONY OF

STRATTON FRENCH

ON BEHALF OF

CONSERVATION LAW FOUNDATION

JUNE 30, 2010

CORRECTED JANUARY 10, 2011

Mr. French's testimony provides an evaluation of the groundwater, surface water and soil analyses conducted by Entergy VY following the discovery of leaks at the facility. Mr. French identifies key shortcomings in the hydrogeologic assessment, data collection and evaluation of contamination at the site, as well as the remediation efforts both being undertaken and proposed by Entergy VY for the site.

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I. Identification and Qualifications

Q: Mr. French, please state your name, occupation and business address.

A: My name is Stratton French. I am a Consulting Hydrologist. My address is 1831 Lightening Ridge Road, Plainfield, Vermont 05667.

Q: Summarize your professional education and experience.

A: My resume is attached as Exhibit CLF-SF-1. I have been working in the field of Hydrology / Hydrogeology in New England since 1986, and in Vermont since 1995. I have been a self-employed Consulting Hydrologist engaged in private practice since 2001. I received an MS in Hydrology from UNH in 1994 and was certified (CGWP) through the Association of Ground Water Scientists and Engineers in 1997. The work I have been primarily involved with falls into two main categories: water supply development, and contaminant hydrogeology. In the water supply realm I have been involved with every aspect from prospecting and siting sources, to production well installation, testing and permitting public and private water supplies in both unconsolidated and bedrock environments, and source protection delineation. With regard to contaminant investigations I have worked on many projects in various capacities to characterize the subsurface conditions in order to determine the degree and extent of groundwater contamination, and assess whether remedial efforts are feasible and justified, and if so what form of remediation best would apply. These projects have ranged from straightforward, single point source hydrocarbon releases to more involved, multiple source RCRA and CERCLA sites involving solvents, metals and other groundwater contaminants. I have experience in evaluating and implementing soil and groundwater remediation plans and have conducted numerical modeling simulations to optimize groundwater extraction scenarios to control free phase and dissolved phase hydrocarbon contaminants.

II. Introduction and Summary

Q: On whose behalf are you testifying?

A: My testimony is sponsored by the Conservation Law Foundation.

Q: What is the purpose of your direct testimony?

A: The purpose of my testimony is to provide the Public Service Board with information regarding the adequacy of Entergy VY's efforts to address the leaks at the Vermont Yankee facility, their impacts on groundwater and surface water, and remediation.

Q: What information is your testimony based on?

A: I reviewed the affidavits and exhibits submitted by Entergy VY in this proceeding. I also reviewed most of the discovery responses provided by Entergy VY and attended the site visit at the Vermont Yankee facility on April 29, 2010. I also reviewed the other documents specifically identified in this testimony and the Vermont Department of Health website regarding the Vermont Yankee investigation. My testimony and opinions are based on the information in these materials as well as my background and experience in the field of contaminant hydrogeology.

III. Hydrogeologic Assessment / Entergy VY's Preparedness

Q: Has Entergy VY identified the potential for contamination at its property?

A: Yes. Entergy VY provided ample information that the potential for groundwater contamination at nuclear power plants, and the release of tritium in particular, has been recognized by the nuclear industry for many years (see Attachment A.CLF:EN.2-1.1 the White Paper (Exhibit CLF-SF-2), and Attachment A.CLF:EN.2-1.4 (Exhibit CLF-SF-3) the Task Force Report).

The Nuclear Energy Institute's Groundwater Protection Initiative (GPI), endorsed by the Nuclear Regulatory Commission (NRC), was "*binding for all nuclear utilities*" and established that by July 2006, a "*site specific action plan to assure timely detection and effective response… to radiological releases in groundwater*" be developed at each plant (Attachment A.CLF:EN.2-1.1 p.5 (Exhibit CLF-SF-2)). In response, Entergy VY commissioned a Hydrogeologic Assessment of its power station in Vernon, issued in January, 2007 (Attachment A.CLF:EN.2-1.2 (Exhibit CLF-SF-4)). This was a "non-intrusive" assessment that included no subsurface investigation, and was essentially a compilation and review of existing information collected by others. Specific recommendations for characterizing, understanding and monitoring the hydrogeology of the site included installation of five perimeter monitoring wells, and five interior piezometers, known as sentinel wells, near "*underground components and buried piping*" to "*improve understanding of potential release areas*" (p. 18).

The "*potential release areas*" at the VY site are well documented in the Hydrogeologic Assessment, with lists of all the engineering systems, structures and components comprising a "*potential direct pathway to ground*", or even a "*secondary pathway*" (p.7). Buried underground piping and other components at VY figure prominently in the narrative and lists of this report (Tables 1 & 2), as well as the recognition that "*these underground components (e.g. buried piping) have been in place many years*", and the remarkable admission that neither a "*clear understanding of the condition of these items*" exists, nor does any "*real means to predict their integrity over time*" (p.17).

In early 2007, Entergy VY was well aware of both the potential for groundwater contamination from numerous sources on its property, as well as its lack of any groundwater monitoring network or capacity to identify, and therefore adequately address, a release of contaminants.

Q: What action did Entergy VY take?

A: In November of 2007, Entergy VY installed just three of the ten monitoring points recommended in its Hydrogeologic Assessment. Information from three monitoring wells is insufficient to characterize the subsurface hydrostratigraphic conditions, and is the bare minimum necessary to establish groundwater flow direction, provided the wells are strategically placed and properly triangulated. In the case of the Vermont Yankee facility, these wells, GZ-1, GZ-3 and GZ-5, were installed on a line parallel to the Connecticut River at widely spaced intervals, approximately 400 – 500 feet apart, and far from any of the plant systems identified as potential sources of contamination.

Q: Were these actions adequate?

A: No. In light of the placement of these wells near the river, far apart and away from the plant operations, they could do no more than serve as a downgradient flag that a release had occurred somewhere in the plant, several months previously. In fact, these wells were positioned so far apart that the tritium plume as currently defined almost bypassed them altogether, flowing predominantly between GZ-3 and GZ-5, and intersecting GZ-3 along the northern edge.

Although identified as the "*initial step in a multi-phase approach*" (A.CLF:EN2-1 (Exhibit CLF-SF-5)), no additional efforts to understand the hydrogeologic regime, or monitor the many known potential sources, were undertaken by VY in the more than two years that elapsed between the initial well installation (Nov. 2007), and when tritium was eventually identified in GZ-3 (Jan. 2010).

This well installation effort was designed to "*determine quickly*" groundwater impacts, and "*quickly assess*" potential threats to public health, however, this professed need for speed did not ultimately transpire. More than six weeks elapsed between when the sample containing tritium was collected (Nov. 17, 2009), and when it was reported (Jan. 7, 2010). It is quite likely

this tritium entered the subsurface many additional months prior to the sampling date, during which time it migrated downgradient to near the Connecticut River where it was found at GZ-3. The Supplemental Report to the Comprehensive Reliability Assessment of the Vermont Yankee Nuclear Facility prepared by Nuclear Safety Associates (Supplemental CRA) states that between the Advanced Off-Gas (AOG) Building and the Turbine Building at the plant, "*instances of ground subsidence (sink holes) have occurred since July 2008*." (Supplemental CRA, Redacted Version, April 30, 2010, p. 78)(Exhibit CLF-SF-6). This area of ground subsidence was "*ultimately determined to be the source of the leakage*." *Id.* Furthermore, as the Supplemental CRA notes, Condition Reports investigating the sinkholes were inadequate and "*represent missed opportunities to possibly discover the AOG leakage sooner*." *Id.* at 85.

Despite the clearly articulated need, the "network" of three monitoring wells established by Entergy VY was an insufficient effort to address the documented risk of potential groundwater impact at this property. Once tritium was detected, these wells provided only limited and inadequate capacity to identify the source and/or location of the groundwater contamination, as illustrated by the six weeks or more of investigation necessary between when tritium was first identified in GZ-3 (early January), and when the release point was finally identified (mid to late February).

At a minimum, a comprehensive network of monitoring points and sentinel wells was needed to allow timely identification and termination of the tritium leak.

Q: Did Entergy VY's monitoring lead to the discovery of the leak location?

A: No. According to the NRC Inspection Report issued May 20, 2010, it was a "*soil depression*" observed near the AOG building that "*prompted installation… of GZ-10,*" from which samples containing very high tritium activity indicated the nearby source. (Exhibit CLF-SF-7). It was, therefore, ground subsidence due to rapid subsurface fluid flow at the release point that

ultimately guided investigators to the source, not an existing monitoring well network from which detailed groundwater flow direction and radiochemistry data could be collected.

The NRC investigation concluded Entergy VY's response to the GPI "*was not sufficiently detailed*," "*did not provide sufficient specificity to identify the source area*," and did not "*include fundamental definition of ground water flow units, or their hydraulic relationships*." (Exhibit CLF-SF-7). This NRC document went on to report that, once identified, the source of tritium "*was not readily discernable due to an absence of monitoring wells adjacent to plant systems, structures and components containing radioactive fluids, as recommended in the GPI*." (Exhibit CLF-SF-7). These absent monitoring wells were also recommended in Entergy VY's own Hydrogeologic Assessment.

Q: Should Entergy VY have been aware of potential leaks where they were found?

A: Yes. Notably, the advanced off-gas (AOG) network to which the tritium leak was eventually traced, is the <u>first</u> system listed as having a "*potential direct pathway to ground*" in the Results section of the Executive Summary of the Hydrogeologic Assessment. (Exhibit CLF-SF- 4 p.1). This document contains sensible, technically sound recommendations regarding the need for and approach to groundwater monitoring at the VY property, and catalogues many of the potential sources of radiological contamination at the plant. Unfortunately, very few of the listed "*Options For Moving Forward*" in this Assessment (Table 3) had been implemented when tritium was discovered three years later in early 2010. It was only after the fact, since tritium was found in GZ-3, that additional monitoring apparatus was installed and additional hydrogeologic information collected at the site.

IV. Soil Characterization For Remediation / Anomalous Sampling Results

Q: Please identify soil contamination found during the leak investigation.

A: Entergy has provided the analytical results of soil sampling efforts completed within the trench excavation located around and beneath the condensate drain line, which runs from the AOG pipe tunnel to the AOG drain pit structure. This excavation was reportedly completed February 25, 2010 to access and confirm the underground release points of tritium into the subsurface in this area. Soil sampling results from two different efforts, completed on February 26, 2010 and March 18, 2010 were provided (Attachment A.CLF.EN.2-2a (Exhibit CLF-SF-8) and Attachment A.CLF.EN.1-19.4 (Exhibit CLF-SF-9) respectively). Several radionuclides have been documented at various depths at the bottom surface, and beneath the surface, of this trench, the base of which lies approximately 12 feet below the ground surface. MN-54, Co-60, Zn-65 and Cs-137 have all been identified in soil within this excavation; evidence of Sr-90, a soluble and extremely hazardous radionuclide, has been recently discovered in this trench (VT DOH Investigation Update – 5/21/10 (Exhibit CLF-SF-10)). In addition to tritium, these various radionuclides were all released from breaches in the underground piping in this area.

Q: Has Entergy VY adequately evaluated the remediation necessary?

A: No. The soil sampling results are being used to direct the remedial approach, and quantify the volume of contaminated soil material to be removed from the trench where the tritium release was first identified - in Entergy VY's own words samples were collected to "*estimate the amount of soil to be removed for remediation*" (A.CLF:EN.2-2 (Exhibit CLF-SF-8)). Based on the results of these sampling efforts, Entergy VY has proposed to remove soil from two locations measuring four feet by four feet, and to a depth of four feet, and scraping some additional soil off the bottom surface of the excavation, for a total of 150 cubic feet of soil removal -- less than one dump truck load of soil.

Soil sampling to characterize the degree and extent of contamination prior to remedial efforts is both needed and typical when addressing soil contaminated with any hazardous material. What is atypical in this instance is that the scope of remedial efforts in this trench was established by Entergy VY, despite sampling results indicating the extent of soil contamination is not known or adequately defined. Furthermore, the degree of contamination reported is suspect, casting doubt on the sampling and/or analytical programs utilized. The information known is not adequate to characterize the degree or extent of contamination or the remediation needed.

Q: Please explain how the extent of soil contamination is identified.

A: When characterizing the vertical extent of any soil contamination, samples should, and usually are collected within the contaminated zone down to a depth where results indicate a decreasing, very low, or ideally non-detectable level of impact. This approach is utilized in the horizontal dimensions as well, and is used to bound the limits of remedial effort and thereby quantify the expected volume of material to be removed.

Q: Has Entergy VY accurately determined the extent of soil contamination or the appropriate remediation needed?

A: No. The data collected show that the boundaries of the contamination have not been identified. Consequently the data does not support the extent of the remediation being undertaken.

Q: Please explain.

A: On February 26, 2010, sixteen soil samples were collected from various depths at five separate locations in the condensate drain line excavation trench. At three of the locations four samples apiece were collected (at depths of 0, 2, 4, and 6 feet below the excavation base). At two locations, only two samples apiece were collected. At the four sampling locations where samples were collected to a depth of 6 feet (172A North, 172A Elbow, 172A SE & SW), all four locations

recorded radioactivity at this depth, the deepest point from which samples were obtained. Consequently, the lower limit of impact in this trench has not been defined, and lies somewhere below a depth of six feet beneath the trench base.

Moreover, at two of these locations (172A SE & SW), the soil sample collected from 6 feet recorded the highest total activity of any sample collected within the profile above it. This indicates that the degree of contamination at these two locations is increasing with depth. This data does not support setting the proposed lower limit of soil removal at only four feet.

The results of soil sampling completed on March 18, 2010 indicate several radionuclides present at varying activity levels along the base of the excavation at all 11 locations where sampling occurred, and positive radioactive results at a depth of two feet below the base at 7 of these 11 sampling locations. No additional samples were collected below the two-foot depth on this date. These results indicate a fairly widespread horizontal extent of impact within the soil materials in this excavation trench.

Q: Should additional samples have been taken?

A: Yes. Based on the data collected, Entergy should have sampled at greater depths and at more locations, within this trench. No sample was collected deeper than 6 feet at any location. In light of these results, the rationale behind the proposed remedial effort is unsupported. Limiting soil removal to a depth of only four feet at just two locations is not indicated by the soil sampling results Entergy VY collected and provided. Additional soil sampling to characterize the extent of radiological contamination at depths greater than six feet, and at more locations, is needed to accurately assess the limits of subsurface impact in the trench excavation. This added data should be utilized to develop an appropriate and justifiable remedial plan for soil contaminated with radionuclides in this area. The plan proposed is not justified or appropriate based on the data collected.

Q: Have you identified additional problems with the sampling results?

A: Yes. The sampling results are anomalous and are not reliable.

Q: Please explain.

A: There are problems with the sampling results, or the reporting of these results, provided for the February 26, 2010 sampling program. The results of the 4 samples collected (at 0, 2, 4 and 6 feet) at two distinct locations (172A North & 172A Elbow) are exactly the same for both the various isotopes identified, and the total radioactivity measured. Moreover, exactly the same isotopes and activity were also recorded at a third location (SW) from the 0 and 2 foot depths, the only two samples collected at this location. To be clear, at any one location different isotopes and different total activity values are reported at different depths within the vertical profile, yet at three different locations the same isotopes are identified and the same total activity is recorded at common depths. As such, three of the five total sampling locations investigated on this date share identical radiological profiles with respect to both the isotopes identified, and total radioactivity measured.

These results are anomalous. The likelihood that the same radioisotopes exhibiting the exact same combined activity level would be found at two locations, let alone three, and that this relationship would repeat through the soil profile where as many as four samples are collected at periodic depths, is exceedingly low. By comparison, a review of the March 18, 2010 soil sampling results reveals the activity level of each individual isotope found at the two depths where samples were collected. On this sampling date, all individual results are unique and none combine to equal the same total activity of any particular sample. The anomalous February 26, 2010 results indicate quality assurance and/or quality control problems during either sample collection, sample handling or laboratory analysis and reporting, and call into question the entire soil sampling and/or analytical programs and procedures Entergy VY used on this date, as well

as the results presented. Normally an outcome such as this would prompt a review of practices and, at a minimum, a re-sampling effort prior to developing remedial goals and methods. The results are not reliable and Entergy VY did not undertake the minimal actions needed to ensure appropriate remediation.

V. Radionuclides in Soil at Depth

Q: Please explain your understanding of Entergy VY's analysis of radionuclide contamination at soil depths.

A: Testimony submitted on March 31, 2010 by the Chemistry Manager at Vermont Yankee, Mr. Jeffrey A. Hardy, indicates that in addition to tritium, various isotopes such as Co-60, Zn-65, Mn-54 and Cs-137 are contained in the condensed steam that had pooled in the AOG pipe tunnel, and leaked out to enter the subsurface from this structure, and from the nearby steam drain line. Mr. Hardy explains that these isotopes would not have migrated far, but instead "*would have attached to the soil near the release site, which acted like an ion exchange filter*", (Hardy Affidavit, 3/31/10, p.5 ln.16). This testimony indicates these radionuclides are not mobile and that they readily bind to soil grains in close proximity to the point of release into the subsurface, and that only tritium would infiltrate the soil column vertically to enter the groundwater regime where it reached the water table.

Q: Do you agree with Mr. Hardy's evaluation?

A: No. Entergy VY's own data does not support Mr. Hardy's conclusions. Additional soil sampling results have been provided by Entergy (Attachment A.CLF:EN.2-6 (Exhibit CLF-SF-11), GZA Well Soil Sample Results 4-7-2010). These samples were collected on various dates at various locations from various depths below ground throughout the VY property during the soil boring

program associated with recent monitoring well installation efforts to trace the tritium source. During drilling activities to access the design depth at which a monitoring well is to be constructed, soil samples are routinely collected at regular intervals in order to characterize the subsurface materials in the area through which groundwater, and associated groundwater contaminants, are flowing.

All soil samples collected during the monitoring well soil boring program completed between January and March were apparently screened for radioactivity at VY's on-site laboratory before being released off-site for further, presumably geotechnical, analysis. The seven GZA Well Soil Sample Results Entergy VY provided were collected from five different locations on the VY property, corresponding with monitoring wells GZ-4, 7, 13, 14 and 19. These seven soil samples were retained on-site due to their radioactivity. Along with tritium, samples from these five well locations contained at least one other radioisotope, including either Cs-137, Co-60 or Zn-65; the sample from GZ-14D contained both radioactive cobalt and zinc. The depths at which these samples were obtained range from near the ground surface (3 feet at GZ-19), to far below the ground surface (75 feet at GZ-14D). Four of these seven samples were collected from between 40 and 50 feet below ground. All five monitoring well locations where the soil samples were collected lie within, or directly adjacent to, the tritium plume as depicted on Exhibit EN:MS-4. In addition, four of the wells are positioned considerably downgradient from the nuclear plant and near the river, comprising some of the furthest downgradient monitoring points at the VY site.

Based on the downgradient locations and significant depths from which these samples were obtained, these isotopes migrated to the various positions where they were found and therefore, are not immobile as claimed. Nor did ionic exchange bind these radioactive materials to the soil near where it was released, as Entergy contends. The data collected fails to support

Entergy VY's claims. While the process outlined by Mr. Hardy may be occurring to some degree - a documented impact is clearly evident in soil at the release points – identifiable portions of the isotopes released from the AOG pipe tunnel are migrating further than Entergy's ionic exchange model would suggest. One of these soil samples contained more than one radioisotope other than tritium; Co-60 and Zn-65 were recorded at a depth of 75 feet when GZ-14D was installed. According to Exhibit EN:MS-3 this well lies directly downgradient from the release points identified to date. This data indicates that these isotopes are not in fact immobile. If they were, they would not be identified at this downgradient location and at considerable depth.

Q: Has Entergy VY provided a reasonable explanation for the existence of this contamination at depth?

A: No. In A.CLF:EN.2-6b (Exhibit CLF-SF-11). Entergy compares these soil sampling results from significant depths to previous soil results obtained within inches of the ground surface in 1993 and 1999 for a decommissioning study, finding the recent, deep results to be "*within the range*" of the prior characterizations, apparently based on the level of radioactivity alone. The response goes on to mention that the recent soil samples were obtained at "*locations where the soil had been disturbed to various depths during the life of the plant.*" The implication appears to be that the radioactivity found at considerable depth during the soil boring/well installation effort is the result of surface deposition that, at some point in the past, had been redistributed to 40, 50, even 75 feet below ground at these five separate locations, some of which are considerably downgradient well away from plant systems. The migration of tritium throughout the site, and to these specific locations, via groundwater transport has clearly been demonstrated. These other isotopes were released and entered the subsurface with the tritium. A more likely explanation for their occurrence at these distant locations is that these radioisotopes migrated beyond the release

point along groundwater flow pathways. This conclusion is supported by Entergy VY's own sampling data.

VI. Groundwater Remediation Plan / Extraction Well Capture Zone

Q: Are Entergy VY's activities and plans sufficient to remediate groundwater contamination?

A: No. Entergy VY's plans are inadequate and are not likely to remediate much of the contamination at the site.

Q: Please explain your understanding of what is occurring.

A: The extraction well at the VY site, installed and activated on April 7th and designated GZ-EW-1A, has been removing tritiated groundwater from beneath the site in an attempt to control the downgradient migration of this radiological contamination. Recovered groundwater is stored on-site for reuse in plant operations. The recovery well has been pumping at a reported rate of 3-4 gallons per minute (gpm) on a variable schedule based on VY's "s*torage capacity and plant-makeup water requirements*" (A.CLF:EN.2-3a) (Exhibit CLF-SF-12). The overall objective of this groundwater remediation program, best stated in the 5/20/10 NRC Inspection Report, is "*to prevent tritium migration to the bedrock aquifer and to minimize releases of tritium to the Connecticut River*." (Exhibit CLF-SF-7 p.9).

While these are sensible and admirable goals, they will not be achieved by the planned activities. To achieve these goals requires an effective groundwater interception and cut-off strategy to remove contaminants from the ground across the extent of the identified impact area. This is not occurring. Instead, Entergy VY's current remedial approach employs a single recovery well operating at a low pumping rate.

Q: Please explain why the activities are not adequate.

A: Based on Attachment A.CLF:EN2-7d.1 (Exhibit CLF-SF-13), the six-inch diameter recovery well is completed in sand, which is relatively permeable to groundwater flow. This recovery well is positioned roughly between GZ-7 and GZ-21 and based on Entergy VY's Exhibit EN-MS-4, the tritium impact area in shallow groundwater extends approximately 50 feet north, and 100 feet south, of GZ-EW1A, and extends to the east northeast towards, and into, the Connecticut River. To date, Entergy VY has produced no documentation that the current pumping rate of this recovery well is sufficient to extend the radius of influence, or the capture zone, of the well to the boundaries of the tritium impact area. Entergy VY has provided no data to support its claim that all or even a significant amount of contamination in the impact area will be collected.

Q: Do you agree with Entergy VY that its remediation efforts will capture most of the tritium contamination?

A: No. In permeable materials such as those identified near this well, the drawdown and radial extent of a pumping well are limited, particularly at low withdrawal rates. The region from which groundwater is drawn into this well in both the vertical and horizontal dimensions has not been established for this extraction well, and is likely quite small relative to the tritium plume dimensions. Consequently, Entergy's remediation strategy "*using low-flow pumping*" of EW-1A at "*3.5 gallons per minute,*" (Exhibit CLF-SF-7, p.9) fails to accomplish the stated goals.

It is likely tritiated groundwater has been discharging from the VY facility into the Connecticut River since at least December 2009, or earlier. As mentioned previously, sinkholes existed over a year prior to this date at the facility (Supplemental CRA at 78)(Exhibit CLF-SF-6). Furthermore, as the Supplemental CRA notes, Condition Reports investigating the sinkholes were inadequate and "*represent missed opportunities to possibly discover the AOG leakage sooner*." *Id.* at 85. Despite the installation and operation of GZ-EW1A in April, this off-site

discharge has and will continue until an effective strategy to control and capture groundwater across the extent of the tritium impact area is developed and implemented.

To capture the contamination, an additional extraction well or wells on a line perpendicular to groundwater flow and pumping in tandem, in order that the combined capture zones extend to the plume boundaries to intercept the entire cross-sectional area of tritium impact, is needed. This is the one routine manner in which contaminated groundwater would be captured for remediation of a contaminated site. Alternatively, a single recovery well pumping at a significantly higher volume (at least 10 times the existing extraction rate) would be needed to contain the tritium plume. The VT DOH has recognized the futility of the current approach, and has "*suggested that another extraction well be installed,*" yet reports Entergy VY has "*no specific plans to add a new extraction well*" (VT DOH Investigation Update – 5/28/10 (Exhibit CLF-SF-10)). The NRC reports that, as of late April, "*the centroid of the plume has moved past this monitoring well and northeast towards the Connecticut River,*" referring to monitoring well GZ-21 positioned southeast of, but quite close to, the recovery well. (Exhibit CLF-SF-7, p.8). As such, the NRC recognizes that the heart of the tritium plume, the centroid where the highest concentrations are found, bypassed the recovery well a few weeks after it began operating, and continues to flow downgradient to the river.

Q: Is the targeted volume of water to be extracted justified?

A: No. According to the NRC, Entergy VY's "*remediation plan is to remove approximately 300,000 gallons"* of groundwater from the recovery well "*over a two to three month period"* (Exhibit CLF-SF-7, p.6). This significant yet arbitrary extraction volume and duration was first cited on the VT DOH website on April 16, 2010 within a few days of the recovery well installation. Groundwater extraction to recover contaminants is typically governed by on-going monitoring of the recovered water, and the aquifer from which it is sourced, to understand the

effects and impact of the groundwater withdrawal. No information has shown that this is being undertaken here. Instead, an arbitrary extraction volume target was determined at the outset by Entergy VY. It is significant only in that it indicates their remediation plan is not based on the hydraulic response of the aquifer beneath VY, and the groundwater contaminants in it, to the pumping of the recovery well. Instead it is based on some other unknown or unidentified and unsubstantiated metric. With some effort, the hydraulic response to pumping is largely predictable, quantifiable, and easily measurable. To date, Entergy VY has failed to provide any measurement of the effectiveness of its pumping activities. It is unlikely the current pumping efforts are sufficient to effectively remediate groundwater contamination at the site and capture the bulk of the tritium that has entered the ground.

Q: What is the effect of inadequate remediation?

A: The site will not be cleaned up by Entergy VY's current efforts. Contamination will remain at the site, in the soil and in groundwater, and will continue to discharge into the Connecticut River. It is generally accepted that, once a release has been identified and stopped, the quicker soil and/or groundwater contamination is addressed and remediated, the easier and cheaper this effort will be. If not cleaned up now, it will migrate further into the environment, either vertically or horizontally, or both. It will be both more difficult and more costly to remediate in the future. As demonstrated by the data available about the radioactive contamination at present, it has moved and will continue to move unless it is removed from the site. As with any contamination by a hazardous substance, the contamination at VY will continue to threaten and harm the environment, and future use of the land and water resources.

Q: Is contamination reaching bedrock groundwater?

A: Quite likely. With regard to safeguarding the bedrock aquifer, the presence and persistence of tritium in GZ-13D and the early detection of it in GZ-14D indicates tritium is in the deep

surficial groundwater right at the bedrock surface in at least two downgradient locations, and has been there for months.

These wells comprise two of the three locations at the VY site where deep wells extending to the bedrock surface have been installed. Cobalt-60 was also found at depth in soil samples collected at both locations, as was Zn-65 at GZ-14D. These soil samples were obtained within a few feet of the bedrock surface at depths of 49 and 75 feet below ground (Attachment A.CLF:EN.2-6 (Exhibit CLF-SF-11)). This represents clear evidence that radionuclides released from VY, tritium and other radioisotopes, have reached the bedrock surface, and threaten the water supply aquifer beneath it. The downward vertical hydraulic gradients measured within the overburden deposits (Shaw testimony – 3/31/10) provide the mechanism for these radionuclides to reach the bedrock surface. Although less transmissive silt layers have been identified beneath the site, these materials were found to be discontinuous and therefore do not provide an effective barrier to vertical flow. Currently there is no monitoring of the bedrock aquifer in this area so there is not direct data to confirm contamination of this aquifer, or the lack thereof. However, every indication is that the bedrock is, or soon will be, contaminated by tritium.

Q: What actions has Entergy VY taken regarding bedrock aquifer contamination?

A: Entergy VY deactivated the Cobb well, a drinking water well at the site. This was a sensible initial precaution by Entergy VY when it discovered tritium at GZ-3, positioned approximately 60 feet away from the Cobb well. This bedrock water supply well sits downgradient from the source area within the tritium impact area, and continued use of it could potentially draw tritiated groundwater within the surficial materials down into the bedrock aquifer.

Exhibit EN-MS-2 indicates monitoring well #10 penetrates the bedrock surface and extends beneath it by at least 20 feet. This monitoring well appears to be very close to the source area and likely predates the tritium release in 2009, although it is not shown on any other figure

released by Entergy VY, or on the Attachment (A.CLF:EN.2-7d.1 (Exhibit CLF-SF-13)) intended as an "*updated version*" of EN-MS-2 on which it is depicted. Moreover, no radiochemistry data has been provided from this well, which would represent information from the upper reaches of the bedrock aquifer where tritium would most likely be found. However, since this well penetrates the bedrock surface it could potentially provide a conduit for tritium and/or other radioisotopes to enter the bedrock system from the surficial units above it. This monitoring well and any like it that extends into the bedrock (such as well #18) should be closely evaluated, and if found to be poorly or improperly constructed should be abandoned securely via standard industry practice. Otherwise this well could be used to monitor the top of the bedrock system.

Q: Are Entergy VY's actions adequate to protect bedrock groundwater?

A: No. The risk that tritium and other radionuclides could further compromise water quality in the bedrock aquifer beneath VY should not be underestimated. The NRC recognizes that "*The greatest potential impact on health and safety of the public would be if tritium could migrate to the bedrock aquifer*." (Exhibit CLF-SF-7, p.8). The groundwater remediation plan that Entergy VY is currently following is doing little to preclude this. Other than removing some amount of tritiated water at a low withdrawal rate from the shallow groundwater at the top of the surficial aquifer, this remedial effort is largely ineffective at protecting the bedrock aquifer. The stated goals of the remediation plan are not being met. Groundwater containing tritium continues to discharge to the Connecticut River. Tritium and other radionuclides have been detected at the bedrock surface for months. It may simply be a lack of monitoring capacity within the bedrock beneath the site that explains why it has not yet been confirmed within this aquifer.

VII. Tritiated Groundwater Discharge to River

Q: Is tritiated groundwater being discharged into the Connecticut River?

A: Yes. Many statements by Entergy VY concede that tritium released from the plant has reached and discharged into the Connecticut River via groundwater flow. It is likely this has been occurring since, or possibly before, tritium was confirmed in a sample obtained from a monitoring well positioned near the river (GZ-3) in November of 2009. Exhibit EN-MS-4, drafted with data collected in February, indicates tritiated groundwater discharges into the river along a stretch of shoreline that is greater than 300 feet in length.

Q: Discuss the significance of the lack of water sampling data confirming tritium in the Connecticut River.

A: In an attempt to understand the impact of site groundwater contamination on the Connecticut River, Entergy VY has periodically collected water samples from the river, and plans to continue collecting "*shallow river-water samples from a location immediately offshore from GZ-14* " (A.CLF:EN.2-9). No tritium has been detected above the MDA thus far in any of these river samples. In fact, tritium is unlikely to be recorded in future samples in light of the significant dilution effects that this large, moving, surface water body instantly imparts on tritiated groundwater as it slowly but continuously discharges into it through the riverbed. Entergy VY recognizes this fact. Testimony submitted on March 31, 2010 by Michael Shaw states "*Given the large volume of water flowing in the Connecticut River relative to site groundwater flow, it is unlikely that detectable levels of tritium will be measured in the Connecticut River*" (Shaw Affidavit, 3/31/10, p.9 ln.13-15). These river water samples, while perhaps a sensible precaution, are neither an accurate nor legitimate measure of impact on this water body.

Q: Could more accurate measures be taken?

A: Yes. To effectively assess the environmental impact of tritium discharging into the Connecticut River, an accurate measure of the volume and activity level of tritiated groundwater at or near the point of discharge is required. The current monitoring well network includes several perimeter wells positioned approximately 100 feet from the edge of the river. A volumetric discharge can be reasonably accurately determined from the existing well network, yet samples characterizing the tritium level of groundwater entering the river cannot. As such, samples collected at or quite near the riverbank where groundwater is discharging into the river are needed.

Unfortunately, "*Entergy VY confirms that there are no plans to obtain groundwater samples closer to the river*." (A.CLF:EN.2-9). This is shortsighted. If this area is inaccessible to standard well installation methods, relatively simple, manual techniques could be employed at several locations along the riverbank to install shallow, small diameter monitoring apparatus from which groundwater could be obtained. These samples would be collected from the soil materials directly adjacent to the river and therefore would accurately represent the tritium activity levels of shallow groundwater as it discharges into the river. Radiochemistry data from groundwater at the river's edge could be used in concert with that from more distant and deeper perimeter wells to establish a representative value of tritium activity entering the river, than data from distant wells alone. Using this information along with the cross-sectional flow area and groundwater migration rate, obtained from perimeter monitoring wells, groundwater discharge at a known activity level could be determined. From this data a precise tritium load, or flux, into the Connecticut River would be available that would accurately quantify the ongoing environmental impact on this river from tritium released into the subsurface at VY.

Q: What is the effect of not accurately measuring the impact?

A: The data needed is relatively easy to collect. Without this data, one cannot credibly claim there is no impact. It is known that tritium is reaching the Connecticut River and that this has an

impact on the environment. Tritium is a substance that is not allowed to be discharged by Entergy VY in unlimited quantities. (See Permit No. 3-1199 (NPDES No. VT0000264) to Entergy Nuclear Vermont Yankee for discharges from Vermont Yankee (attachment A.CLF:EN.1-16a.1 to ENVY's April 12, 2010, discovery response) (Attachment ANR-CT-2). Furthermore, Entergy VY has no authority to discharge tritiated water to the Connecticut River from any source other than the identified discharge outfalls. *Id.* Entergy VY has no authority to release tritiated water to the Connecticut River from groundwater. Without measurements, one cannot determine that the releases are even within the substantive limits of Entergy VY's discharge permit. *Id.*

Q: Does this complete your testimony?

A: Yes it does.

The foregoing testimony was prepared by me or under my supervision and is true and accurate to the best of my knowledge, information and belief.

_____

Stratton French

STATE OF VERMONT

COUNTY OF WASHINGTON, SS

Subscribed and sworn before me this ____ day of _____, 2010.

Before me,

_____

Notary Public

My Commission expires: _____