Date: February 22, 2010 (Final)
To: Catherine Benham, Joint Fiscal Office, Vermont Legislature
Through: Ezra Hausman, Synapse Energy Economics
CC: Stephen Klein, Joint Fiscal Office, William Steinhurst, Synapse Energy Economics
From: Bruce Lacy
Subject: Questions regarding Tritium, Spent Nuclear Fuel and Security

During the February 11, 2010 hearing regarding Vermont Yankee conducted by the Vermont Senate Committee on Natural Resources and Energy, several questions were raised regarding Tritium contamination, Spent Nuclear Fuel and Security. Answers to these questions, with additional information in the appendices, are as follows:

1. What are the standards for ground water contamination at the Vermont Yankee site?

The US Nuclear Regulatory Commission (NRC) does not have a separate and distinct ground water standard. NRC standards for protection of public health and safety are based on the concept of total dose by all pathways from all sources. The following table summarizes these standards.

NRC regulated facility or activity	Total radiation (energy) exposure to the public
Liquid effluents such as tritiated water discharged from operating commercial nuclear power plants, e.g. Vermont Yankee	3 millirem/year
Facilities involved in the generation of electricity from nuclear energy including operating commercial nuclear power plants, e.g. Vermont Yankee and related uranium fuel processing facilities	25 millirem/year
Facilities other than those involved in generation of electricity from nuclear energy such as academic or research reactors or medical facilities	100 millirem/year

NRC licensees, e.g. Vermont Yankee, are required to calculate the exposure to the public for any radioactive effluents from the plant. The NRC provides guidance for this detailed and complex calculation. Discussions with NRC staff on February 18, 2010, indicate that the Vermont Yankee staff is working on the required calculations.

If the Legislature wishes to follow this issue, it would likely find it useful to request that the results of the Vermont Yankee calculation for the tritiated water leak be provided as soon as the calculation has been completed and verified in accordance with NRC guidelines and requirements.

Additional discussion of the NRC radiation standards for plant operation and decommissioning including how the radiation exposure is calculated and comparison to normal background and human activity radiation exposure is in Appendices A, B and C.

2. Are groundwater contamination clean up costs operating costs or decommissioning costs?

Whether clean up costs are operating or decommissioning costs depends upon when the clean up in done. The NRC severely restricts disbursements from decommissioning trust funds prior to final cessation of operation of commercial nuclear power plants. Consequently if clean up is done prior to final cessation, it will be an operating cost. If cleaned up is done during decommissioning, it will be a decommissioning cost.

3. Where will the money collected as part of Vermont Yankee operation for the Nuclear Waste Fund (NWF) go over the long term?

Given the recent cancellation of the program for developing a facility at Yucca Mountain, Nevada, there is currently no clear answer to this question and there is much speculation about what the future will and should look like with regard to the NWF.

Appendix D provides additional discussion on this question.

4. What is the experience with Tritium contamination at other plants, including amount of leakage, how it was discovered and short and long term corrective actions?

Various official and media sources suggest reports of tritium contamination or spills at as many as 27 nuclear power plant sites in the US. Examination of the data and discussion with NRC staff indicates that the majority of these events are of very low significance. These low significance events are primarily spills of water from containers, e.g. buckets or barrels, inside buildings and the spills were contained in the buildings and either drained into water collection systems designed for that purpose or were cleaned up by mopping floors to collect the water.

Eight events resulted in contamination of the ground outside of buildings, which in some cases spread offsite. Appendix E provides a summary of the experience at these eight sites.

5. What is the role of Nuclear Regulatory Commission in the licensing of spent nuclear fuel dry casks and the interim storage of spent nuclear fuel at reactor sites?

NRC's role is to ensure that dry storage is accomplished in a safe manner. This is carried out by engineering evaluation of the various cask designs and licensing of those designs for use, plus SNF facility licenses governing entities that possess and maintain an SNF facility. Engineering reviews indicate that current cask designs are suitable for storage for decades, possibly as much as a century. NRC limits the period of SNF facility licenses in order to ensure that the licensee's performance and qualifications are up for review at intervals. Originally license periods were for 10 years, but based on experience NRC is now shifting toward 20 year license periods.

The precise form of NRC licensing depends upon whether the dry storage facility is considered part of an existing reactor licensed facility, or is a stand alone facility.

6. How has security preparedness at nuclear power plants changed over time and why has it changed?

Concern for security preparedness at nuclear power plants is not a new issue. The NRC has had security preparedness requirements for nuclear power plants throughout the history of licensing those plants. The level of those concerns and of efforts around security preparedness has continually increased over time based on NRC proactive review of the perception of threat.

Additional discussion is in Appendix F.

Appendix A

Discussion of NRC radiation protection standards applicable to ground water contamination

Contamination standards at commercial nuclear power plant sites such as Vermont Yankee are set by the US Nuclear Regulatory Commission (NRC). These standards are not in competition with or to be confused with US Environmental Protection Agency standards that apply elsewhere. Both have common scientific foundations.

The NRC has standards for exposure to the public during the operation of the power plant and for when the power plant is decommissioned and the site is released for unrestricted use. The NRC discussion of its operating radiation standards is included in Appendix B

NRC standards are based on calculating the total radiological exposure over time to members of the public from all sources of radiation from all ingestion pathways. Sources include contamination from fission product related radio nuclides and Tritium. Ingestion pathways include drinking water, food sources, irrigation of crops, vegetables and milk products and direct radiation exposure. The NRC provides detailed guidelines on how to calculate such exposure and nuclear power plant operators are required by their licenses to make such calculations in evaluating contamination.

The Radiation (energy from the nucleus of an atom in the form of particles and rays) exposure to humans is measured in millirem (one thousandths of a rem, also mrem or mr). The NRC standards can be summarized as follows:

NRC regulated facility or activity	Total radiation (energy) exposure to the public
Liquid effluents such as tritiated water discharged from operating commercial nuclear power plants, e.g. Vermont Yankee	3 millirem/year
Facilities involved in the generation of electricity from nuclear energy including operating commercial nuclear power plants, e.g. Vermont Yankee and related uranium fuel processing facilities	25 millirem/year
Facilities other than those involved in generation of electricity from nuclear energy such as academic or research reactors or medical facilities	100 millirem/year

There is no single specification for groundwater.

In addition to meeting the above standards, the NRC requires nuclear power plant operators to maintain radiation exposure for the public and their employees As Low As Reasonably Achievable (ALARA). This means that the plant operator must demonstrate that they not only met the standard, but that all reasonable measures were taken to ensure that it was as low as reasonable achievable below the standard.

Normal background radiation exposure to the public, not related to commercial nuclear power plants, is 300-500 millirem/year depending upon altitude, regional geology and other natural factors such as radon accumulation in homes. Additional radiation exposure to the public is also accumulated through activities such as airplane travel, radon and medical treatments. Comparative values for different sources of radiation exposure are included in Appendix C.

Appendix B

(the information in Appendix B is extracted from

www.nrc.gov/reading-rm/doc-collections/fact-sheets/tritium-radiation-fs.html)

NRC Radiation Protection Limits

“The NRC is continuously evaluating the latest radiation protection recommendations from international and national scientific bodies to ensure the adequacy of the standards the agency uses. Among those standards, the NRC and EPA have established three layers of radiation protection limits to protect the public against potential health risks from exposure to radioactive liquid discharges (effluents) from nuclear power plant operations. The NRC has determined that doses to the general public from the unintended release of tritium at nuclear power plants are significantly below even the most stringent layer of these protective limits and, therefore, does not pose a risk to public health and safety.

Layer 1: 3 mrem per year ALARA objective — Appendix I to 10 CFR Part 50

The NRC requires that nuclear plant operators must keep radiation doses from gas and liquid effluents as low as reasonably achievable (ALARA) to people offsite. For liquid effluent releases, such as diluted tritium, the ALARA annual offsite dose objective is 3 mrem to the whole body and 10 mrem to any organ of a maximally exposed individual who lives in close proximity to the plant boundary. This ALARA objective is 3% of the annual public radiation dose limit of 100 mrem.

The NRC selected the 3 mrem and 10 mrem per year values because they are a fraction of the natural background radiation dose, a fraction of the annual public dose limit, and an attainable objective that nuclear power plants could realistically meet. Power plants that meet these objectives are considered to be ALARA in reducing exposures to the general public from nuclear power plant effluents (AEC 1971, NRC 1975).

Nuclear power plant operators must monitor the authorized releases (effluents) from their plants. If a given nuclear power plant exceeds half of these radiation dose levels in a calendar quarter, the plant operator is required to investigate the cause(s), initiate appropriate corrective action(s), and report the action(s) to the NRC within 30 days from the end of the quarter.

Layer 2: 25 mrem per year standard — 10 CFR 20.1301(e)

In 1979, EPA developed a radiation dose standard of 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ of an individual member of the public. The NRC incorporated these EPA standards into its regulations in 1981, and all nuclear power plants must now meet these requirements. These standards are specific to facilities that are involved in generating nuclear power (commonly called the “uranium fuel cycle”), including where nuclear fuel is milled, manufactured, and used in nuclear power reactors. EPA determined the basis of the standards by comparing the cost-effectiveness of various dose limits in reducing potential health risks from operation of these types of facilities. EPA assumed the standards would be able to be met for up to four fuel cycle facilities (e.g., four reactors) at one location (EPA, 1976a). Notably, the NRC's ALARA objectives are lower than these EPA standards (NRC, 1980).

Layer 3: 100 mrem per year limit – 10 CFR 20.1301(a)(1)

The NRC's final layer of protection of public health and safety is a dose limit of 100 mrem per year to individual members of the public. This limit applies to everyone, including academic, university, industrial, and medical facilities that use radioactive material.

The NRC adopted the 100 mrem per year dose limit from the 1990 Recommendations of the International Commission on Radiological Protection (ICRP). The ICRP is an organization of international radiation scientists who provide recommendations regarding radiation protection related activities, including dose limits. These dose limits are often implemented by governments worldwide as legally enforceable regulations. The basis of the ICRP recommendation of 100 mrem per year is that a lifetime of exposure at this limit would result in a very small health risk and is roughly equivalent to background radiation from natural sources (excluding radon) (ICRP, 1991). Thus, the ICRP equated 100 mrem per year to the risk of riding public transportation – a risk the public generally accepts (ICRP, 1977). The U.S. National Commission on Radiological Protection and Measurements (NCRP) also recommends the dose limit of 100 mrem per year (NCRP, 1993).

For liquid effluents, including tritiated water, any licensee can demonstrate compliance with the 100 mrem per year dose standard by not exceeding the concentration values specified in Table 2 of Appendix B to 10 CFR Part 20. These concentration values, if inhaled or ingested over the course of a year, would produce a total effective dose of 50 mrem.

Drinking Water Standards

The EPA uses its authority under the Safe Drinking Water Act to set the Federal legal limits for contaminants in drinking water. Water suppliers must provide water that meets these standards, called maximum contaminant levels. EPA's drinking water standards do not apply to private drinking water wells, such as those that may be impacted by tritium that is inadvertently released from nuclear power plants. However, many State authorities have adopted the EPA's drinking water standards as legally enforceable groundwater protection standards, and those standards are often used in assessing laboratory test results of water from private wells. For more information on drinking water and health, visit http://www.epa.gov/safewater/dwh/index.html (EPA, 2006a). EXIT

Picocurie (pCi) is a term that scientists use to describe how much radiation and, therefore, how much tritium, is in the water. A pCi is a unit that can be directly measured by laboratory tests.

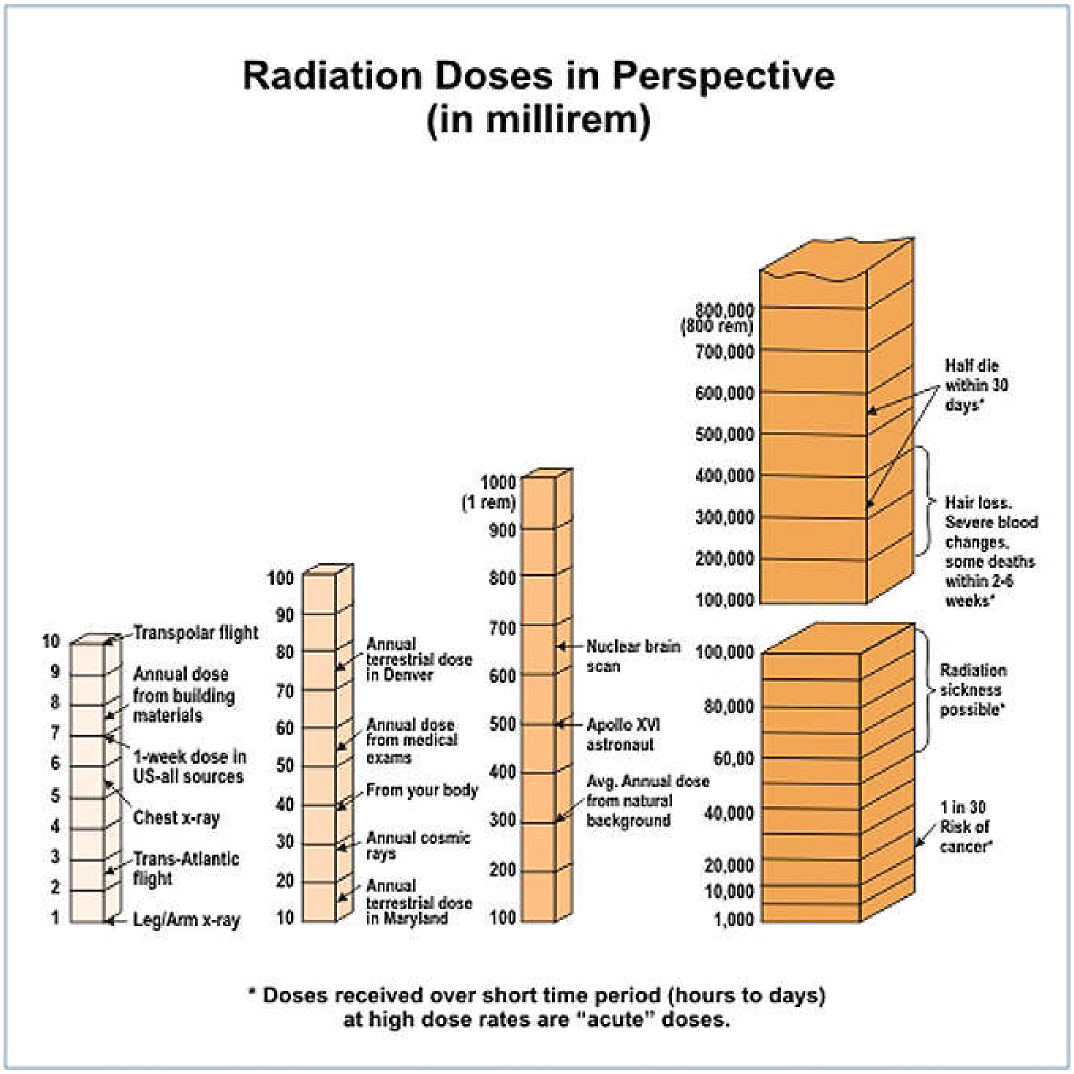
In 1976, EPA established a dose-based drinking water standard of 4 mrem per year to avoid the undesirable future contamination of public water supplies as a result of controllable human activities. In so doing, EPA set a maximum contaminant level of 20,000 picocuries per liter (pCi/L) for tritium. This level is assumed to yield a dose of 4 mrem per year. If other similar radioactive materials are present in the drinking water, in addition to tritium, the sum of the annual dose from all radionuclides shall not exceed 4 mrem per year. Water treatment plant operators use this drinking water standard, along with monitoring requirements, to remain vigilant regarding the amount of radioactivity in drinking water and provide a means to gauge if the concentration of contaminants in finished drinking water is increasing or decreasing over time. This standard was expected to be exceeded only in extraordinary circumstances (EPA, 1975; EPA, 1976b).

Since EPA developed the 1976 drinking water standard, scientists have improved the calculation methods to equate concentrations of tritium in drinking water (pCi/L) to radiation doses in people (mrem). In 1991, EPA calculated a tritium concentration to yield a 4 mrem per year dose as 60,900 pCi/L – a threefold increase from the maximum contaminant level of 20,000 pCi/L established in 1976. However, EPA kept the 1976 value of 20,000 pCi/L for tritium in its latest regulations. For more information on the basis and history of the Radionuclide Rule, visit http://www.epa.gov/safewater/radionuc.html (EPA, 2006b). EXIT"

Appendix C

Radiation Doses in Perspective

(from www.nrc.gov/images/about-nrc/radiation/factoid2-lg.jpg.)



Appendix D

Background on the Nuclear Waste Fund and the federal program for disposal of spent nuclear fuel

The NWF was established by Congress in 1983 as part of the Nuclear Waste Policy Act to provide a source of funds to support development of a permanent repository for disposal of spent nuclear fuel. The concept was that those who benefit from nuclear generation should pay for the disposal of the spent nuclear fuel. Utilities and state commissions have dutifully paid their contributions of a tenth of a cent/kwhr for all nuclear electricity generated, including electricity generated prior to 1983.

The program for development of a permanent repository has a varied history.

The US Department of Energy proceeded in accordance with the NWPA to identify suitable prospective sites for both interim and permanent storage and disposal facilities and reported on the identified sites to Congress.

As a result of prospective sites being identified, Congress amended the NWPA in 1987 to order the DOE to focus its efforts solely on the Yucca Mountain site in Nevada, one of several recommended by the DOE as a prospective site, and prohibited the DOE from any initiative or effort related to interim storage facilities until such time as a licence had been granted for Yucca Mountain. This is the state of the law as it stands today.

In the years following 1987, the DOE has focused its efforts on the Yucca Mountain site in accordance with the public law. The effort has encountered numerous difficulties, not the least being continuing issues of adequate appropriations by Congress, policy slowdowns and decisions that prevented movement forward from the various administrations and successful efforts by Nevada to delay progress.

The NWPA and associated standard contracts with utilities for disposal of spent nuclear fuel, stipulate the DOE to begin disposing of spent nuclear fuel by 1998. This date has not been achieved and utilities are now in a mode of continuous litigation with the US Department of Justice to seek damages for the expense of interim storage at their sites that would not have been required had the DOE begun to dispose of SNF in 1998. Damages are paid from the Department of Justice's Judgments Fund, not the NWF.

While the DOE recently successfully submitted a license application to the NRC for licensing of Yucca Mountain, the current administration has cancelled the project and established a Blue Ribbon Panel of experts to evaluate the national strategy for disposal of SNF and high level radioactive waste. This is similar, but not identical, to the effort in the early 1980's that led to the NWPA of 1983.

Contributions to the NWF by utilities continue. This is subject to increasing debate by utilities and groups representing state regulatory commissions and state legislatures, first as a result of federal government missing the 1998 date and now even more urgently as a result of the Yuccas Mountain project being cancelled.

Since 1983 the NWF has continued to accumulate funds due to payments by utilities being materially larger than appropriations by Congress. The net influx of money into the NWF has had a small but positive benefit, not unrecognized by Congressional appropriators, for budget balancing accounting.

NWF contributions and disbursements are approximately as follows:

$31B collected
<u>$ 7B disbursed</u>
$24B fund balance

The contribution amount attributable to Vermont Yankee customers or use of nuclear generated electricity in Vermont including out of state sources indicates a total Vermont contribution to the NMW ranging from approximately $160M to $300M.

Appendix E

Tritium experience at other nuclear facilities

Site	Onsite/Offsite	Discussion
Braidwood, IL	Offsite	suspicious groundwater was sampled, used reverse flow for cleanup
Prairie Island, MN	Offsite	routine monitoring detected in offsite sampling well, ongoing monitoring
Dresden, IL	Offsite	routing monitoring of offsite well found to be above minimum detectable level, ongoing monitoring
Brunswick, NC	Offsite	ongoing monitoring
Oyster Creek, NJ	Onsite	routine monitoring detected in discharge canal, ongoing monitoring
Salem/Hope Creek, NJ	Onsite	detected in onsite monitoring well at levels below EPA drinking water standard, ongoing monitoring
Indian Point, NY	Onsite	routine monitoring, source was fuel pool, ongoing monitoring
Vermont Yankee, VT	Onsite	detected as part of routine monitoring of onsite monitoring well, ongoing monitoring pending resolution

Appendix F

Changes in Security Preparedness

The NRC has and continues to monitor security requirements for nuclear facilities. Whether this interest in security is proof of a threat posed by a nuclear facility or is simply prudent practice in a complex world is a matter of debate.

The NRC's approach is built on the premise that terrorists or other security threats target the easiest available target that will produce the most dramatic impact. While an attack on a nuclear power plant would certainly garner headlines, the security measures in place ensure that nuclear plants and other similar facilities are "hard" targets and as such terrorists are effectively deterred.

NRC security requirements were first developed in the 1970's. The initial requirements included fences, cameras, lighting, access control to the facility itself, internal door control and staff to monitor and implement the requirements. These physical requirements have been upgraded over time to include perimeter monitoring, site access control, extensive use of additional cameras and motion sensors.

The requirements for qualification, training and equipping of security staff have also increased substantially over the same time period. While the initial security staff role in the 1970's was primarily one of monitoring and access control, it has changed dramatically over time. The NRC continually monitors "the threat" of general terrorist capability toward any kind of facility, including nuclear energy facilities.

NRC regulations update the threat regularly and nuclear facility licenses correspondingly add staff, training and equipment to deter the threat. Details of the threat are not made publicly available. Requirements associated with the current threat will identify such things as the number, type, motivation, knowledge, equipment and experience of prospective terrorists. Licensees are required to demonstrate through their training, including regular tactical drills with skilled adversaries, that their security forces are prepared to respond successfully to the current threat definition.

Dry storage facilities for SNF are provided security at levels comparable to reactor facilities.

Threat of attack from the air, e.g. the World Trade Center event, has also been examined by the NRC and licensees. While nuclear facilities were initially designed and constructed to withstand accidental impact by small aircraft, they were not specifically designed with the intentional impact of a large commercial jet in mind. However, analysis by NRC and licensees concluded the primary and secondary containments, including wet fuel pools; due to their designs provide adequate protection from such an attack.

Analyses by NRC and licensees of dry storage facilities for SNF have concluded that their designs provide adequate protection from air attacks.