Report of the State Nuclear Safety Advisor submitted to the Governor and 121st Legislature

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INTRODUCTION

The annual report of the State Nuclear Safety Advisor is required by 25 M.R.S.A. 51. A typical report reflects the status of the State's one nuclear power plant owned by Maine Yankee Atomic Power Company. In years past, nuclear facility radioactive releases, plant outages and State testing were frequent themes. The plant closed for decommissioning in 1997. Last year, the report highlighted security issues after the events of 9/ll/01. This year, security is still a focus as well as emerging plans for the 'end state' at the former Maine Yankee nuclear power station. Also identified are new security needs and approaches for state and local government, and possibilities for public/private programs that address radioactive materials management in an era of economic downturn.

Nationally, the nuclear energy industry believes there is a renewed interest in the United States in nuclear energy as a power supply. The belief is due to increased productivity at plants and to clean air attributes needed to counter global warming. For the first time in decades at least two companies, Dominion Energy and Entergy, will apply for licenses from the Nuclear Regulatory Commission to build new nuclear plants. Dominion is planning for a site in South Carolina, near the mega-nuclear complex at Savannah River. Entergy proposes a plant in Mississippi.

As a maturing innovation, nuclear power plants now have fewer outages, a positive environmental effect associated with climate change, and support from an energy-oriented administration in the White House. Globally, nuclear energy use has steadily increased, with the number of plants worldwide now more than triple that of the 103 operating U.S. plants. The Three Mile Island and Chernobyl disasters chilled interest in commercial nuclear power expansion in this country. The proposed new plants could resurrect a dormant nuclear plant construction business. Even so, both legislative policy and sufficient energy options for Maine make this state an unlikely choice for a new nuclear power plant in the foreseeable future.

The prime subject of this report is nuclear material management at the Maine Yankee nuclear power facility in Wiscasset. Maine Yankee currently manages high level radioactive material (almost exclusively spent nuclear fuel), low level radioactive material (classed as A, B and C) and Greater Than Class C (GTCC) material. Portsmouth Naval Shipyard, a pioneering facility in the Navy's nuclear propulsion program, is reviewed briefly. The report also provides a short summary of the commercial nuclear facilities nearby in Seabrook, New Hampshire and New Brunswick, Canada.

EXECUTIVE SUMMARY

The year 2002 was active nationally and in Maine for spent nuclear fuel issues. The U.S. Congress, with strong support from Maine's Congressional delegation, affirmed the President's nomination of Yucca Mountain in Nevada as the nation's spent nuclear fuel repository for byproduct material from commercial power plants and the nuclear navy program. The affirmative vote not only sent the Yucca project forward to licensure, but also signaled to the global nuclear community that the U.S. is committed to safeguard spent fuel in remote geologic isolation. Finland is the only other country to have identified and voted on a remote geologic site for its country's spent fuel. Russia has proposed at least one Arctic island and a former 'closed city' used in its nuclear weapons program for storage and reprocessing facilities. Minatom, the Russian equivalent of the NRC, proposed the sites not only for Russian nuclear materials but also to serve, for a fee of $1,000 a metric ton, a global market. Currently, Britain and France serve the global community, except for the U.S., by reprocessing commercial spent nuclear fuel as a spent fuel management service.

Only a relative handful of plants worldwide have shutdown and commenced decommissioning. In the U.S., nineteen plants are closed and in the process of decommissioning. See Appendix A. Maine Yankee is often profiled at national and international conferences and events because of its progress in decommissioning, volume of spent fuel remaining, and its status as one of the largest U.S. plants to decommission. The plant was one of six examined as part of the NRC environmental assessment procedures review for decommissioning plants. See Appendix B. An English consultant contrasted Maine Yankee recently with decommissioning in England where nuclear plants must be stored, not demolished, due to a lack of debris disposal facilities. In a reverse of the U.S. situation, spent fuel, however, is quickly removed offsite to the British Nuclear Fuel Ltd (BNFL) reprocessing facility.

Maine Yankee accomplishes decommissioning according to a plan to terminate its license to operate under NRC oversight. Maine Yankee completed a major, third revision of its License Termination Plan in 2002, including new commitments to groundwater testing and final site survey (FSS). **Section I reports on the significant events of Maine Yankee's Decontamination and Decommissioning (D&D) for the year 2002 and outlines emerging issues for 2003.**

Maine Yankee continues to ship *low level radioactive materials*, classed as waste under federal law to EnviroCare in Utah and Barnwell, South Carolina. Abbreviated as LLRW, it is materially, legislatively and politically distinct from spent fuel. The old reactor pressure vessel remains onsite and scheduled for shipment to Barnwell, South Carolina sometime in the next six years. It is a major piece of radioactive debris awaiting removal. **Section II discusses the Maine Legislature's decision in 2002 to leave the Texas Compact** as a redundant safety net for the State's *low level* radioactive materials. Maine's hospitals, research labs and small industry generate a small but steady stream of LLRW that is also typically transported by truck to the EnviroCare facility or to Barnwell. Maine Yankee ships its huge volumes of uncontaminated concrete by rail to a landfill facility in Niagara, New York.

High-level radioactive material in Maine exists in large quantity as spent nuclear fuel from the Maine Yankee facility and Portsmouth Naval Shipyard (PNS or Shipyard). The spent fuel from PNS is routinely and uneventfully shipped to Idaho's National Engineering and Environmental Laboratory (INEEL) facility where it is stored, awaiting shipment to Yucca Mountain. So far, INEEL's spent fuel storage facilities are not available for commercial spent fuel from shut down plants. By statute and contract, the U.S. Department of Energy (DOE) is responsible for removing spent fuel from Maine Yankee, but because the DOE has failed to fulfill this obligation, Maine Yankee commenced loading of spent nuclear fuel from its spent fuel pool into dual purpose dry cask storage/transport canisters in late summer. Maine Yankee believes dry storage is more cost effective and secure in the long term than wet storage. As of the end of December, eleven canisters of spent fuel and four canisters of Greater Than Class C (GTCC) materials moved to the Independent Spent Fuel Storage Installation (ISFSI, pronounced "is-FISS-ee"). When complete in 2003, a total of sixty-four canisters will await transport from the ISFSI, the most canisters at a dry storage facility in the country at either a shutdown or operating plant. **Section III describes spent fuel and GTCC dry cask storage issues, and outlines state policy considerations to promote transport options.**

Maine frequently interacts with the responsible federal agencies, particularly the Nuclear Regulatory Commission (NRC) and the Department of Energy (DOE), over federal duties owed to the State as well as to Maine Yankee. Maine encourages the NRC to perform diligent oversight of decommissioning to State standards, and advocates to the DOE for the prompt removal of GTCC and spent fuel materials. Maine's Attorney General and State Special Counsel filed a Petition for Hearing in November after the NRC issued a new security Order. The Atomic Safety and Licensing Board (ASLB) was asked to consider granting the State a hearing on the extent to which—and for how long--Maine Yankee and the NRC will rely on State and local protection to implement the measures required by an NRC security Order. The State believes the Order requires new State security duties and appears inconsistent with DOE public statements on duration of the State's security duties. Both NRC staff and Maine Yankee objected to the State's petition for hearing. **Section IV briefly outlines the differing and similar interests of the parties in the ASLB proceeding, and suggests an approach to the State's view that more security resources are required.**

Naval spent fuel from Maine travels via rail to a federal center of management, i.e. the DOE facility in Idaho, for inspection and storage. In 2002, as part of its transport program, the Shipyard invited regional responders, this office and other local and state officials to observe or participate in a naval spent fuel shipment accident exercise. Attended by federal and state radiological health officials and emergency preparedness and response personnel from the Northeast states, Arizona, Idaho, Nevada, Oregon, Pennsylvania and Virginia and by the Confederated Tribes of the Umatilla Indian Reservation from Oregon, the accident exercise resulted in better coordination among the emergency response agencies and improved communication protocols, according to event sponsors. Both Maine and New Hampshire responders were integral to the planning and execution of the exercise. **Section V gives a brief overview of the accident exercise and Shipyard accomplishments for the year. The section concludes with mention of neighboring nuclear installations: FPL Energy Seabrook Station in New Hampshire and Point LePreau Generating Station in New Brunswick, Canada.**

Section VI is a summary outline of the status of federal and state proceedings commenced or concluded during 2002. The section identifies the case or proceeding by title and outlines procedural history, outcome or status. The report concludes in **Section VII** with **recommendations for an enhanced nuclear safety preparedness program and for an appropriate link between nuclear safety and site redevelopment for the property north of Ferry Road.**

SECTION I Maine Yankee Decontamination and Decommissioning (D&D)

Background and Overview

Maine Yankee Atomic Power Company, owner of Maine's only nuclear power plant, is also the decommissioning oversight contractor (DOC) for the facility. Located on Montsweag Bay in Wiscasset, Maine Yankee generated electricity for 25 years but was officially closed in August 1997. The former power production facility is undergoing dismantlement with major demolition of the turbine building completed early in 2002, and destruction of the containment polar crane assembly completed on December 19. The crane demolition is the first stage of a multistage demolition of the containment (dome) building. The company decided to cease actively marketing Bailey Point for a new development in 2002 due primarily to new security issues arose after 9/11.

For the second time in as many years, Maine Yankee management changed presidents when Wayne Norton resigned to join Shaw Group in early December. The board selected Ted Feigenbaum, formerly site vice president and chief nuclear officer for Seabrook Power Plant and a former Maine Yankee board member, as the new company leader.

In 2001, Maine Yankee adjusted the D&D[1] schedules so that primary decommissioning completion changed from late 2004 to early 2005. Maine Yankee management recently confirmed that it will complete

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[1] The D&D process includes four stages: preparation and planning; removal and disposal of radioactive equipment and materials; cleanup of residual radioactivity on the site; and restoration of the site for another use.

site activity and the last stage of D&D in the first quarter of 2005. The projected final completion date of 2023 in the License Termination Plan includes what the company calls a "second decommissioning" of the ISFSI. The ISFSI will be demolished and decommissioned after all dry storage canisters are removed from the site to a center of management or disposal facility.

Significant Events and Notable Activities in 2002 at Maine Yankee's facility

From the State's perspective, four significant events and three notable activities occurred during the sixth year of Maine Yankee D&D.

The significant events were: 1) NRC issuance of manufacturer's transport license in addition to the storage license for the dual purpose canisters containing spent fuel, 2) NRC approval of Maine Yankee's commencement of loading and moving spent fuel to the ISFSI pad without a public hearing, 3) Maine Yankee completion of GTCC loading and transport to ISFSI after incorporating State documentation requests for the stored materials; and 4) NRC issuance of an Order to enhance security measures without consideration for Maine's long term safety preparedness burden. Notable activities were 1) personnel changes, 2) orderly destruction at the plant site and progress due to cavity water discharge and monitoring, confirmatory surveys of abandoned buildings, backlands sampling completion, fire pond tests and removal, reactor pressure vessel lift to transport way station, ISFSI dry run and E600 instrument use investigation as well as significant cooperative effort on the third revision of Maine Yankee's 920-page License Termination Plan; 3) ongoing work by Maine Yankee and the State on the cumulative risk assessment task required under Maine law. Beginning in 2003, tasks will commence on an 'end state' business plan by Maine Yankee for eventual dissolution of the corporation. See Appendix C. A brief overview of each of the events and activities is presented below.

1. EVENT: NRC issuance of storage canister transport license

Maine Yankee contracted with Nuclear Assurance Corporation (NAC) from Atlanta, Georgia, to provide dual purpose storage/transport canisters for spent nuclear fuel in order to complete D&D. NAC spent more than five years to obtain the transport approval for the canister. It obtained the *storage* certification in early 2001. NAC received the *transport* certificate of compliance on October 31. Maine Yankee and state officials met several times concerning the need to obtain the license before the end of 2002. Prior to issuance of the storage only certification, the State of Maine complained to the NRC that it should not approve any NAC dual purpose canister for storage without simultaneously granting approval for transport. The State was concerned that the spent fuel would be loaded and subsequently stored in Maine with too much uncertainty about future transportability. The complaint settled when the NRC agreed to formally contact the DOE, the authorized transport agent, about the status of the canister design. The DOE agreed in writing it will transport spent fuel from Maine Yankee in any canister approved for transport by the NRC.

2. EVENT: ISFSI development and operation without formal public review

Maine Yankee built and now operates an Independent Spent Fuel Storage Installation after it permanently ceased operations. By 2002, the company had transported and stored four canisters of Greater Than Class C byproducts and eleven canisters of spent nuclear fuel at the ISFSI. The NRC regulations understandably allow a sequence of plant closure followed by spent fuel storage operations for plants that shutdown prior to 1998, the year DOE was by statute and contract to commence spent fuel removal service for all plants. However, the State has advised the NRC that continuation of the NRC's policy for shutdowns to create new spent fuel storage facilities after 1998 under a Part 50 operations license contradicts the legislative history for the Atomic Energy Act and the Nuclear Waste Policy Act. Currently, it is NRC interpretation that shut down plants may choose to construct a dry storage facility under a Part 50 (or Part 72 general) license (no public hearing required) or under a site specific Part 72 license (public hearing required). See Appendix F-map. Maine Yankee chose to construct the ISFSI under its operating Part 50 license while simultaneously exempting certain Part 50 requirements because it no longer operates a reactor. It also actively pursues Part 50 license termination.

3. EVENT: GTCC loading and documentation

Greater Than Class C waste is so problematic that the defense department originally labeled it "orphan waste." That is, no one wants it and it hasn't a home anywhere. GTCC is often activated metal, e.g. irradiated stainless steel, with such a high radioactivity content that it poses potential sufficient threat to people such that it cannot be disposed of in near surface or above ground facilities but requires the same geologic isolation as spent fuel. As of 2002, Maine Yankee loaded and stored four spent fuel canisters of GTCC material at the ISFSI. GTCC management and future disposal is a serious problem for the company and for the State. Maine law—38 MRSA 1493—requires a referendum for a *low level* radioactive waste storage facility. The NRC changed GTCC rules so that the material is no longer under state jurisdiction, but may be stored like spent fuel. Although DOE is assigned federal responsibility for GTCC waste disposal, there is no explicit federal plan to execute this responsibility. Maine law is clear that no person may store or dispose of similar material that is less radioactive (class A, B and C) without a statewide referendum. Maine Yankee Greater Than Class C material is now stored above ground indefinitely—although GTCC cannot by federal law be disposed of above ground. With no identified destination for disposal beyond tentative designation to a future geologic repository, it is difficult to distinguish how *indefinite storage* of GTCC at an ISFSI is distinguishable from *disposal* in anything other than name.

Nationally, Maine Yankee and other members of the industry continue to push hard for the federal government to solve the GTCC issue. It is a frequent topic of discussion at conferences and symposia. Maine Yankee, with the

State's strong urging, pioneered a template in its ample documentation of GTCC loading and preparation for transport. The company consulted criteria required by the DOE's Waste Isolation Pilot Project (WIPP) in New Mexico. Under current law, WIPP can only dispose of transuranic material in its salt deposit facility, but WIPP is occasionally mentioned at industry gatherings as a logical destination for GTCC material from decommissioned nuclear facilities.

4 EVENT: NRC issues Order to enhance security at an ISFSI

The NRC embarked on a "top to bottom review" of security conditions at the nation's operating and decommissioning plants after 9/11. The NRC Commissioners have not concluded the review or announced results. Critics of both industry and the NRC say a security review is long overdue for a variety of reasons. The NRC announced last year it will require actual stress tests, in addition to reliance on computer models, beginning in 2004. One NRC source stated that the high costs of these tests--which destroy expensive canisters under simulated conditions to gather data--means implementation is on an indefinite schedule. Nonetheless, the announcement was broadly welcomed as a significant step by the federal agency to enhance public confidence.

The NRC conferred extensively with Maine Yankee management and other industry officials about security needs at an ISFSI. The NRC subsequently issued an Order to enhance security at all ISFSIs. The Order required most of what Maine Yankee already has in place after earlier 9/11 NRC advisories. However, a generic Order with requirements to prepare for a new threat to security created more questions than it answered from the State's perspective. A federal court ruled in 1999 that the DOE has not just delayed removal of Maine Yankee's fuel, it failed to perform in 1998 and is liable for that failure. The DOE maintains in court documents that Maine Yankee's fuel may well remain on site longer than the 20 year license period or the 30 year period that the NRC approves for initial dry storage safe condition duration. The State views DOE statements as a signal that the spent fuel is destined to remain in Maine for at least one if not two more generations if DOE is relied upon to accept and transport it under existing federal programs.

Although the post 9/11 security measures at Maine Yankee's site includes a new use of firearms, concrete barriers and high technology detection equipment, the role of the security force at Maine Yankee has not changed since before 9/11. Essentially, the role of the security force at Maine Yankee or any nuclear plant is to protect itself against design basis threats and then engage the assistance of local law enforcement as soon as possible if a threat is detected. The NRC issued a security Order to the licensee that requires State preparation and training for a new threat solely because that licensee, Maine Yankee, is storing spent fuel. While the plant operated, there was a direct program with laws in place, regular local law enforcement training, and monies for equipment. Indirectly, there were more personnel on site with long-term community ties, and generous property taxes for robust local security support and emergency responder programs. The dismantlement of the programs has accompanied dismantlement of the plant. The State receives inconsistent information from the NRC and DOE, post 9/11, as to duration and scale of a supplemental readiness program. Maine provides part of the security program for stranded radioactive materials left after Maine Yankee's decommissioning, and yet there is no adequate provision created for the added burden to limited State resources.

The following notable activities began in 2002 or reached a significant stage.

1. **ACTIVITY: Personnel changes**

Significant personnel changes took place in 2002. NRC Chairman Richard Meserve announced he will leave the NRC in March 2003. Maine Yankee experienced major personnel changes with the departures of Operations Manager Bill Odell, President Wayne Norton and Community Advisory Panel staffer Catherine Ferdinand, among others. Maine Yankee's spent fuel canister provider, NAC, Inc., received the resignation of longtime president Ed Davis in July, and Jim Levine, an executive vice president at Arizona Public Service

Commission, immediately assumed company leadership. Recently, industry veteran Peter Wallier replaced Mr. Levine at NAC. State radiation employee Dale Randall moved to a Maine Yankee contractor and, a former Maine Yankee contractor employee, Olin Hale assumed the position in December. Wiscasset area Senator Marge Kilkelly, longtime area legislator and Advisory Panel chair left public office at the end of 2002, but plans to remain as chair of the Community Advisory Panel.

2. **ACTIVITY: Orderly plant destruction and cooperation on LTP3**

An ongoing success story is the careful and orderly destruction of plant structures and buildings. Remarkable in scale, the demolitions themselves are further complicated by remediation, or the decontamination of surfaces, including walls and pipes. The company is appropriately proud of its high worker safety record to date.

The cooperation level among and between the plant, the community and the State on the tasks required to terminate the license remains strong. Another success story is the State's interagency commitment to coordinate and share Maine Yankee duties. The Department of Environmental Protection, the Bureau of Health Engineering/Division of Radiation Protection Program, the Office of the Nuclear Safety Inspector, the Maine State Police, the Maine Emergency Management Agency, Department of Marine Resources, the Public Utility Commission, the Office of Public Advocate and the Attorney General's office routinely interacted in 2002 to coordinate State response to Maine Yankee issues. Technical support from academics and specialists was also employed. State officials worked to review or advise on major demolition accomplishments by Maine Yankee by reaching across agencies, often led by State Nuclear Inspector Pat Dostie. Decommissioning decisions by Maine Yankee affect the environment, public safety and health, and State resources. The LTP underwent a third major revision in 2002, in part due to requests for specificity by the NRC, the State and by Maine Yankee's own efforts toward meticulous documentation of its closure program. See Appendix D.

3. **ACTIVITY: Final site survey preparations/cumulative risk assessment**

As reported in 2001, after contaminated materials are removed from the site, Maine Yankee is required to conduct a final site survey (FSS). This survey is the test for the quality of clean up and the assumptions and predictions made by the former power producer on the status of the site. The NRC and the State made it a priority in 2002 for Maine Yankee to clarify and explain in detail its methodology and assumptions for the final site survey, especially its use of and procedures for the radiation detection instrument called the E600, manufactured by Eberline. The NRC and State are scheduled to conduct confirmatory surveys in first quarter of 2003 to verify the ability of Maine Yankee to document decontamination and detect any residual contamination of the site. Most foundations of buildings will remain on site and decontamination is critical to meeting site standards for unrestricted release.

Two years ago, the federal Environmental Protection Agency, Maine's Department of Environmental Protection and Maine Yankee's contractor first met to discuss the state's required cumulative risk assessment (CRA). The CRA is an analysis of 1) the radiological, chemical and hazardous materials remaining at the site and 2) after decommissioning, the cumulative risk to human health[2]. Further meetings took place throughout 2002 to create a document that will serve as a basis for the cumulative risk assessment. The CRA schedule is still under review but completion is not likely to occur until after 2005. At that time, the site will be tested for radiological and chemical cleanliness, using 'as left' measurements.

Events Scheduled for 2003

No significant event is scheduled for 2003 that meets the same level as events in 2002, either nationally or locally. The demolition of the containment's dome, the signature landmark at the Maine Yankee site is not scheduled until the

[2] See 14-A MRSA 1455 for mandate to conduct a CRA study.

third quarter of 2004. Symbolically, for company management and workers, and community members, that event may rival events during 2002. The 2002 significant events were *Executive and Legislative branch agreement on the suitability of Nevada's Yucca Mountain* for a federal repository, the *public meeting on the LTP Rev 2* in Wiscasset in March, and the initiation of *movement of spent fuel from wet to dry storage* at Maine Yankee.

However, in 2003, the *petition for hearing* on the NRC security Order will be resolved, *spent fuel movement to the ISFSI* will be completed or mostly completed, and there is likely to be progress in Russia on an international spent fuel storage facility. Maine Yankee may also go to trial on its lawsuit against the DOE this year.

Closer to home, an event scheduled for early 2003 is the initial implementation of Maine Yankee management's plan for its end state business plan. According to the company, the Maine Yankee mission statement is undergoing change and new guiding principles, a schedule, budget and implementation plan are under review by managers. Any loss of key personnel or contracting out of important financial functions will signal that corporate change is underway.

Maine Yankee distinguishes between its operation as "steady state" and "end state." Steady state means technical expertise and security for the ISFSI is in place and working, i.e. the transition from decommissioning to only ISFSI operation. End state describes the dissolution of the company after the fuel is off site and the ISFSI is decommissioned. If appropriate, end state plans could include repayment of capital to the Maine Yankee multiple owners.

According to various owners' SEC 8-K filings with the Securities and Exchange Commission, the company will reportedly file a rate case with the Federal Energy Regulatory Commission in late 2003 to cover unexpected costs mainly due to increases in the projected costs of spent fuel storage, security and liability and property insurance. Maine Yankee has emphasized that the FERC request is to cover an annual estimate change, and not the total D&D costs, which won't be known for some time. The Maine Yankee request to the FERC is estimated in SEC reports at $40 million through 2022. The total expected decommissioning costs for Maine Yankee are $536 million in 1998 dollars ($654 in 2002 dollars).

SECTION II Low Level Radioactive Waste (LLRW)

Texas Compact

Ten years ago, arrangements between and among Maine, Vermont and Texas to dispose of low level radioactive waste generated in their states led to a compact, called the Texas Compact. The Texas Compact was authorized by and subject to the Low Level Radioactive Waste Policy Act Amendments to the Atomic Energy Act of 1954 (42 USC § 2011 *et seq.*) as of 1993. Last year, Maine's legislature approved a Governor's bill to extricate from the Compact, which started a two year withdrawal process. Maine Yankee asked for a Governor's bill (supported by the Public Advocate office) due to concern about latent financial liability to ratepayers should Texas site a facility or even create a Compact Commission. The Texas legislature meets again in 2003 and during the session may consider the implications of Maine's intent to withdraw. The State of Maine's position on the Texas Compact is that Maine confronts changed circumstances not anticipated during the Texas Compact negotiations just a few short years ago. If Texas believes Maine's membership in the Compact provides protection for that state at a cost commensurate with Maine's need, this session of Texas legislature provides opportunity for that discussion. Vermont, the remaining Compact member, has had no objection to Maine's initiation of withdrawal from the Compact.

In the meantime, private facilities have provided capacity for the low level radioactive waste stream from Maine generators that would otherwise seek disposal at a Texas facility. The primary stream is the result of Maine Yankee's decommissioning, now 70% complete overall, excluding spent fuel and GTCC. Approximately 25% of all materials classified as contaminated radioactive materials have been shipped off site to date. As reported in previous reports, the expectation is that approximately 1,016,000 cubic feet total of decommissioning waste from Maine Yankee will use disposal services at a Utah or South Carolina facility prior to the scheduled completion of Maine Yankee's decommissioning.

Besides Maine Yankee's waste volumes, other Maine low-level waste generators report little change from recent years; their volumes ranging between 1,054 cubic feet to 1,421 cubic feet according to records maintained by Maine's Department of Human Services, Division of Health Engineering. See Appendix E. Whether Maine should renegotiate terms for remaining in the Compact, if invited to do so, depends on several variables. The variables include a legal interpretation supporting negotiation without Congressional action, the ability for Maine to be a member at a fee substantially less than $25 million, and the ability of a Compact to offer benefit to Maine after Maine Yankee decommissioning is completed. After Barnwell closes to all waste except from Atlantic Compact states in less than a decade (see below), only one commercial facility will be open to accept low level waste from Maine. No matter how small the generator, any radioactive byproduct from a Maine company or hospital will either have to return to the manufacturer, be sent to a disposal facility or remain on site.

Barnwell, South Carolina

One of two national private LLRW facilities is located in Barnwell, South Carolina. In June 2000, South Carolina entered into the Atlantic Compact with New Jersey and Connecticut. The decision by South Carolina to join Connecticut and New Jersey means the two northern states continue to send their low-level radioactive waste out of state. At the same time, the agreement allows South Carolina to eventually exclude other states from sending LLRW to the Barnwell facility. The facility will remain open commercially for a phase-out period that concludes in or around 2008.

Transportation of LLRW

The decommissioning of Maine Yankee creates a large increase in the amount of low-level radioactive waste generated and transported through Maine by rail. Rail shipments have been the primary mode of transport for LLRW to EnviroCare's facility in Clive, Utah. When LLRW is shipped to the disposal facilities by ground transportation, it is regulated by the U.S. DOT under 49 CFR Parts 100-179. In the rare occurrence of a transportation accident involving LLRW, the state and federal emergency management agencies have established an emergency response plan. The DOT regulations address third-party bodily injury and property damage and cleanup. They require minimum limits for insurance per occurrence. All transporters of LLRW must comply with the Motor Carrier Act of 1980.

SECTION III Spent Nuclear Fuel and Greater Than Class C Material at the Independent Spent Fuel Storage Facility (ISFSI)

Maine Yankee produced 1,434 used nuclear fuel assemblies during operation from 1972 to closure in 1997. The removal and disposal of the spent nuclear fuel (frequently designated as SNF) assemblies is the responsibility of the Department of Energy by law and by contract with Maine Yankee. Until the DOE accepts and transports the SNF, Maine Yankee, like some other nuclear plants around the country, has decided to store used fuel in steel canisters surrounded by a vertical concrete cask (VCC). The canisters are placed inside the concrete overpack on a concrete pad. There is measurable radiation emitted, due to penetration of radiation through the casks and to a subsequent phenomenon called skyshine. Skyshine occurs when the emitted radiation scatters. The scattering radiation bounces against air molecules in the atmosphere and often contributes a dose of radiation to plants and living beings at ground level at some distance from the source casks. The State will post measurements of ISFSI radiation to date in the first quarter of 2003 on the advisor webpage. Tests for radiation from the ISFSI show little measurable activity from the eleven canisters so far, and provide a baseline for the expected measurable, if low impact, radiation once the ISFSI is fully operational.

Maine Yankee purchased sixty-four containers to store spent fuel and GTCC waste. The State's information shows the company spent approximately $64 million to date in ISFSI construction and operation, or an average of $1 million per canister. The events of 9/11 strengthened local concern for the Maine Yankee spent fuel to move away from Wiscasset. Local officials asked that fuel move to some federal site that already manages and protects defense-generated and foreign reactor materials, recognizing there are better options than an isolated decommissioned site with stranded spent nuclear fuel. The community, State and Maine Yankee may have a harder time to pursue innovative alternatives once the investment to dry store (called a sunk cost factor) is made. At the same time, Maine Yankee management states it is committed to exploring alternatives to the operation of an onsite ISFSI for spent fuel and GTCC management. As a matter of policy, the State maintains the ISFSI materials should move to a federal center of management before Yucca Mountain is operational (optimistically predicted for 2010, but likely to be significantly later).

Although international options for spent fuel management are available to commercial nuclear facilities in other countries (the island nation of Japan is a notable example), the U.S. has yet to formally participate to innovative global market solutions to expand spent fuel services worldwide for U.S. industry. While work continues on making a Russian facility a reality, quarrels over the inclusion of reprocessing services using monies flowing from the U.S. has slowed progress. France continues to provide spent fuel management service, e.g. Japan's nuclear industry. A scandal within Japan's nuclear industry and governmental oversight agency last year cost a great deal in public confidence there and halted spent fuel shipments for a period of time. France made headway in its goal to privatize its nuclear industry with the formation of AREVA, a multinational corporation with French government support that has purchased some American based companies, including Canberra Instruments of Connecticut. One of AREVA's subsidiaries, Framatone, is a Maine Yankee contractor. Whether international alternatives become available to U.S. plants is not a technical issue, but a policy to be made by federal decisionmakers.

As discussed above, although Greater Than Class C material is a small part of Maine Yankee's decommissioning waste volume, it is perhaps the most pernicious problem. It is highly radioactive metal with no use, subject of no plan by any entity for disposal (except that its destination must be a repository that already will be full of spent fuel), and now stored in Maine with some question about state authorization. For its part, Maine Yankee packaged the GTCC material in transportable canisters and completed basic shipment documentation at the time of loading.

SECTION IV Security Issues

The State has a legitimate interest in ensuring the safety and security of its citizens. The NRC has long required Maine Yankee, as a licensee, to implement security measures. New NRC Orders are intended to enhance security during and after decommissioning. Maine Yankee's ability to carry out such Orders is of crucial importance to the community. The Orders are safeguarded, i.e. classified, and the State maintains that the recent Order assumes some additional use of State and local law enforcement and emergency response resources, even if only to prepare for an event that never occurs.

The State has petitioned the ASLB for a hearing, potentially a closed hearing, to discuss the implications on the State of the most recent NRC Order to Maine Yankee. The NRC objected to the State's request, taking the position the State lacks standing because the Order applies only to Maine Yankee and not the State. Maine Yankee also objected, based in part on its interpretation of an NRC letter to mean no additional State resources are required as a result of a new Order.

The State's Petition says that the State is adversely affected by the recent NRC Order due to its interest in protecting its citizens. A distinguishing factor from other similarly situated industry is the NRC role in security needs determination. A second factor is the unknown duration of time for State security supplementation because the 1998 deadline for DOE initiation of performance was not met and the DOE has not committed to a Maine Yankee fuel removal schedule.

A variety of avenues for resolution of State concerns are currently pending in discussions with the NRC and Maine Yankee. The focus of those discussions is the theme that adverse safety and health effects resulting from the threat of or actual radiological events such as accidents and sabotage need not be feared so long as adequate resources and programs exist. Responsible state personnel will be able to carry out best practices in security measures and emergency preparedness to prevent or mitigate the effects of such events. Industry contribution to a state's costs associated with preparing and implementing plans to deal with the effects of potential nuclear events in states that host commercial nuclear facilities is not uncommon .

How the State plans to meet the duties that accompany the indefinite hosting of spent fuel is worth taking time to calculate. The costs are real although sometimes difficult to identify fully or in discreet line items; furthermore, there are no viable alternatives to meeting the security tasks required.

Specific security issues and safeguards information cannot be easily shared but can be—and are—increasingly discussed in the context of best practice and standards. Training, data analysis and communication networks form the human and equipment foundation for security infrastructure. In 2002, Maine's state police chief inspected test program sites used by Israeli police units that determine actual security resources necessary and the deployment of resources.

The purpose of new nuclear safety preparedness programming would be to recoup the specific costs of state security and response support for spent fuel management as a consequence of DOE's refusal to transport the materials to a federally secured, interim storage site. Until DOE performs, the State must improvise the significant protections and expertise available at a federal installation or center of management in a post 9/11 society. While the often extraordinary funding associated with spent fuel management and protection is best dedicated to federal sites in states where infrastructure and personnel now exist, some new arrangement is appropriate if Maine must host stranded radioactive materials indefinitely. See Appendix F for Maine's ratepayer payments through September 2002 for DOE spent fuel service ($168.6 million)

SECTION V Portsmouth Naval Shipyard

Portsmouth Naval Shipyard (PNS), located on Seavey Island in Kittery, continues to serve the Navy for maintenance and overhaul of Los Angeles Class nuclear-powered submarines. On October 5, 2002, Captain Kevin McCoy, USN, celebrated his first anniversary as shipyard commander. Captain McCoy reports in his annual year end message, published in a shipyard bullet *The Periscope*, that their mission is to continue improvement in the yard's cost and schedule performance and to demonstrate that they are the "Nation's submarine maintenance experts."

During the year, the Shipyard received recognition from the DOE as a recipient of the Federal Energy and Water Management Award. The Navy also applauded the yard for service to sailors with the Zumwalt Award for Excellence in Bachelor Quarters Operations.

The shipyard hired nearly 300 new employees in the trades and engineering codes. It started a $32 million renovation of its power plant and commenced major building repairs, upgrades to yard-wide utilities and improved dry-dock facilities. It continues to rely on an enhanced security program managed by its extensive Security Department.

Each year, the Naval Nuclear Propulsion Program issues and distributes to the State a report entitled, "Environmental Monitoring and Disposal of Radioactive Wastes from U.S. Naval Nuclear-Powered Ships and Their Support

Facilities." The report notes that nearly all Naval Nuclear Propulsion Program radioactive shipments contain only low-level radioactivity and are classified under Department of Transportation regulations as low specific activity, surface contaminated object, or "limited quantity shipments." The predominant radionuclide associated with these shipments is cobalt 60. Most low-level shipments are made by truck. Although air shipments are occasionally used, these shipments only involve very low-level radioactivity and are not transported on passenger planes.

PNS continues to ship spent nuclear fuel (SNF) by rail, typically one or two shipments a year. Since 1957, all SNF has been shipped via rail to a licensed DOE facility in Idaho, the Idaho National Engineering and Environmental Laboratory (INEEL) for evaluation and storage. During that time, and according to Navy sources, the Naval Nuclear Propulsion Program shipped 744 containers (3 more than last reported) through the end of 2002 without an accident resulting in release of radioactivity or injury.

In June, 2002, PNS hosted a full day of naval spent fuel transportation program briefing and accident exercise in Kittery for responders. More than 150 participants and observers were involved. Most were from New England, but some traveled from other parts of the country. This spent fuel transportation accident exercise was only the fourth such exercise since 1996 conducted and hosted by the Naval Nuclear Propulsion Program. The cost for six months of preparation for and the one day implementation of the exercise was approximately $148,500.00, excluding time and equipment contributed by local fire departments, emergency response units and public safety officials.

In anticipation for the opening of a Yucca Mountain or other licensed federal repository, PNS will continue to ship its SNF from Maine through New Hampshire and points west to its destination in Idaho for evaluation and storage through 2035.

FPL Energy Seabrook Station

FPL Energy bought 88.2 percent of the Seabrook, New Hampshire nuclear power plant in November 2002 for $798 million from Northeast Utilities, of Berlin, Conn., and several smaller shareholders. FPL Energy Seabrook Station, the newest subsidiary of FPL Energy, recently announced it will cut 190 jobs, trimming the workforce from 790 to about 600 people by November 2003.

Under former executive Ted Feigenbaum, now president of Maine Yankee, the Station received the International Standardization Organization (ISO) 14001 certification for environmental program excellence – becoming only the third plant in the industry to receive such recognition. Seabrook also safely completed its best refueling outage in its 12 years of commercial operation. The new site vice president of FPL Energy Seabrook is Mark Warner, who came to FPL Energy from Nuclear Management Company. Previously, he served as site vice president, Three Mile Island, for Exelon Corporation.

In March, the Nuclear Regulatory Commission hosted an annual assessment meeting of the plant at the Seabrook Community Center. Seabrook Station performance ratings were presented to the public. The NRC deemed the plant safely operated. Some community members or activists and a state legislator questioned the NRC's security assessments post 9/11.

The State of New Hampshire also instituted a potassium iodide (KI) distribution program last year. The tablets are helpful in adult and child thyroid protection in the event of excessive release of radioactive iodine (I-131), associated with operating plants. Shut down nuclear plants no longer produce radioactive iodine. Maine is the only New England state that chose not to request federal KI supplies to distribute to the public. The tablets are commercially available and can cause harm if used inappropriately or by persons with thyroid conditions or allergies to iodine or shellfish.

Point LePreau Generating Station

The nuclear power station known as Point LePreau, located in the town of Point LePreau, New Brunswick, Canada, is scheduled for refurbishment in 2007. The renovation will cost more than C$180 million and result in an outage for approximately 18 months. Last year, New Brunswick's provincial governor proposed that provincial management of the four energy producers in New Brunswick be terminated and the industries be privatized. To that end, a bill is scheduled for submission to its parliament in 2004 to create a holding company with four subsidiaries. Point LePreau Generating Station must look for a partner or purchaser under the terms of the legislation.

Point LePreau currently dry stores hundreds of canisters of spent fuel. The CANDU spent fuel rods are shorter and more compact than fuel rods used in American nuclear reactors. An agreement-in-principal between the Canadian and American governments envisages the importation and burning of MOX fuel in CANDU reactors to meet nonproliferation treaty goals. The political reality for accomplishing trade in fuel services, even fuel with irretrievable plutonium, means that implementation of this international bargain is still in the future. In addition, the Canadian government is following the U.S. example of a geologic repository solution and began to collect fees from nuclear utilities this year for a national repository fund.

An agreement between governments signed in 2000 at the 25th Annual Conference of New England Governors and Eastern Canada Premiers provides for international emergency management assistance across borders. Such response includes nuclear emergencies. At a meeting in New Brunswick attended by Maine officials last June, members expressed concern about implementation of the agreement due to U.S. restrictions on the movement of military equipment and personnel across international boundaries, even for training purposes.

Section VI Proceedings

At the end of December, only proceedings related to Maine Yankee were pending. The status of legal and administrative proceedings of interest is as follows:

Docket #50-309; 72-30

Pending before Atomic Safety and Licensing Board

Request for Petition hearing

Filed December 13, 2002

State of Maine petitioned the NRC pursuant to 10 CFR Sec. 2.714 to challenge implementation of an Order modifying Maine Yankee's Part 50 license as the operator of an Independent Spent Fuel Storage Installation (ISFSI) under a general license provision of 10 CFR Part 72. The State requests that the Order not be implemented before a hearing is held that includes the NRC, the licensee, the State and the Department of Energy. The State maintains that the Order creates new security requirements that will result in an unsustainable burden on the State and adversely affect the public health and safety, given the likely duration of the burden.

Docket # 50-309-OLA/ASLBP #00-780-03-OLA

Settled August 30,2001

In the Matter of Maine Yankee Atomic Power Co.

The State and Maine Yankee executed a settlement agreement after the State petitioned the NRC Licensing Board for party status in order to present formal comments on the Maine Yankee License Termination Plan (LTP). The settlement, concluded on August 30, was the culmination of a year of State comments on the LTP and intense dialogue among the State, Maine Yankee and the local activist, Raymond Shadis. As a result, Maine Yankee substantially rewrote the LTP to incorporate the State and Mr. Shadis' comments and to address stakeholder concerns. In addition, the settlement agreement provided mechanisms that have been implemented successfully to resolve outstanding technical issues and to determine whether the NRC considers the intertidal zone in Bailey Cove to be a part of the plant site that must satisfy site-release criteria. To date, Maine Yankee has created a matrix to itemize settlement agreement terms either implemented or included in the LTP Rev. 3. A major open item remains on outstanding groundwater issues that are expected to be resolved in the first quarter of 2003.

Docket # 50-309

Declined

NRC Review of Maine Yankee Exemption Request under 10 CFR 73.55 for Revised Security Plan

After the events of September 11, the State wrote to Chairman Meserve requesting that security exemptions made for Maine Yankee's ISFSI be withdrawn and the same security required at operating plants be maintained at the ISFSI. The NRC declined to comply with the requested withdrawal and has initiated a program of Orders to address security issues.

Docket #s 99-5138, 5139, 5140

Decided August 30, 2000; damage claims pending

Maine Yankee Atomic Power Company, Connecticut Yankee Atomic Power Company and Yankee Atomic Electric Company v. United States,

United States Court of Appeals for the District of Columbia Circuit

On ***August 30, 2000***, the Court of Appeals in the Federal Circuit issued a decision determining a breach of contract by DOE. A motion for rehearing was filed November 15, 2000 and denied by the court on December 12, 2000. Fourteen utilities have since filed similar claims and motions were made to consolidate. The three Yankee companies successfully defended its right to proceed due to the maturity of its complaint and discovery. As of December 2002, both the federal government and the Yankees had filed briefs on the measure of damages. The federal government claims Maine Yankee has no damages because all the Maine Yankee spent fuel will not move for decades, even if a federal repository is available. Maine Yankee currently claims $105 million only through 2010 but is able to submit, and will likely submit, a revised damages claim that is materially higher. The State is not a party to DOE litigation, but monitors this litigation closely.

SECTION VII Policy Recommendations

Two recommendations result from the work of the past year.

The first recommendation is for State policymakers to consider the impact of repealed legislation that formerly provided resources for comprehensive, routine training, equipment and programs for State and local responders and public safety officials who are on-call for Maine Yankee events. So long as terrorism is a threat and the NRC issues Orders for security measures that implicate State resources, the State should have a financial mechanism from dedicated funds to support State security analysts and State and local responders. Such support means State personnel will be thoroughly prepared to protect their own and the public's health and safety. Proposals for policymakers to consider in the first quarter of 2003 will likely be generated from current discussions underway in the Atomic Safety License Board proceeding.

The second recommendation is that the State take a pro-active role concerning site redevelopment, including connecting with the Wiscasset Regional Development Corporation as it creates a program to encourage investment on Maine Yankee property north of Ferry Road. Industries that are affiliated with nuclear energy or transportation or security or decommissioning will understand the high degree of site clean up provided by the Maine Yankee decommissioning. Businesses unfamiliar with nuclear energy will have a steep learning curve that may be insurmountable at certain levels within non-nuclear organizations. Compatible industries may also provide and look for synergy with a potential international "nuclear materials and the environment" forums center at Chewonki. A wide variety of affiliates to nuclear power production--manufacturers of instruments, transport components and specialty structures--exist that serve commercial nuclear energy clients and also nonproliferation programs. The specific State roles would be 1) to inform and encourage the development officials or representatives to contact appropriate niche entities and 2) to host acquisition managers when any site visits are made. While businesses interested in additional spent fuel storage are not eligible or desirable, business entities familiar with or that support programs for fuel *movement* would be a good knowledge investment to promote the removal of spent fuel stored nearby. A component of safe nuclear material management is continued activity, oversight and research. A major investment at Ferry Road should be part of the broad strategy to provide a safe environment in the State, even as it unwillingly hosts spent fuel and GTCC material.

Resources and References

The following web pages provide facts and images on decommissioning of the Maine Yankee Atomic Power Plant, and general issues of radiation control and management

http://janus.state.me.us/dhs/eng/rad/rad.shtm
http://www.maineyankee.com/
www.state.me.us/spo/nuclear/

Other sites of interest that include topics covered in the Report:

http://janus.state.me.us/dep/rwm/myankee/homepage.shtm
http://www.ports.navy.mil
http://seabrookstation.com
http://www.nbpower.com/en/about/nuclear/project_status.pdf
http://www.nrc.gov/public-involve/public-meetings/webcast-live.html
http://epa.gov/epaoswer/osw/index.htm
http://inel.gov/national/national.html
http://www.envirocareutah.com
http://www.cogema.com/cogema/uk/fs_accueil.htm
http://www.altfutures.com "The Future of Radiation Protection: 2025"
http://www.radwaste.org/decom.htm
http://necnp.org "New England Coalition against Nuclear Pollution"

NOTE: Prior year Nuclear Safety Advisor Reports may be found in hard copy in the Maine State Legislative Law Library and recent reports are online at www.state.me.us/spo/nuclear/

Acknowledgments and Errata:

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In response to the 2002 Report, two reviewers suggested additions to the Glossary in future reports that have been incorporated in the 2003 Report. The correct acronym for the tri-annual Packaging and Transportation of Radioactive Materials mentioned in last year's report is PATRAM.

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GLOSSARY

Excerpt from the 1996 DOE publication *Closing the Circle on the Splitting of the Atom* and glossaries listed at the end of the document.

Alpha particle. A particle consisting of two protons and two neutrons, given off by the *decay of* many elements, including uranium, plutonium, and *radon.* Alpha particles cannot penetrate a sheet of paper. However, alpha-emitting isotopes in the body can be very damaging.

Atom. The basic component of all matter. The atom is the smallest part of an element that has all of the chemical properties of that element. Atoms consist of a *nucleus* of protons and *neutrons* surrounded by electrons.

Beta particle. A particle emitted in the *radioactive decay of* many *radionuclides. A* beta particle is identical with an electron. It has a short range in air and a low ability to penetrate other materials.

Calcine. A process that uses heat to reduce liquid high-level waste into a dry, powdery form. Also the powdered waste that results from this process.

Cesium. An element chemically similar to sodium. Isotope cesium-137 is one of the most important *fission products,* with a *half-life* of about 30 years.

Chain reaction. A self-sustaining series of nuclear fission reactions, *when neutrons* liberated by fission cause more fission. Chain reactions are essential to the functioning of *nuclear reactors* and weapons.

Chemical separation. Also known as *reprocessing;* a process for extracting *uranium* and plutonium from dissolved irradiated targets *and spent nuclear fuel* and *irradiated targets.* The fission products that are left behind are *high level wastes.*

Cladding. The outer layer of metal over the fissile material of a nuclear fuel *element.* Cladding on the Department of Energy's *spent fuel* is usually aluminum or zirconium.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). A Federal law, enacted in 1980, that governs the cleanup of hazardous, toxic, and radioactive substances. The Act and its amendments created a trust fund, commonly known as Superfund, to finance the investigation and cleanup of abandoned and uncontrolled hazardous waste sites.

Criticality. A term describing the conditions necessary for a sustained nuclear *chain reaction.*

Curie. One curie is 37 billion *radioactive decays* per second.

Decay (radioactive). Spontaneous disintegration of the *nucleus* of an unstable *atom,* resulting in the emission of particles and energy.

Decay product. The *isotope* that results from the *decay* of an unstable *atom.*

Decommissioning. Retirement of a nuclear facility, including *decontamination* and/or dismantlement.

Decontamination. Removal of unwanted radioactive or hazardous contamination by a chemical or mechanical process.

Defense Waste Processing Facility. A *high-level-waste vitrification* plant built at the *Savannah River Site.*

Department of Energy (DOE). The cabinet-level U.S. Government agency responsible for nuclear weapons production and energy research and the cleanup of hazardous and radioactive waste at its sites. It was created from the *Energy Research and Development Administration* and other Federal Government functions in 1977.

Depleted uranium. *Uranium* that, through the process of *enrichment,* has been stripped of most of the *uranium 235* it once contained, so that it has more *uranium 238* than *natural uranium.* It is used in some parts of nuclear weapons and as a raw material for *plutonium* production.

Deuterium. A naturally occurring *isotope* of *hydrogen.* Deuterium is lighter than *tritium,* but twice as heavy as ordinary hydrogen. Deuterium is most often found in the form of *heavy water*

Dose. As used here, a specific amount of *ionizing radiation* or toxic substance absorbed per unit mass by a living being.

Dry cask storage. The storage of *spent nuclear fuel* without keeping it immersed in water.

Enrichment. The process of separating the *isotopes* of *uranium* from each other. Other elements can also be enriched. In the United States this is done using the *gaseous diffusion* process.

Enriched uranium. *Uranium* that, as a result of the process of *enrichment,* has more *uranium 235* than natural uranium.

Environmental contamination. The release into the environment of *radioactive,* hazardous and toxic materials.

Environmental Management. An Office of the *Department of Energy* that was created in 1989 to oversee the Department's waste management and environmental cleanup efforts. Originally called the Office of Environmental Restoration and Waste Management, it was renamed in 1993. Often abbreviated EM.

Environmental Protection Agency. A Federal agency responsible for enforcing environmental laws, including the *Resource Conservation and Recovery Act;* the *Comprehensive Environmental Response, Compensation and Liability Act;* and the Toxic *Substances Control Act.* The Environmental Protection Agency was established in 1970.

Fissile. Capable of being split by a low-energy *neutron.* The most common fissile *isotopes* are *uranium 235* and *plutonium 239.*

Fission. The splitting or breaking apart of the *nucleus* of a heavy *atom* like *uranium* or *plutonium,* usually caused by the absorption of a *neutron.* Large amounts of energy and one or more *neutrons* are released when an atom fissions.

Fission products. The large variety of smaller atoms, including cesium and *strontium,* left over by the splitting of *uranium* and plutonium. Most of these atoms are *radioactive,* and they *decay* into other *isotopes.* There are more than 200 isotopes of 35 elements in this category. Most of the fission products in the United States are found in *spent nuclear fuel* and *high-level waste.*

Fuel (nuclear). *Natural or enriched uranium* that sustains the *fission chain reaction* in a *nuclear reactor. Also* used to refer to the entire fuel *element,* including structural materials such as *cladding.*

Fuel element. Nuclear reactor fuel including both the *fissile* and structural materials, such as *cladding,* typically in the shape of a long cylinder.

Gamma radiation. High-energy electromagnetic *radiation* emitted in the *radioactive decay of* many *radionuclides.* Gamma rays are similar to X-rays. They are highly penetrating.

Gaseous diffusion. The process used to make *enriched uranium* in the United States.

Geologic repository. A place to dispose of *radioactive* waste deep beneath the earth's surface.

Half-life. The time it takes for one-half of any given number of unstable atoms to *decay.* Each *isotope* has its own characteristic half-life. They range from small fractions of a second to billions of years. A general "rule of thumb" in health physics is that the hazardous period for a given isotope is 10 half-lives.

Hanford Site. *A* 570-square-mile Federal government-owned reservation in the desert of southeast Washington State. Established in 1943 as part of the *Manhattan Project,* the Hanford Site's chief mission has been the production of plutonium for use in nuclear weapons. Hanford is home to nine *production reactors* and four *chemical separation plants.*

Health physics. The science *of radiation* protection practiced by professionals charged with controlling the beneficial uses of ionizing radiation while protecting workers and the public from potential hazards associated with exposure to radiation.

Highly enriched uranium. *Uranium* with more than 20 percent of the *uranium 235* isotope, used for making nuclear weapons and also as *fuel* for some isotope-production, research, and power reactors. *Weapons-grade uranium is* a subset of this group.

High-level waste. Material generated by chemical *reprocessing of spent fuel* and *irradiated targets.* High-level waste contains highly *radioactive,* short-lived fission products, hazardous chemicals, and toxic heavy metals. High-level waste is usually found in the form of a liquid, a solid *saltcake,* a sludge, or a dry powdery *calcine.*

Hydrogen. The lightest element. Two of the three *isotopes* of hydrogen have been used in nuclear weapons: *deuterium* and *tritium.*

Idaho National Engineering and Environmental Laboratory (INEEL). An 893-square-mile Federal government-owned reservation in the eastern Idaho desert. The Idaho National Engineering Laboratory is the site of many research and test reactors and of the Idaho Chemical Processing Plant, where *spent nuclear fuel* from the U.S. Navy and from *research reactors was reprocessed.*

Inert gas. A gas that does not react chemically with other substances. The inert gases are helium, neon, argon, krypton, xenon, and radon. Also occasionally used inaccurately to refer to nitrogen.

Ionizing radiation. *Radiation* that is capable of breaking apart *molecules* or *atoms.* The splitting or *decay of* unstable *atoms* typically emits ionizing radiation.

Irradiate. To expose to *ionizing radiation,* usually in a *nuclear reactor. Targets* are irradiated to produce *isotopes.*

Isotopes. Different forms of the same chemical element that differ only by the number of *neutrons* in their *nucleus.* Most elements have more than one naturally occurring isotope. Many more isotopes have been produced in reactors and scientific laboratories.

Lithium. The lightest metal, and the third lightest element. Lithium has two naturally occurring *isotopes,* lithium 6 and lithium 7. Lithium 6 *targets* are *irradiated* to manufacture *tritium.*

Los Alamos National Laboratory. The U. S. Government laboratory, established in 1943 as part of the *Manhattan Project that* designed the first nuclear weapons. Located in northern New Mexico, about 60 miles north of Albuquerque.

Low-enriched uranium. *Uranium* that has been *enriched* until it consists *of* about 3 percent *uranium* 235 and 97 percent *uranium 238.* Used as *nuclear reactor fuel.*

Low-level waste. A catchall term for any *radioactive* waste that is not *spent fuel, high-level, or transuranic waste.*

Mined geologic disposal. See *geologic repository.*

Mixed waste. Waste that contains both chemically hazardous and *radioactive* materials.

Molecules. Larger structures formed by the bonding of *atoms*

National Environmental Policy Act. A Federal law, enacted in 1970, that requires the Federal government to consider the environmental impacts of, and alternatives to, major proposed actions in its decisionmaking processes. Commonly referred to by its acronym, NEPA.

Natural uranium. Uranium that has not been through the *enrichment process.* It is made of 99.3 percent uranium 238 and 0.7 percent uranium 235.

Neutron. A massive, uncharged particle that comprises part of the *nucleus.* Uranium and plutonium atoms *fission* when they absorb neutrons. The chain reactions that make *nuclear reactors* and weapons work thus depend on neutrons. Manmade elements can be manufactured by bombarding other elements with neutrons in production reactors.

Nevada Test Site. A 1,350-square-mile area of the southern Nevada desert that has been the site of most of the U.S. *underground and* atmospheric tests since it opened in 1951. The site is some 65 miles northwest of Las Vegas.

Nonproliferation. Efforts to prevent or slow the spread of nuclear weapons and the materials and technologies used to produce them.

Nuclear reactor. A device that sustains a controlled nuclear fission *chain* reaction.

Nucleus. The clump of protons and *neutrons at* the center of an atom that determine its identity and chemical and nuclear properties.

Oak Ridge. A 58-square-mile reservation near Knoxville, Tennessee. Oak Ridge was established as part of the *Manhattan Project* in 1943 to produce *enriched uranium.* Today it is the location of K-25 and Y-12 plants and the Oak Ridge National Laboratory (which was initially referred to by the arbitrary code name, "X-10.").

Pad. A flat concrete or asphalt surface used for the temporary storage of wastes. Its purpose is to keep wastes from leaching into the soil.

PCBs. A group of commercially produced organic chemicals used since the 1940s in industrial applications throughout the nuclear weapons complex. Most notably, PCBs are found in many of the gaskets and large electrical transformers and capacitors in the gaseous diffusion plants. PCBs have been proven to be toxic to both humans and laboratory animals. "PCB" is an abbreviation of the full name, "polychlorinated biphenyls."

Plutonium. A manmade *fissile* element. Pure plutonium is a silvery metal that is heavier than lead. Material rich in the plutonium 239 *isotope is* preferred for manufacturing nuclear weapons, although any plutonium can be used. Plutonium 239 has a *half-life of* 24,000 years.

Plutonium residues. Materials left over from the processing of plutonium that contain enough plutonium to make its recovery economically worthwhile.

Plutonium pit. A vernacular term that refers to the spherical core of a thermonuclear weapon. This pit is the "trigger" of the primary portion of the weapon that, when compressed, reaches a critical mass and begins a sustained nuclear fission chain reaction.

Radiation. Energy transferred through space or other media in the form of particles or waves. In this document, we refer to *ionizing radiation,* which is capable of breaking up *atoms* or *molecules.* The splitting, or *decay,* of unstable *atoms* emits ionizing radiation.

Radioactive. Of, caused by, or exhibiting *radioactivity.*

Radioactivity. The spontaneous emission of *radiation* from the *nucleus of* an *atom. Radionuclides* lose particles and energy through the process of *radioactive decay.*

Radionuclide. *A radioactive* species of an *atom.* For example, *tritium* and *strontium 90 are* radionuclides of elements hydrogen and strontium.

Radon. A radioactive *inert gas* that is formed by the decay of radium. Radium is, in turn, a link in the decay chain of *uranium 238.* Radon, which occurs naturally in many minerals, is the chief hazard of *uranium mill tailings.*

Reprocessing. Synonymous with *chemical separation.*

Research reactor. A class of *nuclear reactors* used to do research into nuclear Physics, reactor materials and design, and nuclear medicine. Some research reactors also produce *isotopes* for industrial and medical use.

Resource Conservation and Recovery Act (RCRA). A Federal law enacted in 1976 to address the treatment, storage, and disposal of hazardous waste.

Saltcake. A cake of dry crystals of nuclear waste found in *high-level-waste* tanks.

Saltstone. *A* concrete-like material made with *low-level radioactive waste.*

Savannah River Site. A *plutonium* and *tritium* production site, established in 1950, covering 300 square miles along the Savannah River in South Carolina, near Augusta, Georgia. Five *production, reactors* and two *chemical separation plants* are located here.

Shielding. Material used to block or absorb *radiation.* Often placed between sources of radiation and people or the environment.

Spent nuclear fuel. *Fuel elements and targets* that have been *irradiated* in a nuclear reactor.

Strontium. An element. *Isotope* strontium 90 is one of the most common *fission products.* It has a half-life of about 30 years. Strontium is chemically similar to calcium.

Superfund. A term commonly used to refer to the *Comprehensive Environmental Response, Compensation and Liability Act.*

Thorium. An element. Thorium is a byproduct of the *decay of uranium.*

Toxic Substances Control Act. A Federal law, enacted in 1976 to protect human health and the environment from unreasonable risk caused by exposure to or the manufacturing, distribution, use, or disposal of substances containing toxic chemicals.

Transport cask. A container used to transport *spent nuclear fuel* and other *radioactive* materials. Its purpose is to shield people from radiation while it is transported.

Transuranic elements. All elements beyond *uranium* on the periodic table. All *of* the transuranic elements are manmade.

Transuranic waste. Waste contaminated with *uranium 233* or *transuranic elements* having *half-lives of* over 20 years in concentrations *of* more than I ten-millionth *of* a *curie* per gram of waste.

Tritium. The heaviest isotope of the element *hydrogen.* Tritium is three times heavier than ordinary hydrogen. Tritium gas is used to boost the explosive power of most modern nuclear weapons, inspiring the term, "hydrogen bomb." It is produced in *production reactors* and has a *half-life* of just over 12 years.

Uranium. The basic material for nuclear technology. It is a slightly *radioactive* naturally occurring heavy metal that is more dense than lead. Uranium is 40 times more common than silver.

Uranium 233. A manmade *fissile isotope of uranium.*

Uranium 235. The lighter of the two main *isotopes of uranium.* Uranium 235 makes up less than 1 percent of the uranium that is mined from the ground. It has a *half-life* of 714 million years. Uranium 235 is the only naturally occurring fissile element.

Uranium 238. The heavier of the two main *isotopes* of *uranium.* Uranium 238 makes up over 99 percent of uranium as it is mined from the ground. It has a *half-life of 4.5* billion years. It is not easily split by *neutrons.*

Vitrification. A process that stabilizes nuclear waste by mixing it with molten glass. The glass is poured into metal canisters, where it hardens into logs. Plants for vitrifying *high-level-waste* have been built in the United States at *West Valley,* New York, and the *Savannah River Site.*

Waste Isolation Pilot Plant (WIPP). A *geologic repository* intended to provide permanent disposal deep underground for transuranic wastes. Located 2,150 feet underground in a salt bed near Carlsbad, New Mexico.

West Valley Demonstration Project. A plant near Buffalo, New York, used to demonstrate the *reprocessing of spent nuclear fuel* from commercial nuclear power plants. West Valley operated from 1966 to 1972. A *vitrification* plant for *high-level waste has* been built at the site.

Yucca Mountain. A site on, and adjacent to, the *Nevada Test Site* that was designated by President Bush in 2002 as suitable for use as a geologic repository for the Department of Energy's *high-level wastes* and *spent fuel from* commercial nuclear reactors. The repository must be licensed by the NRC before it can operate.

For more terms, see also
http://ehc.astate.edu/gloss.txt
http://www.hanford.gov/docs/annualrp99/appb.pdf
http://tis.eh.doe

Appendix A

Table 3-2. Permanently Shutdown Plants

Nuclear Plant	Reactor Type	Thermal Power	Shutdown Date [a]	Decommissioning Option[b]	Location	Fuel Status and License Termination Date
Plants Currently in Decommissioning Process						
Big Rock Point	BWR	240 MW	08/30/97	DECON	Michigan	Fuel in pool
Dresden, Unit 1	BWR	700 MW	10/31/78	SAFSTOR	Illinois	Fuel in ISFSI
Fermi, Unit 1	FBR	200 MW	09/22/72	SAFSTOR[c]	Michigan	No fuel onsite
GE-VBWR	BWR	50 MW	12/09/63	SAFSTOR	California	No fuel onsite
Haddam Neck	PWR	1825 MW	07/22/96	DECON	Connecticut	Fuel in pool
Humboldt Bay, Unit 3	BWR	200 MW	07/02/76	SAFSTOR[c]	California	Fuel in pool
Indian Point, Unit 1	PWR	615 MW.	10/31/74	SAFSTOR	New York	Fuel in pool
La Crosse	BWR	165 MW	04/30/87	SAFSTOR	Wisconsin	Fuel in pool
Maine Yankee	PWR	2700 MW	12/06/96	DECON	Maine	Fuel in pool[d]
Millstone, Unit 1	BWR	2011 MW	11/04/95	SAFSTOR	Connecticut	Fuel in pool
Peach Bottom, Unit 1	HTGR	115 MW	10/31/74	SAFSTOR	Pennsylvania	No fuel onsite
Rancho Seco	PWR	2772 MW	06/07/89	SAFSTOR[c]	California	Fuel in ISFSI/Partial DECON proposed in 1997
San Onofre, Unit 1	PWR	1347 MW	11/30/92	SAFSTOR[c]	California	Fuel in pool
Saxton	PWR	28 MW	05/01/72	SAFSTOR[c]	Pennsylvania	No fuel onsite/Currently in DECON
Three Mile Island, Unit 2	PWR	2772 MW	03/28/79	Accident cleanup followed by storage	Pennsylvania	Approx 900 kg fuel onsite/ Post-defueling monitored storage
Trojan	PWR	3411 MW	11/09/92	DECON	Oregon	Fuel in pool
Yankee Rowe	PWR	600 MW	10/01/91	DECON	Massachusetts	Fuel in pool[d]
Zion, Unit 1	PWR	3250 MW	02/21/97	SAFSTOR	Illinois	Fuel in pool
Zion, Unit 2	PWR	3250 MW	09/19/96	SAFSTOR	Illinois	Fuel in pool
Terminated Licenses						
Fort St. Vrain	HTGR	842 MW	08/18/89	DECON	Colorado	Fuel in ISFSI/License terminated in 1997
Pathfinder	BWR	190 MW	09/16/67	SAFSTOR	South Dakota	No fuel onsite/License terminated in 1992
Shoreham	BWR	2436 MW	06/28/89	DECON	New York	No fuel onsite/License terminated in 1995

(a) The shutdown date corresponds to the date of the last criticality.

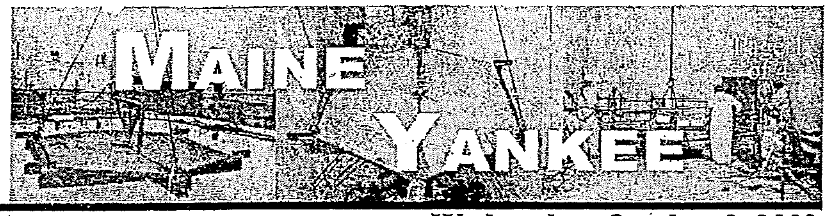
(b) The option shown in the table for each plant is the option that has been officially provided to NRC. Plants in DECON may have had a short (1 to 4 yr) SAFSTOR period. Likewise, plants in SAFSTOR may have performed some DECON activities or may have transitioned from the storage phase into the decontamination and dismantlement phase of SAFSTOR.

(c) These plants have recently performed or are currently performing the decontamination and dismantlement phase of SAFSTOR.

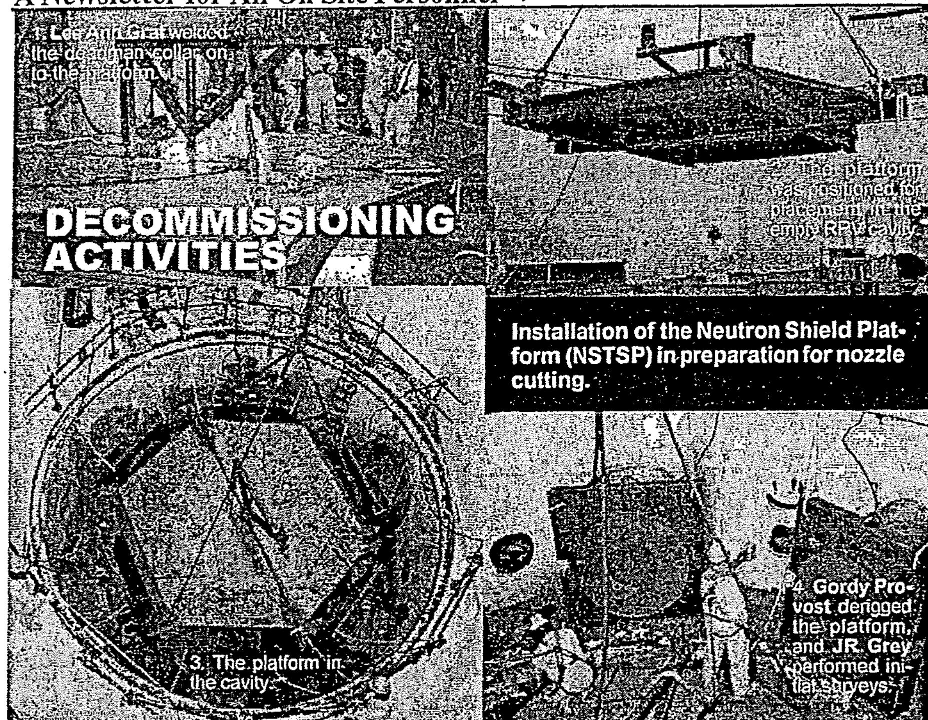
(d) Licensee is in process of transferring fuel to dry storage in onsite ISFSI.

Appendix B

The Look Inside
A Newsletter for All On Site Personnel
Wednesday, October 9, 2002



DECOMMISSIONING ACTIVITIES



Installation of the Neutron Shield Platform (NSTSP) in preparation for nozzle cutting.

SITE VISIT

NRC Region 1 Administrator visits, tours Maine Yankee.

Above: Hub Miller, Region 1 director, and Randy Ragland, NRC Inspector, discuss project activities with MY's John McCann.

Hub Miller, Nuclear Regulatory Commission (NRC) Region 1 director, was on site on **Monday October 6**, to tour the site, talk with MY managers and meet with officials from the State of Maine.

(L-R) Ragland, Joe Grant, MY Security director, and Miller, after a tour of the ISFSI.

While on site, Miller attended the morning managers meeting, and met with MY President **Wayne Norton**, and MY Chief Nuclear Officer **Mike Meisner**.

"Mr. Miller was interested in Maine Yankee's recent progress on the decommissioning project, particularly activities related to RPV removal, site security, demolition, and fuel loading activities, as well as Maine Yankee's plans for containment building demolition," said **John McCann**, Sr. Licensing Engineer and visit coordinator. *"Discussion topics also included sump, crevice, and embedded piping remediation in the Spray building, as well as dose projections for that work."*

continued on page 4

END STATE PLANNING UNDERWAY

As the decommissioning project proceeds on schedule, MY continues to prepare for the future by developing specific plans to operate as a corporation. When decommissioning is completed, MY's primary responsibilities will be to store spent fuel and GTCC, and manage the trust funds and finances of the company until all responsibilities have been completed. An **"end state team"** has been established to create a plan that combines departmental end state planning efforts in to one cohesive company-wide business plan. *"Maine Yankee is fortunate to have such a well-qualified team of professionals to pull together this plan,"* said Team Sponsor and MY Vice President and Chief Financial Officer **Micky Thomas**. *(See page four for a list of team members.)*

One of the first jobs of the 12-member team was to develop a draft table of contents for the plan. The basic elements of the plan include a revised mission statement; major business assumptions, risks, and opportunities; strategic options and alternatives; company organization; scheduling; budget; and an executive summary.*"The end state plan is essentially a business plan that will guide Maine Yankee activities in moving toward the end of the Maine Yankee corporation,"* said Thomas.

continued on page 4

End State Team

Sponsor:
Micky Thomas, *Vice President & Chief Financial Officer*

Co-Sponsor:
Carrie Guerrette, *Treasurer*

Team Members

Business Management:
Todd Smith, *Business Manager*

TI, admin, and document control issues:
Garry Stewart, *IT/Administrative Support Manager*

Human Resource Issues:
Lois Curtin, *Human Resources Manager*

ISFSI Technical Issues:
Paul Plante, *Fuel & GTCC Transfer Project Manager*

Regulatory and Licensing Issues:
Mike Whitney, *License Termination Plan Project Manager*

ISFSI Operations Issues:
John Niles, *ISFSI Manager*

Board Issues:
William Finn, *Secretary, MY Board of Directors*

Consultants:
Teb Bowman and Randy Moon, *Wass Consulting group*

Coordinator:
John Arnold, *Special Projects*

End State

continued from page 1

The end state team is assembling data from various MY departments regarding activities needed and fundamental requirements in working toward MY's two end states *(ISFSI steady state operation and ultimate corporate disolution)*. Team members are also identifying areas where more information is needed. The next phase of work will be to identify risks and opportunities in reaching these end states.

The team is working to complete initial drafting of the plan by month end. Mickey Thomas is keeping the MY Board of Directors apprised of progress on the plan.

Wass Consulting group,a well-respected nuclear power business consulting group, is assisting the team in assembling the plan.

If you have questions, comments, or suggestions for the end state plan, please contact **John Arnold** at X4535.

NRC Administrator Visits Site

continued from page 1

Several MY managers gave Miller a tour of various site areas including the RCA building and grounds; the industrial area; the Spray building; and the ISFSI and SOB. Following the tour, Miller met with State Nuclear Safety Advisor Paula Craighead, Colonel Mike Sperry of the State Police, and Lt. Colonel William Snedeker from the Maine State Special Services division. Miller left MY in the early afternoon, after an exit meeting with Norton and Meisner.

Radiation Protection Reminders

DOSIMETRY

Be sure **to log out your electronic dosimeter** *(ED)* when leaving the restricted area *(RA)*. Radiation workers need to log out and return their EDs to the storage rack when exiting the portal monitor. The dosimetry supervisor has authorized some workers to wear their dosimetry (TLDs and EDs) outside of the RA.

Authorized Workers:

* Radiation workers assigned to support Rad waste shipping activities
* Rad workers assigned to support ISFSI work
* Nightshift personnel (during HIS system back up):

If you need to perform work activities outside of the RA, and dosimetry is required, please contact the Dosimetry Supervisor (5368) or the Technical Support Supervisor (4919) for authoization.

FIRE POND SURVEYS

FSS is surveying the fire pond area. *Please contact the FSS department before entering the area.*

REMINDER:

Maine Yankee celebrates Columbus Day next **Monday, October 14.**

Appendix C

Table E-1. First- and Second-Tier Matrices Issues and Activities

Issues
Onsite/offsite land use
Water use
Water quality
Air quality
Aquatic ecology
Terrestrial ecology
Threatened and Endangered Species
Radiological
Radiological accidents
Occupational issues
Cost
Socioeconomics
Environmental justice
Cultural impacts
Aesthetic issues
Noise

Activities
Remove fuel
Organizational changes
Stabilization
Post-shutdown surveys
Create nuclear island
Chemical decontamination of primary loop
Large component removal
Storage preparation activities for SAFSTOR
Storage (SAFSTOR)
Decontamination and Dismantlement phases of DECON, SAFSTOR, and ENTOMB1
System dismantlement
Structure dismantlement
Entombment
Low-level waste packaging and storage
Transportation
License termination activities

Table E-2. Site Visits

Nuclear Plant	Description	Plant Type	Thermal Power	Decommissioning Method
Big Rock Point	Single nuclear unit	BWR[a]	240 MW	DECON
Humboldt Bay, Unit 3	Single nuclear plant at multi-unit fossil fuel facility	BWR	200 MW	SAFSTOR
Maine Yankee	Single nuclear unit	PWR[b]	2700 MW	DECON
Rancho Seco	Single nuclear unit	PWR	2772 MW	SAFSTOR
Trojan	Single nuclear unit	PWR	3411 MW	DECON
Zion, Units 1 and 2	Multiple nuclear units	PWR	3250 MW	SAFSTOR

(a) boiling water reactor.
(b) pressurized water reactor.

Appendix D

STATE OF MAINE
EXECUTIVE DEPARTMENT
STATE PLANNING OFFICE
38 STATE HOUSE STATION
AUGUSTA, MAINE
04333-0038

ANGUS S. KING, JR.
GOVERNOR

PAULA M. CRAIGHEAD
STATE NUCLEAR SAFETY ADVISOR

December 2, 2002

UNITED STATES NUCLEAR REGULATORY COMMISSION
Attention: Document Control Desk
Washington, DC 20555

and

Larry Camper, Chief, Decommissioning Branch
U.S. Nuclear Regulatory Commission
Two White Flint North
Room T-7F27
Washington, DC 20555-0001

RE: License No. DPR-36 (Docket No. 50-309)

The recently submitted License Termination Plan, Revision 3, for Maine Yankee's Part 50 license has been initially reviewed by a team of staff and consultants for the State of Maine. In general, State reviewers find the document is significantly improved over the second version of the Plan*. We believe it will likely serve a more useful purpose than its predecessor plans and promises the kind of assurance the Nuclear Regulatory Commission and stakeholders, including the State, seek for how closure of a commercial nuclear power plant is properly conducted.

The creation of the Plan is unusual. Unlike planning that takes place primarily in advance of execution, this Plan is created before, during and after execution. Because it is a dynamic document, this version of the LTP is difficult to assess and evaluate at any fixed point in time. The third version is a product of a less structured process than the prior version. In this instance, changes were often made by way of multiparty phone calls and emails and then 'closed out' in sections rather than as part of a finally changed document. Fortunately, the changes to date are generally improvements to the prior revision. The State applauds the countless hours the Maine

* The exception is Section 7 which has not changed or improved. The State questions why the licensee is allowed to decline the NRC request to update costs estimates for the remainder of decommissioning, how it can rely on fuel removal by 2023 for financial planning purposes, and how it can assume no change in estimates for security costs after recent NRC Orders are anticipated. At the same time, we acknowledge that detailed financial plans incorporating spent fuel security and disposal is a burdensome duty in this case, unjustly imposed on added to both Maine Yankee and NRC's primary areas of responsibility. The implications for the State and local community are too important to ignore, however.

OFFICES LOCATED AT: 184 STATE STREET
PHONE: (207) 287-8936 Internet: www.state.me.us/spo FAX: (207) 287-6424

Yankee and NRC staffs have spent to create a product far superior to others of its kind. The NRC staff has shown an ability to go beyond mere diligent effort in the ongoing evaluation, especially on the E600 instrument use and performance, and on the groundwater testing program. In these two areas, the State maintains a wait-and-see attitude. We look forward to the NRC confirmatory tests next March on final site surveys. We understand that Maine Yankee links its preferred plan to remove all groundwater wells used for radionuclide testing to its confidence in media measurements, especially soil test accuracy. Should measurements or tests subsequently prove less than satisfactory during the March confirmatory session, or thereafter, the Plan's commitment to investigate groundwater, and possibly to other remediation options, will need execution.

The State has asked Maine Yankee to document its commitments in the August 2001 Settlement Agreement and incorporate them appropriately in this Plan. As of the date of this letter, half of that review and documentation has been provided. Until the State knows, for example, how the licensee believes it has met the promise to "provide the State with a table or tables" listing parameters of dose modeling in the current Plan revision, we are unable to comment favorably on the many changed sections of the Plan that are linked to dose projections.

In a separate letter to Maine Yankee, the State documents items in some detail that we believe will clarify a number of points the State view on the item listed should an issue arise in the future. If the Plan's third revision meets its promises, we believe there will be nothing to discuss on the list. These items were provided as a courtesy to the licensee.

Thank you again for your attention, commitment and frequent demonstrations of listening to the State's concerns. We look forward to continuing, cooperative review or oversight, as appropriate, of Maine Yankee's decommissioning program.

Sincerely,

Patrick Dostie
State Nuclear Safety Inspector

Paula Craighead
State Nuclear Safety Advisor

Cc Wayne Norton, Maine Yankee
Mike Meisner, Maine Yankee
Mike Whitney, Maine Yankee
Eric Howes, Maine Yankee
Chairman Meserve, NRC
Bill Kane, NRC
Charles Miller, NRC
Mike Webb, NRC
Chairman Meserve, NRC
Brooke Barnes, State of Maine
Phil Haines, State of Maine
Don Hudson, Chewonki Foundation
Marge Kilkelly, Maine Yankee CAP chair
Raymond Shadis

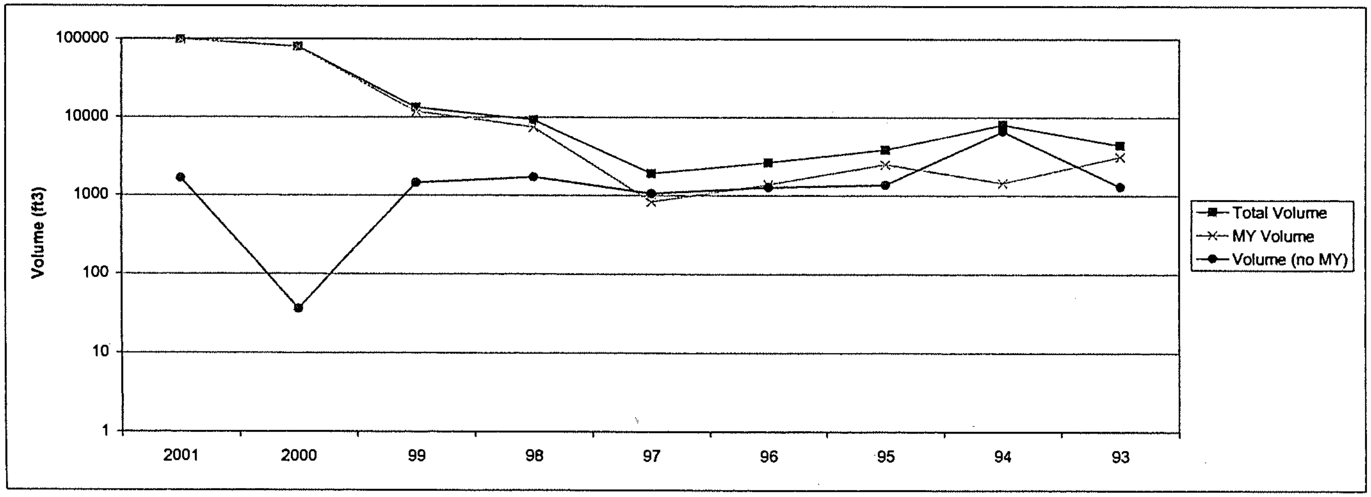
Appendix E

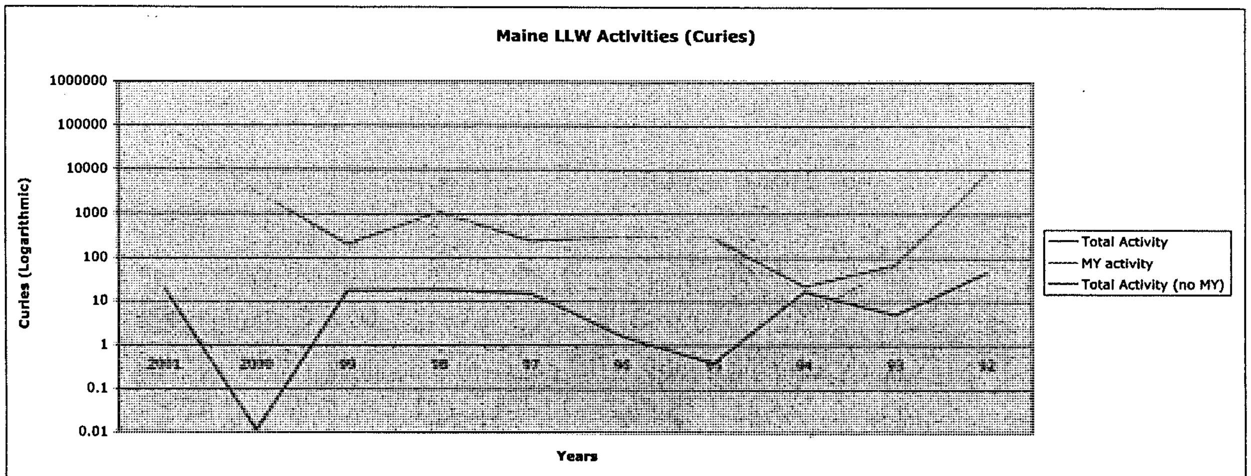
WASTE GENERATOR	2001 ft3	2001 Ci	2000 ft^3	2000 Ci	1999 ft^3	1999 Ci	1998 ft^3	1998 Ci	1997 ft^3	1997 Ci
Bigelow Lab For Ocean Science										
Bowdoin College					1.50E+01	3.00E-05	1.50E+01	3.00E-05		
Colby College, Dept. of Biology					1.50E+01	2.00E-05				
Foundation For Blood Research							7.50E+00	2.00E-06		
IDEXX Corp.	33	0.000053	36	1.10E-02	5.80E+01	2.00E-03	2.55E+01	1.60E-02	2.60E+01	1.10E-02
Immunotech							5.00E-01	8.80E-05		
Jackson Laboratories										
Maine Medical Center	89.6	0.0118								
Maine Yankee	97558	110814.8	7.86E+04	3.16E+03	1.17E+04	1.90E+02	7.40E+03	1.05E+03	8.26E+02	2.29E+02
MDI Biological Laboratory					7.50E+00	2.00E-05	7.50E+01	3.00E-03	3.80E+01	3.00E-03
Northeast Labs	204.56	0.0058156								
Philips Elmet					7.50E+00	2.72E-07				
Portsmouth Naval Shipyard	1258.2	19.388	N/R	N/R	1.20E+03	1.73E+01	1.33E+03	1.79E+01	8.15E+02	1.18E+01
University of Maine	30	0.03549			1.13E+02	1.25E-01	1.50E+01	2.00E-02	1.75E+02	3.65E+00
University of New England	7.35	0.001036			5.30E+00	2.50E-02	7.00E+00	5.00E-08		
University of Southern Maine							8.00E-02	8.00E-06	0.00E+00	8.00E-06
Ventrex Laboratories/HYCOR							2.03E+02	1.50E-01		
TOTALS	**9.92E+04**	**1.11E+05**	**7.87E+04**	**3.16E+03**	**1.31E+04**	**2.07E+02**	**9.08E+03**	**1.07E+03**	**1.88E+03**	**2.44E+02**
Generators reporting disposal	7		2		9		11		6	

Black bars indicate a company that has changed name, closed, or left the state.

"The data presented in the chart is reported by the Division of Health Engineering (DHE), Bureau of Health, Department of Human Services and represents the year 2001 low level radioactive waste (LLRW) disposed in that year. The data was collected in the year 2002 during the annual DHE March survey. The information is collected from over 130 Maine radioactive materials licensees who return the information on a written form to DHE before or by August. The DHE charges a fee in the maximum amount of $135,000 (Statutory capped maximum account balance) for the volume and activity of material reported by each generator. The fee is 50% based on volume (FT^3) and 50% based on radioactivity (Curies). The minimum fee for a generator is $100.00 and the total charged is based on the programs expenses and usually ranges from $70,000 to $100,000. DHE reports that it is difficult to compare volumes among generators due to the predisposal processing of waste generated by Maine Yankee Atomic Power Company (MY). MY reports a compacted volume amount and other generators do not because it is not economically feasible to compact small quantities. All LLRW generators are reporting and generating Class A waste, except Maine Yankee which generates Class A, B, C and Greater Than Class C (GTCC). The types of materials reported are gloves, bench coverings, plastic lab ware, lab coats and biohazard waste. Some liquid wastes are shipped as dry after they are absorbed by clay products, similar to pet litter, or solidified in concrete. These are wastes typically generated and shipped by laboratories, colleges and hospitals. According to DHE files, paper companies generate LLRW that is sealed sources contained within measuring or gauging equipment that are removed from the equipment when replaced or upgraded with new equipment. Those sealed source materials are usually Cesium 137 or Cobalt 60 and are dry wastes that are accepted for disposal as Class A. There have been no filings by new LLRW generators for the previous two reporting years."

	2001	2000	99	98	97	96	95	94	93	92
Total LLRW volume (ft^3)	99180	78679	13134	9075.87	1879.9	2615.5	3807.3	7975.6	4366.3	10378.6
Total Activity	110834	3160.0	206.97	1069.129	243.99	303.61	290.401	21.758	69.1239	7994.82
MY volume	97558	78643	11712.9	7397	826	1361	2460	1432.6	3094	6166
MY activity	110815	3160.0	190	1051	229	302	290	4.72	64.2	7950
Total volume (no MY)	**1622**	**36**	**1421.1**	**1678.87**	**1053.9**	**1254.5**	**1347.3**	**6543**	**1272.3**	**4212.6**
Total Activity (no MY)	**19.44**	**1.10E-02**	**16.97**	**18.1291**	**14.99**	**1.61**	**0.401**	**17.038**	**4.9239**	**44.82**





Appendix F

NUCLEAR WASTE FUND
RATEPAYER PAYMENTS BY STATE
THROUGH 9-30-02 (MILLIONS OF DOLLARS)

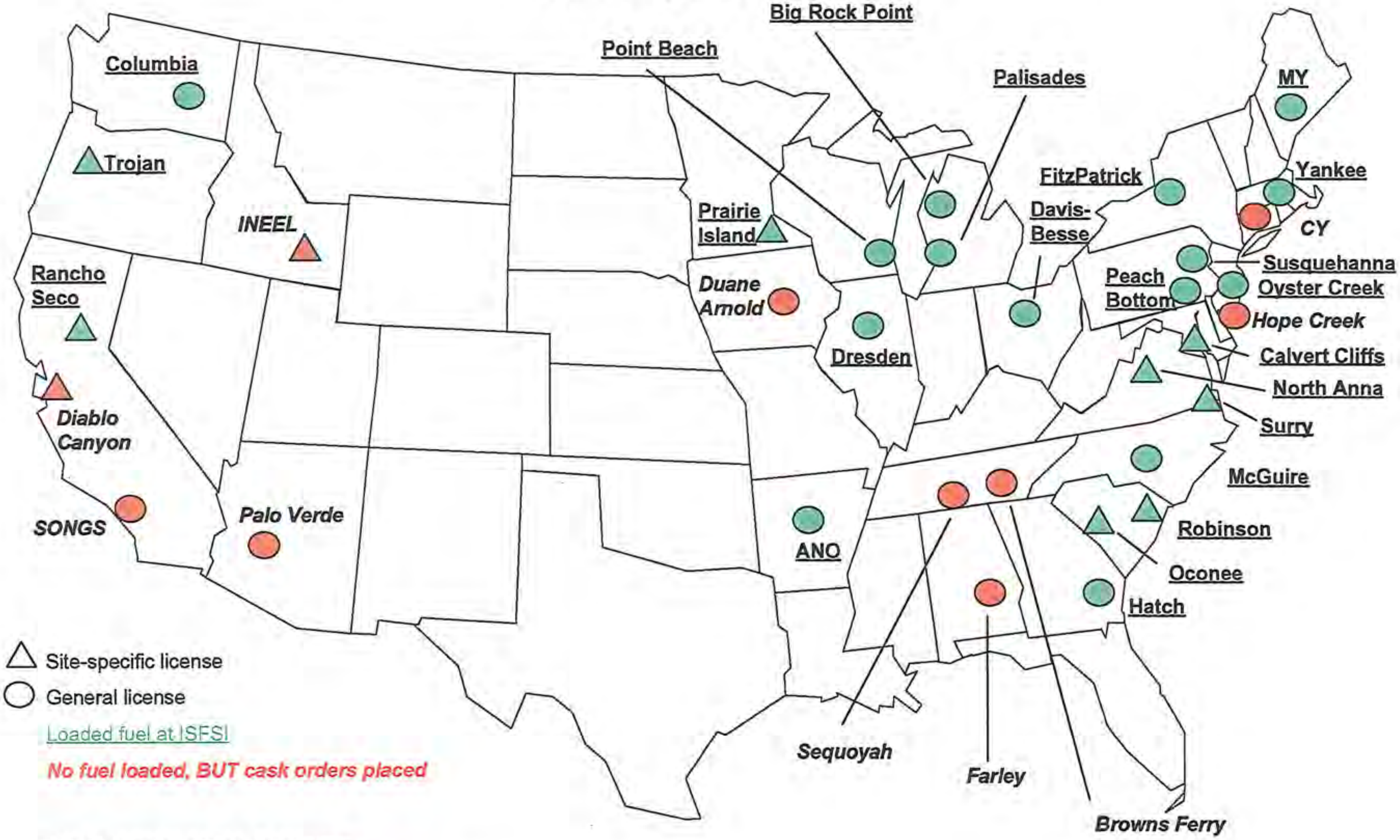
STATE	PAYMENTS (1 mill/kwh, One Time+Int)	RETURN ON INVESTMENT	TOTAL (PAY+RETURN)	DEBT*	FUND ASSETS** (TOTAL + DEBT)
AL	401.5	221.5	623.0	0	623.0
AR	220.9	121.9	342.8	146.9	489.7
AZ	168.5	93.0	261.5	0	261.5
CA	708.1	390.7	1098.8	0	1098.8
CO	0.2	0.1	0.3	0	0.3
CT	203.1	112.1	315.2	301.0	616.2
DE	31.1	17.2	48.3	0	48.3
FL	617.0	340.4	957.4	0	957.4
GA	439.5	242.5	682.0	0	682.0
IA	174.2	96.1	270.3	38	308.3
IL	1167.1	643.9	1811.0	816.7	2627.7
IN	154.2	85.1	239.3	193.5	432.8
KS	87.7	48.4	136.1	0	136.1
KY	100.7	55.6	156.3	0	156.3
LA	200.7	110.7	311.4	0	311.4
MA	241.7	133.4	375.1	137.1	512.2
MD	276.5	152.5	429.0	0	429.0
ME	45.3	25.0	70.3	98.3	168.6
MI	188.3	103.9	292.2	166.6	458.8
MN	241.2	133.1	374.3	0	374.3
MO	169.1	93.3	262.4	5.1	267.5
MS	116.0	64.0	180.0	0	180.0
NC	1052.5	580.7	1633.2	0	1633.2
ND	12.6	7.0	19.6	0	19.6
NE	140.1	77.3	217.4	0	217.4
NH	49.2	27.1	76.3	20.2	96.5
NJ	477.1	263.2	740.3	165.6	905.9
NM	49.1	27.1	76.2	0	76.2
NY	531.3	293.1	824.4	425.3	1249.7
OH	301.5	166.3	467.8	27.5	495.3
OR	75.1	41.4	116.5	0	116.5
PA	880.4	485.7	1366.1	55.9	1422.0
RI	3.8	2.1	5.9	5.2	11.1
SC	470.6	259.6	730.2	0	730.2
SD	3.3	1.8	5.1	0	5.1
TN	321.1	177.2	498.3	0	498.3
TX	450.8	248.7	699.5	0	699.5
VA	502.7	277.3	780.0	0	780.0
VT	71.2	39.3	110.5	119.1	229.6
WA	106.1	58.5	164.6	0	164.6
WI	322.7	178.0	500.7	0	500.7
SUBTOTAL	11773.8	6495.8	18269.6	2722	20991.6
FEDERAL	19.8	10.9	30.7	0	30.7
INDUSTRY	16.8	9.3	26.1	0	26.1
TOTAL	11810.4	6516	18326.4	2722	21048.4

* Funds owed for fuel burned before 1983 but not yet paid by utilities (as allowed by DOE contract)
** before withdrawals for expenditures by DOE

Prepared by Ron Howe, Michigan Public Service Commission staff

rhowe@michigan.gov 517 241-6021

Existing and Planned U.S. ISFSIs
January 2003



Appendix G

Radiation Protection Considerations for Nuclear Power Facility Decommissioning

Appendix G

Radiation Protection Considerations for Nuclear Power Facility Decommissioning

Radiological issues are associated with the process of decommissioning nuclear reactor facilities, including power reactors, at the end of their operating lives. Both occupational workers and members of the public will be affected by these processes as a result of direct exposures to sources of radiation and as a result of small releases of radioactive materials in gaseous and liquid effluents. This appendix is intended to provide pertinent background information for analyses in this Generic Environmental Impact Statement Supplement.

G.1 Radiation Protection Standards

The primary U.S. Nuclear Regulatory Commission (NRC) standards for protection of workers and members of the public are found in 10 CFR Part 20. These standards are consistent with guidance to Federal agencies prepared by interagency committees and issued by the President. The Federal guidance is based on recommendations published by national and international organizations, such as the National Council on Radiation Protection and Measurements (NCRP), the International Commission on Radiological Protection (ICRP), and the United Nations Scientific Committee on the Effects of Atomic Radiation. Proposed changes to regulations are typically published in the Federal Register for public comment before enactment of the final rule. The most recent major revision to the NRC radiation protection regulations in 10 CFR Part 20 were enacted in 1991, with several amendments issued in the intervening years. Implementation of the regulations became mandatory for NRC licensees in 1994.

G.1.1 Concepts, Terminology, Quantities, and Units Used in Radiation Protection

Title 10 CFR Part 20 was first promulgated in 1957. In 1961, the regulation was amended to add an appendix containing maximum permissible concentrations and a new occupational dose limit structure for whole-body exposure to external radiation (1.25 rem/quarter, or 3 rem/quarter with 5 rem/yr average as a limit on the cumulative dose). The 1991 revision differs considerably from the previous regulations with respect to basic concepts, terminology, radiation dose quantities, and the associated dose units. This section is included to familiarize readers with these concepts.

G.1.1.1 Conventional Quantities and Units

In 10 CFR Part 20, the unit "rad" is usually used for the quantity "radiation absorbed dose" whenever early biological effects are the concern. When latent effects (e.g., cancer and genetic effects) are being considered, the unit "rem" is used for the dose equivalent (DE) quantity. The absorbed dose in rads is multiplied by an overall efficiency factor *Q* to obtain the DE in rem. Each type of radiation has its own value of *Q*, which in a very general way permits adding absorbed doses from different radiations to estimate the probability of stochastic effects. Values of Q in 10 CFR Part 20 are indicated in Table G-1.

Table G-1. Quality Factors and Absorbed Equivalents

Radiation	Absorbed Dose, rad	Q	Dose Equivalent, rem
x -, gamma or beta radiation	1	1	1
Alpha particles	1	20	20
Neutron (spectrum unknown)	1	10	10

Note: To convert rem to sievert, multiply by 0.01.

These values of *Q* reflect the overall efficiency of a given type of radiation in causing latent effects and are not used for early effects such as acute radiation syndrome. The values were derived in consideration of the ability of the various radiations to ionize atoms in water as well as the relative biological effectiveness factors observed for specific effects.

G.1.1.2 International System of Units

The International System (SI) units of particular interest in radiation protection are the gray (Gy), sievert (Sv), and becquerel (Bq), as shown in Table G-2. The SI units are part of the metric system; however, they are not yet widely used in the United States.
Title 10 CFR 20.2101 requires the records to be reported in the units of curie, rad, and rem. The major concern of the NRC staff is that use of both the conventional and SI units would introduce confusion under emergency conditions.

Table G-2. Conventional and SI Units

Quantity	Conventional Unit	SI Unit	SI Unit Conversions
Absorbed dose	rad (100 ergs/gram)	gray (Gy) (10,000 ergs/gram)	100 rad = 1 Gy
Dose equivalent	rem (Q x rad)	sievert (Sv) (Q x gray)	100 rem = 1 Sv
Activity	curie (Ci) (3.7 x 10^{10} disintegrations per second)	becquerel (Bq) (1 disintegration per second)	1 Ci = 3.7 x $10^{(10)}$ Bq

G.1.1.3 Collective Dose

Previous revisions of 10 CFR Part 20 made no use of the collective DE (in person-rem). However, this quantity is used by the NRC in risk analyses and in its decision-making processes. The collective DE may be obtained as the sum of all individual doses or as the product of the average individual dose and the number of people exposed. The linear-nonthreshold hypothesis is accepted by the NRC for purposes of standards setting. Such acceptance means that standards based on the hypothesis, coupled with the "as low as reasonably achievable" (ALARA) concept, are believed to provide an adequate degree of protection.

G.1.1.4 Risks from Radiation Exposure

The current regulations in 10 CFR Part 20 are based on concepts first developed by the ICRP in Publication 26 (ICRP 1977). The ICRP system is based on the recognition of two basic types of radiation-induced health effects: stochastic and nonstochastic. Stochastic effects, such as cancer and hereditary effects, are considered to be probabilistic in nature. For stochastic effects, the probability of the effect, but not the severity, is dose-dependent (i.e., once a malignancy occurs). Its severity is no different if the dose that preceded it were 1 Sv (100 rem), 0.1 Sv (10 rem), or zero. The objective of radiation protection policies is to control the probability of these effects to acceptable levels. In contrast, the severity of nonstochastic effects, but not the probability of occurrence, depends on the radiation dose. Examples of radiation-induced nonstochastic effects include cataracts in the lens of the eye or burns on the skin surface. Nonstochastic effects typically do not occur unless the dose exceeds a threshold, which is specific to each type of effect. Once the threshold dose is exceeded, the effect occurs, and the severity of the effect depends on the dose received by the affected tissue or organ. For example, a radiation-induced cataract caused by a 4-Sv (400-rem) dose to the lens of the eye would impair vision to a greater extent than one following a dose of 1 Sv (100 rem). Therefore, radiation protection for nonstochastic effects is designed to keep radiological exposures to sensitive tissues below the threshold levels at which the effects would begin to appear.

In January 1990, the National Research Council (NAS 1990) published a report on the health effects of exposure to low levels of ionizing radiation. This report was prepared by the Committee on Biological Effects of Ionizing Radiation (BEIR) known as the BEIR-V Committee, organized by the Council for this purpose. The BEIR-V report concluded that the risk of radiation exposure was greater than estimates published by previous committees (NAS 1972, NAS 1980). In light of this data, the ICRP requested comment from a number of organizations on a draft of its revised recommendations on radiation protection. In 1991, the ICRP issued Publication 60 (ICRP 1991) recommending lower limits for occupational exposures. With regard to this Supplement, the primary importance of these developments lies in the selection of the most appropriate radiation risk coefficients to use for evaluating health effects. For a more complete history of the development of radiological risk estimates, see NRC (1996), Appendix E.

G.1.1.4.1 Stochastic Effects

Stochastic effects refer to health effects, such as cancer and inheritable genetic effects, for which the probability of occurrence is related to radiation dose. Based on the BEIR-V study (1990), the risks were estimated as 4 to 5 excess cancer deaths among 10,000 people receiving 100 person-Sv (10,000 person-rem). The following statement appears in the executive summary of the BEIR-V report (NAS 1990, p. 6):

> On the basis of the available evidence, the population-weighted average lifetime excess risk of death from cancer following an acute dose equivalent to all body organs of 0.1 Sv [0.1 Gy of low-linear energy transfer (LET) radiation] is estimated to be 0.8 percent, although the lifetime risk varies considerably with age at the time of exposure. For low-LET radiation, accumulation of the same dose over weeks or months, however, is expected to reduce the lifetime risk appreciably, possibly by a factor of 2 or more.

The 0.8-percent estimate is equivalent to 800 excess cancer fatalities among 100,000 people, each exposed to 0.1 Sv (10 rem). It is important to note that the risk values tabulated in the report are for a population size of 100,000 and that the 0.8-percent estimate is applicable to instantaneous, uniform irradiation of all organs. With regard to the lower extreme of the dose range over which the estimate is applicable, the Committee observes elsewhere in the BEIR-V report that "in general, the estimates of risk derived in this way for doses of less than 0.1 Gy (10 rem) are too small to be detectable by direct observation in epidemiological studies." The report does not provide a risk estimate for instantaneous doses of fewer than 0.1 Sv (10 rem). The Committee's estimate is considered useful for estimating fatalities among large populations, including all ages, that are irradiated instantaneously and uniformly to individual external radiation doses of 0.1 Sv (10 rem) or more. Risk assessments based on the Japanese experience are subject to substantially greater uncertainty when applied to conditions typically encountered in environmental exposures from normal facility operations, where

- exposures are protracted
- the exposed population is small
- individual doses are much lower than 0.1Sv (10 rem)
- irradiation is caused by internally deposited radionuclides and is not uniform throughout the body
- the exposed population differs significantly from the atomic bomb survivor study group or
- some combination of these conditions exists.

For stochastic effects, the ICRP adopted the risk associated with 0.05 Sv (5 rem) in a year, delivered to every organ, as the basis for its dose-limitation system (ICRP 1977). Therefore, the stochastic annual limit on intake (ALI) for each radionuclide is the quantity that, if inhaled, would cause the same stochastic risk as a uniform, whole-body dose of 0.05 Sv (5 rem) delivered by external sources in 1 year. To establish these ALIs, the ICRP considered the possibility that a given radionuclide taken into the body eventually reaches the bloodstream and is then distributed selectively to the various organs and tissues, where DE is delivered over a time course determined by the retention capabilities of the organ or tissue and the physical characteristics of the radionuclide. Using a radiation risk coefficient specific for each organ or tissue and the 50-year integrated dose equivalent to the tissue, the risk associated with each is estimated. The total risk to the worker per quantity of this radionuclide inhaled is the sum of the individual organ or tissue risks. The intake that will produce the same overall stochastic risk as 0.05 Sv/yr (5 rem/yr) of uniform external radiation can then be readily calculated as the ALI. Of course, a worker may be exposed to several airborne radionuclides and to external radiation as well. In that case, the total risk is still limited to that associated with 0.05 Sv (5 rem) in a year from uniform external radiation. Compliance is achieved if the fraction of the external dose limit that is received, added to the fraction of ALI inhaled for each radionuclide, does not exceed unity.

The risk of hereditary effects is included in a special way that, in the view of the ICRP, renders it additive to the cancer fatality risk. The ICRP considered only detrimental effects that the worker is likely to experience personally, so that effects manifested after the second generation are not included in the genetic risk coefficient used. The coefficient is also limited to very serious genetic effects (i.e., those comparable in severity to premature death).

Although all organs and tissues receive the same DE under uniform exposure conditions, the cancer risks for a given dose in each organ are not the same. Each organ or tissue contributes to the overall risk based on the relative sensitivity of tissue to radiation-induced cancer. This fraction is called the weighting factor, and the sum of the weighting factors for all tissues is unity. The product of the weighting factor and the DE is the effective dose equivalent (EDE). This quantity is used for both external and internal irradiation and may be used for individual organs and tissues or for the sum of all organs and tissues. The unit used for either quantity is the same as for the DE, namely, the sievert (or rem). In the unique case of uniform irradiation of all organs and tissues, the sum of their EDEs is by definition equal to the whole-body DE. The EDE may be determined irrespective of the degree of uniformity among the organ or tissue doses. The sum of the EDEs is not allowed to exceed 0.05 Sv/yr (5 rem/yr).

The committed dose equivalent (CDE) is a quantity defined as the 50-year integrated DE to a specific organ or tissue following the inhalation of a radionuclide. This quantity is still used, but only in connection with nonstochastic effects. The committed effective dose equivalent (CEDE) is the same quantity as the CDE, with the exception that, in the case of the CEDE, each dose equivalent is multiplied by the tissue or organ weighting factor. The rem (or sievert) is also the unit for both of these quantities.

The mathematical weighting method used by the ICRP is shown in Table G-3. The first column lists the organs, and the second column lists the risk coefficients from ICRP Publication 26 (1977) and their sum, namely, 1.65×10^{-4}. This sum is the total annual risk to the exposed person, assuming exposure to these organs at 0.01 Gy/yr (1 rad/yr).[a] The fraction of this risk per rad for each organ can be obtained by dividing its risk coefficient by 1.65×10^{-4}. These fractions represent the relative sensitivity of the organs; they are the weighting factors and are designated by the symbol w_T, where T represents the organ or tissue. The weighting factors appear in column three of the table. If T is the dose equivalent to tissue T, then $w_T H_T$ is the

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(a) Multiplication by 5 gives the annual risk at 0.05 Gy/yr (5 rad/yr) (i.e., 8.25×10^{-4}/yr). This risk value means that if groups of 10,000 workers were to receive the dose limit every year for their entire careers, data as of the mid-1970s indicate that an average of 8.25 fatal occupational radiation-induced cancers per year would occur within each group. Assuming the approximate worst case of 45 years of exposure, the toll theoretically would be about 370 deaths per group, or almost 4 percent.

weighted DE. For example, w_T for the lung is 0.12. If a weighted lung dose of H rem is set equal to a highly penetrating, uniform whole-body dose of 5 rem, then

$0.12\, H = 0.05$ Sv (5 rem) and
$H = 4.17$ Sv (41.7 rem).

By hypothesis and analogy, an annual DE of 0.417 Sv (41.7 rem) to only the lung would have the same effect as 0.05 Sv (5 rem) to all of the organs combined. For this reason, $w_T H_T$ is called the EDE.

Nonstochastic effects have thresholds, and they become more severe as the dose gets larger. The ICRP believes that none of the thresholds will be exceeded if the annual dose to any tissue or organ does not exceed 0.5 Gy (50 rad). This nonstochastic limit is reflected in Table G-3, where it is evident that nonstochastic effects are controlling for all but four organs that have the largest weighting factors, the most sensitive organs with respect to stochastic effects.

Table G-3. ICRP Publication 26 Risk Weighting System

Organs	Risk Coefficients, Effects per Organ-rem	Weighting Factors	Organ DE Causing Same Risk as 5 rem to Whole Body, rem	Annual DE Permitted, Exposure of One Organ, rem/yr
Gonads	4×10^{-5}	0.25	20	20
Breasts	2.5×10^{-5}	0.15	33-1/3	33-1/3
Lung	2×10^{-5}	0.12	41-2/3	41-2/3
Red marrow	2×10^{-5}	0.12	41-2/3	41-2/3
Bone	5×10^{-6}	0.03	166-2/3	50
Thyroid	5×10^{-6}	0.03	166-2/3	50
1st RO[a]	1×10^{-5}	0.06	83-1/3	50
2nd RO	1×10^{-5}	0.06	83-1/3	50
3rd RO	1×10^{-5}	0.06	83-1/3	50
4th RO	1×10^{-5}	0.06	83-1/3	50
5th RO	1×10^{-5}	0.06	83-1/3	50
Totals	1.65×10^{-4}	1.0		

(a) The remainder organs (ROs) are the five organs that receive, from a given radionuclide, the highest EDE, integrated over 50 years.
Note: To convert rem to sievert, multiply by 0.01.

G.1.1.4.2 Nonstochastic Effects

Nonstochastic effects refer to those, such as radiation-induced cataracts, for which the severity of the effect depends on radiation dose. They typically are not observed unless the radiation dose exceeds a minimum threshold, whereas the probability of stochastic effects is assumed to be greater than zero, although very small, even at very low doses. Therefore, radiological protection for nonstochastic effects is based on limiting exposures to levels that prevent the effect, rather than on controlling the probability of occurrence, as discussed previously for stochastic effects. For tissues such as the lens of the eye, the skin, and the extremities, radiation protection standards are intended primarily to control the dose from external sources. For internal organs, it is necessary to control the dose from internally deposited radionuclides as well. Because radiation can damage or kill cells if the dose is sufficiently high, a nonstochastic dose limit must be established for all tissues, including tissues other than those mentioned above.

ICRP Publication 41 (1983) provides the technical justification supporting the position that, with the exception of the lens of the eye, nonstochastic effects will not be observed among adults if the DE from external and internal radiation combined to every organ and tissue is less than 0.5 Sv/yr (50 rem/yr). The NRC is not aware of later radiobiological information indicating that this dose limit should be changed and notes that the ICRP retained this value in the 1990 revision of its recommendations (ICRP 1991).

G.1.1.4.3 Risk Coefficient Selection for This Supplement

The BEIR-V risk estimate can be arithmetically converted to the more familiar terminology of 8 cancer fatalities among 10,000 people exposed to 10 person-Sv (10,000 person-rem), leading to a convenient risk coefficient of 8 x 10^{-4} fatalities per person-rem. This coefficient is considered useful for estimating fatalities among large populations irradiated instantaneously and uniformly to individual external radiation doses of 0.1 Sv (10 rem) or more. However, since no dose or dose rate effectiveness factor (DDREF) is included in this risk factor, the fatality estimates become speculative as the individual doses and the size of the exposed population become progressively smaller. A DDREF of 2 has been recommended by the ICRP (1991) for doses below 0.2 Gy (20 rad) and dose rates below 0.1 Gy/h (10 rad/h), which corresponds to a risk coefficient 4.0 x 10^{-4} cancer fatalities per person-rem.

The risk coefficients for fatal cancer and hereditary effects (listed in Table G-4) are taken from ICRP (1991). The coefficients are consistent with the risk factors reported in BEIR-V if a DDREF of 2 is applied. The somewhat higher risk coefficients for the general population as compared to workers reflects the fact that individuals under age 18 at the time of exposure are more susceptible to radiation-induced cancer. A person must be 18 years or older to be

Table G-4. Nominal Probability Coefficients Used in this Supplement[(a)]

Health Effect	Occupational	Public
Fatal cancer	4	5
Hereditary	0.6	1

(a) Estimated number of excess effects among 10,000 people receiving 100 person-Sv (10,000 person-rem).
Source: ICRP Publication 60 (1991).

employed as a radiological worker. Excess hereditary effects are listed separately because radiation-induced effects of this type have not been observed in any human population, as opposed to excess malignancies that have been identified among people receiving instantaneous and near-uniform exposures of 0.1 Sv (10 rem) or more. As applied to low-level environmental and occupational exposures, risk factors for radiological health effects are subject to substantial uncertainty. The lower limit of the range for these risk coefficients is assumed to be zero because there may be biological mechanisms that can repair damage caused by radiation at low doses and/or dose rates.

G.1.2 Occupational Protection Standards

Occupational radiation protection standards have been in effect since 1947, and have generally been revised downward over the years, from 1.0 roentgen/wk (or about 50 roentgen/yr) in 1947 to the current 0.05 Sv/yr (5 rem/yr) total effective dose equivalent (TEDE). For an historical overview of development of these regulations, see NRC (1996), Appendix E. The current regulation implements the concept of TEDE, as developed by ICRP Publication 26 (1977). This methodology accounts for both exposure to radiation from external sources and intakes of radionuclides into the body in assessing compliance with the standards. Standards that were previously in effect applied only to external dose and did not account for dose from intakes of radionuclides by workers, which were assessed separately. In practice, radionuclide intakes account for a small fraction of the total dose received by workers at nuclear power facilities.

Historical dose data for nuclear power plant workers are presented in Section G.2. Table G-5 presents a summary of the occupational standards in the 1991 revision of 10 CFR Part 20. On an annual basis, the whole-body limit has decreased from 12 roentgen (3 roentgen per quarter) in 1957 (external radiation only) to 0.05-Sv (5-rem) TEDE (external plus internal).

Regulatory control over the intake of radioactive materials in the workplace has always been a complex issue. Beginning in 1991, the NRC adopted the method published by the ICRP in Publication 26 (ICRP 1977). Under the ICRP method, the dose to each significantly irradiated organ is weighted according to its radiation sensitivity. The weighted doses are summed to produce an EDE that can be added to the dose from external sources.

The revised 10 CFR Part 20 provides additional flexibility for establishing more accurate dose controls. It allows the use of actual particle-size distribution and physiochemical characteristics of airborne particulates to define site-specific derived air concentration limits. With NRC approval, these modified concentration limits can be used in lieu of generic values provided in 10 CFR Part 20. Such adjustments result in more precise estimates that use actual exposure conditions, as compared to generic assumptions.

The 1991 revision to 10 CFR Part 20 codifies a requirement that licensees implement a program to maintain radiation doses ALARA. Compliance with the commitments is required through the licensing process in 10 CFR Part 50 and the technical specifications. Two Regulatory Guides have been issued to provide guidance on ALARA programs for nuclear power plants: one on ALARA philosophy in NRC Regulatory Guide 8.10, Rev. 1R (NRC 1977), and one on implementation in NRC Regulatory Guide 8.8, Rev. 3 (NRC 1978). Nuclear power plant licensees are required to maintain and implement adequate plant procedures that contain ALARA criteria. During plant licensing, applicants commit to implement ALARA programs consistent with Regulatory Guides 8.8 and 8.10.

Table G-5. Occupational Dose Limits for Adults in 10 CFR Part 20[(a)]

Tissue	External Radiation	Internal Plus External Radiation
Whole Body	0.05 Sv/y (5 rem/yr) total DE,[(b)] not to exceed 0.5 Sv/y (50 rem/yr) total DE to any individual organ or tissue other than the lens of the eye	0.05 Sv/yr (5 rem/year) TEDE,[(c)] not to exceed 0.5 Sv/yr (50 rem/yr) total DE to any individual organ or tissue other than the lens of the eye
Lens	0.15 Sv/yr (15 rem/yr)	
Extremities, Including Skin	0.5 Sv/yr (50 rem/yr)	
All Other Skin	0.5 Sv/yr (50 rem/yr)	

(a) These revised 10 CFR Part 20 standards became effective on January 1, 1994.
(b) The total DE is the sum of the EDE (at 1 cm [0.39 in] depth) and the CDE from nuclides deposited in the body.
(c) The TEDE is the sum of the EDE (at 1 cm depth [0.39 in]) and the CEDE from nuclides deposited in the body.

G.1.3 Public Radiation Protection Standards

For many years, the ICRP and NCRP recommended dose limits for the public that were 10 percent of those for workers. During the 1980s, both organizations adopted a more conservative value of 2 percent. In 1985, the ICRP released a statement that its principal limit for the whole body was 0.001 Sv/yr (0.1 rem/yr) EDE (ICRP 1985). However, a subsidiary limit of 0.005 Sv/yr (0.5 rem/yr) is authorized, provided that the average dose over a lifetime does not exceed 0.001 Sv/yr (0.1 rem/yr). The ICRP limit for the skin and lens of the eye is 0.05 Sv/yr (5 rem/yr). In 1987, the NCRP recommended limits of 0.001 Sv/yr (0.1 rem/yr) EDE for the whole body under conditions of continuous or frequent exposure and 0.005 Sv/yr (0.5/yr) for infrequent exposure (NCRP 1987). The NCRP limit for the lens of the eye, skin, and extremities is 0.05 Sv/yr (5 rem/yr).

The 1991 revision of 10 CFR Part 20 implements guidelines consistent with the recommended limit of 0.001 Sv/yr (0.1 rem/yr) EDE (see Table G-6). Provision is made for temporary increases to 0.005 Sv/yr (0.5 rem/yr) with prior authorization and justification. Hourly and annual dose rate limits for unrestricted areas are also included.

Licensees may also demonstrate compliance with the provisions of 10 CFR Part 20 by showing that annual average concentrations of radioactive material released in gaseous and liquid effluents at the boundary of an unrestricted area do not exceed the values specified in 10 CFR Part 20, Appendix B, Table 2.

Table G-6. Dose Limits for an Individual Member of the Public under 10 CFR Part 20[(a)]

Applicability by Pathway	Dose Limits
Annual dose, all pathways[(b)]	1 mSv/yr (0.1 rem/yr) TEDE[(c)]
External dose rate, unrestricted areas	0.02 mSv/h (0.002 rem/h) or 0.5 mSv/yr (0.05 rem/yr)
Temporary Annual Dose, all pathways[(d)]	5 mSv/yr (0.5 rem/yr) TEDE[(c)]
ALARA dose constraint, air emissions[(e)]	0.1 mSv/yr (0.01 rem/yr) TEDE[(c)]

(a) These revised 10 CFR Part 20 standards became effective on January 1, 1994.
(b) Excludes contribution from materials disposed to sanitary sewers.
(c) The TEDE is the sum of the EDE (at 1 cm depth) and the CEDE from nuclides deposited in the body.
(d) Temporary increases in the public dose limit are subject to prior authorization from the NRC and other constraints to ensure the increase is justified and controlled to be ALARA.
(e) This is not a 10 CFR Part 20 dose limit, but is given to ensure consistency with air emissions standards for Federal facilities in 40 CFR Part 61.

The NRC has not established standards for radiological exposures to biota other than humans on the basis that limits established for the maximally exposed members of the public would provide adequate protection for other species. In contrast to the regulatory approach applied to human exposures, the fate of individual nonhuman organisms is of less concern than the maintenance of the endemic population (NCRP 1991). Experience has shown that population stability is crucial to survival of most species. However, in many ecosystems individual members of a species may suffer relatively high mortality rates from natural causes without creating detrimental effects to the population as a whole. The exception might be for threatened or endangered species where protection of the individual may be required in order to avoid detrimental effects on a relatively small population.

Evaluations of radiation exposures to nonhuman biota at nuclear power facilities have not identified exposures that could be considered significant in terms of harm to the species, or which approach the public exposure limits in 10 CFR Part 20. Limiting exposure in humans to 1 mSv/yr (100 mrem/yr) will lead to dose rates to plants in animals in the same area of less than 1 mGy per day (100 mrad per day). The International Atomic Energy Agency (IAEA) concludes that there is no convincing evidence from scientific literature that chronic radiation dose rates below 1 mGy per day (100 mrad per day) will harm plant or animal populations (IAEA 1992). Because of the relatively lower sensitivity of nonhuman species to radiation, and the lack of evidence that nonhuman populations or ecosystems would experience detrimental effects at radiation levels found in the environment around nuclear power stations, effects on these biota are not evaluated in detail for the purposes of this Supplement.

In addition to the basic standards mentioned above, 10 CFR 50.36(a) contains license conditions that are imposed on licensees in the form of technical specifications applicable to effluents from nuclear power reactors. These specifications ensure that releases of radioactive materials to unrestricted areas during normal operations, including expected operational occurrences, remain ALARA. Appendix I to 10 CFR Part 50 provides numerical guidance on dose-design objectives and limiting conditions for operation for light-water reactors (LWRs) to meet the ALARA requirements. As a part of the licensing process, all licensees have provided reasonable assurance that the design objectives will be met for all unrestricted areas even during the decommissioning process. Title 10 CFR Part 20 requires compliance with the U.S. Environmental Protection Agency regulation 40 CFR Part 190, which also contains ALARA limits. The dose constraints are summarized in Tables G-7 and G-8.

Specific radiological criteria for license termination were added to 10 CFR Part 20 in 1997, and the basis for public health and safety considerations is discussed in NUREG-1496 (NRC 1997). These criteria limit the dose to members of the public to 0.25 mSv/yr (25 mrem/yr) from all

Table G-7. 10 CFR Part 50, Appendix I, Design Objectives and Annual Limits on Radiation Doses to the General Public from Nuclear Power Facilities[(a)]

Tissue	Gaseous	Liquid
Total body	0.05 mSv (5 mrem)	0.03 mSv (3 mrem)
Any organ, all pathways		0.01 mSv (10 mrem)
Ground-level air dose	0.1 mGy (10 mrad) gamma and 0.3 mGy (30 mrad) beta	
Any organ,[(b)] all pathways	0.15 mSv (15 mrem)	
Skin	0.15 mSv (15 mrem)	

(a) Calculated doses.
(b) Particulates, radioiodines.

Table G-8. 40 CFR 190, Subpart B, Annual Limits on Doses to the General Public from Nuclear Power Operations[(a)]

Tissue	Limit	Source
Total body	0.25 mSv (25 mrem)	All effluents and direct radiation from nuclear power operations
Thyroid	0.75 mSv (75 mrem)	"
Any other organ	0.25 mSv (25 mrem)	"

(a) Calculated doses.

pathways following unrestricted release of a property. In cases where unrestricted release is not feasible, the licensee must provide for institutional controls that would limit the dose to members of the public to 0.25 mSv/yr (25 mrem/yr) during the control period and to 1 mSv/yr (100 mrem/yr) after the end of institutional controls. These criteria will largely determine the types and extent of activities undertaken during the decommissioning process to reduce the radionuclide inventory remaining onsite.

G.2 Nuclear Power Plant Exposure Data

G.2.1 Occupational Dose Experience

Individual occupational doses are measured by NRC licensees as required by the basic NRC radiation protection standard, 10 CFR Part 20. The exposure pathway of primary interest is from sources that are external to the body. Measurements of the whole-body dose are normally derived from personal dosimeters worn by each worker, and they represent a relatively uniform dose to all organs of the body. Since 1984, many of the nuclear power plants have provided dosimetry programs accredited by the National Bureau of Standards (NBS, now National Institute of Standards and Technology [NIST]). In 1988, NBS/NIST accreditation became an NRC requirement.

Whole-body dose data from NRC-licensed LWRs are shown in Table G-9 for the years 1973 through 1999 (NRC 2000). For each year, the number of reactors, the number of workers receiving measurable exposures, the average annual dose per worker, the collective dose for all reactors combined, and the number of individuals exceeding 0.05 Sv (5 rem) are listed. Until 1991, the limit for exposure to workers was 0.03 Sv per quarter (3 rem per quarter), or a maximum of 0.12 Sv/yr (12 rem/yr), with an average of 0.05 Sv/yr (5 rem/yr). The collective dose is the sum of doses to workers at all plants. The collective doses to nuclear plant workers decreased from a peak of over 55 person-Sv/yr) (55,000 person-rem/yr) in 1983-1984 to less than 15 person-Sv/yr (15,000 person-rem/yr) in 1998-1999, although there are currently about 25 percent more operating plants than in the mid-1980s. Average annual doses to workers have likewise decreased from just under 0.01 Sv/yr (1 rem/yr) in the early 1970s to less than 0.25 mSv/yr (0.25 rem/yr) after 1997. Whole-body doses exceeding 0.05 Sv/yr (5 rem/yr) have been infrequent since 1985, and no doses at that level have been reported since 1989. Nuclear power plant workers may also be exposed to airborne radioactive material, primarily fission and corrosion products, but such exposures have historically been small in comparison with external doses. A study of intake data indicated that for cobalt-58 and cobalt-60, the most prevalent radionuclides, very few of the workers had organ burdens of more than 1 percent of the maximum permissible (see Baker 1996).

These data indicate that occupational exposures within the nuclear power industry have been significantly reduced since 1973. Individual doses are characteristically far below the regulatory limit, and the annual average is less than 5 percent of the 5 rem per year limit that is now in effect. Effective implementation of the ALARA concept is largely responsible. The range of risks associated with these exposures are discussed in Section G.1.

Occupational doses at reactors that are undergoing decommissioning are typically lower than those accumulated at operating facilities, as indicated in the Table G-9 data for reactors that are no longer operating. Between 1995 and 1999, the collective dose from shutdown facilities typically amounted to a few hundred person-rem per year, and the annual average dose per worker was comparable to, or lower than, that for operating facilities. A comparison in Table G-10 of the occupational doses at 12 facilities before and after they were shutdown confirms that decommissioning would not be expected to increase occupational doses on average, although some phases of the process may result in temporarily higher collective doses depending on the activities in progress and the number of workers involved.

Table G-9. Occupational Dose at Light Water Reactors (LWRs) - Comparison of Operating Reactors to Reactors No Longer in Operation[(a)]

Year	Number of Workers with Measurable Exposure[(b)]	Collective Dose, person-rem[(e)]	Average Dose per Worker with Measurable Exposure, rem[(c)]	Total Number with Dose > 5 rem[(d)]	Number of Reactors	Average Collective Dose per Reactor-Year, person-rem[(e)]
Operating Reactors						
1973	14,780	13,962	0.945	--	24	582
1974	18,139	13,650	0.753	--	33	414
1975	28,234	20,901	0.740	--	44	475
1976	34,515	26,105	0.756	--	52	502
1977	38,985	32,521	0.834	351	57	571
1978	42,777	31,785	0.743	159	64	497
1979	60,299	39,908	0.662	180	67	596
1980	74,629	53,739	0.720	391	68	790
1981	76,772	54,163	0.706	210	70	774
1982	79,309	52,201	0.658	135	74	705
1983	79,709	56,484	0.709	169	75	753
1984	90,520	55,251	0.610	74	78	708
1985	86,926	43,048	0.495	1	82	525
1986	93,979	42,386	0.451	0	90	471
1987	96,231	40,406	0.420	0	96	421
1988	96,013	40,772	0.425	1	102	400
1989	100,084	35,931	0.359	0	107	336
1990	98,567	36,602	0.371	0	110	333
1991	91,086	28,519	0.313	0	111	257
1992	94,172	29,297	0.311	0	110	266
1993	86,193	26,364	0.306	0	108	244
1994	71,613	21,704	0.303	0	109	199
1995	70,821	21,688	0.306	0	109	199
1996	68,305	18,883	0.276	0	109	173
1997	68,372	17,149	0.251	0	109	157
1998	57,466	13,187	0.229	0	105	126
1999	59,216	13,666	0.231	0	104	131
Average 1973-1999	69,545	32,603	0.514	73		430
Average 1995-1999	64,836	16,915	0.259	0		157
Permanently Shutdown Reactors[(f)]						
1995	699	262	0.375	0	6	44
1996	974	165	0.169	0	8	21
1997	1144	136	0.119	0	7	19
1998	2178	430	0.197	0	11	39
1999	2856	430	0.151	0	13	33
Average 1995-1999	1,570	285	0.202			31

(a) Data Source: NUREG-0713, Vol. 21 (NRC 2000).
(b) 1973-1976 data are not adjusted for multiple reporting of transient individuals.
(c) To convert rem to sievert, multiply by 0.01.
(d) Number of workers by dose range not available for 1973-1976. The dose limit was 3 rem/quarter (12 rem/yr) before the 1991 revision of 10 CFR Part 20; thereafter, it was reduced to 5 rem/yr.
(e) To convert person-rem to person-sievert, multiply by 0.01.
(f) Includes plants not in operation for a full year as of December 31 of the reporting year.

Table G-10

Occupational Whole-Body Dose at Decommissioning Reactors, Comparison of Dose During Operations to Dose During Decommissioning

						Average Annual Occupational Dose, person-rem/yr			Maximum Annual Occupational Dose, person-rem/yr		
Nuclear Plant	Reactor Type	Capacity, MWe	Years in Operation	Years Post Shutdown	D&D Method	Normal Power Operations	Post Shutdown	Post Shutdown as % of Operations	Operations	Post Shutdown	Post Shutdown as % of Operations
Ft. St. Vrain	HTGR[a]	330	10	12	DECON	3	106	4076.9	6	210	3500
Big Rock Point	BWR[b]	67	34	2	DECON	166	116	69.7	277	144	52.0
La Crosse	BWR	48	17	13	SAFSTOR	247	19	7.8	313	105	33.5
Humboldt Bay, Unit 3	BWR	63	13	25	SAFSTOR	294	183	62.4	339	1905	561.9
Yankee Rowe	PWR[c]	175	30	8	DECON	159	75	47	246	156	63.4
Haddam Neck	PWR	560	28	3	DECON	355	137	38.5	590	261	44.2
Maine Yankee	PWR	860	25	3	DECON	326	154	47.1	653	173	26.5
Trojan	PWR	1080	17	7	DECON	346	38	11	567	52	9.2
San Onofre, Unit 1	PWR	436	25	8	SAFSTOR	512	16	3.1	880	16	1.8
Rancho Seco	PWR	873	14	10	SAFSTOR	385	9	2.3	787	41	5.2
Zion, Units 1 and 2	PWRs	2080	24	2	DECON	645	8	1.2	1043	12	1.2
Average All LWR						343	75	29	570	287	79.9
Average BWR						235	106	46.6	310	718	215.8
Average PWR						390	62	21.5	681	102	21.6
Average DECON						333	88	35.8	563	133	32.7
Average SAFSTOR						359	57	18.9	580	517	150.6

(a) High-temperature gas-cooled reactor.
(b) Boiling water reactor.
(c) Pressurized water reactor.

Table G-11. Occupational Dose by Activity During Decommissioning

Nuclear Plant	Reactor Type	Capacity, MWe	D&D Method	Cumulative Dose Post Shutdown, person-rem[(a)]	Percent of Total Cumulative Dose to Completion by Activity: Large Component Removal, %	Systems, Structures, and Components Removal, %	Other Decon Activities, %	SNF Management, %	Transportation, %	SAFSTOR Activities, %
Fort St. Vrain	HTGR[(b)]	330	DECON	433	45.1	25.6	13.8		15.5	
Big Rock Point	BWR[(c)]	67	DECON	700						
Haddam Neck	PWR[(d)]	560	DECON	996	37	28.7	19.3	8.7	6.1	
Maine Yankee	PWR	860	DECON	946	9.9	12.8	74.2	3		
Trojan	PWR	1080	DECON	556	22.7	50.7	5.4	21.2		
Zion, Units 1 and 2	PWRs	2080	SAFSTOR	637						
Humboldt Bay, Unit 3	BWR	63	SAFSTOR	354			50.8		3.7	45.5
Rancho Seco	PWR	873	SAFSTOR	483	39.1	47.6	5.8			7.5
San Onofre, Unit 1	PWR	436	SAFSTOR	1100						
Average All Plants				689	26.9	28	36.9	8.3	8.4	18.1
Number of Plants				9	6	6	7	4	3	3
Occupational Dose in Decommissioning BWRs										
Average BWR				527			50.8		3.7	45.5
Number of Plants				2			1		1	1
BWR SAFSTOR				354			50.8		3.7	45.5
BWR DECON				700						
Occupational Dose in Decommissioning PWRs										
Average PWR				786	23.2	28.4	38.7	8.3	6.1	4.4
Number of Plants				6	5	5	5	4	1	2
PWR SAFSTOR				792	23.3	25	47.2	0.3		4.4
PWR DECON				784	23.2	30.8	33	11	6.1	

(a) Dose is estimated for activities during decommissioning at plants that have not reached license termination.
(b) High-temperature gas-cooled reactor.
(c) Boiling water reactor.
(d) Pressurized water reactor.

Table G-12. Reactor Vessel Removal Information and Data

Nuclear Plant	Total Bequerels (Curies) Removed	Personnel Exposure person-sievert (person-rem)	Segmented components/ Lineal inches cut	Cutting Methods	Considerations for Planning and Implementation
Haddam Neck (in progress)	2.8 x 10^{16} (750,000)	1.77 (177)	• Core baffle • Core former plates • Core barrel in active fuel region • Lower core support plate • Lineal inches cut - 23,251	• Abrasive water • MDM cutting	• Worker exposure • Airborne contamination • Waste form and disposal costs • Cavity cleanup requirements • Schedule
San Onofre, Unit 1 (in progress)	1.2 x 10^{16} (330,000)	0.73 (73)	• Core region of the core barrel • Core baffles/formers • Lower core support plates • Lineal inches cut - 10,821	• Abrasive water • MDM cutting	
Maine Yankee (in progress)	Not available	(actual to date) 0.24 (24)	• Upper guide structure • Upper core barrel • Core support barrel • Mid-core region • Thermal shield • Lineal inches cut - 14,000	• Abrasive water jet (AWJ) • Conventional machining	• Avoid thermal processing • Use AWJ and conventional machining vs. plasma arc and MDM/EDM to reduce the occupational dose • Modeled all the cuts in a 3D CAD system before actually performing any of the dismantlement • Segregating, capturing, and confining AWJ cutting waste • Solid waste collection system • Cavity water treatment system • Much Maine Yankee dismantlement done under water and remotely, which cut down the worker dose • Abrasive Feed Assist System (patent pending) • Underwater AWJ Vision Enhancement - remote operability (patent pending) • Minimized amount of secondary waste • For underwater equipment, a maintenance and reliability issue • Sequence of cuts (low to high activity) reduced occupational exposure
Big Rock Point (in progress)	Not available	Not available	N/A	N/A	

Table G-12. (contd)

Nuclear Plant	Total Bequerels (Curles) Removed	Personnel Exposure (person-rem)	Segmented components/ Lineal inches cut	Cutting Methods	Considerations for Planning and Implementation
Trojan (completed)	74,000 (2,000,000)[(a)]	0.72 (72)	N/A	N/A	• Used the fuel transfer crane to lift the reactor vessel and place in the container • Removed reactor vessel with internals intact • The internals were grouted in place with low-density cellular concrete • Placed the reactor vessel on a heavy haul trailer for road transport to the rail • Shipped the reactor vessel with internals to U.S. Ecology, Richland, WA • Eliminated 74,000 Bq (2 million curies) from the Trojan nuclear facility site

(a) The Trojan plant reactor vessel was removed and shipped intact to the disposal facility; reactor vessel internals were not removed as in the other plants listed in this table.

Tables G-11 and G-12 list available data regarding the distribution of the cumulative collective worker dose among the major types of activities that would occur during a typical decommissioning process. The lack of resolution in much of the data and the small number of facilities involved (10) precludes a detailed analysis. However, it appears that the largest share of occupational doses might be expected for three general classes of activities: (1) large component removal (reactor vessel, steam generators), (2) removal of other plant systems, structures, and components, and (3) the remaining general decontamination activities. Data for removal of the reactor vessel (Table G-12) indicate that the choice of removal method (i.e., intact or segmented) may influence the collective dose associated with the operation. Data for plants electing the SAFSTOR alternative were not substantially different from plants undergoing more immediate DECON. The one exception was at Humboldt Bay, where the plant was maintained in a shutdown condition over an extended period of time. In that case, SAFSTOR activities accounted for a relatively large fraction of the total estimated occupational dose. In all cases, the estimated cumulative doses through the end of decommissioning for these plants were within the estimates presented in the 1988 GEIS (NRC 1988).

G.2.2 Dose to Members of the Public

Doses to members of the public from power reactor effluents were summarized in a series of NRC reports entitled *Dose Commitments Due to Radioactive Releases from Nuclear Power Plant Sites.* The last volume published covers reactor operations during 1992 (NUREG/CR-2850, Baker 1996). Radioactive material is released in gaseous (airborne, and may contain particulates, such as radioiodine) and liquid (aqueous) effluents under stringently controlled conditions in accordance with technical specifications and NRC regulations. The term "dose commitment" indicates that the reported doses come from the inhalation and ingestion of radionuclides, as well as from external radiation from noble gases. The population dose caused by direct radiation from plant facilities is negligible. Table G-13 presents results obtained for the 18-year period ending in 1992. The public doses represent collective person-rem received by those who live within an 80-km (50-mi) radius of a site; data for individual sites also appear in this report. The population dose within 80 km (50 mi) of each plant is calculated for each operating reactor in the United States. The total collective dose is then obtained by combining the doses received by these populations. As with the occupational doses, collective dose to the public from reactor effluents has been decreasing steadily since the mid-1980s. The collective dose to members of the public is smaller by several orders of magnitude than the dose to plant workers.

Data on maximally exposed individuals from gaseous effluents is also reported annually to the NRC by each nuclear utility. Data for the period 1985-1987 were compiled in NUMARC (1989) and summarized in NRC (1996). A summary of the data is presented in Table G-14.

Inspection of this table reveals that the maximum doses to individuals via gaseous effluents are on the order of a few mrem per year, and the dose to an individual is orders of magnitude lower for most plants.

Table G-13. Summary of Collective Public and Occupational Doses for All Operating Nuclear Power Facilities Combined[(a)]

Year	Number of Operating Reactors[(b)]	Collective Public Dose, person-rem			
		Liquid Effluents	Gaseous Effluents	Total	Average per reactor-yr, person-rem
1975	44	76	1300	1300	30
1976	52	82	390	470	9.0
1977	57	160	540	700	12
1978	64	110	530	640	10
1979	67	220	1600	1800	27
1980	68	120	57	180	2.6
1981	70	87	63	150	2.1
1982	74	50	87	140	1.9
1983	75	95	76	170	2.3
1984	78	160	120	280	3.6
1985	82	91	110	200	2.4
1986	90	71	44	110	1.2
1987	96	56	22	78	0.81
1988	102	65	9.6	75	0.74
1989	107	68	16	84	0.79
1990	110	63	15	78	0.71
1991	111	70	17	88	0.79
1992	110	32	15	47	0.43

(a) Collective public dose calculated for those living within an 80-km (50-mi) radius of a nuclear plant site.
(b) Includes plants in operation at least 1 full year at the end of the reporting year.
Source: NUREG/CR-2850 (Baker 1996).
Note: To convert person-rem to person-sievert, multiply by 0.01.

Table G-14. Estimated Doses to the Maximally Exposed Individual from Routine Gaseous Effluents from Operating Facilities, mrem[(a)]

	1985	1986	1987
Average	2.8E-01	2.6E-01	9.1E-02
Minimum	7.8E-04	4.9E-04	1.0E-06
Maximum	1.8E+00	4.3E+00	8.9E-01
Number of plants reporting	26	33	34

(a) Data compiled from reports submitted to the NRC by each nuclear utility.
Adapted from NUMARC (1989).
Note: To convert millirem to millisievert, multiply by 0.01.

A comparison of more recent effluent release rates from both operating and decommissioning facilities (Table G-15) indicates that the gaseous release rates for many types of effluents are similar. Decommissioning facilities reported no emissions of radioiodine in their gaseous effluents, which would be as expected after the plants are shut down and defueled. Most of the iodine isotopes are short-lived and are not present in plants that have been out of operation for any length of time. Releases of longer-lived fission gases and particulate materials in gaseous effluents continue after the end of operation because of the need to maintain plant ventilation systems during activities associated with the decommissioning process. Radionuclide emissions in liquid effluents were typically lower in the shutdown facilities because the reactor core cooling systems were not operating, and the levels of radionuclides in circulating water systems needed to maintain the spent fuel pool are lower than in primary coolant for an operating plant.

Recent DEs to members of the public from emissions at operating and decommissioning facilities were similar, and the doses from gaseous effluents were within the ranges published in NRC (1996) for operating facilities. Both individual and collective doses were very low for liquid and gaseous effluents. Although information was available for a relatively small sample of facilities, there does not appear to be any reason to project substantial increases in emissions or public doses from reactors undergoing decommissioning compared to the levels experienced during normal operation of those facilities.

Table G-15. Summary of Effluent Releases Comparison of Operating Facilities and Decommissioning Facilities

Operating Reactors						
Reactor Type	**PWR**			**BWR**		
	Average	**Max**	**Min**	**Average**	**Max**	**Min**
Capacity (MWe)	829	912	760	972	1154	786
Gaseous Effluents - Total (Ci)	5.8E+01	1.5E+02	4.0E-01	9.3E+01	1.7E+02	1.2E+01
Fission and Activation Gases (Ci)	4.4E+01	1.4E+02	7.5E-02	8.3E+01	1.6E+02	1.5E+00
Iodines (Ci)	6.4E-07	1.3E-06	0	2.3E-03	5.1E-03	0
Particulates (Ci)	1.9E-05	3.8E-05	3.3E-07	8.9E-04	1.6E-03	3.0E-04
Gross Alpha (Ci)	--	--	--	--	--	--
Tritium (Ci)	1.4E+01	3.7E+01	3.2E-01	1.0E+01	1.2E+01	6.2E+00
Liquid Effluents - Total (Ci)	5.2E+02	6.7E+02	4.2E+02	1.2E+01	1.9E+01	6.9E+00
Fission and Activation Products (Ci)	1.6E-01	3.7E-01	8.5E-02	6.2E-02	9.4E-02	1.2E-02
Tritium (Ci)	5.2E+02	6.7E+02	4.2E+02	1.2E+01	1.9E+01	6.9E+00
Dissolved and Entrained Gases (Ci)	1.0E-01	3.8E-01	2.2E-04	4.3E-03	6.7E-03	1.8E-03
Gross Alpha (Ci)	1.2E-03	1.9E-03	4.4E-04	2.4E-06	3.8E-06	0
Decommissioning Reactors						
Reactor Type	**PWR**			**BWR**		
	Average	**Max**	**Min**	**Average**	**Max**	**Min**
Capacity, MWe	970	1080	860	65	67	63
Gaseous Effluents - Total (Ci)	2.1E+01	4.0E+01	2.6E+00	1.1E+02	2.1E+02	1.2E+00
Fission and Activation Gases (Ci)[(a)]	1.6E+01	1.6E+01	1.6E+01	2.1E+02	2.1E+02	2.1E+02
Iodines (Ci)	--	--	--	--	--	--
Particulates (Ci)	0	0	0	1.0E-04	2.0E-04	0
Gross Alpha (Ci)	--	--	--	0	0	0
Tritium (Ci)	1.3E+01	2.4E+01	2.6E+00	1.2E+00	1.2E+00	1.2E+00
Liquid Effluents - Total (Ci)	7.8E-01	1.4E+00	1.2E-01	3.3E-01	1.3E+00	1.0E-03
Fission and Activation Products (Ci)	3.5E-02	6.7E-02	2.6E-03	3.3E-01	1.3E+00	2.0E-04
Tritium (Ci)	7.4E-01	1.4E+00	1.2E-01	9.5E-04	1.1E-03	8.0E-04
Dissolved and Entrained Gases (Ci)	--	--	--	--	--	--
Gross Alpha (Ci)	0	3.0E-05	0	0	0	0

(a) The average, maximum, and minimum values for this radionuclide category are identical within each reactor type because only one facility of each type reported detectable emissions. Other facilities either did not report emissions for this category or indicated that emissions were below detection limits and, therefore, were not included in the calculation.

G.3 References

10 CFR 20. Code of Federal Regulations, Title 10, *Energy*, Part 20, "Standards for protection against radiation."

10 CFR 50. Code of Federal Regulations, Title 10, *Energy*, Part 50, "Domestic licensing of production and utilization facilities."

40 CFR 61. Code of Federal Regulations, Title 40, Protection of Environment, Part 61, "National emissions standards for hazardous air pollutants; regulations of radionuclides."

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G.4 Related Documents

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