Journal of Law and Policy

Volume 23 | Issue 1 Article 6

2014

Thousands of Half-Lives To Go: Weighing The Risks of Spent Nuclear Fuel Storage

Amanda Matos

THOUSANDS OF HALF-LIVES TO GO: WEIGHING THE RISKS OF SPENT NUCLEAR FUEL STORAGE

*Amanda Matos**

In 2012, following the Fukushima nuclear disaster, and in light of executive and congressional roadblocks to developing a reliable plan for away-from-reactor nuclear waste storage, the D.C. Circuit ruled in New York v. Nuclear Regulatory Commission *that the Nuclear Regulatory Commission's ("NRC") plan for nuclear storage was unacceptable and required revision. The court ruled that the NRC must assess the long-term risks of storing nuclear waste at or near nuclear power plants. In response, the NRC issued a draft Generic Environmental Impact Statement ("draft GEIS") which fundamentally altered its thirty-year position on waste storage, claiming that at-reactor waste storage for indefinitely long periods of time could be accomplished within acceptable safety limits. This note argues that the NRC's at-reactor waste storage risk projections in the draft GEIS are based on a flawed analysis.*

Specifically, this note demonstrates that the NRC has (1) fallen short in its determination of the probability of the occurrence of a disaster, and (2) failed to provide a reasonable method of tying this probability to the associated environmental consequences. The NRC purports to have determined that at-reactor waste storage is safe for an eternal period of time, despite not more than seventy years of storage experience.

---

* J.D. Candidate, Brooklyn Law School, 2015. This note is dedicated to my husband, Yacob Rahav, who I will love longer than the half-life of plutonium. Special thanks to my parents and sister for their unwavering love and support. I also thank the members of the JLP staff for their careful edits and feedback.

This note tracks the history of severe nuclear disasters vis-à-vis the prediction of future events, and analyzes judicial assessments of challenges to NRC policy. This note argues that the NRC violated the National Environmental Policy Act ("NEPA"), which requires that federal agencies properly assess the environmental risks of their actions, by inaccurately reporting environmental risks to the public. This note concludes that, given the inadequacy of the NRC risk assessment, the NRC failed to comply with the court's mandate.

INTRODUCTION

Wearing a surgical mask, Ms. Hiroko Watabe visits her home once per month, provided that she is willing to assume the risk of exposure to highly radioactive materials.[1] Along with 83,000 other people who face the same constraints, she was displaced by the 2011 Fukushima nuclear accident in Japan.[2] Although there were major nuclear accidents within the thirty-two years prior to Fukushima, including the Three Mile Accident in the United States and the Chernobyl disaster in Ukraine, many policymakers predicted that events like the Fukushima disaster would occur extraordinarily infrequently.[3]

Nuclear power plants generate electric power by using heat generated by the decay of enriched uranium.[4] About 5 years after

---

[1] Martin Fackler, *Japan's Nuclear Refugees, Still Stuck in Limbo*, N.Y. TIMES (Oct. 1, 2013), http://www.nytimes.com/2013/10/02/world/asia/japans-nuclear-refugees-still-stuck-in-limbo.html?pagewanted=all&_r=0.

[2] *Id.*

[3] AJ SOFTWARE & MULTIMEDIA, *Major Nuclear Power Plant Accidents*, ATOMIC ARCHIVE, http://www.atomicarchive.com/Reports/Japan/Accidents.shtml (last visited Oct. 7, 2014). The Three Mile Island accident occurred in 1979, and the Chernobyl accident occurred in 1986. *Id.*

[4] *Uranium Enrichment*, WORLD NUCLEAR ASS'N, http://www.world-nuclear.org/info/Nuclear-Fuel-Cycle/Conversion-Enrichment-and-Fabrication/Uranium-Enrichment/ (last updated Aug. 2014). The splitting of uranium during the process of nuclear fission results in small fragments whose total mass is slightly less than that of the original uranium atom. INST. FOR ENERGY & ENVTL. RESEARCH, *Basics of Nuclear Physics and Fission*, http://ieer.org/resource/factsheets/basics-nuclear-physics-fission/ (last updated May 2012). The "missing mass" is converted into vast amounts of energy, as

fresh nuclear fuel is inserted into the reactor, it is no longer efficient for energy generation; such spent nuclear fuel (SNF) must then be removed from the reactor.[5] SNF, the highly toxic byproduct of nuclear fuel, remains radioactive for thousands of years after it is removed from a nuclear reactor core.[6] Since SNF emits lethal amounts of radiation and generates intense heat following its removal from the reactor, it must be isolated in massive pools of water.[7] At each nuclear power plant site, tons of SNF awaiting long-term safe disposal have accumulated in these pools.[8]

---

called for by Einstein's famous equation, $E=mc^2$. *Id*. In addition, neutrons generated during this process convert some uranium into plutonium. *What is Uranium? How Does it Work?*, WORLD NUCLEAR ASS'N, http://www.world-nuclear.org/info/Nuclear-fuel-cycle/introduction/what-is-Uranium--How-Does-it-Work-/ (last updated Mar. 2014) [hereinafter *What is Uranium?*]. Some of this highly toxic plutonium is present in nuclear fuel upon removal from the reactor. *See id.* (discussing the production of plutonium by nuclear fission); *see also* Jan A. Gevers Leuven, *A Medical Look at Plutonium*, http://www.nvmp.org/pluto4.htm (last visited Oct. 7, 2014) (explaining the toxic effects of plutonium).

[5] BLUE RIBBON COMM'N ON AMERICA'S NUCLEAR FUTURE, REPORT TO THE SECRETARY OF ENERGY 10 (Jan. 2012) [hereinafter BLUE RIBBON COMM'N REPORT], *available at* http://www.nei.org/corporatesite/media/filefolder/BRC_FinalReport_Jan2012.pdf.

[6] *Id.* at 10–11.

[7] John W. Rachow, *The Growing Problem of Spent Nuclear Fuel*, PHYSICIANS FOR SOC. RESP. (2014), http://www.psr.org/environment-and-health/environmental-health-policy-institute/responses/the-growing-problem-of-spent-nuclear-fuel.html. According to the Institute for Policy Studies,"[s]pent fuel rods give off about 1 million rems (10,000 Sv) of radiation per hour at a distance of one foot — enough radiation to kill people in a matter of seconds." Robert Alvarez, INST. FOR POLICY STUDIES, *Spent Nuclear Fuel Pools in the U.S.* 1 (May 2011) *available at* http://www.ips-dc.org/wp-content/uploads/2011/05/spent_nuclear_fuel_pools_in_the_US-final.pdf. Moreover, the SNF could unleash a catastrophic fire if the fuel is exposed to air. *Id.* at 18. In addition, "[a] severe pool fire could render about 188 square miles around the nuclear reactor uninhabitable, cause as many as 28,000 cancer fatalities, and spur $59 billion in damage." *Id.*; s*ee also* discussion *infra* Parts I.A, C.

[8] BLUE RIBBON COMM'N REPORT, *supra* note 5, at 11. Roughly 75 percent of SNF in the U.S. is stored in pools to cool and shield the radioactivity of the fuel. *Id*. at 11, 14; *see also* discussion *infra* Part I.A.

Ongoing operation at each of the 104 commercial reactor sites in the U.S. continually generates substantial quantities of SNF.[9] In order to manage the quantity and hazards of SNF, Congress passed the Nuclear Waste Policy Act of 1982 (NWPA), which called for the establishment of permanent underground repositories ("geologic sites"), where SNF would be stored after an initial period of pool storage.[10] These geologic sites were considered a safer alternative than long-term on-site storage of waste at nuclear power plants.[11] Subsequently, Congress amended the NWPA to designate a single permanent repository inside Yucca Mountain, Nevada.[12] The Nuclear Regulatory Commission (NRC), which oversees and licenses commercial reactors and nuclear waste storage facilities,[13] intended to house and monitor SNF at Yucca Mountain for a period of up to one million years.[14] The Yucca Mountain plan has been highly contested on both political and practical grounds, and after thirty years of repeated postponements, it is now possible that this repository will never be built.[15] In the absence of a definitive Yucca Mountain plan, there is a pressing need for a storage solution. The current practice of storing SNF at nuclear sites has widely been considered an unacceptable long-term solution.[16]

---

[9] *Id.* at 14.

[10] *Id.* at 20. The Department of Energy is responsible for designating sites for the establishment of permanent geologic repositories. *Id.* at 22. These designations are subject to the NRC's approval. *Id.*; *see also* discussion *infra* Part I.B.

[11] *Id.* at 20.

[12] Omnibus Budget Reconciliation Act of 1987, Pub. L. No 100-203, Title V, § 5011(a), (1987) (amending 42 U.S.C. §10172).

[13] U.S. NUCLEAR REGULATORY COMM'N, NUCLEAR POWER PLANT LICENSING PROCESS 1 (July 2004), *available at* http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0298/br0298r2.pdf.

[14] Waste Confidence- Continued Storage of Spent Nuclear Fuel, 78 Fed. Reg. 56776, 56797 (proposed Sept. 13, 2013) (to be codified at 10 C.F.R. pt. 51).

[15] *See* BLUE RIBBON COMM'N REPORT, *supra* note 5, at 23–24. The Department of Energy continually delayed its application for a permanent repository as a result of legal challenges and lack of funding from Congress. *Id.* at 23; *see also* discussion *infra* at Part I.B.

[16] *See, e.g.*, BLUE RIBBON COMM'N REPORT, *supra* note 5 at iv, 10–11, 26–

The Energy Reorganization Act of 1974 established the NRC as an independent agency to regulate the nuclear industry.[17] The NRC commissioners are nominated for a five-year term by the President, and must be confirmed by the Senate.[18]

Beginning in 1984, the NRC issued a set of guiding principles for safe SNF management referred to as the Waste Confidence Decision (WCD).[19] The WCD provided assurance that after an initial period of at-reactor storage (e.g., thirty years), SNF would be transferred to a permanent repository.[20] Although courts tend to defer to the NRC's findings, in *New York v. U.S. Nuclear Regulatory Commission*[21] in 2012, the D.C. Circuit broke new ground in calling for the NRC to account for the possibility that a permanent repository will never be established.[22] The court mandated that the NRC assess the risks involved in permanent storage in the absence of Yucca Mountain.[23] In response, the NRC issued a draft Generic Environmental Impact Statement (draft GEIS), in which it provided an assessment of the environmental effects of short-term, long-term, and permanent storage of nuclear waste at or near nuclear power plant sites.[24] The NRC based its report on a controversial risk assessment technique, which purports

---

27.

[17] U.S. NUCLEAR REGULATORY COMM'N, THE NRC: WHO WE ARE AND WHAT WE DO 2, *available at* http://pbadupws.nrc.gov/docs/ML1424/ML14241A663.pdf.

[18] *Id.* at 4.

[19] New York v. U.S. Nuclear Regulatory Comm'n, 681 F.3d 471, 473 (D.C. Cir. 2012). Based on the original WCD assurances: "1) safe disposal in a mined geologic repository is technically feasible, 2) such a repository will be available by 2007-2009, 3) waste will be managed safely until the repository is available, 4) SNF can be stored safely at nuclear plants for at least thirty years beyond the licensed life of each plant, and 5) safe, independent storage will be made available, if needed." *Id.*

[20] *Id.*

[21] *Id.* at 471.

[22] *Id.* at 473.

[23] *See id.*

[24] U.S. NUCLEAR REGULATORY COMM'N, WASTE CONFIDENCE GENERIC ENVIRONMENTAL IMPACT STATEMENT: DRAFT REPORT FOR COMMENT xxii (2013) [hereinafter DRAFT GEIS], *available at* http://pbadupws.nrc.gov/docs/ML1322/ML13224A106.pdf.

to mathematically predict the likelihood and consequences of a nuclear accident.[25] Despite the risks of nuclear waste storage, the commission's draft GEIS is optimistic, and concludes that long-term environmental effects of continued on-site storage will generally be minimal.[26]

This Note argues that the NRC's draft GEIS contains profound weaknesses because of uncertainties, oversimplifications and frank inaccuracies in its risk assessment and presentation. Accordingly, this Note further argues that (1) NRC failed to comply with the D.C. Circuit's ruling in *New York v. U.S. Nuclear Regulatory Commission*, and (2) that future challenges should be subject to greater judicial scrutiny.[27]

Since the NRC did not sufficiently account for the risks of storing SNF in the vicinity of a nuclear reactor, the draft GEIS was not a legally satisfactory outcome of the D.C. Circuit's ruling in *New York v. U.S. Nuclear Regulatory Commission*. In particular, the NRC's report's projections assume the ability to store SNF far beyond what has ever been accomplished. Nuclear waste has never been stored for more than approximately seventy years,[28] yet the NRC separately analyzes and forecasts safe storage for each of a 160- to 240-year timeframe and for an unlimited timeframe, which the NRC refers to as "long-term" and "indefinite" storage, respectively.[29] Furthermore, the draft GEIS oversimplifies risk quantification by reducing the presentation of risk assessment to one of three words: "small," "moderate," and "large."[30] Based on this nomenclature, the NRC concludes that the risk of major environmental impacts with continued SNF storage will generally be "small."[31]

---

[25] *Id.* at xxviii.

[26] *Id.* at xlii–xliii, liii–liv.

[27] *See infra* Part V.

[28] BLUE RIBBON COMM'N REPORT, *supra* note 5, at 19 (explaining that "spent fuel and [high level waste] has been produced in the United Stated since the 1940s").

[29] DRAFT GEIS, *supra* note 24, at xxvi, xlii–xliii, liii–liv.

[30] *Id.* at xxviii.

[31] *Id.* at xlii–xliii, liii–liv.

The D.C. Circuit's refusal to defer to the NRC's WCD safety assurances in *New York v. U.S. Nuclear Regulatory Commission*[32] can be considered a natural result of 2011 Fukushima accident, in which massive amounts of radiation were released into the environment. The draft GEIS presents another flawed SNF storage strategy, and will likely face similar legal challenges.[33] Given the uncertainties and oversimplifications in the draft GEIS's risk assessment, these future challenges should be subject to greater judicial scrutiny.[34]

Part I of this Note provides an overview of the hazards of generating and storing nuclear waste. This section also discusses the environmental effects of SNF storage. In particular, it reviews Three Mile Island, Chernobyl, and Fukushima, severe nuclear accidents that continue to influence environmental decision making. In addition, this section examines plans for developing a national repository in the U.S, and the ensuing standstill. Part II provides case law background and an analysis of *New York v. U.S. Nuclear Regulatory Commission*, a landmark case which led to the NRC's development of the draft GEIS. Part III discusses and analyzes the NRC's risk assessment in the draft GEIS, and explores judicial review of the NRC's risk assessment approach. Part IV provides a critique of the draft GEIS and analyzes both the deficiencies involved in the NRC's risk assessment, as well as its oversimplified presentation of risk to the public. Part V argues that the draft GEIS should be subject to greater judicial scrutiny. Part

---

32 New York v. U.S. Nuclear Reg. Comm'n, 681 F.3d 471, 476 (D.C. Cir. 2012).

33 Eric Schneiderman, who spearheaded the lawsuit in *New York v. U.S. Nuclear Regulatory Commission*, stated that the draft GEIS is "significantly flawed," because the report fails to adequately account for the risks involved with storing SNF. Eric Scheiderman, Testimony of N.Y. State Attorney Gen. Eric T. Schneiderman on the Waste Confidence Draft Generic Envtl. Impact Statement (DGEIS) and Proposed Rule (Oct. 30, 2013), *available at* http://www.ag.ny.gov/pdfs/Janice%20Dean%20Testimony%2010.30.13.5.pdf In addition, as of January 31, 2013, there were nine pending legal challenges to the NRC regarding their environmental decision-making. U.S. Nuclear Reg. Comm'n, Annual Report on Court Litigation 1–12 (Jan. 31, 2014), *available at* http://www.nrc.gov/reading-rm/doc-collections/commission/ secys/2013/2013-0013scy.pdf.

34 *See infra* Part V.

VI concludes that the NRC failed to comply with the mandate of *New York v. U.S. Nuclear Regulatory Commission* and that there should be a less deferential standard of review for the NRC's findings as a result of the Fukushima disaster.

I. BACKGROUND ON THE RISKS OF STORING NUCLEAR WASTE

A. Short-Term Methods of Storing Spent Nuclear Fuel

SNF is an extremely hot byproduct of nuclear fuel that is no longer energy efficient, and remains radioactive for thousands of years.[35] SNF is highly hazardous: "[c]lose proximity to a single 10-year-old spent fuel assembly would deliver a fatal whole-body radiation dose in about three minutes."[36] Each year, the nuclear industry produces 2000 to 2400 metric tons of spent fuel, which is typically stored, cooled, and contained[37] in spent fuel pools at nuclear power plants. Unless SNF is adequately cooled, the heat that the fuel generates is intense enough to ignite the fuel and disseminate highly radioactive matter into the atmosphere.[38] Failure to contain SNF poses the risks of pool fires and leakage of radioactive contents.[39] Furthermore, these spent fuel pools have limited storage capacity.[40] Because of the safety risks involved and the limited storage capacity, spent fuel pools were built with the understanding that pool storage would be temporary.[41] SNF has been stored in pools for decades, and as of January 2012,

---

[35] Rachow, *supra* note 7.

[36] *Id.*

[37] *Id.* at 23–24.

[38] Eli Kintisch, *Contention over Risk of Fire from Spent Fuel Pools*, SCIENCEMAG.ORG (March 16, 2011, 7:16 PM), http://news.sciencemag.org/2011/03/contention-over-risk-fire-spent-fuel-pools.

[39] *See* New York v. Nuclear Regulatory Comm'n, 681 F.3d 471, 475, 477 (D.C. Cir. 2012) (explaining that pool fires may result if the pump which must continuously supply cooled water fails).

[40] U.S. NUCLEAR REG. COMM'N, RADIOACTIVE WASTE: PRODUCTION, STORAGE, DISPOSAL 10 (May 2002), *available at* http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0216/r2/br0216r2.pdf.

[41] BLUE RIBBON COMM'N REPORT, *supra* note 5, at 33.

amounted to 50,000 metric tons, or 110 million pounds.[42]

After the first few years of obligatory pool storage to cool the SNF, there are two options for further SNF storage: (1) ongoing pool storage; or (2) dry storage.[43] Dry storage involves encasing the fuel in concrete and steel.[44] This is considered a more secure and thus preferable option to continued pool storage.[45] Less than twenty-five percent of the nation's SNF has been removed to dry storage,[46] but this percentage is expected to increase because SNF pools are full or near capacity.[47] However, SNF can only be stored in dry casks for roughly 100 years,[48] and therefore this storage method cannot be a permanent solution.[49] A long-term safe and reliable storage solution for SNF is essential, but remains unavailable.

B. The Need for Permanent Storage

SNF contains radioactive plutonium, which is generated during the nuclear fuel cycle[50] and remains radioactive for tens of thousands of years.[51] Plutonium gradually decays into non-radioactive elements.[52] The time required for this decay is

---

[42] *Id*. at 11. One metric ton is approximately 2200 pounds. *Id.* at 14. An additional 15,000 tons of SNF has accumulated in dry storage amounting to a total of 65,000 tons of SNF. *See id.* at 11.

[43] *Id.*

[44] *Id.*

[45] *Id*. at 34.

[46] *Id.*

[47] INT'L PANEL ON FISSILE MATERIALS, SPENT FUEL FROM NUCLEAR POWER REACTORS 12–15 (June 2011), *available at* http://fissilematerials.org/library/ipfm-spent-fuel-overview-june-2011.pdf.

[48] Rachow, *supra* note 7.

[49] U.S. NUCLEAR REG. COMM'N, RADIOACTIVE WASTE: FACT SHEET 1–2 (April 2007), *available at* http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/radwaste.pdf.

[50] *What is Uranium?*, *supra* note 4.

[51] RADIOACTIVE WASTE: FACT SHEET, *supra* note 49, at 1–2.

[52] *Id.* at 2. Robert Busby, *The United States's Failure to Establish a High-Level Nuclear Waste Storage Facility is Threatening its Ability to Effectively Support Nuclear Nonproliferation*, 30 GEO. WASH. J. INT'L L. & ECON. 449, 454 (1996).

measured by the "half-life,"[53] which, for one form of plutonium in SNF, is 24,000 years.[54] Other components of nuclear fuel can have even longer half-lives,[55] rendering the SNF dangerous to humans for still longer periods of time. Congress and the NRC therefore planned a permanent repository with the understanding that no containment structure in the form of pools or dry storage could possibly be certifiable for this amount of time.[56]

In 1982, Congress passed the NWPA,[57] which mandated that the Department of Energy designate a permanent site for underground storage of high-level radioactive waste,[58] subject to the NRC's approval.[59] A 1987 amendment to the NWPA designated Yucca Mountain in Nevada as the sole site for a national geologic repository, with a 1998 deadline for acceptance of SNF.[60] The NRC provided assurances that the repository would provide one million years of storage.[61]

In light of political and practical complexities, this deadline has been repeatedly extended.[62] In 2008, the Department of Energy submitted its first license application to the NRC for operating a national repository at Yucca Mountain.[63] However, the Obama Administration has opposed the development of a permanent

---

[53] *Radiation and Life*, WORLD NUCLEAR ASS'N, (Dec. 2012) http://www.world-nuclear.org/info/Safety-and-Security/Radiation-and-Health/Radiation-and-Life/. The half-life is the time for half of the radioactive material to become non-radioactive; after one half-life, half of the radioactivity is gone, and after two half-lives, three quarters is gone. *Id*. Only after a large number of half-lives is the radioactivity meaningfully depleted. *See id*.

[54] Busby, *supra* note 52.

[55] *Id.*

[56] BLUE RIBBON COMM'N REPORT, *supra* note 5, at 20.

[57] 42 U.S.C. § 10131(a)(2) (2014).

[58] *See* BLUE RIBBON COMM'N REPORT, *supra* note 5, at 27. Underground storage would reduce the risks of a radioactive release, and is therefore considered a safer alternative to above-ground storage of SNF. *Id.* at 27, 29.

[59] 42 U.S.C. § 10132(b)(1)(A) (2014).

[60] BLUE RIBBON COMM'N REPORT, *supra* note 5, at 23.

[61] *See* Waste Confidence- Continued Storage of Spent Nuclear Fuel, 78 Fed. Reg. 56776, 56805 (proposed Sept. 13, 2013) (to be codified at 10 C.F.R. pt. 51).

[62] *Id.* at 23–24.

[63] *Id.* at 23.

repository,[64] and thus submitted budget proposals in 2009 that discontinued funding for the Yucca Mountain repository.[65] The Administration also moved to withdraw the license application for Yucca Mountain.[66] The NRC did not grant the motion to withdraw, but suspended licensing proceedings for Yucca Mountain in 2011.[67]

Because of the NRC's inaction, in *In re Aiken County*,[68] in 2013, South Carolina and Washington State[69] filed a complaint against the NRC in the D.C. Circuit on the grounds that the licensing proceedings should continue, which would enable the transfer of SNF from local storage to the Yucca Mountain repository.[70] In response, the court granted a writ of mandamus against the NRC, ordering them to decide whether to grant the Department of Energy's application for licensing a repository at Yucca Mountain.[71] The court ruled that the NRC, as an executive agency, was obligated to proceed with the licensing process, but acknowledged that Congress has the power to discontinue funding or suspend licensing for Yucca Mountain.[72] Since this ruling, the federal government's Yucca Mountain plan remains in limbo.[73]

The failure to actualize the Yucca Mountain plan was the basis for the plaintiffs' action in *New York v. U.S. Nuclear Regulatory*

---

[64] The Obama administration's explanation is that Yucca Mountain is not a feasible option for permanent storage. TODD GARVEY, CONGRESSIONAL RESEARCH SERV., CLOSING YUCCA MOUNTAIN 3 (June 4, 2012), *available at* http://fas.org/sgp/crs/misc/R41675.pdf.

[65] *Id.* at 3; *see also id.* at summary. In response, Congress has restricted funding for the project. *Id*. at 3.

[66] BLUE RIBBON COMM'N REPORT, *supra* note 5, at 23.

[67] GARVEY, *supra* note 64, at summary. The NRC indicated that it suspended the proceedings due to lack of funding from Congress. *In re* Aiken County, 725 F.3d 255, 387 (D.C. Cir. 2013).

[68] *Aiken County*, 725 F.3d at 385.

[69] Various entities and individuals in South Carolina and Washington were petitioners as well. *Id.*

[70] *Id.*

[71] *Id.* at 385–86.

[72] *Id.* at 386.

[73] New York v. U.S. Nuclear Regulatory Comm'n, 681 F.3d 471, 471, 474 (D.C. Cir. 2012).

Commission,[74] in which the D.C. Circuit ruled that the NRC was obligated to formulate a plan for long-term SNF storage—one that addressed the possibility that a national repository would never become available.[75] In response, the NRC issued the draft GEIS, which was required to comply with the court's mandate.[76]

C. History of Nuclear Reactor Accidents: Three Mile Island, Chernobyl, and Fukushima

Severe nuclear accidents at Three Mile Island, Chernobyl, and Fukushima illustrate the potentially devastating effects of nuclear accidents. An analysis of these disasters is important because of two parallel aspects of reactor fuel and spent nuclear fuel: (1) toxicity and (2) risk analysis.

First, the accidents illustrate the disastrous consequences resulting from the widespread dissemination of nuclear fuel during an accident, including death, illness, societal disruption, and property damage.[77] Each of these incidents involved the release of fresh nuclear fuel; but a release of SNF, which is significantly more radioactive, would be even more disastrous.[78] According to a General Accounting Office Report, "one of the most hazardous materials made by man is spent nuclear fuel. . . . [T]he fuel's intense radioactivity can kill a person exposed directly to it within minutes or cause cancer in those who receive smaller doses."[79]

Second, the NRC relies on a mathematical assessment of fuel management safety referred to as probabilistic risk assessment (PRA)[80] for both the analysis of SNF safety[81] and the analysis of

---

[74] *Id.* at 474.

[75] *Id.* at 478–79, 483.

[76] *See* DRAFT GEIS, *supra* note 24.

[77] *See, e.g.*, Melanie L. Oxhorn, *The Norms of Nuclear Accidents after Chernobyl*, 8 J. NAT. RESOURCES & ENVTL. L. 375, 377–78 (1992-1993) (explaining the tragic effects of the Chernobyl disaster).

[78] Rachow, *supra* note 7.

[79] *Id.* (citing U.S. GEN. ACCOUNTING OFFICE, GAO-03-426, SPENT NUCLEAR FUEL: OPTIONS EXIST TO FURTHER ENHANCE SOCIETY, G.A.O. Doc. No. 03-426, (2003)).

[80] *Probabalistic Risk Assessment (PRA)*, U.S. Nuclear Reg. Comm'n, http://www.nrc.gov/about-nrc/regulatory/risk-informed/pra.html (last updated

reactor safety.[82] The destruction of five nuclear reactors in these three accidents[83] is inconsistent with PRA predictions. Therefore, PRA-based assessments of SNF safety in the draft GEIS cannot be assumed to be reliable.

The first of these accidents occurred in 1979 when a nuclear reactor's core partially melted and leaked radioactive gases at Three Mile Island's power plant near Middletown, Pennsylvania.[84] The Three Mile Island accident is considered the worst commercial nuclear reactor disaster in the United States.[85] Although radioactive release from the accident was reportedly minimal,[86] experts contend that radioactive emissions were significantly higher than reported.[87] In addition, although researchers found no

---

July 17, 2013).

[81] *Id.*; DRAFT GEIS, *supra* note 24, at xxviii.

[82] *See* Limerick Ecology Action, Inc. v. U.S. Nuclear Regulatory Comm'n, 869 F.2d 719, 725–26 (3d Cir. 1989) (explaining NRC's use of PRA for its study of reactor safety).

[83] *See* Massachusetts v. U.S. Nuclear Regulatory Comm'n, 708 F.3d 63, 75 (1st Cir. 2013) (explaining that Massachusetts listed "five historical core damage events (Three Mile Island, Chernobyl, and three units at Fukushima)").

[84] U.S. NUCLEAR REGULATORY COMM'N, THREE MILE ISLAND FACT SHEET 1 (Feb. 2013) [hereinafter NRC, THREE MILE ISLAND FACT SHEET], *available at* http://www.nrc.gov/ reading-rm/doc-collections/fact-sheets/3mile-isle.html.

[85] The Learning Network, *March 28, 1979: Nuclear Accident Occurs at Three Mile Island Plant*, N.Y. TIMES (March 28, 2012 4:02 AM), http://learning.blogs.nytimes.com/2012/03/28/march-28-1979-nuclear-accident-occurs-at-three-mile-island-plant/. Moreover, health effects of the accident are reportedly negligible, but critics contend that the studies are incomplete. Lawrence K. Altman, *Study of Three Mile Island Finds Negligible Increase in Cancer*, N.Y. TIMES (Sept. 1, 1990), http://www.nytimes.com/1990/09/01/us/study-of-three-mile-island-accident-finds-negligible-increase-in-cancer.html.

[86] NRC, THREE MILE ISLAND FACT SHEET, *supra* note 84, at 1. Moreover, the EPA reported that water, soil, and plant samples in the vicinity of the reactor were uncontaminated. *Id*. However, other researchers found evidence of radioactive contamination in the environment. *Id*.

[87] Sue Sturgis, INST. FOR S. STUDIES, *Investigation: Revelations about Three Mile Island disaster raise doubts over nuclear plant safety*, FACING SOUTH (April 2, 2009), http://www.southernstudies.org/2009/04/post-4.html. For example, according to nuclear expert Arnie Gundersen, data suggest that a hydrogen explosion occurred following the accident, which could have unleashed higher doses of radiation than reported. *Id.* Gundersen also noted that the official reports underestimate the radiation release from TMI, and explained:

significant increase in cancer rate after the disaster,[88] critics argue that the findings are incomplete; cancer caused by radiation can take decades to develop.[89] The cost of the cleanup at Three Mile Island amounted to $1 billion and took fourteen years.[90]

In 1986, a cataclysmic disaster unfolded when a nuclear reactor at the Chernobyl power station in Ukraine exploded, resulting in an extensive and intense radiation release.[91] Approximately 350,000 people in the plant's vicinity were evacuated,[92] and five million people were exposed to radioactive fallout.[93] Moreover, the disaster increased the risk of cancer for those who lived in the area of Chernobyl at the time of the disaster, [94] and rendered substantial land areas uninhabitable.[95]

In 2011, an earthquake and an ensuing tsunami triggered a severe nuclear disaster at the Fukushima Nuclear Power Complex

---

"I think the numbers on the NRC's website are off by a factor of 100 to 1000." *Id*. In addition, a health physics technician stated that "[w]hat happened at TMI was a whole lot worse than what has been reported. Hundreds of times worse." *Id.*

[88] Altman, *supra* note 85.

[89] *Id.*

[90] *14-Year Cleanup at Three Mile Island Concludes*, N.Y. TIMES (Aug. 15, 1993), http://www.nytimes.com/1993/08/15/us/14-year-cleanup-at-three-mile-island-concludes.html.

[91] U.S. NUCLEAR REG. COMM'N, CHERNOBYL NUCLEAR POWER PLANT ACCIDENT FACT SHEET 1 (May 2013), *available at* http://www.nrc. gov/reading-rm/doc-collections/fact-sheets/chernobyl-bg.html. The accident is attributed to a flaw in the reactor's design and failed emergency plans. *The Chernobyl Accident*, NAT'L CANCER INST., http://chernobyl.cancer.gov/about_accident.html (last visited Oct. 7, 2014).

[92] Pavol Stracansky, *Chernobyl Effects Could Last for Centuries*, PRAVDA.RU (Aug. 30, 2010), http://english.pravda. ru/science/earth/30-08-2010/114807-chernobyl_effects_could_last_fo-0/.

[93] *Chernobyl Nuclear Accident*, NAT'L CANCER INST., http://chernobyl.cancer.gov/ (last visited Oct. 7, 2014). Moreover, the number of casualties reported ranges from 4,056, which is considered a gross underestimate, to 500,000. Stracansky, *supra* note 92.

[94] Dr. Ilya Sandra Perlingieri, *Chernobyl: The Horrific Legacy*, GLOBAL RESEARCH (Apr. 25, 2009), http://www.globalresearch.ca/chernobyl-the-horrific-legacy.

[95] *Id.*

in Japan.[96] As a result of electrical power failures from the tsunami, the plant's cooling system malfunctioned,[97] resulting in the explosion of three nuclear reactors and the release of large amounts of radioactive waste.[98] In the immediate aftermath of the disaster, 150,000 people were evacuated from the surrounding area.[99] The effects persist, as radioactive waste from the power complex continues to leak into the Pacific Ocean.[100] As of October 2013, approximately 110,300 residents have not returned to their homes because of heightened radiation[101] and it is projected that the cleanup will take forty years.[102]

The United States is at risk of its own Fukushima.[103] According to a *New York Times* report, "most of the nuclear plants in the [U.S.] share some or all of the risk factors that played a role at Fukushima."[104] These risks include plant construction along

---

[96] *Japan Lessons Learned*, U.S. NUCLEAR REGULATORY COMM'N, http://www.nrc.gov/reactors/operating/ops-experience/japan-dashboard.html (last updated Sept. 15, 2014).

[97] THE FUKUSHIMA NUCLEAR ACCIDENT INDEP. INVESTIGATION COMM'N, THE NATIONAL DIET OF JAPAN 14, 30 (2012), *available at* http://www.nirs.org/fukushima/ naiic_report.pdf.

[98] *Id.* at 30.

[99] *Id.* at 19.

[100] *Japan's Fukushima Plant Has Been Leaking Contaminated Water "For 2 Years,"* REUTERS (Aug. 7, 2013, 4:12 AM), http://www. reuters.com/article/2013/08/07/japan-fukushima-water-idUST9N0F303V2013 0807.

[101] *See Is It Safe For Any of Fukushima's 160,000 Nuclear Refugees To Return To Home?*, TEN THOUSAND THINGS (Oct. 12, 2013, 2:46 PM), http://tenthousandthingsfromkyoto.blogspot.com/2013/10/is-it-safe-for-any-of-fukushimas-160000.html. This number includes 83,000 refugees who resided within an exclusion zone around Fukushima, and—as of October 2013—this includes one third of 70,000 residents outside the exclusion zone who have not relocated to their homes. *Id*.

[102] Justin McCurry, *Fukushima Two Years On: The Largest Nuclear Decommissioning Finally Begins*, THE GUARDIAN (March 6, 2013, 12:15 EST), http://www.theguardian.com/environment/2013/mar/06/fukushima-nuclear-decommissioning-plant-safety.

[103] Tom Zeller, Jr., *U.S. Nuclear Plants Have Same Risks, and Backups, as Japan Counterparts*, N.Y. TIMES, Mar. 14, 2011, at A10, *available at* http://www.nytimes.com/2011/03/14/world/asia/14industry.html.

[104] *Id.*

"tsunami-prone coastlines or near earthquake faults, aging plants and backup electrical systems that rely on diesel generators and batteries that could fail in extreme circumstances."[105]

In addition to the aforementioned severe accidents, there have been numerous smaller nuclear reactor accidents, which "involve[d] a loss of life or more than $50,000 in damages."[106] As of 2010 there have been ninety-nine such accidents at nuclear power plants worldwide, with fifty-seven percent of all nuclear-related accidents occurring within the U.S.[107] Additionally, based on NRC records, "there were 56 serious [safety] violations at [U.S.] nuclear power plants from 2007 to 2011."[108]

D. SNF-Related Malfunctions at Nuclear Sites

Maintaining the SNF containment system requires both a properly functioning cooling system and the prevention of leakage of radioactive materials from the pools.[109] There have been accidents involving failures of the cooling system, and with radioactive leakage.[110]

There would be catastrophic results in the event of a spent fuel fire. According to Dr. Robert Alvarez, a Clinton Administration policy advisor, "[a] severe pool fire could render about 188 square miles around the nuclear reactor uninhabitable, cause as many as 28,000 cancer fatalities, and spur $59 billion in damage."[111] During

---

[105] *Id.*

[106] GAR SMITH, NUCLEAR ROULETTE: THE TRUTH ABOUT THE MOST DANGEROUS ENERGY SOURCE ON EARTH 34 (2012) (explaining Professor Benjamin Sovacool's explanation of what should constitute a nuclear accident).

[107] Benjamin K. Sovacool, *A Critical Evaluation of Nuclear Power and Renewable Electricity in Asia*, 40 J. CONTEMP. ASIA 369, 379–80 (2010).

[108] Pierre Thomas, Jack Cloherty, & Andrew Dubbins, *Records Show 56 Safety Violations at U.S. Nuclear Power Plants in Past 4 Years*, ABC NEWS (March 29, 2011), http://abcnews.go.com/Politics/%20us-nuclear-power-plants-safe/story?id=13246490. These violations include "missing or mishandled nuclear material, inadequate emergency plans, faulty backup power generators, corroded cooling pipes and even marijuana use inside a nuclear plant." *Id.*

[109] BLUE RIBBON COMM'N REPORT, *supra* note 5, at 11–12.

[110] *See* Alvarez, *supra* note 7, at 2.

[111] Alvarez, *supra* note 7, at 18 (explaining the results of a Brookhaven National Laboratory report for the NRC).

the Fukushima disaster, there was an explosion and a spent fuel fire at Fukushima Unit 4 following water loss at a spent fuel pool.[112] The explosion destroyed the reactor building and disseminated radioactive debris.[113]

The loss of large amounts of water from a spent fuel pool exposes the SNF to the atmosphere and thereby risks igniting a pool fire.[114] According to the Institute for Policy Studies, "[o]ver the past 30 years, there have been at least 66 incidents at U.S. reactors in which there was a significant loss of spent fuel water."[115] For example, the Florida Power and Light's spent fuel pool safety margin was below the allowable limit at a reactor near Miami for a five-year period before the NRC discovered and addressed the problem.[116]

In addition, the leakage of radioactive materials is a common problem at U.S. nuclear power plants and spent fuel pools are one of the most prevalent sources of such leaking.[117] The NRC reports that "at least forty-eight of sixty-five [U.S. commercial nuclear reactor] sites" have experienced tritium leakage.[118] Although government standards permit a limited leak of radioactive water, the National Academy of Sciences reports that "any exposure to radioactivity . . . [can increase] cancer risk."[119]

---

[112] *Id.* at 4. The NRC observed that, "[g]iven the amount of decay heat in the fuel in the pool, it is likely that in the days immediately following the [Fukushima] accident, the fuel was partially uncovered." U.S. NUCLEAR REG. COMM'N, RST ASSESSMENT OF FUKUSHIMA DAIICHI UNITS 13 (March 26, 2011), *available at* http://cryptome.org/0003/daiichi-assess.pdf. As a result, there was a hydrogen explosion, and "a major source [sic] term release." *Id*.

[113] Alvarez, *supra* note 7, at 4.

[114] INT'L PANEL ON FISSILE MATERIALS, *supra* note 45, at 5.

[115] Alvarez, *supra* note 7, at 2.

[116] *Id.*

[117] *A Quarter of U.S. Nuclear Plants Leaking*, CBSNEWS (Feb. 1, 2010), http://www.cbsnews.com/news/a-quarter-of-us-nuclear-plants-leaking/.

[118] *Radioactive Leaks Found at 75% of U.S. Nuke Sites*, CBSNEWS (June 20, 2011, 9:07 AM), http://www.cbsnews.com/2100-201_162-20072884.html. Tritium is radioactive hydrogen, and primarily poses health risks when present in drinking water. Jeff Donn, *PART II: AP IMPACT: Tritium Leaks Found at Many Nuke Sites*, AP, http://www.ap.org/company/awards/part-ii-aging-nukes (last visited Oct. 7, 2014).

[119] *Id.*

In summary, the environmental impacts of pool storage of SNF are formidable, threatening both the environment and public health. Although previous severe nuclear accidents involved the nuclear core, the consequences of an SNF-related accident are significant, potentially more catastrophic, and mandate the development of a robust long-term safety plan.

II. LEGAL FRAMEWORK FOR EVALUATING RISKS OF NUCLEAR WASTE STORAGE

A. Introduction

In a seminal case, *New York v. U.S. Nuclear Regulatory Commission*, the D.C. Circuit ruled that for the first time, the NRC must account for the possibility that a national geologic repository may never be built.[120] The court directed the NRC to detail and assess the risks of permanent storage of SNF at nuclear power plants.[121] Despite a judicial posture of deference to the NRC's projections about nuclear waste storage,[122] the D.C. Circuit ruled that the NRC's findings in the Waste Confidence Decision Update in 2010 were inadequate because the NRC failed to discuss the possibility of storage without a permanent repository.[123] The Waste Confidence Decision refers to the NRC's reports about "the safety and environmental impacts of storing SNF beyond the license life for operations of a nuclear power plant."[124] The original WCD declared:

1) Safe disposal in a mined geologic repository is technically feasible;
2) Such a repository will be available by 2007–2009;
3) Waste will be managed safely until the repository is available;

---

[120] New York v. U.S. Nuclear Regulatory Comm'n, 681 F.3d 471, 483 (D.C. Cir. 2012).
[121] *Id.*
[122] *See supra* Part II.C for discussion of judicial review of NEPA claims.
[123] *New York*, 681 F.3d at 478.
[124] DRAFT GEIS, *supra* note 24, at xxiii.

4) SNF can be stored safely at nuclear plants for at least thirty years beyond the licensed life of each plant; and
5) Safe, independent storage will be made available if needed.[125]

In the 2010 WCD Update, the NRC revised statement 2 to report that "a suitable repository will be available 'when necessary'"; instead of the previous assurance of availability by 2007–09.[126] In addition, the NRC amended statement 4, extending the duration of safe SNF storage on site from thirty years to sixty years.[127]

B. National Environmental Policy Act ("NEPA")

In *New York v. Nuclear Regulatory Commission*, the D.C. Circuit ruled that the NRC must comply with NEPA in assessing the environmental impacts of long-term SNF storage without the Yucca Mountain repository.[128] NEPA requires federal agencies to issue an Environmental Impact Statement (EIS)[129] when reporting on "major Federal action[s] significantly affecting the quality of the human environment."[130] This statement must include "any adverse environmental effects," "alternatives to the proposed action," and requires federal agencies to report "the environmental impacts to the public."[131] Alternatively, a federal agency can prepare an environmental assessment to determine if the federal action will have a significant environmental impact and can release a Finding of No Significant Impact if the agency concludes that an EIS is unwarranted.[132]

An agency's draft GEIS must abide by the requirements of an

---

[125] *New York*, 681 F.3d at 475.

[126] *Id.*

[127] *Id.*

[128] *Id.* at 474.

[129] *See* Regulations for Implementing NEPA, 40 C.F.R. § 1502.1–.5 (2005).

[130] *New York*, 681 F.3d at 476–77 (quoting National Environmental Policy Act of 1969, 42 U.S.C. § 4332(2)(C) (2012)).

[131] 42 U.S.C. § 4332(2)(C) (2014).

[132] *New York*, 681 F.3d at 476.

EIS "to the fullest extent possible."[133] The draft GEIS is considered "generic" because the projections pertain to all commercial nuclear waste storage sites rather than to specific sites.[134]

C. Judicial Review of NEPA Claims

Courts review claims under NEPA based on a highly deferential standard of review. In accordance with section 10 of the Administrative Procedural Act (APA),[135] courts will "hold unlawful and set aside agency action, findings, and conclusions found to be arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with the law."[136] Courts tend to defer to an agency's conclusions[137] so long as the agency provides a "credible rationale and a substantial factual basis" when it presents findings in its specialized area.[138] In particular, when applying the arbitrary and capricious standard, courts "consider whether an agency decision is based on . . . relevant factors and whether there has been a clear error of judgment."[139] For example, in *Baltimore Gas & Electric Co. v. Natural Resources Defense Council, Inc.*,[140]

---

[133] Regulations for Implementing NEPA, 40 C.F.R. § 1502.9 (2005).

[134] DRAFT GEIS, *supra* note 24.

[135] *See generally* Chevron v. Natural Res. Def. Council, Inc., 467 U.S. 837, 843 (1984) (explaining the high level of deference given to agency actions).

[136] 5 U.S.C. § 706(2)(A) (2014).

[137] *See* Massachusetts v. U.S. Nuclear Regulatory Comm'n, 708 F.3d 63, 73 (1st Cir. 2013) (discussing the judicial posture of deference to agency findings, particularly when reviewing NRC decisions); *see also Chevron*, 467 U.S. at 843 (noting that courts should defer to an agency's interpretation of an ambiguous statutory matter provided that the agency's interpretation is reasonable).

[138] *See, e.g.*, N.J. Envtl. Fed'n v. U.S. Nuclear Regulatory Comm'n, 645 F.3d 220, 230 (3d Cir. 2011).

[139] *See, e.g.*, Citizens to Pres. Overton Park v. Volpe, 401 U.S. 402, 411–12, 416 (1971) (explaining that judicial review of agency actions under Section 10 of the APA should entail "searching and careful" inquiry of the administrative record to ensure that agency decisions are not arbitrary and capricious).

[140] Balt. Gas & Elec. Co. v. Natural Res. Def. Council, Inc., 462 U.S. 87 (1983).

in 1983, notwithstanding the highly deferential standard of review, the D.C. Circuit held that an NRC report purporting to show the safety of its permanent storage plan must account for uncertainties regarding environmental impacts on a long-term basis.[141] The Supreme Court reversed and held that the NRC's finding that permanent storage of nuclear waste would not have a significant environmental impact constituted compliance under NEPA.[142] The Court held that the NRC's findings were sufficient and thereby merited deference under section 10 of APA.[143] The Court reasoned that judicial inquiry of alleged violations of NEPA is limited to "determining if an agency adequately considered and disclosed the environmental impact of its actions."[144]

Notwithstanding the lenient standard applied to NEPA claims, the NRC's environmental assessments "must be thorough and comprehensive."[145] In determining whether an agency complied with NEPA, the court requires that the agency "consider every significant aspect of the environmental impact of a proposed action"[146] and "inform the public that it has indeed considered environmental concerns in its decisionmaking [sic] process."[147] Pursuant to NEPA, an agency must "take a 'hard look' at the environmental consequences before taking a major action."[148] In particular, an EIS must be presented in a way that a layperson can "understand and consider meaningfully the factors involved."[149]

---

[141] Natural Res. Def. Council, Inc. v. U.S. Nuclear Regulatory Comm'n, 685 F.2d 459, 467 (D.C. Cir. 1982), *rev'd*, 462 U.S. 87 (1983). The NRC issued environmental data, finding that "[nuclear] wastes will have no effect on the environment after they are [permanently] sealed in salt mines," and thus instructed licensing decisions to "conclusively assume that such wastes will emit no radiological effluents into the environment after final burial." *Id*.

[142] *Balt. Gas & Elec. Co*., 462 U.S. at 89.

[143] *See id.*

[144] *Id*. at 98.

[145] New York v. U.S. Nuclear Regulatory Comm'n, 681 F.3d 471, 481 (D.C. Cir. 2012).

[146] *See, e.g.*, *Balt. Gas & Elec. Co*., 462 U.S. at 97 (quoting Vt. Yankee Nuclear Power Corp. v. Natural Res. Def. Council, Inc., 435 U.S. 519, 553 (1978)).

[147] *See, e.g.*, *id.*

[148] *Id.*

[149] Limerick Ecology Action, Inc. v. U.S. Nuclear Regulatory Comm'n,

D. New York v. U.S. Nuclear Regulatory Commission

1. History of WCDs

The WCDs originated as a result of the D.C. Circuit's ruling in *Minnesota v. U.S. Nuclear Regulatory Commission* in 1979, which required the NRC to assess whether a national repository would be established by 2007–09, and "if not, whether SNF can be stored safely at sites beyond those dates."[150] In 1984, The NRC provided its original WCD, concluding that a geologic repository would become available by 2007–09; it first amended the WCD to report availability by 2025, and that "SNF can be stored safely at nuclear reactor sites for at least thirty years beyond the licensed life of each plant."[151] In a further amendment, the NRC issued a WCD Update in 2010, which stated that a permanent repository would become "available 'when necessary,'" instead of by a set deadline.[152] In addition, the NRC extended the timeline for which SNF can be safely stored "without significant environmental impacts" to "at least 60 years beyond the licensed life for operation."[153]

2. *New York v. Nuclear Regulatory Commission*

Four states, the Prairie Island Indian community, and environmental groups challenged the merits of the NRC's WCD Update and requested judicial review of the updated report.[154] In 2012, in *New York v. U.S. Nuclear Regulatory Commission*, the court held that the WCD Update constitutes a "major federal

---

869 F.2d 719, 737 (1989).

[150] New York v. U.S. Nuclear Regulatory Comm'n, 681 F.3d 471, 474–75 (D.C. Cir. 2012) (quoting Minnesota v. U.S. Nuclear Regulatory Comm'n, 602 F.2d 412, 417 (D.C. Cir. 1979)).

[151] *Id.*

[152] *Id.*

[153] Waste Confidence Decision Update, 75 Fed. Reg. 81,037 (Dec. 23, 2010) (to be codified at 10 C.F.R. pt. 51).

[154] *New York*, 681 F.3d at 473.

action" under NEPA, on the grounds that the report will be the basis of nuclear power plant licensing decisions.[155] The court thereby invalidated the WCD Update[156] and directed the NRC to evaluate the environmental effects of continued SNF storage if a geologic repository is not established.[157] Although the court's review was governed by section 10 of APA, which is highly deferential to the agency's decisions,[158] the court would not defer to the NRC's findings because it found that the WCD Update was too insubstantial; stating that "the Commission's obligations under NEPA require a more thorough analysis than provided for in the WCD Update."[159]

The court emphasized that NEPA requires the NRC to assess risks involved based on "the probability of a given harm occurring *and* the consequences of that harm if it does occur."[160] In particular, the court specified that the NRC must assess the risks of SNF leakage into groundwater by factoring in the potential effects of sustained on-site storage into its evaluation.[161] The court also called for the NRC to evaluate the risk of spent fuel pool fires,[162] which can occur if fuel rods are exposed to the air.[163] The court's ruling has had a major policy impact, requiring that the NRC account for environmental impacts of long-term nuclear waste storage, conceivably acknowledging that we are living in a post-Fukushima world.

Whereas the courts in *Minnesota v. U.S. Nuclear Regulatory Commission*, and *Baltimore Gas* deferred to the NRC's assurances that a permanent geologic repository would become available, the court in *New York v. U.S. Nuclear Regulatory Commission* ruled that the WCD Update, which extended the NRC's three-decade-

---

155 *Id.* at 476.

156 *Id.* at 481.

157 *Id.* at 478.

158 *See* discussion *infra* Part III.B.3.

159 *New York*, 681 F.3d at 478.

160 *Id.* at 479.

161 *Id.* at 481.

162 *See id.* at 479.

163 *Can Spent Fuel Pools Catch Fire?*, FAIREWINDS ENERGY EDUC. (Aug. 19, 2012), http://www.fairewinds.org/can-spent-fuel-pools-catch-fire/.

long assurance about the availability of an underground permanent repository,[164] was no longer acceptable. The court mandated that the NRC produce a safe storage plan that recognized the possibility that the long-awaited permanent repository may never be constructed.[165]

III. THE NRC'S DRAFT GEIS

In response to *New York v. U.S. Nuclear Regulatory Commission*, in August 2013, the NRC issued a draft GEIS, its report on the projected environmental risks of storing SNF without a permanent geologic repository.[166] A mandatory public commenting period followed to encourage public input regarding the environmental assessment process.[167] NEPA obligates the NRC to review the comments and respond in its final EIS as it deems necessary.[168] The NRC also temporarily halted licensing and relicensing of nuclear power plants pending final EIS approval.[169] On August 26, 2014, the NRC unanimously approved a Continued Storage Rule which incorporates the findings of the draft GEIS.[170] Based on the NRC's adoption of the Continued Storage Rule, the

---

[164] *New York*, 681 F.3d at 475, 480–81.

[165] *Id.* at 478–79.

[166] DRAFT GEIS, *supra* note 24, at iii.

[167] *Id.* at lxiii. *See generally* Purpose, 40 C.F.R. § 1500.1 (2005) (describing CEQ Regulations for Implementing NEPA and explaining that the purpose of the public commenting period is to ensure public input in the environmental assessment process); Response to Comments, 40 C.F.R. § 1503.4 (outlining how the NRC is to review the comments and respond as it deems necessary in the final EIS).

[168] 40 C.F.R. § 1500.1.

[169] *Id*. at xxvi.

[170] *NRC Approves Final Rule on Spent Fuel Storage and Ends Suspension of Final Licensing Actions for Nuclear Plants and Renewals*, U.S. NUCLEAR REGULATORY COMM'N (Aug. 26, 2014) http://pbadupws.nrc.gov/docs/ML1423/ML14238A326.pdf; Matthew L. Wald, *Nuclear Waste is Allowed Above Ground Indefinitely*, N.Y. TIMES (Aug. 29, 2014), http://www.nytimes.com/2014/08/30/us/spent-nuclear-fuel-is-allowed-to-be-stored-above-ground.html?_r=0.

NRC lifted its suspension of final licensing decisions for prolonged operation of thirty-four nuclear reactors at twenty-two sites.[171]

A. The NRC's Assessment of Environmental Impacts in the Draft GEIS

In the draft GEIS, the NRC presents its assessment of the risks of environmental impacts of SNF storage for each of three timeframes: short-term, long-term, and indefinite.[172] Acording to the draft GEIS, prior to the starting point of these timeframes, a nuclear reactor is licensed for up to eighty years.[173] Based on the NRC's definition, short-term storage begins at the end of the reactor license period and extends for an additional sixty years.[174] The NRC defines long-term storage as a period of time "for 100 years beyond the short-term storage timeframe."[175] The indefinite storage timeframe begins at the end of the long-term storage timeframe, and extends for a limitless period of time, based on the "[assumption] that [no permanent] repository becomes available."[176] These timeframes are summarized in the following table:

[171] *Memorandum and Order on Continued Storage*, U.S. NUCLEAR REGULATORY COMM'N, 1–3, 12 (Aug. 26, 2014), http://www.nrc.gov/reading-rm/doc-collections/commission/orders/2014/2014-08cli.pdf.

[172] DRAFT GEIS, *supra* note 24, at xxv.

[173] *Id*. at 12.

[174] Prior to "short-term SNF storage," a reactor is licensed for up to eighty years. *Id.* at xxv.

[175] *Id.* at 12. However, SNF storage may begin as early as four years after granting the initial license. *See* BLUE RIBBON COMM'N REPORT, *supra* note 5, at 32.

[176] DRAFT GEIS, *supra* note 24, at xxvii.

Timeframe	NRC's Definition	Age of SNF at End of Timeframe
Short-Term Storage	60 year period after the licensed operating life of a reactor	60[177] - 140[178] years
Long-Term Storage	100 year period after the short-term storage timeframe	160 - 240 years
Indefinite Storage	Storage for the indefinite future	Unlimited number of years

For each timeframe, the NRC classifies and analyzes the environmental risk of SNF storage using the following terms: small, moderate, or large.[179] A "small" risk is when "[e]nvironmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource."[180] A "moderate" risk is when "environmental effects are sufficient to alter noticeably, but not to destabilize important attributes of the resource."[181] "Large" pertains to "environmental effects [that] are clearly noticeable and are sufficient to destabilize important attributes of the resource."[182] The NRC conducted this analysis for each of nineteen resource areas,[183] as shown in the table below. This framework for risk assessment provides the impetus for determining whether continued storage of nuclear waste is feasible.[184]

---

177 The low end of this SNF age range corresponds to fuel that was stored at the *end* of the eighty-year reactor license period. *Id.*

178 The high end of this SNF age range corresponds to fuel that was stored at the *beginning* of reactor operations. *Id.*

179 *Id.* at xxviii.

180 *Id.*

181 *Id.*

182 *Id.*

183 *Id.*

184 *See id.* at xxix.

Table 2- Environmental Impacts of At-Reactor Continued Storage of Spent Nuclear Fuel

Resource Area	**Short-term Storage**	**Long-term Storage**	**Indefinite Storage**
Land Use	SMALL	SMALL	SMALL
Socioeconomics	SMALL	SMALL	SMALL
Environmental Justice[185]	No disproportionately high and adverse impacts		
Air Quality	SMALL	SMALL	SMALL
Climate Change	SMALL	SMALL	SMALL
Geology and Soils	SMALL	SMALL	SMALL
Surface Water Quality Use	 SMALL SMALL	 SMALL SMALL	 SMALL SMALL
Groundwater Quality Use	 SMALL SMALL	 SMALL SMALL	 SMALL SMALL
Terrestrial Resources	SMALL	SMALL	SMALL
Aquatic Ecology	SMALL	SMALL	SMALL
Special Status Species and Habitats	"determined as part of Endangered Species Act"	Not likely to adversely affect	Not likely to adversely affect
Historic and Cultural Resources[186]	SMALL	SMALL, MODERATE, or LARGE	SMALL, MODERATE, or LARGE
Noise	SMALL	SMALL	SMALL
Aesthetics	SMALL	SMALL	SMALL
Waste			

[185] "Environmental justice" pertains to "environmental impacts on minority and low-income populations." *Id.* at xxvii, 3-8.

[186] "Historical and cultural resources" refers to historic sites that can be listed in the *National Register of Historic Places*, and includes places with cultural significance to Native Americans. *Id.* at 3–29.

Management LLW Mixed Waste Nonradioactive Waste	 SMALL SMALL SMALL	 SMALL SMALL SMALL	 SMALL SMALL to MODERATE SMALL to MODERATE
Transportation Traffic Health Impacts	 SMALL SMALL	 SMALL SMALL	 SMALL SMALL
Public and Occupational Health	SMALL	SMALL	SMALL
Accidents	SMALL		
Terrorism Considerations	SMALL		

Although the NRC does not indicate why the resource areas are listed in this particular order,[187] the list ranges from the relatively subtle, such as noise and aesthetics, to the most concerning—nuclear waste management and public and occupational health—which appear fifteenth and seventeenth on the list, respectively.[188]

For most resource areas, the NRC projects that the risk of significant environmental impacts from SNF storage is small.[189] For the short-term timeframe, the NRC projects that the risk of environmental impacts is small for all seventeen resource areas.[190] For the long-term timeframe, the NRC finds that there is a small risk of environmental impact for all resource areas listed, except for a "small, moderate or large" risk for "historical and cultural resources."[191] For the indefinite timeframe, the NRC finds that the risks are the same as the risks during the long-term timeframe,[192]

---

[187] *See, e.g.*, *id.* at xxv, xxix.

[188] *Id.* at xlii–xliii.

[189] *Id.*

[190] *Id.* The remaining two resource areas have alternative designations, also indicating that the environmental risks will be insignificant. *Id*.

[191] *Id.* The remaining two resource areas have the same minimal risks as projected for short-term storage. *Id*.

[192] *Id.* at xliii.

but indicates that sub-categories of waste management, which include SNF,[193] would entail a "small to moderate" risk.[194] For all timeframes, the NRC finds that public and occupational health risks are small. [195]

Most importantly, for the indefinite period, the NRC's risk assessment supports its conclusion that a permanent geologic repository is no longer necessary. Based on the NRC's findings for indefinite storage—a limitless time period—the risks will never be large.[196] In particular, the NRC projects that the risks are minimal for the most critical resource areas—those pertaining to public health and welfare.[197] The NRC "solves" the no-permanent-repository problem by purporting to show that no matter what the timeframe, local storage is feasible.

In the draft GEIS, in addition to providing assessments of environmental effects for on-site storage, the NRC provides parallel assessments of independent spent fuel storage facility (ISFSI) storage.[198] An ISFSI is a facility where, after an initial period of pool storage and cooling, SNF is stored in dry concrete casks,[199] as opposed to ongoing pool storage.[200] According to the NRC, an ISFSI is "licensed separately from a nuclear power plant and [is] considered independent even though it may be located on the site of another NRC-licensed facility."[201] Storing SNF in ISFSIs rather than pools can thus be considered the NRC's proposal to comply with NEPA's requirement that an agency discuss "alternatives to the proposed actions."[202] In the draft GEIS, the NRC provides a separate risk assessment of ISFSI storage for each of the nineteen resource areas. The NRC determined that the

---

193 *Id.* at xxx.

194 *Id.* at xliii.

195 *Id.*

196 *Id.* at xlii–xliii.

197 *Id.*

198 *Id.* at liii–liv.

199 BLUE RIBBON COMM'N REPORT, *supra* note 5, at 35.

200 *Id.* at 14.

201 *Storage of Spent Nuclear Fuel*, U.S. NUCLEAR REG. COMM'N, http://www.nrc.gov/waste/spent-fuel-storage/faqs.html (last updated July 7, 2014).

202 42 U.S.C. § 4332(2)(C) (2012).

risks are generally small[203] and on par with those of at-reactor SNF storage. This finding supports the NRC's view that SNF storage can continue indefinitely without a permanent geologic repository. Whether SNF is stored at reactor sites or at ISFSIs, the NRC concludes that the risks will not be large.[204]

B. *The NRC's Probabilistic Risk Assessment*

1. Probabilistic Risk Assessment Calculation

Probabilistic Risk Assessment (PRA) is a computational method used by the NRC in its draft GEIS to evaluate the risk of environmental impacts related to storage and management of SNF.[205] Since nuclear accidents are infrequent, the NRC chose not to use the frequency of prior accidents to predict future accidents.[206] Instead, the Commission used PRA, which relies on mathematical models to determine accident frequency[207] and consequences.[208]

The NRC's PRA considers "what can go wrong, how likely is it, and what are the consequences."[209] To determine PRA–based risk, the NRC multiplies its estimate of the probability of the event (a very small number) by the consequence (a large number). Based on this method, the risk is found to be a small number.[210] Thus, by using very small values for event frequencies, the calculated risk

---

[203] DRAFT GEIS, *supra* note 24, at liii.

[204] *Id.* at lviii.

[205] *Risk Assessment in Regulation*, U.S. NUCLEAR REG. COMM'N, http://www.nrc.gov/about-nrc/regulatory/risk-informed.html (last updated Nov. 6, 2013).

[206] *See* Massachusetts v. U.S. Nuclear Regulatory Comm'n, 708 F.3d 63, 71 (1st Cir. 2013).

[207] *Risk Assessment in Regulation*, *supra* note 196.

[208] American Nuclear Society, *Apostolakis: On PRA*, 43 NUCLEAR NEWS INTERVIEW 27, 27 (2000) *available at* http://www2.ans.org/pubs/magazines/nn/docs/2000-3-2.pdf.

[209] *Risk Assessment in Regulation*, *supra* note 196.

[210] DRAFT GEIS, *supra* note 22, app. F-1.

may be numerically small, even though the consequences can be significant.[211]

In accordance with this method, in the draft GEIS, the NRC predicts minimal risk as a result of using very small event frequency values for accidents associated with SNF storage.[212] For example, the NRC calculation of the results of a spent fuel pool fire indicated that up to 27,000 deaths might result, with a cost of up to $58.7 billion.[213] The NRC determined that the chance of this event is remote, calculating two or fewer predicted events per million years, based on its PRA.[214] The NRC thereby "finds that the environmental impacts from spent fuel pool fires are SMALL during the short-term storage timeframe."[215]

The NRC's PRA also yields similar findings in calculating the risk of radiation release related to packaging of SNF into dry casks. The report indicates that the cancer fatality rate for initial cask loading with fuel would be about two cases per trillion years.[216] One trillion years is more than 200 times the estimated age of the Earth.[217]

2. Conflict Between PRA-Based Predictions and Historical Data-Based Predictions

Various experts have claimed that the NRC's PRA methodology is fundamentally flawed because PRA is not based on historical assessment of risk, i.e., the assessment based on

---

[211] *Id.* ("[T]he probability-weighted impacts, or risk, from a spent fuel pool fire for the short-term storage timeframe are SMALL because, while the consequences from a spent fuel pool fire could be significant and destabilizing, the probability of such an event is extremely remote.").

[212] DAVID LOCHBAUM ET AL., FUKUSHIMA: THE STORY OF A NUCLEAR ACCIDENT 192 (2014).

[213] DRAFT GEIS, *supra* note 24, at app. F-4.

[214] *Id.* tbl.F-1.

[215] *Id.* at app. F-12.

[216] *Id.* at app. B-14.

[217] The age of the Earth is approximately 4.55 billion years. Paul S. Braterman, *How Science Figured Out the Age of Earth*, SCI. AM. (Oct. 20, 2013), http://www.scientificamerican.com/article/how-science-figured-out-the-age-of-the-earth/.

accidents that have already happened.[218] For example, based on PRA modeling, the reactor core meltdowns at Fukushima were predicted to occur extremely infrequently,[219] i.e., once per one million years to once per ten million years of reactor operation;[220] which contrasts with the historical reality: three core melt-downs at Fukushima in 2011.[221] According to nuclear engineer Arnie Gundersen, "the lesson of real life disagrees with the lessons of the PRA."[222] Gundersen's lessons of real life are the historical assessment. He goes on to explicitly state the difference between the historical prediction and the PRA-based prediction for reactor catastrophes:

> In the last thirty-five years we've had five meltdowns: Three Mile Island, Chernobyl, and three at Fukushima. So if you put thirty-five in the numerator and five in the denominator, you come up with an accident about every seven years.[223]

Gundersen further states that his calculation indicating a historically-based prediction of one meltdown per seven years ignores about one dozen other meltdowns that occurred before Three Mile Island.[224]

Although Gundersen specifically addressed nuclear reactor meltdowns, his statement addresses the general unreliability of the PRA methodology. PRA methodology for predicting SNF safety entails the same limitations as PRA methodology for predicting reactor safety. For example, the NRC's calculated spent fuel pool

---

[218] *See* Arnie Gundersen, Chief Eng'r at Fairewinds Assoc., Address at the Fukushima Nuclear Accident: Ongoing Lessons for New York Panel at the 92nd Street Y (Oct. 8, 2013), *available at* http://www.fairewinds.org/fukushima-daiichi-nuclear-accident-ongoing-lessons/.

[219] NAT'L RESEARCH COUNCIL, LESSONS LEARNED FROM THE FUKUSHIMA NUCLEAR ACCIDENT FOR IMPROVING SAFETY OF U.S. NUCLEAR PLANTS app. I-3 (2014).

[220] *Id.*

[221] Yoko Wakatsuki, *New Radioactive Water Leak at Japan's Fukushima Daiichi Plant*, CNN (Feb. 20, 2014, 7:28 AM), http://www.cnn.com/2014/02/19/world/asia/japan-fukushima-daiichi-water-leak/.

[222] Gundersen, *supra* note 218.

[223] *Id.*

[224] *Id.*; Sovacool, *supra* note 107.

fire frequency—which indicates two or fewer expected events per million years[225]—contrasts with the observation that there has already been one pool fire in 2011 at the Fukushima site.[226]

3. Judicial Review of the NRC's PRAs

For the few cases that review the NRC's PRAs, the courts' assessments are governed by section 10 of APA,[227] which is highly deferential to agencies such as the NRC.[228] Because PRA is based on complex technical methods,[229] courts are particularly inclined to defer to the NRC's PRA findings.[230] However, courts reviewed PRA methodology in both *Limerick Ecology Action, Inc. v. U.S. Nuclear Regulatory Commission*[231] and *Massachusetts v. U.S. Nuclear Regulatory Commission*,[232] with contrasting results. Both cases involved judicial review of the NRC's decisions to forgo further safety assessments at nuclear power plants on the basis of its optimistic PRA findings.[233] Whereas the Third Circuit in *Limerick* refused to defer to the NRC's safety assurances based on the PRA,[234] the First Circuit in *Massachusetts v. U.S. Nuclear Regulatory Commission* deferred to the NRC's PRA-based

---

225 *See supra* Part III.B.1.

226 Alvarez, *supra* note 7, at 4. The historical model indicates an event frequency of one event per less than seventy years. *See* BLUE RIBBON COMM'N REPORT, *supra* note 5, at 19.

227 *See, e.g.*, Massachusetts v. U.S. Nuclear Regulatory Comm'n, 708 F.3d 63, 73–76 (1st Cir. 2013) (applying this "arbitrary and capricious" standard in assessing the NRC's PRA-based findings).

228 *See, e.g.*, *id.* at 73 (explaining that this highly deferential standard of review is "particularly marked with regards to NRC actions" which are based on technical findings).

229 *Risk Assessment in Regulation*, *supra* note 205.

230 *See, e.g.*, *Massachusetts*, 708 F.3d at 73–76 (deferring to the NRC's PRA-based results on the grounds that the NRC's findings are based on the agency's expertise).

231 Limerick Ecology Action, Inc. v. U.S. Nuclear Regulatory Comm'n 869 F.2d 719, 719 (3d Cir. 1989).

232 *Massachusetts*, 708 F.3d at 63.

233 *See Limerick*, 86 F.2d at 727; *see also Massachusetts*, 708 F.3d at 69–71.

234 *Limerick*, 869 F.2d at 736.

findings.[235]

In *Limerick*[236] in 1989, the Third Circuit recognized the limitations of the NRC's PRA calculations.[237] The views of dissenting NRC Commissioners bolstered the court's skepticism. NRC Commissioner Dr. Victor Gilinsky noted that PRAs "are based on uncertain and unreliable calculational [sic] techniques."[238] NRC Commissioner James Asselstine further explained that "the unreliability of PRA analysis precluded confidence in the NRC's judgment about reactor safety."[239]

The court applied careful scrutiny in reviewing the NRC's PRA. It rejected the NRC's finding—that it need not review severe accident mitigation design alternatives (SAMDAs)[240] in its decision to license Limerick nuclear power plant because its PRA indicated that "existing plants pose no undue risk to public health and safety."[241] The court thereby held that the NRC violated NEPA[242] explaining that the NRC's PRA is unreliable and therefore could not be a justifiable basis for its refusal to consider SAMDAs.[243] The court was also mindful that the NRC's decision to disregard SAMDAs was issued following the Three Mile Island Accident.[244] The court noted that the "Limerick plant is twenty-five miles from Philadelphia,"[245] and recognized the heightened risks of operating a nuclear power plant in the vicinity of a major city.[246] Based on the dissenting Commissioners' opposition to

---

[235] *Massachusetts*, 708 F.3d at 73.

[236] *Limerick*, 869 F.2d at 719.

[237] *Id.* at 727 & n.5.

[238] *Id.* at 727 n.5 (quoting Dr. Victor Gilinsky, Safety Goal Development Program, 48 Fed. Reg. 10772-02 (March 14, 1983)).

[239] *Id.* at 727.

[240] SAMDAs refer to "possible plant design modifications that are intended . . . to lessen the severity of the impact of a[] [nuclear] accident should one occur." *Id.* at 731.

[241] *Id.* at 727.

[242] *Id.* at 743.

[243] *Id.* at 743.

[244] *Id.* at 726.

[245] *Id.* at 722.

[246] *Id.* at 738–39.

PRA, the recent disaster at nearby Three Mile Island, and Limerick's proximity to Philadelphia, the court recognized that the NRC's PRA-based assurances were inadequate.[247]

However, in *Massachusetts v. U.S. Nuclear Regulatory Commission*[248] in 2013, the First Circuit employed a more deferential approach to the NRC. In light of the Fukushima disaster, Massachusetts petitioned the NRC to revise its risk assessment as stated in a prior EIS.[249] This prior EIS would inform the relicensing decision for the Pilgrim nuclear power plant.[250] The NRC denied Massachusetts' petition based on its conviction that PRA is more accurate than "direct experience" prediction based on the history of prior accidents.[251] The court affirmed the NRC's denial of Massachusetts' petition,[252] rejecting Massachusetts' contention that the NRC should have employed a direct experience model to estimate nuclear reactor meltdown frequency.[253] The direct experience model determines core meltdown frequency "by taking five historical core damage events (Three Mile Island, Chernobyl, and three units at Fukushima) and dividing that number by the number of operating years of all nuclear power plants worldwide."[254] Based on this calculation, "the frequency of core damage events is approximately ten times higher" than the NRC's PRA estimate.[255] However, the court accepted the NRC's contention that five accidents do not constitute enough historical data to make a more reliable model than PRA.[256] The court

---

[247] *See id.* at 722, 726–27 (considering these factors in rejecting the NRC's PRA-based assessment).

[248] Massachusetts v. U.S. Nuclear Regulatory Comm'n, 708 F.3d 63 (1st Cir. 2013).

[249] *Id.* at 66.

[250] *Id.*

[251] *Id.* at 75–76.

[252] *Id.* at 78.

[253] *Id.* at 75.

[254] *Id.* at 70. Fukushima is considered as three events because reactors at buildings 1, 3, and 4 exploded. *See* LOCHBAUM ET AL., *supra* note 212, at 74, 80, 265.

[255] *Massachusetts*, 708 F.3d at 75.

[256] *Id.* at 76.

accordingly deferred to the NRC's methodology under section 10 of APA's standard of review.[257]

The court's ruling in *Massachusetts v. U.S. Nuclear Regulatory Commission* amounted to a refusal to consider the increased persuasiveness of the historical method of risk analysis, which now includes three additional reactor meltdowns at Fukushima.[258] Whereas the court in *Limerick* adopted a probing inquiry of PRA,[259] the court in *Massachusetts v. U.S. Nuclear Regulatory Commission* adhered to a deferential approach; in the latter case, the court refused to accept the state's arguments that in light of the Fukushima disaster, the probability of either a core meltdown or SNF accident was higher than estimated by the pre-Fukushima EIS.[260]

IV. CRITIQUE OF THE DRAFT GEIS

The NRC's projections in the draft GEIS are inadequate on several grounds. First, the NRC's PRA assessments entail a gross underestimate of the risks involved with sustained SNF storage,[261] and the reported findings lack sufficient clarity. Second, the draft GEIS does not comport with NEPA's requirement to sufficiently inform the public about environmental impacts of agency actions.[262] Finally, the findings in the draft GEIS amount to a fundamental change of the NRC's position: for decades, the Commission based its position on the premise that a permanent geologic repository was necessary;[263] it has now taken the position that a plan without a repository is feasible, but has failed to account for this change of position.

---

[257] *See id.* at 75.

[258] *See* Gundersen, *supra* note 218.

[259] Limerick Ecology Action, Inc. v. U.S. Nuclear Regulatory Comm'n 869 F.2d 719, 736–41 (3d Cir. 1989).

[260] *Massachusetts*, 708 F.3d at 75.

[261] *See, e.g.*, DRAFT GEIS, *supra* note 24, at xlii–xliii.

[262] *See, e.g.*, Balt. Gas & Elec. Co. v. Natural Res. Def. Council, Inc., 462 U.S. 87, 100–01 (1983).

[263] *See* BLUE RIBBON COMM'N REPORT, *supra* note 5, at 20.

A. Flawed Risk Assessment

The NRC's risk assessment is flawed because it is based on periods of storage far longer than what has ever been accomplished.[264] Because the operation of nuclear plants generates byproducts that remain radioactive for thousands of years,[265] safe SNF storage must match this extended time period. In the draft GEIS, the NRC projects that SNF can be stored in the vicinity of reactors for an unlimited period of time.[266] However, SNF has never been stored for more than approximately seventy years.[267] As a result, NRC's statements about long-term and unlimited-term at-reactor storage entail a high degree of uncertainty. In *Baltimore Gas*, the Court's acceptance of the NRC's assertion that a permanent geologic repository would become available demonstrates the fallacy of relying on the NRC's projections without further probing.[268]

B. Thwarting of Meaningful Public Understanding

Risk presentation in the draft GEIS contains oversimplifications and gross underestimates. The NRC's designation of the terms small, medium, and large[269] is too vague to allow for understanding of the risk of continued SNF storage. This presentation therefore runs contrary to NEPA's requirement that the agency inform the public of potential environmental impacts of a proposed action.[270] As the First Circuit discussed in *Limerick*, this requirement calls for the agency to provide a report that allows the public to consider critically and substantially the environmental impacts involved. [271]

---

[264] *See, e.g*, DRAFT GEIS, *supra* note 24, at xxvi.

[265] Busby, *supra* note 52, at 453–54.

[266] DRAFT GEIS, *supra* note 24, at xlii–xliii.

[267] *See* source cited *supra* note 28.

[268] *See id.* (accepting the NRC's finding that a permanent geologic repository would become available).

[269] DRAFT GEIS, *supra* note 24, at xxviii; *see also* discussion *supra* at Part II.

[270] *See, e.g.*, *Balt. Gas & Elec. Co.*, 462 U.S. at 91.

[271] Limerick Ecology Action, Inc. v. U.S. Nuclear Regulatory Comm'n,

The NRC website also reflects a pattern of understatement of environmental risks.[272] The risk assessments are overly optimistic in light of prior experience with nuclear accidents[273] and the inherent hazards of storing SNF.[274] The NRC's explanation of risk distorts the impact of an accident, which undermines the public's understanding of risks involved. The NRC states: "PRA might estimate that an accident would create one chance in a million that a person living near the plant would experience radiation exposure equivalent to a chest x-ray, and one chance in a billion that some people would develop cancer over the next 50 years."[275] The words "might estimate" are misleading because the NRC's statement implies a degree of risk that is much lower than the risk determined from prior accidents or from the Commission's own risk calculations. [276] In actuality, accidents with far greater radiation exposure than "equivalent to a chest x-ray" and increased cancer rates in excess of "one chance in a billion" have occurred.[277] According to *The International Journal of Cancer*,

> Chernobyl may have caused about 1,000 cases of thyroid cancer and 4,000 cases of other cancers in Europe, representing about 0.01% of all incident cancers since the accident. Models predict that by 2065 about 16,000 cases . . . of thyroid cancer and 25,000 . . . cases of other cancers may be expected due to radiation from the accident . . . .[278]

Furthermore, the NRC's statement that an accident would result in a risk that "some people would develop cancer over the next 50 years," contrasts sharply with the Commission prediction, in the draft GEIS, of an expected 20,000 to 27,000 deaths from

---

869 F.2d 719, 736–41 (1989).

[272] DRAFT GEIS, *supra* note 24, at xlii–xliii, liii–liv.

[273] For discussion of nuclear accidents, see *supra* Part I.C.

[274] For discussion of the hazards of SNF storage, see *supra* Part I.A.

[275] *Probabilistic Risk Assessment (PRA)*, *supra* note 77.

[276] *Limerick*, 869 F.2d at 739.

[277] *See supra* Part I.C for discussion of nuclear accidents.

[278] Elisabeth Cardis et al., *Estimates of the Cancer Burden in Europe from Radioactive Fallout from the Chernobyl Accident*, 119 INT'L J. CANCER 1224, 1224 (2006).

radiation release in the event of a spent fuel fire.[279] Recalling the format of the PRA calculation in the case of an SNF accident,[280] the risk evaluation is performed by multiplying the chance of an event (i.e. the chance of a spent fuel pool fire) by a calculated dollar-based consequence of the event (i.e. the cost based on lives lost).[281] This cost is determined by valuing a human life at one to three million dollars.[282] The draft GEIS cost determination for an SNF accident is at least $55.7 billion,[283] which is consistent with a cost per life of about two million (27,000 deaths multiplied by $2 million). The NRC uses the PRA methodology to justify the additional arithmetic step of multiplying the $55.7 billion cost by the PRA estimate of the likelihood of the event: two to 2.4 fires per reactor per million years.[284] The NRC thereby factors in this very low value, which it claims is the likelihood of the event (approximately two per million years) and concludes that "the environmental impacts from spent fuel pool fires are SMALL."[285] By claiming that PRA legitimizes this multiplication step (i.e. multiplying by the fraction 2/1,000,000), the NRC justifies its finding that the risk is small, even though 20,000 or more lives are at stake.[286]

The NRC's selection and presentation of another exemplary case involving an oversimplified version of a risk calculation is also deceptive. The NRC states: "[c]ombining the probability of an accident with its consequences gives us a measure of risk. For instance, the consequences of a large meteor striking your house

---

279 DRAFT GEIS, *supra* note 24, at app. F-4 tbl.F-1.

280 *See supra* Part III.B.1 and accompanying text.

281 DRAFT GEIS, *supra* note 24, at app. F-2.1 (located on page 542). "The probability-weighted consequence [risk] is computed by multiplying a consequence, such as cumulative dose, cost to the local economy or area of land contamination, by the probability of the accident's occurrence." *Id*. at app. F-2.1. The NRC equates the term "risk" with probability-weighted consequence. *Id*. at app. F-1.

282 LOCHBAUM ET AL., *supra* note 212, at 193.

283 DRAFT GEIS, *supra* note 24, at app. F-4 tbl.F-1., F-7.

284 *See id.* at F-1, F-4 tbl.F-1 (applying PRA and showing the accident frequency in scientific notation).

285 *Id.* at F-12.

286 *See id.* at lix, F-1.

would be devastating, but the risk is low because the probability of such an accident is very small."[287]

The meteor example is obfuscating for two reasons. First, the example conflates the chance of death due to a meteor strike with the chance of death due to a nuclear disaster.[288] Second, the example also shows how great personal and societal impacts can be dramatically downplayed by assigning dollar values to them that are essentially nullified in the NRC's risk assessment: multiplying the dollar cost by an extremely small number (the purported event frequency, which in the exemplary case, is the chance of a meteor hitting one's home).[289] According to former NRC chairman Gregory Jaczko:

> There will be ways that Mother Nature, that human mistakes and errors will lead to these kinds of severe accidents at nuclear power plants. But moreover, what this accident is telling us is that society does not accept the consequences from these severe accidents. Society does not ultimately find it acceptable to evacuate hundreds of thousands of people, to have areas of land be permanently contaminated, to spend close to half-a-trillion or more dollars to deal with the aftermath of an accident at a facility that is simply designed to generate electricity.[290]

Jaczko's view, as stated above, indicates that the NRC's risk equation, which is said to demonstrate a low value of risk, does not comport with society's evaluation of risk. If Jaczko is correct that society finds Fukushima-level events unacceptable, the NRC's risk equation yields false results.

As the D.C. Circuit explained in *New York v. U.S. Nuclear Regulatory Commission*, the risks of SNF storage include the risk

---

[287] *Id.*

[288] *See* LOCHBAUM ET AL., *supra* note 212, at 192 (explaining that the NRC's likening the chances of losing one's life from a nuclear accident to a meteor hitting someone as misleading).

[289] *Id*. at 192–93.

[290] Gregory Jaczko, Cong. Advisory Panelist for the Nat'l Nuclear Sec. Admin., Address at the Fukushima Nuclear Accident: Ongoing Lessons for New York Panel at the 92nd Street Y (Oct. 8, 2013).

of pool fires and radioactive leakage into groundwater.[291] However, on the NRC website, illustrative examples involve the risks of unicycling, skydiving, and climbing Mount Everest.[292] The NRC fails to indicate that these examples entail (a) in the cases of the unicycle and extreme sports, a personal choice to assume the risk and (b) in the case of a meteor strike, a situation in which the person or society at risk cannot make a decision to avoid the catastrophic event. None of these NRC examples reflect former NRC Chief Commissioner Jaczko's view that the acceptance of extreme risk must be a societal decision.

C. Philosophic Inconsistency Regarding National Permanent Storage Facility

The NRC's projection in its draft GEIS that SNF storage without a permanent repository is safe does not comport with its prior understanding that continued SNF storage without a permanent geologic repository could not be considered a safe option.[293] The unavailability of a permanent repository has not rendered local SNF storage safer than previously expected. Moreover, the NRC does not account for its altered position that local storage is feasible and safe.[294] For thirty-two years—from the time of *Minnesota v. U.S. Nuclear Regulatory Commission* through *New York* v. *U.S. Nuclear Regulatory Commission*—the NRC provided official assurances that licensing decisions could proceed with the assumption that a permanent repository would become available.[295] The assurances were the cornerstone of the original

---

[291] New York v. U.S. Nuclear Regulatory Comm'n, 681 F.3d 471, 478–79 (D.C. Cir. 2012).

[292] *Risk Assessment in Regulation*, *supra* note 205.

[293] BLUE RIBBON COMM'N REPORT, *supra* note 5, at 27 ("[D]eep geologic disposal is the scientifically preferred approach [that] has been reached by every expert panel that has looked at the issue . . . ."). *See supra* Part I.B for discussion of the permanent storage option.

[294] *See* DRAFT GEIS, *supra* note 24, at xxiii–xxiv (explaining that the draft GEIS is being issued in response to *New York v. U.S. Nuclear Regulatory Commission* without further explanation for the NRC's revised position).

[295] *New York*, 681 F.3d at 475.

WCD in 1984 and each of the updates through 2010;[296] which were to be realized by the NRC's plan that a permanent repository would store nuclear waste at Yucca Mountain for one million years.[297] In the roughly one year period between the D.C. Circuit's ruling in *New York v. U.S. Nuclear Regulatory Commission* and publication of the draft GEIS,[298] the NRC determined that a permanent repository was no longer necessary and that storage for an unlimited time was possible without this repository.[299] The draft GEIS describes no technological breakthrough that supports this change in position.

V. THE DRAFT GEIS DOES NOT WARRANT DEFERENCE

The NRC's draft GEIS should be unacceptable notwithstanding a highly deferential standard of review under section 10 of the APA.[300] The NRC's findings should be considered "arbitrary and capricious"[301] given the speculative basis for its risk assessment. The courts are equipped to evaluate the NRC's PRA findings, as shown in *Limerick*, in which dissenting NRC Commissioners provided expert information.[302]

The Commission's projections that SNF can be safely stored without Yucca Mountain are speculative. The NRC purports to demonstrate in its draft GEIS that a permanent repository is unnecessary because of its conclusion that interminable local

---

296 *Id.*

297 Waste Confidence- Continued Storage of Spent Nuclear Fuel, 78 Fed. Reg. 56776 (proposed Sept. 13, 2013) (to be codified at 10 C.F.R. pt. 51); *see also* Alex Funk & Benjamin K. Sovacool, *Wasted Opportunities: Resolving the Impasse in United States Nuclear Waste Policy*, 34 ENERGY L.J. 113, 145 (2013).

298 *See* DRAFT GEIS, *supra* note 24.

299 *See id.* at xxii.

300 *See, e.g.*, Massachusetts v. U.S. Nuclear Regulatory Comm'n, 708 F.3d 63, 73 (1st Cir. 2013).

301 5 U.S.C. § 706(2)(A) (2014).

302 *See, e.g.*, Limerick Ecology Action, Inc. v. U.S. Nuclear Regulatory Comm'n 869 F.2d 719, 725 (3d Cir. 1989) (discussing comments of dissenting NRC Commissioners).

storage of SNF is a safe option.[303] The NRC now claims that nuclear facilities throughout the United States can accomplish what Yucca Mountain was intended to do—provide permanent safe storage of nuclear waste.[304]

The courts should regard the NRC's risk assessments in the draft GEIS as speculative. The court in *Limerick* recognized that significant uncertainties abound in using the NRC's PRA methodology,[305] which is the foundation of risk evaluation in the draft GEIS. As detailed in Part III, it is crucial that courts consider the frequency of prior nuclear accidents rather than PRA-based frequency predictions.[306] According to nuclear expert Gundersen:

> The NRC says that the chance of a nuclear accident is about one in a million. With about 400 operating nuclear reactors [worldwide], if you put one million in the numerator and 400 in the denominator, you wound [sic] up with an accident about every 2500 years. So from the time the Acropolis was built until now, there would be one nuclear accident using those numbers. The NRC uses a technique called probabilistic risk assessment to come up with that number.[307]

Gundersen indicates that "based on five actual meltdowns in the past thirty-five years, the actual accident rate is one per seven years" in contrast to the PRA-based prediction of one event per 2,500 years.[308]

Courts should be especially circumspect in accepting a conclusion that the consequences of a nuclear accident are small.[309] Former NRC Chairman Jaczko discussed this concern in conjunction with the Fukushima accident.[310] According to Robert

---

[303] *See* DRAFT GEIS, *supra* note 24, at xlii–xliii, liii–liv (indicating that the risks of environmental impacts of permanent storage are generally small).

[304] *Id.* at xxii.

[305] *Limerick*, 869 F.2d at 726.

[306] *See* discussion *supra* Part III.A, B.2.

[307] Gundersen, *supra* note 218.

[308] *Id.*

[309] *See* discussion *supra* Part IV (describing inadequacies of NRC's evaluation methods).

[310] *See supra* Part IV.B.

Alvarez, Senior Scholar at the Institute for Policy Studies:

> [A pool fire would] . . . release catastrophic amounts of radioactivity. We estimated that a single pool fire in the United States at a typical reactor could render an area uninhabitable substantially [four to five times] greater than that created by the Chernobyl accident. The Chernobyl accident created an area of uninhabitability that's roughly the size of half of New Jersey.[311]

The greater the gap between NRC accident predictions and the actual occurrence of nuclear accidents, the less deference can and should be expected. The Fukushima accident in 2011—the type that had been predicted to occur approximately once per million years[312]—increased this gap. The D.C. Circuit's decision to invalidate the 2010 WCD Update in *New York v. U.S. Nuclear Regulatory Commission*[313] conceivably was a response to the previous year's Fukushima disaster. The draft GEIS, with its speculative PRA assessments and implicit denial of its thirty-year position that a permanent repository is necessary, should discourage courts from restoring the highly deferential approach. This ongoing gap and the setback for the NRC in *New York v. U.S. Nuclear Regulatory Commission* will likely spawn future legal challenges.[314]

---

[311] Interview by Daphne Wysham with Robert Alvarez, Senior Scholar at Inst. for Policy Studies, Earthbeat at the Real News Network (Mar. 2, 2011).

[312] NAT'L RESEARCH COUNCIL, LESSONS LEARNED FROM THE FUKUSHIMA NUCLEAR ACCIDENT FOR IMPROVING SAFETY OF U.S. NUCLEAR PLANTS app. I-3 (2014).

[313] New York v. U.S. Nuclear Regulatory Comm'n, 681 F.3d 471, 478, 483 (D.C. Cir. 2012).

[314] Eric Schneiderman stated that the draft GEIS is "significantly flawed," because the report fails to adequately account for the risks involved with storing SNF. Eric Scheiderman, N.Y, Att'y Gen., Testimony on the Waste Confidence Draft Generic Envtl. Impact Statement (DGEIS) and Proposed Rule (Oct. 30, 2013), *available at* http://www.ag.ny.gov/pdfs/Janice%2Dean%20Testimony%2010.30.13.5.pdf.

VI. CONCLUSION

The NRC failed to comply with the D.C. Circuit's mandate in *New York v. U.S. Nuclear Regulatory Commission.* Notwithstanding the NRC's complex and detailed analysis in the draft GEIS, the report does not provide a reliable evaluation of the risk and environmental impacts of a major nuclear disaster related to above ground nuclear waste storage. The NRC's risk evaluation methodology is flawed with respect to each of two key issues: (1) determination of the probability of the occurrence of a disaster, and (2) determination of a reasonable method of arithmetically blending this probability with the associated environmental consequences.[315]

In addition, The NRC violated NEPA by improperly reporting environmental risks to the public.[316] The Commission has further strained credibility by (1) presenting misleading non-representative risk examples to the public and (2) altering a thirty-year position—that the ultimate destination for SNF would be a permanent mined geologic storage site.[317] Based on roughly seventy years of prior experience with SNF storage,[318] the NRC claims that SNF can be stored at or near reactors for an eternity.[319]

Given these inadequacies, the NRC's waste management analysis and plans should be considered unacceptable, notwithstanding a highly deferential standard of review under section 10 of the APA.[320] The post-Fukushima world demands a higher degree of judicial scrutiny of the NRC's findings.

---

[315] *See supra* Parts III.B.2, IV.A.
[316] *See supra* Part IV.B.
[317] *See* discussion *supra* Part IV.
[318] *See* source cited *supra* note 28.
[319] *See* DRAFT GEIS, *supra* note 24, at 12.
[320] *See supra* Parts II.C; III.B.3.