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Sent: Thursday, December 26, 2013 9:49 AM
To: Rulemaking1CEm Resource
Subject: FW: NRDC Comments on NUREG-2157 (Docket ID NRC-2012-0246)
Attachments: NRDC Comments on NUREG 2157 20 Dec 2013.pdf; M Leyse Declaration for NRDC.pdf

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From: Fettus, Geoffrey [mailto:gfettus@nrdc.org]
Sent: Friday, December 20, 2013 6:44 PM
To: RulemakingComments Resource
Cc: Hanson, Corinne
Subject: NRDC Comments on NUREG-2157 (Docket ID NRC–2012–0246)

Please find attached – also filed on Regulations.gov.

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Happy Holidays,

Geoff Fettus

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Via Electronic Mail

Ms. Annette L. Vietti-Cook, Secretary
U.S. Nuclear Regulatory Commission,
Washington, DC 20555–0001
ATTN: Rulemakings and Adjudications
Rulemaking.Comments@nrc.gov.

RE: Natural Resources Defense Council Comments on the Draft Waste Confidence Generic Environmental Impact Statement and Waste Confidence Rulemaking (Docket ID NRC–2012–0246)

Dear Ms. Vietti-Cook:

The Natural Resources Defense Council ("NRDC") writes today to comment on the U.S. Nuclear Regulatory Commission's ("NRC" "the agency", or "the Commission") *Draft Waste Confidence Generic Environmental Impact Statement,* 78 Fed. Reg 56621 (Sept. 13, 2013) (hereinafter referred to as the "Draft Waste Confidence GEIS" or "Draft GEIS") and the Waste Confidence—Continued Storage of Spent Nuclear Fuel: Proposed Rule, 78 Fed. Reg. 56766-56805 (Sept. 13, 2013) (hereinafter "Proposed Waste Confidence Rule").

I. Summary of Comments

In 2011, NRDC and a number of other environmental groups, four states and the Prairie Island Indian community petitioned the United States Court of Appeals for the D.C. Circuit for review of a NRC rulemaking regarding temporary storage and permanent disposal of nuclear waste. On June 8, 2012, the D.C. Circuit ruled in favor of petitioners. *See New York, et al. v. NRC*, 681 F.3d 471 (D.C. Cir. 2012) (hereinafter the "Waste Confidence Decision."). The Court held the rulemaking constituted a major federal action necessitating either an environmental impact statement ("EIS") or a finding of no significant environmental impact ("FONSI").

The Court further held the Commission's evaluation of the risks of spent nuclear fuel ("SNF") is deficient in two ways: first, in concluding permanent storage will be available "when necessary," the Commission did not calculate the environmental effects of failing to secure permanent storage—a possibility that cannot be ignored. Second, in determining SNF can safely be stored on site at nuclear plants for sixty years after the expiration of a plant's license, the Commission failed to properly examine future dangers and key consequences. Thus, the Court vacated the

Commission's orders and remanded the matter to NRC for further proceedings. *See New York et al.*, 681 F.3d 471, 483.

In September 2013 NRC issued its Draft GEIS, intending to comply with the Court's Waste Confidence Decision and the subject of today's comments. However, NRC's Draft GEIS fails to comply with the D.C. Circuit's plain direction, thus violating (again) the National Environmental Policy Act, 42 U.S.C. § 4321, *et seq*. The institutional, legal and regulatory history of managing and, perhaps one day, disposing of nuclear waste, is complicated. But the issue of the agency's failure in this instance and what it must to do to rectify this failure is straightforward. As per the Court's direction, NRC must:

> 1) properly identify the major federal action necessitating an environmental impact statement;
>
> 2) evaluate the environmental effects of failing to secure permanent storage, with associated alternatives and mitigation strategies; and
>
> 3) properly examine future dangers and key consequences with respect to spent fuel pool fires and leaks.

NRC has failed to perform each of these actions.

II. NRDC Statement of Interest

NRDC is a national non-profit membership environmental organization with offices in Washington, D.C., New York City, San Francisco, Chicago, Los Angeles and Beijing. NRDC has a nationwide membership of over one million combined members and activists. NRDC's activities include maintaining and enhancing environmental quality and monitoring federal agency actions to ensure that federal statutes enacted to protect human health and the environment are fully and properly implemented. Since its inception in 1970, NRDC has sought to improve the environmental, health, and safety conditions at the nuclear facilities operated by DOE and the civil nuclear facilities licensed by the NRC and their predecessor agencies. NRDC was a petitioner in the original Waste Confidence decision and was a petitioner in the recent proceeding before the United States Court of Appeals for the District of Columbia Circuit where this matter was heard.

III. Background

On June 8, 2012, when the D.C. Circuit vacated NRC's Waste Confidence Decision and Temporary Storage Rule (TSR), which every nuclear power reactor license relied upon when it received an operating license from the agency, it reversed a three decade bar on the public's ability to challenge how the agency regulates the production of nuclear waste, including the agency's determination that the issue of nuclear waste has no impact on licensing nuclear power reactors. It is incumbent on the NRC to comply with the Court and analyze the environmental impacts of managing spent nuclear fuel—generated as a result of licensing nuclear power plants—both a) in the near term and b) in the longer term in the event that no geologic repository is ever developed and used.

A. Initial History of the Waste Confidence Decision

In June of 1977, NRC denied an NRDC petition that forced the question of whether there should be (1) a rulemaking proceeding to determine whether high-level radioactive wastes generated in nuclear power reactors can be permanently disposed of without undue risk to public health and safety, as required under the Atomic Energy Act (AEA); and (2) a withholding of action on pending and future applications for operating licenses for nuclear power reactors until such time as an affirmative determination has been made. NRDC then petitioned the United States Court of Appeals for the Second Circuit to review the NRC decision. In 1978 the 2nd Circuit found in pertinent part:

> [I]t is neither necessary nor reasonable for the Commission to insist on proof that a means of permanent waste disposal is on hand at the time reactor operation begins, so long as the Commission can be reasonably confident that permanent disposal (as distinguished from continued storage under surveillance) can be accomplished safely when it is likely to become necessary. Reasonable progress towards the development of permanent disposal facilities is presently being accomplished. Under these circumstances a halt in licensing of nuclear power plants is not required to protect public health and safety.

Natural Resources Defense Council v. NRC, 582 F.2d 166, 169 (2nd Cir. 1978). The sense of "progress" noted by the 2nd Circuit on the development of permanent disposal facilities provided the basis for what would become the Commission's "Waste Confidence Determination" and the compromise described above.

In a parallel action only one year later, the State of Minnesota challenged an NRC decision granting two operators of nuclear plants amendments to licenses to expand on-site SNF storage *without* first determining whether the federal government could permanently dispose of the nuclear waste. The United States Court of Appeals for the D.C. Circuit held NRC could properly consider the complex issue of nuclear waste disposal in a generic proceeding such as a rulemaking and then apply its determinations in subsequent adjudicatory proceedings, noting the NRC's "reasonable assurance" that a permanent solution would be found. *Minnesota v. NRC*, 602 F.2d 412, 416 (D.C. Cir. 1979). Importantly, the D.C. Circuit remanded the matter before the particular parties to the NRC for further proceedings to determine whether those reasonable assurances existed. *Id.* at 419. This essential situation remained in place for the next thirty years, regardless of what transpired with efforts at nuclear waste disposal.

B. The Original Waste Confidence Findings

These cases gave rise in 1984 to the NRC's initial "waste confidence" rulemaking. In August 1984, after varying rounds of development, the NRC made five findings that constituted the waste confidence decision:

> (1) The Commission finds reasonable assurance that safe disposal of high level radioactive waste and spent fuel in a mined geologic repository is technically feasible.
>
> (2) The Commission finds reasonable assurance that one or more mined geologic repositories for commercial high-level radioactive waste and spent fuel will be available by the years 2007-09, and that sufficient repository capacity will be available within 30 years beyond expiration of any reactor operating license to dispose of existing commercial high level radioactive waste and spent fuel originating in such reactor and generated up to that time.
>
> (3) The Commission finds reasonable assurance that high-level radioactive waste and spent fuel will be managed in a safe manner until sufficient repository capacity is available to assure the safe disposal of all high-level radioactive waste and spent fuel.
>
> (4) The Commission finds reasonable assurance that, if necessary, spent fuel generated in any reactor can be stored safely and without significant environmental impacts for at least 30 years beyond the expiration of that reactor's operating licenses at that reactor's spent fuel storage basin, or at either onsite or offsite independent spent fuel storage installations.
>
> (5) The Commission finds reasonable assurance that safe independent onsite or offset spent fuel storage will be made available if such storage capacity is needed.

49 Fed. Reg. 34659 (Aug. 31, 1984). On the basis of these findings, NRC made a generic determination that spent fuel generated at any reactor can be stored safely and without significant environmental impacts for at least 30 years beyond the expiration of any Commission license. The NRC amended 10 CFR § 51 by adding this generic determination as 10 CFR § 51.23(a).[1]

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[1] Nearly contemporaneous with development of the original Waste Confidence Findings, Congress codified the proposition that disposal of spent fuel in a repository is the only safe means of protecting public health and the environment from spent nuclear fuel over the long term. *See* Section 111 of the

C. Waste Confidence Revisions

The NRC revised the waste confidence rule in 1990, leaving much in place but amending the second and fourth findings as follows:

> Finding 2: The Commission finds reasonable assurance that at least one mined geologic repository will be available within the first quarter of the twenty-first century, and that sufficient repository capacity will be available within 30 years beyond the licensed life for operation (which may include the term of a revised or renewed license) of any reactor to dispose of the commercial high-level radioactive waste and spent fuel originating in such reactor and generated up to that time.
>
> Finding 4: The Commission finds reasonable assurance that, if necessary, spent fuel generated in any reactor can be stored safely and without significant environmental impacts for at least 30 years beyond the licensed life for operation (which may include the term of a revised or renewed license) of that reactor at its spent fuel storage basin, or at either onsite or offsite independent spent fuel storage installations.

55 Fed. Reg. 38474 (Sept. 18, 1990), *see also* a revised 10 CFR § 51.23(a).

In 1999 NRC again confirmed these findings and stated it would revisit the Waste Confidence issue if "significant and pertinent unexpected events occur, raising substantial doubts about the Decisions continued viability." 64 Fed. Reg. 68005 (Dec. 6, 1999).

In October 2008, NRC revisited the matter again and initially proposed to amend finding (2) to read:

> The Commission finds reasonable assurance that sufficient mined geologic repository capacity can reasonably be expected to be available within 50-60 years beyond the licensed life for operation (which may include the term of a revised or renewed license) of any reactor to dispose of the commercial high-level nuclear waste and spent fuel originating in such reactor and generated up to that time.

73 Fed. Reg. 59551. The Commission sought to amend finding (4) to read:

Nuclear Waste Policy Act ("NWPA"), which establishes a national policy of disposing of spent nuclear fuel in a deep geologic repository. 42 U.S.C. §10131.

> The Commission finds reasonable assurance that, if necessary, spent fuel generated in any reactor can be stored safely and without significant environmental impacts for at least 60 years beyond the licensed life for operation (which may include the term of a revised or renewed license) of that reactor at its spent fuel storage basin, or at either onsite or offsite independent spent fuel storage installations.

73 Fed. Reg. 59551 (emphasis added). Findings 1, 3, and 5 of the Waste Confidence remained unchanged. Thus, NRC predicted that a final repository might not be available until fifty to sixty years following the expiration of any reactor license (including any terms for renewed or revised licenses). *Id*. at 46211.

In updating its analysis of the technical feasibility of SNF disposal in 2008, NRC briefly surveyed the available literature and concluded in very general terms that various "advances" made in the United States and elsewhere "continue to confirm the soundness of the basic concept of deep geologic disposal." *Id*. at 46207. For the first time, however, NRC announced that it had rejected bedded salt as a geological medium for SNF repositories "because heat-generating waste, like spent nuclear fuel, exacerbates a process by which salt can rapidly deform." *Id*. at 5955.

In comments on the 2008 Waste Confidence Decision ("WCD"), NRDC and others argued the WCD constitutes a licensing decision with significant environmental impacts requiring the preparation of an EIS.[2] NRDC also pointed out that the WCD fatally undermines the basis for the Table S-3 Rule's FONSI with respect to SNF disposal, because it rejected the central premise on which the FONSI was based: that SNF disposal in a bedded salt repository would be safe because it would result in no release of radioactivity.[3]

Thus, NRDC argued that while the Supreme Court had upheld the validity of Table S-3 in *BG&E*, NRC's rejection of bedded salt as a safe geological medium for SNF disposal now showed that Table S-3 was "seriously wrong."[4] Moreover, "all other geologic settings" could be

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2 *See* ML090410724, *NRDC's February 6, 2009 Comments on the Waste Confidence and Temporary Storage Rules*, at 17 and 19 found online in NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html. Further note regarding citations: all citations are hereby incorporated by reference and are publicly available. If NRC has any difficulty either downloading or obtaining any referenced citations, please do not hesitate to contact the undersigned at NRDC.

3 *Id*. at 19-20.

4 *Id*. (quoting *BG&E*, 462 U.S. at 98, acknowledging the possibility of significant impacts if future evidence were to disprove the zero-release assumption).

expected to leak radionuclides into the environment.[5] Finally, NRDC and several other stakeholders asserted that NRC has no basis for confidence in the ultimate disposal of SNF within the foreseeable future.[6]

D. The 2010 Waste Confidence Determination and the Legal Challenge

In the final 2010 Waste Confidence Determination, NRC reiterated its conclusion that safe SNF disposal is feasible and rejected Petitioners' demand for an EIS. 75 Fed. Reg. 81037-81076 (Dec. 23, 2010). Further, while it concluded SNF could be safely stored at reactor sites for sixty years after termination of licenses, it wholly dispensed with a predicted time frame for the availability of a final repository. Instead, the final Waste Confidence Determination stated only that a repository will be available "when necessary." *Id.*

Also, NRC announced that it would not re-examine the Waste Confidence Determination for decades to come, stating that it has "confidence that either a repository will be available before the expiration of the 60 years post-licensed life discussed in Finding 4 or that the Waste Confidence Decision and TSR will be updated and revised if the expiration of the 60-year period approaches without an ultimate disposal solution for HLW (High Level Waste) and SNF." *Id.*

Separately, in the TSR, NRC revised its FONSI regarding SNF storage impacts to conform to the Waste Confidence Determination's extended timetable, but made no findings regarding the environmental impacts of SNF disposal. 75 Fed. Reg 81032-37 (Dec. 23, 2010).

E. The D.C. Circuit Decision

In 2011, four states, an Indian community, NRDC and a number of environmental groups petitioned the United States Court of Appeals for the D.C. Circuit for review of a NRC rulemaking regarding temporary storage and permanent disposal of nuclear waste. The Court held the rulemaking constituted a major federal action necessitating either an environmental impact statement or a finding of no significant environmental impact. The Court further held the Commission's evaluation of the risks of SNF is deficient in two ways: first, in concluding that permanent storage will be available "when necessary," the Commission did not calculate the environmental effects of failing to secure permanent storage—a possibility that cannot be ignored. Second, in determining that spent fuel can safely be stored on site at nuclear plants for sixty years after the expiration of a plant's license, the Commission failed to properly examine future dangers and key

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5 *See* February 6, 2009 *Comments of the Institute for Energy & Environmental Research* at 35, found online at http://ieer.org/wp/wp-content/uploads/2012/06/WasteConfidenceComments2009.pdf.

6 *See*, *e.g.*, ML090410724, *NRDC 2009 Comments*, at 9-15.

consequences. Thus, the Court vacated the Commission's WCD and TSR and remanded the matter to NRC for further proceedings. *See New York et al*., 681 F.3d 471, 483.

F. The Remand and Associated Actions

Related actions that are direct progeny of this decision commenced in accord with NRC rules for administrative adjudications (issues must be raised within 30 days of a precipitating event), both NRDC and several other environmental groups and at least one state filed contentions (the equivalent of a count in a complaint) raising the waste confidence issue in relicensing challenges. New York filed such a contention in its Indian Point proceeding and NRDC did so in our challenge to the Limerick Generating Station relicensing in Pennsylvania. More than a dozen environmental groups and a few states filed similar contentions in licensing and relicensing cases across the country. What follows is a key paragraph from NRDC's Limerick contention:

> All of the above-listed references to 10 C.F.R. § 51.23 or the Waste Confidence Findings have now been invalidated along with the D.C. Circuit's vacatur of both the Waste Confidence Findings and the Temporary Storage Rule, and as a result NRC Staff must now evaluate and examine, before a decision on Exelon's license can be made: the environmental effects of all reasonable alternatives for on-site and off-site storage of waste during and after the period of extended operation; offsite land, water, and air use impacts of continued operations and the storage of additional spent fuel on real estate values in the surrounding areas; whether the current GEIS adequately evaluates the long term impacts and safety of the generation and long-term storage of radioactive waste; the comparative impacts of spent fuel storage in pools versus in dry casks; the implications of on-site storage of waste for decommissioning; the effects of spent fuel disposal and the effects of spent fuel storage and disposal in the event of extended delay or if no final disposal option or repository is ever identified; and alternatives to mitigate these impacts, among other issues. Many of these issues appear to be site specific and cannot be dealt with generically.[7]

New York entered a similar contention in the Indian Point case and the same is true with the similar waste confidence contentions filed across the country. In response to the

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7 NRDC's Waste Confidence Contention *filed In the Matter of Exelon Generation Company*, LLC. (Limerick Generating Station, Units 1 and 2) (License Renewal Application), Docket No. 50-352-LR, filed July 9, 2012, http://pbadupws.nrc.gov/docs/ML1219/ML12191A409.pdf.

multiple contentions filed with the NRC in individual proceedings, on August 7, 2012 the NRC Commissioners issued CLI-12-16 and stated:

> Because of the recent court ruling striking down our current waste confidence provisions, we are now considering all available options for resolving the waste confidence issue, which could include generic or site-specific NRC actions, or some combination of both. We have not yet determined a course of action. But, in recognition of our duties under the law, we will not issue licenses dependent upon the Waste Confidence Decision or the Temporary Storage Rule until the court's remand is appropriately addressed. This determination extends just to final license issuance; all licensing reviews and proceedings should continue to move forward.

CLI-12-16 at 4. Some few weeks later, the Commissioners indicated its intent to develop a revised Waste Confidence Decision and Rule that addressed the court's remand and directed the staff to continue with licensing reviews and proceedings during this rulemaking. The Commission has directed the staff to complete a revised, final Waste Confidence Decision and Rule by September 5, 2014. *See* SECY-12-0132, Catherine Haney, Director Office of Nuclear Material Safety and Safeguards, *Implementation Of Commission Memorandum And Order CLI-12-16 Regarding Waste Confidence Decision And Rule*, October 3, 2012.

G. An Inadequate Scoping Process

On October 25, 2012, NRC published in the Federal Register the Waste Confidence Scoping Notice, its *Consideration of Environmental Impacts of Temporary Storage of Spent Fuel After Cessation of Reactor Operation: Request for comments on the notice of intent to prepare an environmental impact statement and notice of public meetings*, the subject of our comments today. *See* 77 Fed. Reg. 65137 (October 25, 2012).

In the scoping notice, NRC describes Waste Confidence as representing the Commission's generic determination that SNF can be stored safely and without significant environmental impacts for a period of time after the end of the licensed life of a nuclear power, citing 10 C.F.R. § 51.23 and notes this proposed generic analysis is intended to satisfy the NRC's NEPA obligations with respect to post-licensed life storage of SNF. Discussing the D.C. Circuit's vacatur of the Waste Confidence Determination, NRC states the Court identified three specific deficiencies in the analysis underpinning the agency's current :

> 1. Related to the Commission's conclusion that permanent disposal will be available ''when necessary,'' the Court held that the Commission did not evaluate the environmental effects of failing to secure permanent disposal;

> 2. Related to the storage of spent fuel on site at nuclear plants for 60 years after the expiration of a plant's operating license, the Court concluded that the Commission failed to properly examine the risk of spent fuel pool leaks in a forward-looking fashion;
>
> 3. Also related to the post-licensed life storage of spent fuel, the Court concluded that the Commission failed to properly examine the consequences of spent fuel pool fires.

Id. Acknowledging the Waste Confidence Determination is part of the agency's basis for licensing decisions, NRC stated that to fulfill its responsibilities under NEPA, the agency will prepare an EIS "to support the potential update to the Waste Confidence Decision and Rule." *Id.* NRC then briefly describes the types of environmental impacts it proposes to evaluate.

1. NRDC's November 8 Letter

Two weeks after the issuance of the EIS Scoping Notice, NRDC counsel and counsel for several other environmental groups wrote NRC Chairman Macfarlane requesting the withdrawal of the Waste Confidence Scoping Notice because it failed to satisfy two of the most basic requirements of NRC's regulations for notices of intent to publish an EIS: (1) the Scoping Notice failed to provide a "description of the proposed action;" and (2) the Scoping Notice failed to provide "to the extent sufficient information is available, possible alternatives." *See* 10 CFR § 51.27(a)(2) ("Notice of Intent") and Att. 3, November 8, 2012 letter from NRDC *et al.* to NRC Commissioners.

As explained in our letter, NRC's Waste Confidence Scoping Notice gave no hint of the proposed agency action(s) that give rise to the risk of SNF storage environmental impacts, and thus it required commenters to guess at the nature of the agency's proposed action and the reasonable alternatives it was contemplating to implement it. Moreover, we stated that what little factual information was presented in the Scoping Notice was likely to mislead commenters into viewing the proposed action and its alternatives as merely the generic assessment of some combination of methods for storing SNF, irrespective of the underlying agency actions authorizing creation of intrinsically hazardous SNF requiring safe storage for millennia.

Such a truncated scope of alternatives is far too narrow to satisfy NEPA because it fails to address the underlying agency *action*—the licensing of nuclear reactors—that causes the production of spent reactor fuel and its associated environmental impacts. Therefore, as we stated in the letter, the scoping process would not lead to any analysis of some of the most obvious alternatives for the avoidance or reduction of SNF storage impacts: limitations on or cessations of reactor licensing until there is reasonable assurance of the availability of permanent disposal in a geologic repository. Nor did the scoping notice describe any proposed alternative configurations for prolonged surface storage of the reasonably foreseeable amounts of SNF that the NRC may authorize production of in the future. As a result, the notice failed to give the public sufficient information on which to develop comments on the appropriate scope of the EIS proposed by the NRC, and not surprisingly, the Agency has brought forth a Draft GEIS with a scope of analysis that is woefully deficient.

2. NRC's response to NRDC's Letter

Weeks later NRC responded and declined to reissue or reformulate the Waste Confidence Scoping Notice. *See* Att. 4, December 5, 2012 Response of Chairman Macfarlane to NRDC *et al*. Rather, NRC stated the "update to the Waste Confidence Rule *is* the federal action; the 'no action' alternative is a decision not to prepare the rule and instead to conduct a site-specific analysis of post-licensed life spent fuel storage for each NRC licensing action that relies on Waste Confidence." *See* Att. 4 at 2.

NRC went on to state "the Waste Confidence rule *is not a licensing action*, it does not authorize the initial or continued operation of any nuclear power plant, and it does not authorize storage of SNF. Thus, licensing of specific reactors or storage facilities is not the purpose of this rulemaking, or the proposed action." *Id* (emphasis added). Finally, NRC stated while NRDC is correct that scoping notices prepared under §51.27(a) are required to contain the information identified in our letter,

> [R]equirements in §51.27, regarding the content of scoping notices apply only to scoping notices that are prepared under §51.26, i.e., when an NRC staff director determines that an environmental impact statement should be prepared. In this case, an NRC staff director did not determine that an environmental impact statement should be prepared; instead, the Commission exercised its discretionary authority under §51.20(a)(2) to direct the staff to prepare an environmental impact statement to support an update to the Waste Confidence Rule.

Id.

3. NRC's Defense of Its Scoping Process Lacks Merit

NRC's response signified notable problems for this EIS process at the outset, for the following reasons. First, the agency's grasp of its NEPA obligation conflicts with the holding of the D.C. Circuit that vacated the Waste Confidence Determination and remanded this matter to the agency. The Court squarely addressed this matter in its opinion and we, again, include the entirety of its discussion so there is no mistaking the Court's meaning:

> Under NEPA, each federal agency must prepare an Environmental Impact Statement ("EIS") before taking a "major Federal action significantly affecting the quality of the human environment." 42 U.S.C. § 4332(2)(C). … *The issuance or reissuance of a reactor license is a major federal action affecting the quality of the human environment...*

> ***
> The parties here dispute whether the Waste Confidence Determination [“WCD”] itself constitutes a major federal action. To petitioners, the WCD is a major federal action because it is a predicate to every decision to license or relicense a nuclear plant, and the findings made in the WCD are not challengeable at the time a plant seeks licensure. *The Commission contends that because the WCD does not authorize the licensing of any nuclear reactor or storage facility, and because a site-specific EIS will be conducted for each facility at the time it seeks licensure, the WCD is not a major federal action.* To the Commission, the WCD is simply an answer to this court's mandate in *Minnesota* to ensure that plants are only licensed while the NRC has reasonable assurance that permanent disposal of the resulting waste will be available. The Commission also contends that the WCD constitutes an EA supporting the revision of 10 C.F.R. § 51.23(a), and because the EA found no significant environmental impact, an EIS is not required.
> ***
> We agree with petitioners that the WCD rulemaking is a major federal action requiring either a FONSI or an EIS. *The Commission's contrary argument treating the WCD as separate from the individual licensing decisions it enables fails under controlling precedent.*
> ***
> It is not only reasonably foreseeable but eminently clear *that the WCD will be used to enable licensing decisions based on its findings*. The Commission and the intervenors contend that the site-specific factors that differ from plant to plant can be challenged at the time of a specific plant's licensing, *but the WCD nonetheless renders uncontestable general conclusions about the environmental effects of plant licensure that will apply in every licensing decision*.

New York et al. at 476-477 (explanatory brackets inserted, emphasis added, citations omitted). The D.C. Circuit has heard the argument the Waste Confidence Determination is not a licensing action and rejected it. NRC’s adherence to this position mere months after the decision demonstrates an inclination to flout NEPA and the Court’s decision.

We are unclear how the Court could have been more direct in its language. The NRC action – licensing nuclear power plants – leads to the environmental impacts associated with SNF storage and a lack of disposal options and that is what must be considered under NEPA.[8] To comply with the Court's opinion and NEPA, we see no alternative but for the Commission to withdraw this Draft EIS and reissue it with a properly defined proposed action and reasonable alternatives for achieving the agency's purpose and need for action that are consistent with the purpose of NEPA to foster not "paperwork" but "excellent agency action" that "protect(s) the environment." 40 CFR §1500.1 (c). In pursuit of this objective, the Agency must publish a new Scoping Notice that clearly articulates the scope of reasonably foreseeable environmental impacts flowing from all future agency actions that critically depend on the Proposed Action to license the production and storage of SNF. In the abundance of caution we will nevertheless comment in detail on the many manifest deficiencies in the current Draft GEIS.

4. NRC's Failure to Adequately Comprehend & Respond to Scoping Comments

In its response to the scoping comments filed by NRDC and many others, NRC managed to both misconstrue and disregard them. We could belabor the point for pages, but we will cite the way one of our own comments was handled. First, NRC misconstrued NRDC's following observation regarding the major federal action and reasonable alternatives for implementing it:

> [NRC must] determine whether or how much additional SNF may be generated when there is no permanent, safe and secure waste disposal facility, no date certain by which such a facility will exist and the significant possibility that such a disposal facility may never exist. Further, if such additional SNF is allowed to be generated, what alternatives exist to the current practice of allowing nuclear wastes to be generated and stored at individual reactor sites indefinitely and in spent fuel pools for as long as the licensee chooses? And finally, regardless of how much new SNF may or may not be allowed to be generated, what are the long term storage alternatives and associated environmental impacts for the SNF and high-level radioactive waste that are already in existence? 10 C.F.R. § 51.27(a)(2).

If one examines the "Alternatives" section of NRC's scoping summary document, at no point does NRC even acknowledge, much less respond in a substantive fashion to observations regarding the major federal action and reasonable alternatives for implementing it. Rather, NRC nonsensically suggested parties had submitted "alternatives *to* the Waste Confidence rulemaking … such as stopping all NRC licensing activities, halting any further production of spent nuclear

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[8] NRDC also responded at length in its scoping comments to the Chairman's assertion that scoping notices prepared under the Commissioners' discretionary authority found in § 51.20(a)(2) impliedly have no such obligations as those found in §51.27(a), as such restrictions apply only to scoping notices that are prepared under §51.26. First, nothing in § 51.20(a)(2) removes the Commissions' responsibility to comply with the whole of NEPA. Second, the Chairman's assertion conflicts with the agency's own Waste Confidence Scoping Notice —which at no point references §51.20 – but does, in fact, reference §51.26. 77 Fed. Reg 65138

fuel, and shutting down all existing nuclear power plants." NRC Scoping Summary Document at 26-27 (emphasis added).

Such a response trivializes and distorts the important NEPA compliance issues NRDC and others introduced. At issue is the arbitrary and contrived manner in which the agency has defined the scope of its Proposed Action for NEPA analysis, and the range of reasonable alternatives for avoiding, reducing, and mitigating environmental impacts it must consider before arriving at a final agency decision to pursue a particular course of action.

H. The Release of the Draft EIS: Restructuring the Temporary Storage Rule and the Waste Confidence Determinations.

Several months after the scoping notice and fourteen months after the D.C. Circuit issued the Waste Confidence Decision, NRC released its Draft GEIS and Proposed Rule for public comment. *See* Draft GEIS announcement at 78 Fed. Reg 56621 (Sept. 13, 2013) and the new proposed rule at 78 Fed. Reg. 56766-56805 (Sept. 13, 2013). The new configuration (as opposed the Five Waste Confidence Findings and the Temporary Storage Rule finalized in 2010) consists of a Draft GEIS supporting a proposed new rule, with the Waste Confidence analysis (no longer a set of 5 determinations) found in Appendix B of the Draft GEIS.

We offer specific comments on these matters this day.

IV. NRDC's Specific Comments on the Draft GEIS

A. NRC Must Comply with Both the AEA & NEPA

As we commence NRDC's comments on the Draft GEIS, we remind NRC that the Atomic Energy Act (AEA) precludes the agency from licensing any new nuclear power plant or re-licensing any existing nuclear power plant if it would be "inimical . . . to the health and safety of the public." 42 U.S.C. § 2331(d).[9] In conformance with this requirement, the Commission has stated it will only license a new nuclear power plant "so long as the Commission can be reasonably confident that permanent disposal (as distinguished from continued storage under surveillance) can be accomplished safely when it is likely to become necessary." *NRDC v. NRC,* 582 F.2d 166 (2d Cir. 1978). The Commission's full statement in response was:

> The Commission would not continue to license reactors if it did not have reasonable confidence that the wastes can and will in due course be disposed of safely. The accumulating evidence as discussed below continues to support the Commission's implicit findings of reasonable assurance that methods of safe permanent disposal of high-level wastes can be available when they are needed. Given this, and the fact that at present safe storage methods are presently

[9] *See also*, *cf.*, 42 U.S.C. §2232 and 42 U.S.C. §2235 (b).

> available and highly likely to remain so until a permanent disposal system can be demonstrated and licensed, the Commission sees no reason to cease licensing reactors.

42 Fed. Reg. at 34,393.

Previous iterations of the Waste Confidence Determination included safety-related "reasonable assurance findings" under the AEA, including demonstration of a technical basis for a reasonable level of "confidence" that reactor fuel will be isolated from humans and the environment. 44 Fed. Reg. at 34,393.[10]

In contrast to previous Waste Confidence Findings that ignored NEPA obligations, the agency has now ignored its AEA responsibilities by eliminating any "reasonable assurance" safety findings regarding the safety of spent fuel storage or the availability of spent fuel disposal capacity. The only safety finding in the proposed rule is a statement in the preamble that the NRC lacks confidence to make a reasonable assurance finding regarding the availability of a "disposal solution" at "the end of a reactor's licensed life for operation." 78 Fed. Reg. at 56,784. Further, NRC acknowledges "reasonable assurance" findings regarding an "offsite storage solution" and interim storage are required by law (78 Fed. Reg. at 56,778 n. 1 (citing *Minnesota,* 602 F.2d at 418)), NRC asserts the proposed rule's purpose is to codify the results of a NEPA analysis. *See* 78 Fed Reg. 56,783-84.

The proposed rule and the Draft GEIS do not address why NRC no longer makes a safety finding under the AEA and nor does it answer the question of whether the NRC has a reasonable basis for confidence in the availability of sufficient repository capacity when it is needed. The only place NRDC could identify where NRC approaches the issue is Appendix B, Technical Feasibility of Continued Storage and Repository Availability. Draft GEIS, Appendix B. But in *B.2 Repository Capacity will be Available to Dispose of Spent Fuel*, NRC makes no assertion it has a technical or evidentiary basis for a finding of reasonable assurance that sufficient repository capacity will be available when it is necessary (much less by any date certain). And as our comments will detail, nor does the Draft GEIS contain meaningful analysis of the safety or environmental risks should sufficient repository capacity not become available when it is needed.

Nor does NRC have a sufficient technical understanding of the risks of extended spent fuel storage to support a safety-related reasonable assurance finding. No existing environmental or other study has attempted to predict the environmental impacts of storing spent fuel on site for hundreds of years, or perhaps indefinitely (and the Draft

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10 *See* findings 2 and 4 of the 1984, 1990 and 2008 iterations of the rule – e.g., from 2008, "(2) The Commission *finds reasonable assurance* that sufficient mined geologic repository capacity will be available to dispose of the commercial high-level radioactive waste and spent nuclear fuel generated by any reactor when necessary."

GEIS certainly does not, as our comments detail). Indeed, all NRC's previous Waste Confidence iterations and associated studies were premised on the opposite conclusion –a repository will be available in the near future. NRC has commenced a study of the issue: the "Long-Term Waste Confidence Update Project," where NRC proposes to assess the environmental impacts of storing spent fuel for 200 years after cessation of licensing. *See* the WCD, 75 Fed. Reg. at 81,040.[11] But work on the Long-Term Waste Confidence Update Project had only just begun at the time of the D.C. Circuit's decision, and it is far from complete. NRC currently has no sound footing for its necessary safety findings under the AEA.

Separate from the agency's AEA obligations, NEPA requires that before licensing or re-licensing nuclear power plants, NRC must evaluate the environmental impacts of its licensing decision in an EIS. 42 U.S.C. § 4332(C); 10 C.F.R. § 51.20(b)(2). An EIS must address the environmental impacts of the proposed action and connected actions, including cumulative impacts. 10 C.F.R. § 51.71(d). It must also weigh the costs and benefits of a reasonable array of alternatives for avoiding or mitigating the consequences of the proposed action. *Id.*

Thus, in proposing to license or re-license nuclear power plants, NRC must examine the environmental impacts of the SNF and radioactive waste generated by the plants. It must also evaluate the relative costs and benefits of alternatives for avoiding or mitigating those impacts, including denying or amending licenses so that the radioactive waste is either not produced or there will be some future limitation. *Id* The environmental impacts that must be examined by NRC include the risks posed by SNF interim storage, permanent disposal and the failure to secure permanent disposal. With regard to the latter, the NRC is obligated to examine the potential environmental impacts should institutional control over surface storage of SNF be lost for an extended period of time. Since there is uncertainty regarding when loss of institutional control might occur, how often and for how long, this portion of the analysis should examine the impacts for a range of dates and time periods for loss of institutional control.

The D.C. Circuit further refined this legacy when it wrote:

> The Commission apparently has no long-term plan other than hoping for a geologic repository. If the government continues to fail in its quest to establish one, then SNF will seemingly be stored on site at nuclear plants on a permanent basis. The Commission can and must assess the potential environmental effects of such a failure.
> ***

[11] As the Court observed in *State of New York,* that rulemaking may address "some or all of the problems" that it remanded to the agency. 681 F.3d at 483.

> Nonetheless, whether the analysis is generic or site-by-site, it must be thorough and comprehensive. Even though the Commission's application of its technical expertise demands the "most deferential" treatment by the courts, *Baltimore Gas*, 462 U.S. at 103, we conclude that the Commission has failed to conduct a thorough enough analysis here to merit our deference.

New York et al., 681 F.3d at 479, 480-481.

In order to comply with these controlling precedents, as noted earlier, we ask NRC to withdraw the existing Waste Confidence Draft GEIS and commence with publishing a Scoping Notice with a clear description of the NRC action that leads to SNF storage and disposal impacts: licensing nuclear reactors. Further, we request NRC withdraw the proposed rule until it has substantially improved evidentiary basis upon which to base a reasonable assurance finding about the safety of extended spent fuel storage

In short, *New York et al*. was the natural successor to a lawsuit NRDC brought in 1977 to force NRC to address the public health and environmental impacts of SNF and high-level radioactive waste ("HLW") storage and disposal. *See NRDC v. NRC*, 582 F.2d 166, 169 (2nd Cir. 1978). While NRDC's and Minnesota's original lawsuits had a measure of success as a policy matter by forcing the compromise embodied in the Waste Confidence decision – NRC will not license reactors without "reasonable confidence" in the progress and development of a permanent disposal facility and the ability to safely store SNF—at no point over the last 40 years had NRC prepared an EIS regarding the environmental impacts of SNF and high-level radioactive waste disposal. Moreover, NRC continued to assume in its licensing decisions that SNF and HLW disposal caused no public radiation doses and had no appreciable environmental impacts, long after those assumptions were proven wrong.

After years of work by NRDC and many others, those assumptions have now been vacated by the D.C. Circuit. However NRC has issued a first draft of a NEPA analysis of the environmental impacts of SNF storage and disposal where the agency inadequately contemplates the possibility that a final disposal solution may never be found. Unfortunately, NRC has gotten off on the wrong foot and must: (1) withdraw this first draft and the proposed rule; and (2) commence work on a draft EIS that complies with federal law. The agency must then present reasonable alternatives and subject them to NEPA's "hard look requirements" and rely on reasonable projections, forecasts and assumptions to formulate its alternatives and examine their reasonably foreseeable environmental impacts.

B. Specific Comments

Comments on Chapter 1

1. Page 1-4. "For both power reactor and storage facilities, NEPA requires that the NRC address direct, indirect, and cumulative impacts of its licensing actions. Thus, in issuing a power reactor

license, the NRC must analyze the environmental impacts resulting from the generation of spent fuel by the reactor and its continued storage pending ultimate disposal. Likewise, for an ISFSI [Independent Spent Fuel Storage Installation], the NRC must analyze the impacts of continued storage at the facility until ultimate disposal for the spent fuel is available. The environmental impacts addressed in this draft GEIS are limited to the environmental impacts of continued storage."

> **NRDC Comment**
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> NRDC concurs with the NRC that it must address the direct, indirect, and cumulative impacts of its licensing actions. But NRC's presentation of the proper scope is inadequate and the agency must evaluate the environmental effects of all reasonable alternatives for on-site and off-site storage of waste during and after the period of extended operation; offsite land, water, and air use impacts of continued operations and the storage of additional spent fuel on the surrounding areas; whether the current GEIS adequately evaluates the long term impacts and safety of the generation and long-term storage of radioactive waste; the comparative impacts of SNF storage in pools versus in dry casks; the implications of on-site storage of waste for decommissioning; the effects of spent fuel disposal and the effects of SNF storage and disposal in the event of extended delay or if no final disposal option or repository is ever identified , with extended loss of institutional control over the SNF and the storage facility; and alternatives to mitigate these impacts, among other issues. Many of these issues have a site specific component and cannot be dealt with entirely within the confines of a generic analysis. Rather than seeking to use this DGEIS as blanket to suffocate all future consideration of continued SNF storage issues in future licensing decisions, the NRC should regard this DGEIS as one in which broad programmatic issues and impacts are addressed, thus enabling the "tiering" of subsequent site-specific EIS documents from this overall analysis. Below we expand on the NRC's failure to properly frame the major federal action at issue and present meaningful alternatives.

2. <u>Page 1-5</u>. "This draft GEIS assesses the environmental impacts of continued storage and, if adopted, would provide a regulatory basis for the NRC's proposed amendment to 10 CFR 51.23… This draft GEIS does not authorize issuance of any NRC license, but rather discloses the environmental impacts associated with the continued storage of spent fuel. In addition, this draft GEIS considers alternative approaches to assessing the environmental impacts of continued storage (see Section 1.6)."

> **NRDC Comment**
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> As NRDC details below, this Draft GEIS fails to assess key aspects of the environmental impacts of continued storage and would thus fail to provide a regulatory basis for an amended TSR or even new Waste Confidence Rule. Further, this description of purpose is a fundamental departure from the Waste Confidence Findings of the past and should be explained as such. Specifically, there will no longer be waste confidence findings. Rather,

> there will be a rule supported by a Generic EIS. In contrast to the previous findings, the proposed rule finds only that it is "feasible" to "safely store spent nuclear fuel following the licensed life for operation of a reactor" and that it is "feasible" to "have a mined geologic repository within 60 years following the licensed life for operation of a reactor." 78 Fed. Reg. at 56,804.

3. Page 1-5. "*Proposed Federal Action*. The Commission proposes to issue a revised Rule, 10 CFR 51.23, that generically addresses the environmental impacts of continued storage. This revision would adopt into regulation the environmental impact analyses in this draft GEIS. Further, the revision would state that because the impacts of continued storage have been generically assessed in this draft GEIS and codified in a Rule, NEPA analyses for future reactor and spent fuel storage facility licensing actions would not need to separately consider the environmental impacts of continued storage."

NRDC Comment

As NRDC will describe in detail below, the impacts of continued storage have not been generically assessed in this Draft GEIS and NRC will in any event have to consider certain site specific impacts of long-term storage at nuclear facilities in future "tiered" NEPA analyses. The Draft GEIS misconstrues NRC's NEPA obligation to properly define the nature and scope of the "major federal action" – in this instance a rulemaking – that NRC proposes as a fundamental predicate to all pending and future licensing actions authorizing the production and storage of spent nuclear fuel. In so doing, the Draft GEIS ignores the DC Circuit's unambiguous language vacating *en toto* the Commission's 2010 iterations of the WCD and TSR – "we are invalidating the Commission's conclusions as a whole." *New York et al*., at 482.

Indeed, the DC Circuit rejected the very argument – "the WCD/TSR is not a licensing action" – NRC now employs to arrive at its cramped, unreasonable description of the Commission's purpose and need in seeking to readopt the now vacated WCD and TSR: "(1) to improve the efficiency of the NRC's licensing process by generically addressing the environmental impacts of continued storage; (2) to prepare a single document that reflects the NRC's current understanding of the environmental impacts; and (3) to respond to the issues identified in the remand by the Court in the New York v. NRC decision." Draft GEIS at 1-6.

The failure to analyze meaningful alternatives is a direct result of an improperly framed proposed action and its cramped, unreasonable purpose and need section. Following the Court's guidance and a common sense reading of NEPA and its implementing regulations, a legally compliant definition of the proposed action would be the following:

> *The NRC proposes to reinstate, as a pre-determined stage of its individual licensing actions for nuclear reactors and Independent Spent Fuel Storage*

> *Installations, a binding rule that generically considers, and determines for the purposes of future licensing, reasonably foreseeable and cumulative environmental impacts of continuing to store on the surface of the earth for extended periods, including indefinitely, all spent fuel previously generated and requiring storage pursuant to past Commission licensing actions, and any spent fuel that would be generated pursuant to pending and reasonably foreseeable licensing actions the Commission may undertake in the future.*

But in defiance of the DC Circuit's directions, NRC's Draft GEIS continues present its WCD and TSR decisions as "separate from the individual licensing decisions it enables," and even includes a special box in the Executive Summary to this effect, headlined, "The Waste Confidence rulemaking is not a licensing action." This box then asserts, "Every nuclear power plant or specifically licensed spent fuel storage facility must undergo an environmental review as part of its site-specific licensing process," when the NRC knows full well adoption of the Draft GEIS conclusions would, as the DC Circuit noted, actually *preclude* further NEPA consideration of spent fuel storage issues at the licensing stage! Draft GEIS at xxvi. NRDC notes in passing that we find such mind-numbing doublespeak, on behalf of a Commission charged with safeguarding the public interest, to be regrettable.[12]

We now turn to the Purpose & Need section.

4. Page 1-6. (Purpose of and Need for the Proposed Action) "The purpose and need for the proposed action are threefold: (1) to improve the efficiency of the NRC's licensing process by generically addressing the environmental impacts of continued storage; (2) to prepare a single document that reflects the NRC's current understanding of these environmental impacts; and (3)

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[12] NRC's Proposed Action thus becomes "to adopt into regulation the environmental impact analyses in this Draft GEIS," and the alternative of No Action involves not codifying generic environmental findings at 10 CFR 51.23 and instead "addressing the environmental impacts from continued storage in each of its nuclear power plant and ISFSI initial licensing and license renewal proceedings." Draft GEIS at 1-6. Since addressing environmental impacts in the licensing proceedings has not been the agency's practice to date, and is therefore not part of the environmental status quo, this cannot lawfully comprise the "No Action Alternative." Despite the vast radionuclide inventories, geographic dispersion, temporal sweep, and potential hazards involved in the nuclear waste storage problem, there are just two "[O]ther Reasonable Alternatives" considered in this GEIS: (1) "Develop a GEIS without incorporating the results into a rule...allow[ing] the NRC to adopt these Draft GEIS findings into environmental reviews for future licensing activities, but without the effect of a rule;" and (2) "...issue a policy statement [that] would not bind licensees and applicants like a rule, but would provide notice of the Commission's intent to incorporate the findings of the GEIS into environmental reviews for future licensing activities." *Id.* at 1-7. We discuss the inadequacies of the presented alternatives below.

to respond to the issues identified in the remand by the Court in the *New York v. NRC* decision. The NRC intends to codify the results of its analyses in this draft GEIS at 10 CFR 51.23. NRC licensing proceedings for nuclear reactors and ISFSIs will continue to rely on the generic determination in 10 CFR 51.23 to satisfy obligations under NEPA with respect to the environmental impacts of continued storage."

NRDC Comment

The Purpose and Need of NRC's "proposed" action under NEPA are improperly defined, as is the major federal action at issue. As the DC Circuit and the NRC have acknowledged, an EIS is necessary. See *New York et al*. at 476-477 (explanatory brackets inserted, emphasis added, citations omitted), ("Under NEPA, each federal agency must prepare an Environmental Impact Statement ("EIS") before taking a "major Federal action[ ] significantly affecting the quality of the human environment." 42 U.S.C. § 4332(2)(C). … The issuance or reissuance of a reactor license is a major federal action affecting the quality of the human environment... the WCD rulemaking is a major federal action requiring either a FONSI or an EIS. *The Commission's contrary argument treating the WCD as separate from the individual licensing decisions it enables fails under controlling precedent.*").

So what is the purpose at issue here and why is an EIS necessary? An EIS is necessary not just because the Court directed there be one. An EIS is necessary to address the environmental impacts identified by the Court as necessary for evaluation under NEPA. We now explain what a proper purpose and need section might look like.

A. What NRC Should Have Drafted: The Need for An EIS

1. Licensing Nuclear Power Plants and Allowing the Production of Nuclear Waste is a Major Federal Action with Significant Environmental Impacts.

Since the first days of the atomic age, America has used nuclear fission to generate electricity. As of this day, nineteen percent of the nation's electricity is generated by nuclear reactors.[13] The United States government, via the action of the NRC, licenses nuclear power plants and regulates their impacts on public safety and the natural environment.

The nuclear fuel cycle and the decision to license power reactors have significant environmental and public safety impacts (many of which are not the subject of this EIS and are covered elsewhere). As an example, nuclear plants pose a continuing risk of nuclear accidents, including a small, clear probability of a high-consequence event such as the Fukushima disaster in Japan. Further,

[13] World Nuclear Ass'n, World Nuclear Power Reactors & Uranium Requirements, http://www.world-nuclear.org/info/reactors.html (last visited Dec. 9, 2013).

environmental harms and risks from the nuclear fuel cycle include radionuclide and heavy metals contamination from uranium mining and processing activities, massive freshwater withdrawals and evaporative losses for reactor cooling, excessive thermal discharges to aquatic environments, massive entrainment and destruction of young fish stocks by reactor condenser cooling systems, and the leakage of radionuclides from storage and processing of spent nuclear fuels. Nuclear plants bear potentially catastrophic vulnerability to earthquakes, requiring seismic limitations on siting and co-locating nuclear plants and/or increased costs for improved seismic resistance.

But chief among nuclear power's environmental impacts is nuclear waste – specifically, the production of SNF. As noted above, although nuclear power emits substantially less harmful greenhouse gases than fossil fuels, the nuclear fuel cycle produces a deadly and long-lasting byproduct: highly radioactive spent nuclear fuel. At high doses, radiation exposure will cause death.[14] At lower doses, radiation still has serious health effects, including increased cancer risks and serious birth defects such as mental retardation, eye malformations, and small brain or head size.[15]

Along with serious health consequences, spent nuclear fuel remains dangerous for millennia. The United States Court of Appeals for the D.C. Circuit described it thus: "radioactive waste and its harmful consequences persist for time spans seemingly beyond human comprehension. For example, iodine-129, one of the radionuclides expected to be buried at Yucca Mountain, has a half-life of seventeen million years." *Nuclear Energy Institute, Inc. et al., v. Environmental Protection Agency*, 373 F.3d 1251, 1258 (D.C.Cir. 2004), *citing*, Comm. on Technical Bases for Yucca Mountain Standards, Nat'l Research Council, *Technical Bases for Yucca Mountain Standards*, 18-19 (1995).

2. The Federal Response to the Nuclear Waste Challenge – Geologic Isolation.

Because of the lasting dangers associated with nuclear waste, the federal government more than 50 years ago assumed the burden of disposal of the nuclear industry's waste. Some of this history is described in the background section of

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14 National Institutes of Health, Fact Sheet: http://www.nlm.nih.gov/medlineplus/radiationexposure.html (last visited December 9, 2013).

15 *See* Environmental Radiation Protection Standards for Yucca Mountain, Nevada, 64 Fed. Reg. 46,976, 46,978 (Aug. 27, 1999).

these comments and in Appendix A to these comments, but other full treatments of this long story can be found in the following references.[16]

High level nuclear wastes remain dangerous to humans for long periods of time. The D.C. Circuit observed: "[h]aving the capacity to outlast human civilization as we know it and the potential to devastate public health and the environment, nuclear waste has vexed scientists, Congress, and regulatory agencies for the last half-century." *NEI et al.* at 1257. Because of this danger, since the National Academy of Science's original recommendations in 1957,[17] it has been a nearly consensus view among government, industry and environmental stakeholders that the waste from the nation's nuclear weapons program and its commercial nuclear power plants must be buried in technically sound deep geologic repositories, permanently isolated from the human and natural environments. This principle was codified as national policy nearly 30 years ago in the Nuclear Waste Policy Act (NWPA), 42 U.S.C. § 10131(b)(1) and most recently reiterated in President Obama's "*Blue Ribbon Commission on America's Nuclear Future - Report to the Secretary of Energy, January 31, 2012*" (hereafter "BRC Report").

3. The Failure of the Geologic Repository Process.

For reasons identified extensively in Appendix A to our comments, the federal efforts at developing a repository have failed.[18] Thus, the nation finds itself in a situation not dissimilar from the one it found itself in more than 50 years ago. We have an increasing stockpile of nuclear waste and no current plan for managing the waste for the long term. *See* discussion in *New York et al*. at 474 ("At this time, there is not even a prospective site for a repository, let alone progress toward the actual construction of one. Due to the government's failure to establish a final resting place for spent fuel, SNF is currently stored on site at nuclear plants. This type of storage, optimistically labeled "temporary storage," has been used for decades longer than originally anticipated. The delay has required plants

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16 *See e.g*., *Pariahs and Prophets: Nuclear Energy, Global Warming, And Intergenerational Justice*, Dan M. Berkovitz, Columbia Journal of Environmental Law, Volume 17, No. 2 (1992); *One Hundred Centuries of Solitude: Redirecting America's High-Level Nuclear Waste Policy*, Flynn et al., Westview Press, 1995; *Risk and Decisions About Disposition of Transuranic and High-Level Radioactive Waste*, National Research Council of the National Academies, Committee on Risk Based Approaches, Board on Radioactive Waste Management, Division of Earth and Life Sciences (2005); *How Safe is Yucca Mountain*, Remarks of Thomas B. Cochran, Senior Scientist, NRDC, At the Symposium: Uncertainty in Long-Term Planning- Nuclear Waste Management, a Case Study, Vanderbilt University, January 7, 2008; http://docs.nrdc.org/nuclear/files/nuc_08010701A.pdf.

17 National Academy of Sciences, *The Disposal of Radioactive Waste on Land, Report of the Committee on Waste Disposal of the Division of Earth Sciences* (Washington. D.C. 1957).

18 We also incorporate by reference our 2009 comments to draft Waste Confidence Determinations (ML090410724).

to expand storage pools and to pack SNF more densely within them. The lack of progress on a permanent repository has caused considerable uncertainty regarding the environmental effects of temporary SNF storage and the reasonableness of continuing to license and relicense nuclear reactors.").

4. The Proper Scope & Purpose of the Federal Action.

As a result of all of the above, the agency must evaluate the environmental effects of all reasonable alternatives for on-site and off-site storage of waste during and after the period of extended operation; offsite land, water, and air use impacts of continued operations and the storage of additional spent fuel on the surrounding areas; evaluation of the long term impacts and safety of the generation and long-term storage of radioactive waste; the comparative impacts of spent fuel storage in pools versus in dry casks; the implications of on-site storage of waste for decommissioning; the effects of spent fuel disposal and the effects of spent fuel storage and disposal in the event of extended delay or if no final disposal option or repository is ever identified; and alternatives to mitigate these impacts, among other issues. Many of these issues appear to be site specific and cannot be dealt with generically, but in any event we suggest a legally compliant definition of the proposed action in the next comment.

5. <u>Page 1-6</u>. *Alternatives*. "The NRC could pursue several alternatives, other than the proposed action, to address the environmental impacts of continued storage in its licensing actions. • First, the NRC could take no action and address the environmental impacts from continued storage in each of its nuclear power plant and ISFSI initial licensing and license renewal proceedings. • Second, the NRC could develop a GEIS without incorporating the results into a rule. This approach would allow the NRC to adopt these draft GEIS findings into environmental reviews for future licensing activities, but without the binding effect of a rule. • Third, the Commission could issue a policy statement. The policy statement would not bind licensees and applicants like a rule, but it would provide notice of the Commission's intent to incorporate the findings of the GEIS into environmental reviews for future licensing activities."

NRDC Comment

i. The Framing of the Proposed Action Leads to An Absurd Comparison of Alternatives.

As established above, the issuance or reissuance of a reactor license is a major federal action affecting the quality of the human environment." *New York et.al. at* 7, (*citing New York v. Nuclear Regulatory Comm'n*, 589 F.3d 551, 553 (2d Cir.2009)). The instant DC Circuit ruling further held, "[w]e agree with petitioners that the WCD rulemaking is a major federal action requiring either a FONSI or an EIS. The Commission's contrary argument treating the WCD *as separate from the individual licensing decisions it enables* fails under controlling precedent. ...The WCD makes generic findings that have *a preclusive effect in all future licensing decisions*—it is *a pre-determined "stage" of each* *licensing decision*. NEPA..." *Id*. at 8, emphasis added. In this connection, the Court also noted, "It is not only reasonably foreseeable but eminently clear that the WCD will be used to enable licensing decisions based on its findings.... [the WCD] renders uncontestable general conclusions about the environmental effects of plant licensure that will apply in every licensing decision. See 10 C.F.R. § 51.23(b)."

The failure to analyze meaningful alternatives is a direct result of an improperly framed proposed action. As we suggested above, following the Court's guidance and a common sense reading of NEPA and its implementing regulations, a legally compliant definition of the proposed action would be the following:

> *The NRC proposes to reinstate, as a pre-determined stage of its individual licensing actions for nuclear reactors and Independent Spent Fuel Storage Installations, a binding rule that generically considers, and determines for the purposes of future licensing, reasonably foreseeable and cumulative environmental impacts of continuing to store on the surface of the earth for extended periods, including indefinitely, all spent fuel previously generated and requiring storage pursuant to past Commission licensing actions, and any spent fuel that would be generated pursuant to pending and reasonably foreseeable licensing actions the Commission may undertake in the future*.

An understandable and coherent proposed action would result in meaningful NEPA process. By contrast, in the instant case the failure of this Draft GEIS to take account of the Court's finding the WCD/TSR represents a "predetermined stage of each licensing decision" is evident not only from the wide gap between the Court's plain language and the analytical constructs employed in the Draft GEIS, but also from the fact that the resulting analysis violates a fundamental principle of statutory interpretation: longstanding legal precedent admonishes us not to interpret a statute – NEPA in this instance – in a manner that yields futile results with little or no meaning.[19]

Specifically, NRC Staff has produced a Draft GEIS that, contrary to statute and regulation, fails to consider and compare the environmental impacts (and mitigation options) of a representative range of reasonable alternatives for ensuring prolonged but safe surface storage of spent fuel generated as a direct consequence of past, pending, and

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[19] *See Absurdity And The Limits Of Literalism: Defining The Absurd Result Principle In Statutory Interpretation*, Veronica M. Dougherty, The American University Law Review, Vol. 44:127 (1994) at 127, ("[I]t is a venerable principle that a law will not be interpreted to produce absurd results."), http://digitalcommons.wcl.american.edu/cgi/viewcontent.cgi?article=1523&context=aulr

reasonably foreseeable future licensing actions of the Commission. The Draft GEIS thus yields, *in its own words*, the following "absurd and futile" result: "The environmental impacts of these three [NEPA] alternatives are substantially the same, and the *licensed activities under all three alternatives remain the same*. The alternatives *merely propose alternative means of analyzing* the environmental impacts of continued storage." Draft GEIS at 1-10, emphasis added.

In other words, with a circular reasoning worthy of the famous BBC comedy series "Yes, Minister," this Draft GEIS sets its task as "analyzing alternative means of analyzing*"* the environmental impacts of continued storage, rather than considering reasonably foreseeable *action* alternatives for *implementing* continued storage that could potentially minimize environmental risks and impacts, as the agency is required to do by law. "NEPA's purpose is not to generate paperwork –even excellent paperwork—but to foster excellent *action*." 40 CFR §1500.1 (c).

We are aware of no comparable instance in which a Federal Agency proposing a major federal action – much less one responding to specific NEPA direction from a Federal Court – has sought to substitute a *cost-benefit comparison of alternative procedural pathways for NEPA analysis* in place of the required substantive and searching *environmental impact comparison of reasonable alternatives* required under NEPA. *See* NEPA, 42 U.S.C. §4321, *et seq*.; *see also* 40 C.F.R. §1502.14 and 10 C.F.R. 51.85 and § 51.10-125 and App A. CEQ's regulations governing implementation of NEPA direct that Federal agencies "shall to the fullest extent possible....(b)...emphasize *real environmental issues and alternatives*...(e) Use the NEPA process to identify and assess the *reasonable alternatives to proposed actions that will avoid or minimize adverse effects of these actions* upon the quality of the human environment." 40 C.F.R. §1500.2 (emphasis added).

ii. NRC Has Not Plausibly Defined the Alternative of No Action, or Provided Reasonable Alternatives for Comparison.

In setting out the fundamental purpose of an EIS, CEQ's regulations also state, "It [the EIS] shall provide full and fair discussion of significant environmental impacts and shall inform decisionmakers and the public of the *reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment*. Agencies shall focus on *significant environmental issues and alternatives*..." 40 C.F.R. §1502.1(emphasis added). Satisfying these requirements is a non-discretionary duty of the NRC's NEPA process and obligations under the law. But the analysis of reasonable alternatives in this Draft GEIS fails to meet these requirements. It fails to consider "real environmental issues" *in the context of* "reasonable alternatives to proposed actions that would avoid or minimize adverse impacts," and instead compares the *non-environmental* costs and benefits of codifying its environmental analysis with three alternative procedural pathways for completing NEPA review, an approach fails to comply with

NEPA's basic requirements, and *delivers the absurd result of literally performing NEPA analysis on ways to carry out NEPA analysis*.

Since NRC's framework for NEPA analysis fails at this fundamental level, it stands to reason that this Draft GEIS fails many other specific regulatory standards for a legally sufficient EIS. The analysis of "alternatives, including the proposed action...is *the heart of the environmental impact statement*....it should present *the environmental impacts of the proposal and the alternatives in comparative form*, thus *sharply defining the issues* and providing *a clear basis for choice among options* by the decisionmaker and the public..." agencies *shall rigorously explore and objectively evaluate all reasonable alternatives* ... and devote *substantial treatment to each alternative considered in detail* including the proposed action so that *reviewers may evaluate their comparative merits*." 40 CFR §1502.14 (emphasis added). These requirements affecting the environmental analysis of the proposed action and reasonable alternatives are substantially echoed in the Commission's own regulations at §51.71 (d) and §51.125, Appendix A paras (5) and (7).

But in this Draft GEIS, the required rigorous and objective exploration of all reasonable alternatives, providing an environmental evaluation of their "comparative merits" to identify those that "would avoid or minimize adverse impacts," is reduced to less than 2 pages, *none of which actually describe or compare environmental impacts*! *See* Draft GEIS Subsection 1.6.2 "Other Reasonable Alternatives," p. 1-7. The subsection comparing "reasonable alternatives" is comprised of two short paragraphs, barely 10 lines of text in total. Draft GEIS Subsection 1.6.4 , "Comparison of Reasonable Alternatives" at 1-10.

This is cursory treatment for the supposed "heart of the environmental impact statement." This Draft GEIS is unable to provide such comparative environmental analysis, because it fails to define, consider, and compare the environmental consequences of a range of reasonable alternatives for implementing continued and potentially indefinite storage of spent fuel arising from future licensing actions, including the mandated alternative of No Action. Logically, the latter should be defined in this Draft GEIS, as in thousands of other federal NEPA documents, as the *continuation of the policy and environmental status quo assuming the Agency does not undertake the Proposed Action, or any of the action alternatives assessed in detail and determined to be reasonable*.

iii. The "No Action Alternative" is Not a "No Action Alternative" And It Leads to An Arbitrary and Capricious Result.

As a first point, the environmental status quo already *includes* substantial continued surface storage of spent fuel generated pursuant to previous NRC licensing actions and licenses that remain in force, but *not* the storage of spent fuel arising from pending and future licensing actions that would be enabled by the proposed reinstatement of a revised WCD/TSR.

Thus a NEPA compliant No-Action Alternative would encompass the environmental consequences of continuing to store on the surface the different extant types, ages, and "burn-ups" of spent fuel that fit within this bounding condition, based on the existing pool storage and dry cask capacities and currently available technologies required to responsibly manage this amount of spent fuel under existing licenses and allowable amendments thereto.

This analytically meaningful No Action Alternative would delineate quantitatively the current and projected types, characteristics and volumes of spent nuclear fuel that have been and will be produced over time *under the authority of existing operating licenses until their currently applicable dates of expiration*, the environmental risks and reasonably foreseeable impacts of continuing the current practice of transferring older spent fuel to dry casks only when pool storage capacity is on the verge of being exceeded, and options for mitigating these impacts that the Agency could reasonably be expected to take in the absence of implementing its Proposed Action. Since the Federal government now legally holds nominal title to this spent fuel, NRC must consult with other agencies (e.g. DOE and EPA) and describe the range of reasonably foreseeable actions these agencies could undertake that would alter the environmental risks and impacts from future storage of this spent fuel prior to its disposition in a permanent geologic repository.

In contrast to the above posited scenario, NRC's Draft GEIS arbitrarily and capriciously defines its "No-Action Alternative" as one in which "the NRC would take no action to *generically address the environmental impacts* of continued storage." Draft GEIS at 1-6, line 24. The agency is literally stating that it is comparing the environment impacts arising from *not* preparing a "generic analysis" to the impacts of preparing one! As if this were not sufficiently absurd by itself, the bogus character of this alternative is further exposed by the fact that preparation of the Draft GEIS *is obviously itself an action* that "generically address[es] the environmental impacts of continued storage." In other words, even within its cramped and noncompliant NEPA decision framework, this purported "No Action Alternative" already embodies a major component of the agency's Proposed Action, which by law and judicial precedent it is barred from doing.

The Draft GEIS then compounds its NEPA noncompliance by noting that under the No Action Alternative, which by law must assume the absence of the Proposed Action, the Commission would nonetheless be "likely" to pursue the *same objective* (of making a generic environmental determination) by "first construct[ing] complete analyses of the issues previously addressed by earlier Waste Confidence proceedings resulting in the adoption and revision of 10 CFR 51.23 [i.e. the WCD/TSR] for use in site-specific NEPA reviews, and then incorporat[ing] by reference the applicable findings from the first few published environmental documents that used the analyses. This approach could ultimately lead the NRC *to consider the issue through a generic and replicable analysis*." Draft GEIS at 1-6, line 32 (emphasis added). In short, this capricious and self-interested framing of the "No Action Alternative," which already fails for being devoid of environmental content, also turns out to be a bureaucratic ruse, and just another route to achieving a "a generic and replicable analysis" of spent fuel storage that can be invoked at will into future licensing actions.

iv. The Alternatives Analyzed In the Draft GEIS Are Arbitrary and Capricious.

By statute, a "major federal action" warranting preparation of an EIS is one "significantly affecting the quality of the human environment." 42 U.S.C. § 4332(2)(C). The minor bureaucratic act of selecting among four alternative pathways for completing NEPA documentation on continued spent fuel storage obviously does not, in and of itself, rise to the level of a "major federal action significantly affecting the quality of the human environment," and therefore it cannot legitimately serve as the appropriate decision analysis framework for this Draft GEIS. Not surprisingly, the Draft GEIS tacitly reaches the same conclusion by failing to quantify, compare, contrast, and qualitatively discuss the environmental impacts (including mitigation) of its two supposed "reasonable alternatives."

Indeed, in place of the required comparative NEPA analysis of reasonable alternatives for implementing the proposed action and mitigating environmental harms, we find instead a "Cost-Benefit Analysis" (Draft GEIS Section 7.0) confined to reviewing the legal, financial, and "public perception" costs and benefits of the four agency administrative options that could in some fashion render an the required analysis of the long-term impacts of prolonged surface storage of spent fuel. However, according to the Draft GEIS, these costs and benefits "*do not include the environmental impacts of continued storage*, an activity that will occur regardless of *the alternative that the NRC selects to consider its impacts*." Draft GEIS at 7-1, emphasis added.

But NRC's NEPA obligation cannot be nonsensically reduced to the mere selection of a paperwork alternative for *considering* environmental impacts. Rather the Draft GEIS must analyze the environmental consequences of reasonable alternatives for actually *implementing* continued storage of spent fuel the Commission may authorize in future commercial power reactor and spent fuel facility licensing actions. This analysis must embrace a range of reasonable surface storage alternatives with greater or lesser environmental impacts, over a relevant range of time periods extending from an initial 20-year license renewal to indefinite storage. For more distant time periods, the analysis must consider the consequences for the human and natural environment in the absence of institutional controls.

v. NRDC's Description of a Representative Range of Reasonable Alternatives.

Figure 1 presents an illustrative matrix of reasonable alternatives and the various factors for considering the impacts of each alternative. This matrix is intended to be neither definitive nor exhaustive, but rather indicative of the range of reasonable alternatives NRC must by law consider pursuant to its proposal to determine in advance the environmental impacts of future licensing actions that would authorize continued production and surface storage of SNF for extended periods, including indefinitely. It can hardly be stressed enough that under NEPA, *it is the agency's most important task to formulate a set of reasonable alternatives with greater and lesser environmental impacts that fairly represent the domain of plausible agency actions that could achieve its purpose and need for action while furthering the aims of NEPA.*

Despite being made aware, during and immediately after the public scoping process, of its failure to define a representative range or indeed any reasonable alternatives for detailed environmental analysis, the agency rejected or ignored all these comments and in this Draft GEIS persists in its failure to subject a range of reasonable alternatives for agency action to detailed environmental analysis.

In order to ensure NRC cannot claim commenters did not sufficiently describe the nature of the reasonable alternatives they believe must be considered and subjected to detailed analysis under NEPA, NRDC offers the following narrative descriptions of the alternatives outlined in *Figure 1*, beginning with the appropriate definition for the statutorily mandated evaluation of the consequences of taking "No Action." Each potential reasonable action alternative, whether these or others the agency may belatedly define after considering public comments on this Draft GEIS, must consider all the major factors that could cumulatively or collectively have a bearing on that alternative's environmental impacts. The range of such factors is indicated in *Figure 1* at page32, and includes at a minimum consideration of the following:

- *Relevant timescales*, which are the "Licensed Lifetime of Facilities," "Short-Term Storage" for up to 60 years after license expiration; "Long-term Storage" for up to 160 years after License Expiration; and "Indefinite Storage." Detailed analysis may reveal technical limitations in surface storage technology and fuels that make other specific timescales relevant – for example, some fuels types may not maintain their cladding integrity for the full term of so-called "Short-Term Storage," which already implies a maximum irradiated fuel age of 140 years, and lesser terms will thus need to be considered, or specific mitigation actions proposed.

- *Alternative Storage Modes & Configurations* (Spent Fuel Pools with At-Reactor Dry Storage (ARDS); Upgraded Spent Fuel Pools and License-Extended/Expanded ARDS; Regional Consolidated Dry Storage (RCDS); and a Single National Consolidated Dry Storage Facility (NCDS). Various sequences and combinations of these storage modes need to evaluated and compared in the alternatives analysis.

- *The Safety-Relevant Classes of Spent Fuel Requiring Continued Storage*, (commercial low-enriched uranium (LEU) oxide "Low Burn-up" SNF, commercial LEU oxide "High Burn-up" SNF, and "Other Fuels" requiring special consideration in a prolonged surface storage scenario, e.g. High Temperature Gas Reactor (HTGR), Plutonium MOX, and Damaged fuels).

- *Storage Cask Technology Options*, including repackaging options for deteriorating fuel and fuel stored in non-qualifying casks for transport or extended surface storage, (e.g., "Storage Only"; "Transport Only"; "Dual-Purpose" storage and transport). The Draft GEIS must discuss new proposed and reasonably foreseeable cask and storage technologies and their implications for prolonged surface storage safety and environmental impacts.

- *Reliance vs. Erosion of Institutional Controls as a Function of Time* –The Draft GEIS assumes institutional controls will necessarily ensure continued public safety and security of SNF surface storage facilities, with no significant increases in environmental consequences (we address this misguided proposition later). While this may be deemed reasonable over a short term (e.g. storage during the entire extended term of licensed operation), based on the sad history of managing radioactive and other forms of hazardous waste generated by large U.S. industrial programs, such as the production of nuclear weapons and rocket fuel, this is not a reasonable assumption to apply to the full terms of more extended storage scenarios, in which various levels of degradation and loss of such controls could well occur.

Based on historical experience, for any scenario in which nuclear waste (SNF) is stored on the surface longer than 20 years following expiration of the extended reactor license term – which means some spent fuel could already be 80 years old – the agency must evaluate plausible scenarios in which the responsible commercial entities go bankrupt, or otherwise assert the federal government's sole fiduciary responsibility, which the government then fails with sufficient alacrity to assume, and thus institutional controls are lost, forcing primary reliance on the engineered barriers designed into the storage systems. It is critically important for NRC to assess, and the public to know, the inherent resilience of such storage systems and how long they may reasonably be relied upon to passively protect the environment and the public without active intervention by external institutional managers.

REPRESENTATIVE MATRIX OF FOUR NEPA REASONABLE ALTERNATIVES FOR DETAILED CONSIDERATION IN THE NRC DGEIS for FUTURE LICENSING ACTIONS SUPPORTED BY A REVISED WCD/TSR

	Time Periods & SNF Discharges (in millions of Metric Tons)							Surface Storage Modes				Spent Fuel Classes (%)			Cask Technology Options (including repackaging options)			Institutional Controls	
																		KEPT	LOST
Alternatives	Licensed Life	MT	"Short-Term" Storage	MT	"Long-Term" Storage	MT	Indefinite Surface Storage	SFPs + At- Reactor Dry Storage (ARDS)	Upgraded SFP's + Extended ARDS	Regional consolidated Dry Storage (RCDS)	Single National CDS	"Low Burn-up" SNF	"High Burn-up" SNF	Other: HTGR Pu MOX Damaged	Storage Only	Transport Only	Dual-Purpose	Assume Institutional Controls Apply	Assume Licensed Engineered Barriers Only
"<u>No Action</u>": continued storage of SNF discharges "baked-in" under *existing* licenses	Current licensed reactor SFP's (either 40 or 60 yrs) and ARDS (20 – 60) years		Assumes repository available when *current* storage licenses expire - no extensions		Not Available (N/A)		N/A	Requires all SFP in casks by end of current license term (40 or 60 yrs)	(N/A)	N/A	N/A	Discuss storage amounts, aged fuel issues in DGEIS Analysis	DGEIS must discuss amounts and safe storage issues/ options	DGEIS must discuss amounts and safe storage issues/ options	DGEIS must consider all relevant issues	DGEIS must consider all relevant issues	DGEIS must consider all relevant issues	YES (when < 100 years)	NO (this option is near-term)
<u>RA #1</u>: "License Extension Only" (based on current SFP/ISFI licenses)	Assumes repository when max. license extensions "supportable under current regs" run out		</= 60 years beyond licensed reactor life		Describe feasible options, if any, within ambit of licenses extendable under current rules		Not Feasible: this option assumes license extension only	YES (but discuss risk in credits given to "aging management" programs to maintain safety)	YES (but discuss risk in credits to "aging manage-ment" to maintain safety)	NO (requires new license)	NO (requires new license)	Discuss per above	Discuss per above	Discuss per above	Evaluate options and impacts	Evaluate options and impacts	Evaluate options and impacts	YES	YES (for Long-Term Storage analysis)
<u>RA # 2</u>: Store SNF from current licensed & proposed reactors with COLs received by 12-31-2030	Assume RA # 1 plus SNF from all new reactors with license applications as of 12-31-12.		Licensed life plus 60 years		Short-term storage + 100 years		Describe Aging Limits, New Licensing Req'mnts & Tech Options	YES	YES	YES (define #, capacities, features & size of sites; geographic regions served)	YES (define required capacity and suitable locations)	Discuss per above	Same as above + new fuel types (e.g thorium, U super-dense, silicon-carbide)	Discuss per above	Discuss per above plus evaluate storage impacts of new fuels	Discuss per above plus evaluate storage impacts of new fuel types	Discuss per above plus evaluate storage impacts of new fuel types	YES (for Short- and Long-Term Periods)	YES (for Long Term & Indefinite)
<u>RA # 3</u>: Constant Nuclear Market Share Scenario	Assume RA #1 baseline SNF plus 20 % share of power generation for 60 years		Calculate SNF based on license periods + 60 years of storage		Short-term storage + 100 years		Same as above	YES	YES and NO (Also discuss "Direct to RCDS "Option	YES (discuss same as above)	YES (discuss same as above)	Discuss per above	Discuss same as above	Discuss per above	Discuss per above	Discuss per above	Discuss per above	Discuss per above	Same as above plus evaluate storage impacts of new fuel types
<u>RA# 4</u>: Nuclear "Major Growth" Scenario	RA #1 plus doubling of present nuclear output by 2040 and 60 years of SNF discharges per new reactor		Calculate based on existing /extended and new license terms plus 60 years of continued storage		Short- term storage + 100 years		Same as above	YES	YES and NO (Also discuss "Direct to RCDS "Option"	YES (discuss same as above)	YES (discuss same as above)	Discuss per above	Discuss per above	Discuss per above	Discuss per above	Discuss per above	Discuss per above	Discuss per above	Discuss per above

vi. Defining and Evaluating the Alternative of "No-Action:" NRDC's example.

Logically, and as a matter of law, the alternative of "No Action" should be defined in this Draft GEIS (as it is in thousands of other federal NEPA documents) as the continuation of the policy and environmental status quo assuming the Agency does not undertake the Proposed Action, or any of the action alternatives assessed in detail and determined to be reasonable.

In the instant case, the environmental status quo already includes substantial continued surface storage of spent fuel generated pursuant to previous NRC licensing actions and licenses that remain in force, but does not include the storage of spent fuel arising from pending and future licensing actions that would be enabled by the proposed reinstatement of a revised WCD/TSR. Thus a NEPA compliant analysis of the No-Action Alternative would encompass the environmental consequences of continuing to store on the surface for various terms the different extant types, ages, and "burn-ups" of spent fuel that fit within this bounding condition, based on the existing licensed pool storage and dry cask capacities and currently licensed technologies required to responsibly manage this amount of spent fuel under existing licenses and allowable amendments thereto.

Such an analytically meaningful No Action Alternative would delineate quantitatively the current and projected types, characteristics and volumes of spent fuel that have been and will be produced over time under the authority of existing operating licenses until their currently applicable dates of expiration, the environmental risks and reasonably foreseeable impacts of continuing the current practice of transferring older spent fuel to dry casks only when pool storage capacity is on the verge of being exceeded, and options for mitigating these impacts that the Agency could reasonably be expected to take under its existing rules in the absence of implementing its Proposed Action.

Under current law the Federal government will hold nominal title to this spent fuel. Thus, NRC must consult with other agencies (e.g. DOE EPA, and DOT)[20] and describe the range of reasonably foreseeable actions that these agencies could undertake that could alter the environmental risks and impacts from future storage of this spent fuel prior to its transport and disposition in a permanent geologic repository. Under No Action the DGEIS must evaluate the environmental impacts of the storage of SNF authorized by existing licenses. The no action alternative assumes the agency undertakes no further new licensing actions or license extensions, and instead relies solely on its existing regulatory authorities to approve license amendments and require installation of safety upgrades.

[20] Indicative of NRC's haste to finalize this proposed rulemaking and GEIS, NRDC notes with significant surprise that NRC notes "there are no formal cooperating agencies identified in the Waste Confidence Environmental Review." Draft GEIS at xxvii. Given the major roles assigned to DOE, EPA and DOT in the management, storage, transportation and standard setting for SNF we find such lack of formal cooperation nothing short of astonishing.

vii. Reasonable Alternatives: NRDC's Example

Reasonable Alternative One ("RA" #1) is a "License Extension Only" alternative, based on current-licensed Spent Fuel Pool (SFP) and independent at-reactor dry cask storage installation capacities. It assumes the availability of a government-provided geologic repository whenever the maximum license extension for each at-reactor surface storage facility, safely supportable within current NRC regulations, runs out. This time period can be expected to vary across facilities, and thus in analyzing this alternative, the NRC must construct a time vs tonnage profile of how much SNF would need to be transferred and when. Transfer to a Regional Consolidated Dry Storage (RCDS) or National Consolidated Dry Storage (NCDS) facility would not be possible under this alternative, as these would be new facilities requiring new licensing actions. Cask storage and transport options for each of the relevant fuel classes must be discussed with this timeframe in mind. Detailed analysis of this option could serve to identify future critical decision points and vulnerabilities built into the current spent fuel management structure that need to be addressed if extended surface storage is going to be implemented safely with minimal environmental impacts. If analysis of this option reveals a disconnect between the earliest plausible date for repository availability and expiring surface storage capacity, it could serve to guide NRC, DOE, other decision-makers, and the public to an understanding of how much RCDS or NCDS will be needed, and when. The agency could reasonably explore variants of this alternative, such as new licensing actions for at-reactor dry storage facilities only, to facilitate transfer of spent fuel to safer storage configurations than current SFP's.

Reasonable Alternative Two (RA #2) is a "Near-Term Nuclear Growth" that extends and builds upon the analysis in RA #1 by considering the environmental impacts of SNF storage proceeding from new reactor and storage facility licensing actions based on the proposed revised WCD/TSR, with defined by the universe of COL application requests received by the NRC as of 12/31/2012 and assumed, for the purpose of NEPA analysis, to be granted before the end of 2030. This alternative requires analysis of the extended safe storage requirements and storage technology/facility options for the amount and types of SNF produced under a scenario that assumes a 60-year licensed lifetime for each newly licensed reactor and the same short-, long-, and indefinite storage terms already adopted for the DGEIS truncated analysis of environmental consequences, although in the course of detailed analysis the NRC staff may well uncover the technical and environmental significance of additional relevant timeframes, intermediate between those pre-selected for analysis. For example, certain types of fuel and cask combinations may have limited sharply lifetimes when it comes to preserving the "defense-in-depth" barrier against radionuclide leakage provided by preserving both continued fuel cladding integrity and the structural integrity of cask containment barrier.

This option would also go beyond RA #1 in considering the safety and environmental requirements for, and impacts of new licensing actions authorizing the creation of one or more RCDS facilities, or a single NCDS site, and additional at-reactor storage sites The analysis should seek to identify the environmentally superior configurations or combination of these options for extended surface storage. It would also generically describe the necessary, functions, capacities and technical features that would likely be common to all such facilities of a given type, discuss plausible alternative definitions of the geographic regions that might be served by each such facility (e.g. a single national RCDS site, two RCDS sites covering the Eastern and Western halves of the country, multiple RCDS sites geared to the different specific geotechnical, climate, and weather environments that prevail in different parts of the country, e.g. "Northeast/Mid-Atlantic;" "Southeast" "Midwest" and "Western U.S." This analysis would identify those aspects of continued surface storage that are most sensitive to particular regional or site-specific conditions, such as seismicity, humidity, salinity, peak, low and average temperature ranges, flood-risk, tornado risk, hurricane risk, etc., and thus define the limits of environmental issues subject to resolution in a "Generic EIS," versus those that would need to be further considered in a tiered "regional" and/or site-specific EIS.

Because the time frames and options for agency action are broader than the previous two alternatives, it will need to consider a wider range of cask/fuel combinations, SNF transport options, and alternative consolidated storage configurations, to identify the environmentally preferred sequence and combination(s) of extended pool storage, on-site drycask storage, and offsite consolidated interim storage that appropriately balance the prospective cost, complexity and technical risk of various continued surface storage options with their prospective benefits for public health and the environment.

Reasonable Alternative Three (RA #3): This alternative is based on the "Constant Nuclear Market Share Scenario," a widely perceived minimum nuclear growth scenario among proponents of nuclear energy and de-carbonization that posits nuclear power generation will grow at least enough to maintain its longstanding share of total U.S. grid-connected power generation at 20%. It assumes the RA #1 baseline inventory of SNF plus an added SNF inventory corresponding to a 20 % nuclear share of US power generation for the next 60 years. In connection with all modest-to-major nuclear growth scenarios occurring within the constraint of no geologic repository availability (this option and RA#4 below), it may prove both cost-effective and environmentally beneficial to consider a "Direct to RCDS" option that promptly transfers SNF five years after irradiation from Spent Fuel Pools directly to an RCDS or NCDS, skipping the intermediate step of on-site dry cask storage, which today is focused on freeing-up space in densely-packed SFP's to accept scheduled discharges of irradiated fuel from the reactor. It should also examine an "at-reactor storage only variant" that could prove cost-effective if a geologic repository is developed on a timeframe that makes interim consolidated storage unnecessary or uneconomic. Analysis of this alternative must also consider the potential impacts of new fuels and fuel cycles (examples are listed in the Table) on SFP, transport cask and long-term storage cask performance, in both normal storage conditions and accidents.

Reasonable Alternative Four (RA#4): This alternative, an aggressive "Major Nuclear Growth" scenario, represents a reasonably foreseeable upper bound on the amount of SNF that might be generated by a doubling of present annual nuclear output (measured in terawatt-hours of electricity produced) achieved by 2040, with 60 years of SNF discharges assumed for each new licensed reactor. Thus this scenario envisions sharply increasing nuclear fuel discharges in need of continued surface storage until the year 2100, followed by extended surface storage for periods of 60 and 160 years after this date.

As shown in the Figure, analysis requirements are similar to RA#3, and this alternative, and indeed all extended storage alternatives beyond 30 years, must be subjected to the plausible constraint that institutional controls may begin to fail relatively soon after termination of an operating license for a variety of historically plausible reasons – financial incapacity, corporate dissolution or managerial malfeasance, institutional neglect, political gridlock, war, civil strife, etc. We suggest the historical record suggest 20 years following reactor license termination is an appropriately conservative figure – as noted, some stored fuel will be 80 years old at this point and in need of special measures that may not be forthcoming. But given that the minimum period for continued storage post-licensing considered in the current DGEIS is 60 years, the choice whether to set the dividing line for requiring consideration of partial-to-total "loss of institutional controls" at 30, 40, or 50 years is not crucial to the overall analysis, as long as this remains a significant component of the analysis for each extended storage option.

In place of the required comparative NEPA analysis of reasonable alternatives for implementing the proposed action and mitigating environmental harms, like the one outlined above, we find instead a "Cost-Benefit Analysis" (Draft GEIS Section 7.0) confined to reviewing the legal, financial, and "public perception" costs and benefits of the four agency administrative options that could in some fashion render an the required analysis of the long-term impacts of prolonged surface storage of spent fuel. However, according to the Draft GEIS, these costs and benefits "*do not include the environmental impacts of continued storage*, an activity that will occur regardless of *the alternative that the NRC selects to consider its impacts*." Draft GEIS at 7-1, emphasis added.

But NRC's NEPA obligation cannot be nonsensically reduced to the mere selection of a paperwork alternative for *considering* environmental impacts. Rather the Draft GEIS must analyze the environmental consequences of reasonable alternatives for actually *implementing* continued storage of spent fuel the Commission may authorize in future commercial power reactor and spent fuel facility licensing actions.

And as a final matter, putting aside for a moment the broader question whether NRC's Draft framework used in this GEIS for analyzing its NEPA obligations complies with the statute and applicable regulations—it doesn't—and focusing on the narrower question whether these are even distinct and cognizable "alternatives" with discernible environmental impacts, NRDC is hard pressed to detect any meaningful difference between the proposed alternatives as all but one involve preparation of a Draft GEIS, but not its subsequent adoption into a proposed rule. However, "reasonable alternatives" are, by definition, alternative means (with greater and lesser environmental impacts) for *accomplishing the agency's purpose and need for action*—that is what makes them "reasonable"—and NRC's purpose and need is defined in this Draft GEIS as "improve[ing] the efficiency of the NRC's licensing process by generically addressing the environmental impacts of continued storage."

Since neither of the two "reasonable alternatives" deemed worthy of detailed NEPA analysis could culminate in a discernible agency Record of Decision supporting an agency action that generically determines impacts to "improve the efficiency of the NRC's licensing process," they do not meet the threshold standard of being reasonable alternative means for achieving the agency's stated purpose and need for action. Both alternatives would leave NRC with "Draft GEIS findings" that have no have no legal status, which, if used, would be subject to challenge in site-specific licensing proceedings. In short, the NRC Staff is leading decision-makers and the public through a convoluted, rhetorical hall of mirrors in this Draft GEIS that has nothing to do with good-faith compliance with NRC's legal obligations.

6. Page 1-9. "Cessation of licensing activities and cessation of reactor operations do not satisfy the stated purpose and need for this draft GEIS, which is to improve the efficiency of NRC's licensing process, to prepare a single source that reflects the NRC's current understanding of the environmental impacts of continued storage, and to comply with the remand in the New York v. NRC decision. Abandonment of reactor licensing and the closure of existing plants is not a reasonable alternative to the proposed action because these actions would not meet the NRC's stated objectives in proposing to revise 10 CFR 51.23."

NRDC Comment

This is an inaccurate restatement of the import of NRDC's comments offered during scoping. We address this issue above in our discussion of Scoping. Moreover, since licensing activities may not be resumed absent a Waste Confidence rule, the cessation of licensing activities and reactor operations must necessarily be analyzed under the No Action alternative. Suggesting that this is what NRDC demanded misconstrues the point of NEPA compliance we sought to make the agency understand. Thus, with the above text, NRC inappropriately restricts the alternatives that must be analyzed to comply with NEPA. By any measure, NRC will need to conduct an analysis of spent nuclear fuel either stored permanently at reactor sites or at other above ground (non-repository) site(s), or in various combinations of distributed and consolidated surface storage,as existing stores of spent nuclear fuel and spent fuel yet to be produced from lawfully licensed reactors will continue to pile up. But an analysis that omits an obvious alternative and subset of alternatives directly related to the environmental harms under review is arbitrary and capricious.

7. Page 1-9. "Imposing new regulatory requirements, such as requiring licensees to implement hardened at-reactor storage systems, reduce the density of spent fuel in pools, or expedite transfer of spent fuel from pools to ISFSIs, is outside the scope of this proposed action, which includes alternatives that improve the efficiency of the NRC's licensing process by generically addressing the environmental impacts of continued storage."

NRDC Comment

Consistent with comment #5 above, NRC fails to provide any reasonable basis for not analyzing alternatives that might increase public safety and reduce potential environmental harms by speeding removal of spent nuclear fuel from the pools when appropriately cooled. Moreover, the scope of NEPA does not extend to "imposing new regulatory requirements," and no one is suggesting that it does. But a proper NEPA analysis may uncover *the agency's need to consider* such requirements.

8. Page 1-10. Comparison of Reasonable Alternatives.

NRDC Comment

See Comment #5 above. NRC's inadequate paper alternatives result in the same minimal environmental impacts because the agency has failed to (1) identify the major federal action at issue – licensing nuclear reactors and allowing the production of spent nuclear fuel – and (2) evaluate a set of meaningful alternatives and potential strategies for mitigating the harms. As noted, the analytical framework adopted in this Draft GEIS blatantly subverts the essential purposes of NEPA.

9. Pages 1-12 to 1-17. In pertinent part, NRC writes,

"Institutional controls, i.e., the continued regulation of spent nuclear fuel, will continue. This assumption avoids unreasonable speculation regarding what might happen in the future regarding Federal actions to provide for the safe storage of spent fuel. Although government agencies and regulatory safety approaches can be expected to change over long periods of time into the future, the history of radiation protection has generally been towards ensuring increased safety as knowledge of radiation and effectiveness of safety measures has improved. For the purpose of the analyses in this draft GEIS, the NRC assumes that regulatory control of radiation safety will remain at the same level of regulatory control as currently exists today."

NRDC Comment

The assumptions underlying NRC's evaluation of timeframes are arbitrary and capricious and fail to meet the "hard look" requirements of NEPA.

With respect to NRC's evaluation of the licensed life of the reactor and short-term storage timeframes, we direct the agency to our comments on Appendix E, Analysis of Spent Fuel Pool Leaks, found below.

NRC's fourth timeframe—indefinite storage— consistent with the DC Circuit's directions, assumes a geologic repository does not become available at any point and at-reactor or away-from-reactor ISFSIs would continue to store spent nuclear fuel in dry casks indefinitely. However, NRC goes on to presume the following activities continue uninterrupted for the next several millennia, beyond the span of human history. Specific assumptions articulated by NRC include:

• Continued storage of spent fuel in ISFSIs, including routine maintenance;

• Replacement of ISFSIs and spent fuel canisters and casks every 100 years and thereafter;

• Construction and operation of an away-from-reactor ISFSI (including replacement every 100 years);

• Construction and operation of a Dry Transfer Storage facility (DTS), including replacing the DTS every 100 years thereafter for the millennia to follow.

The NRC acknowledges these activities are the same as those occurring during the "long-term storage period," but, without a repository they must occur repeatedly, forever. NRC defends these assumptions on pages 1-14 and 1-15 and note 2 on those pages.

Described in detail below, NRC's assumptions are arbitrary, capricious and violate NEPA. Institutional controls will fail over the long term and the agency's arbitrary refusal to analyze the consequences of those failures at nuclear waste storage sites around the country violates NEPA's hard look requirement and renders meaningless NRC's response to the DC Circuit's clear directions.

Such a perspective is not NRDC's mere assertion. The National Academy of Sciences and every federal agency that has adopted regulatory requirements related to institutional controls, *including the NRC*, expect failure and have drafted requirements with such an eventuality in mind. Further, every scientific body and federal agency that has examined institutional controls in any context (chemical or radioactive contamination) has evidence of institutional failure. As such is the case, NRC must take account of such failure in its analysis of the environmental impacts of the nuclear waste permitted to be produced under the agency's licensing decisions. And it must do so in this particular EIS.

And finally, in bypassing performing this analysis, NRC would not have had to commence this analysis from whole cloth. DOE, in its Yucca Mountain EIS, provided NRC with at least an initial (albeit inadequate) draft to examine the environmental impacts of the failures of institutional controls at nuclear storage sites. At bare minimum, NRC must return to the drawing board and analyze the environmental impacts of nuclear waste when a geologic repository does not become available and at-reactor or away-from-reactor ISFSIs store spent nuclear fuel in dry casks indefinitely – and institutional controls then fail.

i. Institutional Controls.

Institutional controls, long a part of environmental law, play a crucial role in selecting how best to protect the public from incomplete cleanups where contamination is left on site for extended periods of time. Institutional controls are shorthand descriptions for restrictions placed on land, surface water or groundwater use when it is either technically impossible or economically prohibitive to permanently remove the source of pollution or contamination. The types of restrictions can be "active" institutional controls – often colloquially described as "guns, gates and guards" – or "passive" institutional controls, which range from warning notices to keep trespassers off contaminated sites to deed restrictions specifying how the land can be used henceforth. Regardless of whether institutional controls are active or passive, the purpose is to isolate the remaining contamination or potential harm from the public in an enduring fashion.

The study of institutional controls in environmental law and policy is a legacy of incomplete cleanup of both chemical and radioactive sites around the country [21]. Indeed, the United States has thousands of large and small contaminated sites overlain by a myriad of state and federal regulatory regimes where it was either not cost-effective or technically feasible to reduce the volume of contamination to levels that provide adequate protection for unrestricted uses. Thus, institutional controls exist, agencies adopt policies to implement those controls, and in this Draft GEIS, NRC proposes to conduct nuclear waste management operations for the next several thousand years without any explanation of how those institutional controls might persevere. Draft GEIS at 1-14, 1-15.

[21] On the basic subject of how institutional controls work, see two useful studies of institutional controls in the chemical contamination context: *Estimating The Cost Of Institutional Controls*, John Pendergrass, Environmental Law Institute and Katherine N. Probst, Resources for the Future, March 2005, at http://www.rff.org/rff/Documents/RFF-Report-costs.pdf and *Linking Land Use And Superfund Cleanups: Uncharted Territory*, Robert Hersh, Katherine Probst, Kris Wernstedt and Jan Mazurek Center for Risk Management, at 51-68, 1997 at http://www.rff.org/rff/Documents/RFF-RPT-landuse.pdf.

ii. Agency Adoption of Institutional Controls & the Length of Time Those Controls Can Be Relied Upon.

Several agencies, including NRC, have adopted policies either implementing or relying on institutional controls. Each agency explicitly declines to rely on active institutional controls for more than 100 years and on passive controls or engineered barriers for no more than 500 years. The NRC's licensing requirements for land disposal of radioactive waste adoption state:

> The land owner or custodial agency shall carry out an institutional control program to physically control access to the disposal site following transfer of control of the disposal site from the disposal site operator. The institutional control program must also include, but not be limited to, carrying out an environmental monitoring program at the disposal site, periodic surveillance, minor custodial care, and other requirements as determined by the Commission; and administration of funds to cover the costs for these activities. The period of institutional controls will be determined by the Commission, *but institutional controls may not be relied upon for more than 100 years following transfer of control of the disposal site to the owner.*

10 C.F.R. §61.59(b) (emphasis added).

EPA, along with regulatory requirements for institutional controls in the CERCLA context, has issued environmental radiation protection standards for management and disposal of spent nuclear fuel, high-level and transuranic radioactive wastes. EPA defines active institutional controls in that context as: "(1) controlling access to a disposal site by any means other than passive institutional controls; (2) performing maintenance operations or remedial actions at a site, (3) controlling or cleaning up releases from a site, or (4) monitoring parameters related to disposal system performance." 40 C.F.R. §191.12. EPA defines passive institutional controls in this context as: "(1) permanent markers placed at a disposal site, (2) public records and archives, (3) government ownership and regulations regarding land or resource use, and (4) other methods of preserving knowledge about the location, design, and contents of a disposal system." *Id.* Further, EPA states "active institutional controls over disposal sites should be maintained for as long a period of time as is practicable after disposal; however, performance assessments that assess isolation of the wastes from the accessible environment *shall not consider any contributions from active institutional controls for more than 100 years after disposal*." 40 C.F.R. §191.14(a) (emphasis added).

As an additional insight into how federal agencies have grappled with implementing institutional controls, several years ago NRC staff provided a detailed analysis to the Commissioners on issues associated with implementing the agency's License

Termination Rule (LTR).[22] This work culminated in the Staff's Consolidated Decommissioning Guidance (NUREG-1757)[23]and requirements to comply with 10 C.F.R. §20.1403 *Criteria for license termination under restricted conditions*, which read in pertinent part:

> A site will be considered acceptable for license termination under restricted conditions if: … (b) The licensee has made provisions for legally enforceable institutional controls that provide reasonable assurance that the TEDE from residual radioactivity distinguishable from background to the average member of the critical group will not exceed 25 mrem (0.25 mSv) per year … (e) Residual radioactivity at the site has been reduced *so that if the institutional controls were no longer in effect*, there is reasonable assurance that the TEDE from residual radioactivity distinguishable from background to the average member of the critical group is as low as reasonably achievable and would not exceed either –(1) 100 mrem (1 mSv) per year; or (2) 500 mrem (5 mSv) per year provided the licensee--(i) Demonstrates that further reductions in residual radioactivity necessary to comply with the 100 mrem/y (1 mSv/y) value of paragraph (e)(1) of this section are not technically achievable, would be prohibitively expensive, or would result in net public or environmental harm; (ii) *Makes provisions for durable institutional controls*;(iii) Provides sufficient financial assurance to enable a responsible government entity or independent third party, including a governmental custodian of a site, both to carry out periodic rechecks of the site no less frequently than every 5 years to assure that the institutional controls remain in place as necessary to meet the criteria of § 20.1403(b) and to assume and carry out responsibilities for any

[22] *See Results Of The License Termination Rule Analysis*, May 2, 2003, (SECY-03-0069); online at http://www.nrc.gov/reading-rm/doc-collections/commission/secys/2003/secy2003-0069/2003-0069scy.pdf.

[23] *See*, Consolidated Decommissioning Guidance: Characterization, Survey, and Determination of Radiological Criteria, Final Report, NUREG-1757, Vol. 2, Rev. 1, U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards (September 2006); and *see also* NUREG-0586, Supplement 1 Volume 1, Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities Supplement 1 Regarding the Decommissioning of Nuclear Power Reactors, Main Report, Appendices A through M Final Report, Manuscript Completed: October 2002 Date Published: November 2002 Division of Regulatory Improvement Programs Office of Nuclear Reactor Regulation U.S. Nuclear Regulatory Commission.

> necessary control and maintenance of those controls. (emphasis added).

Thus, in its regulations NRC demonstrates it is cognizant of the need for "durable institutional controls" and the potential consequences to human health and the environment if those controls fail. *See also*, 10 C.F.R. §20.1404 *Alternate Criteria for License Termination.*

iii. "Institutional Controls Will Fail" – National Academy of Sciences.

As seen above, the efficacy and use of institutional controls is a significant and growing element of environmental policy. They have become necessities for the simple reason the polluting entity or government cannot remove the entirety of contamination from a particular site. Federal agencies have adopted regulations explicitly recognizing the difficulties of long-term reliance on institutional controls. And more to the point, there are numerous examples of how and why the institutional controls fail. Even a few examples illustrate the problems facing reliance on institutional controls and the difficulties in formulating "durable," protective remedies for long-term contaminated sites.

The DOE, for example, has created the Office of Legacy Management in its Environmental Management Program. The Office of Legacy Management's mission is to manage the long term stewardship of contaminated nuclear weapons sites *after* whatever cleanup has been done has concluded.[24]

Despite a multi-billion per year cleanup program and an Office of Legacy Management, the government appears to have lost track of significant numbers of formerly utilized sites that remain contaminated. A recent series in the Wall Street Journal by John Emshwiller documented continuing problems at a variety of sites which have receded from the institutional memory of the agencies responsible for assuring they are cleaned up.[25]

Then there is waste the nation has abandoned it cannot track, but evidence of it remains with us today. From 1946 to approximately 1970, the Atomic Energy Commission approved disposing of radioactive wastes by dumping at sea. Wastes were placed in various kinds of packages, predominantly 55-gallon drums, placed on tugs or ships, taken out to ocean dumpsites, and tossed overboard. Radioactivity released from degrading canisters was subsequently found to adsorb instead onto and concentrate in bottom

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[24] *See* DOE's Office of Legacy Management online at http://energy.gov/lm/office-legacy-management.

[25] *See*, e.g., Emshwiller and Singer-Vine, "Waste-Lands: A Forgotten Legacy of Nuclear Buildup," *Wall Street Journal,* October 30, 2013.

sediments. Bottom-dwelling organisms root through those sediments, ingesting the radionuclides and concentrating them in their bodies. They are then consumed by other marine organisms, and then by higher organisms, with radionuclides concentrating as they go up the food chain through a process called bioaccumulation. So, rather than dilution, it turned out there were radioactivity concentration phenomena at work. [26]

Further, a study done by attaching monitoring devices on barrels being dumped found roughly a third of those drums imploded before hitting the ocean floor via the differential pressure. Investigations by EPA personnel in the Alvin submersible of the Farallons Islands dumpsite and one off the East Coast, and earlier similar submersible inspections of the Santa Cruz Basin dumpsite off Santa Barbara, found that in just a few years the barrels had degraded substantially. There was significant corrosion and deformation, and radioactivity was found in the sediments nearby at levels far in excess of fallout background, having leaked from the drums.[27]

Failures of institutional controls in the chemical cleanup context have also been significant. In southern New Jersey, children at a daycare were exposed for significant periods of time to unacceptably high levels of mercury at a former thermometer factory.[28] There are numerous lessons in this particular story, but failure to either clean up the property, or at the least to put a lien on the property and erect signs and fences around it to notify neighbors about the possible hazards, resulted in this statement: "Lisa P. Jackson, the commissioner of the environmental department, conceded in an interview this week that the agency needed better tracking of contaminated sites, clearer cleanup priorities and stronger enforcement efforts. 'This is an example when all three of those kind of collide in a bad way," she said. "It crystallizes some of the things we need to do differently.'"[29]

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[26] For a full treatment of this sad history, s*ee* Jacob Darwin Hamblin, *Poison in the Well: Radioactive Waste in the Oceans at the Dawn of the Nuclear Age,* Rutgers University Press, 2008; and W. Jackson Davis, John Van Dyke, Daniel Hirsch, Mary Anne Magnier, Sherry P. Broeder, *Evaluation of Oceanic Radioactive Dumping Programs,* study presented by the nations of Naura and Kiribati to the London Dumping Convention, LDC7/INF.2, 1982.

[27] *Id*. And for a full recitation of this history in the context of this Draft GEIS and the proposed Waste Confidence rule, *see 50 Years of Power: 500,000 Years of Radioactive Waste*, Daniel Hirsch, Committee to Bridge the Gap, Physicians for Social Responsibility-Los Angeles, Southern California Federation of Scientists 20 December 2013.

[28] *See After Mercury Pollutes a Day Care Center, Everyone Points Elsewhere*, New York Times, Tina Kelly, August 19, 2006, http://www.nytimes.com/2006/08/19/nyregion/19mercury.html?pagewanted=all.

[29] Another excellent press treatment of the long term and related problem of "brownfields," (which allow certain types of pollution to be left in place and capped), is the New York Time's examination of the cleanup of chromium ore in Jersey City, NJ. See *Finding the Bottom of a Polluted Field*, Anthony

There are thousands of sites across the country where unexploded bombs, mortar rounds and other munitions, covering about 10 million acres, according to government records and experts interviewed by ABC News.[30] Even items such as munitions from recent past are unrecognized or not properly handled. ABC News wrote "officials have undertaken an awareness and education campaign to avoid situations like that of Henry Owens, the Tennessee boy whose hand was blown off. 'People have found these things, and they think they are souvenirs, and they bring them home,' Davis said. While 'in most cases, there has to be some kind of force [to detonate a buried ordnance], we really stress what we call the three Rs: recognize, retreat and report. We do not want people picking things up and driving them to the police, or bringing them home,' Davis said."[31]

Finally, in a thorough report addressing concerns that institutional controls may not effectively protecting human health and the environment in the context of chemical contamination, in 2005 the Government Accountability Office reviewed (1) the extent to which institutional controls are used at sites addressed by EPA's Superfund and RCRA corrective action programs; (2) the extent to which EPA ensures that institutional controls at these sites are implemented, monitored, and enforced; and (3) EPA's challenges in implementing systems to track these controls.[32]

The GAO found institutional controls were used at most of the Superfund and RCRA sites where cleanup was completed and waste was left in place. Further, the GAO found that while EPA's guidance advises that four key factors be taken into account in selecting controls for a site (the objective, mechanism, timing and responsibility for the institutional control), 69 of the 108 remedy decision documents examined did not demonstrate that all of these factors were sufficiently considered to ensure that planned controls will be adequately implemented, monitored, and enforced.[33] The GAO explained:

> Although EPA has taken a number of steps to improve the management of institutional controls in recent years, we found that controls at the

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DePalma, February 5, 2006, http://www.nytimes.com/2006/02/05/nyregion/05chromium.html?pagewanted=all.

30 *See* Casualties of War, Chris Francescani, ABC NEWS Law & Justice Unit, Jan. 24, 2008, http://abcnews.go.com/TheLaw/story?id=4179408&page=1.

31 *Id.*

32 See *Hazardous Waste Sites: Improved Effectiveness Of Controls At Sites Could Better Protect The Public,* Government Accountability Office, GAO-05-163, January 2005, http://www.gao.gov/assets/250/245140.pdf.

33 Id. at 5.

> Superfund sites we reviewed were often not implemented before site deletion, as EPA requires. In some cases, institutional controls were implemented after site deletion while, in other cases, controls were not implemented at all. An EPA program official believed that these deviations from EPA's guidance may have occurred because, during the sometimes lengthy period between the completion of the cleanup and site deletion, site managers may have inadvertently overlooked the need to implement the institutional controls.[34]

We conclude this subsection of our response to the NRC's arbitrary and capricious assertion, "[i]nstitutional controls, i.e., the continued regulation of spent nuclear fuel, *will continue*," by noting the observation of the National Academy of Sciences: "institutional controls *will fail*."[35]

iv. The NRC Should Have Analyzed the Environmental Impacts of Nuclear Waste in the Event a Repository Never Opens.

The DC Circuit was explicit in its directions to NRC, "[u]nder NEPA, an agency must, look at both the probabilities of potentially harmful events and the consequences if those events come to pass." *New York et al.* at 478, *citing Carolina Envtl. Study Grp. v. U.S.*, 510 F.2d 796, 799 (D.C. Cir. 1975). In light of federal and state regulatory understanding of institutional controls, the views espoused by the National Academy of Sciences and the GAO – indeed, the entire trajectory of nearly any entity that has addressed the topic of protection of public health and the environment from significant sources of contamination left in place, NRDC finds astonishing NRC's conclusion, without a shred of support, that "[i]nstitutional controls, i.e., the continued regulation of spent nuclear fuel, will continue."

Rather, NRC should have, at minimum, commenced work on a thorough analysis of the environmental impacts of the failure of institutional controls at reactor storage sites or IFSIs. Here, as the NRC acknowledges, (note 2 on page 1-15), a first cut at just such an analysis to at least serve as a starting point was available to them. DOE performed just such an analysis in its Final Yucca Mountain EIS, even though it is inadequate to the task for this Draft GEIS in several important ways, discussed below.[36]

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[34] *Id*. at 6.

[35] *See* National Academy of Sciences/National Research Council, Board on Radioactive Waste Management, *Committee on the Remediation of Buried and Tank Waste, Long-Term Institutional Management of the U.S. Department of Energy Legacy Waste Sites*, August 2000, at page 97 (emphasis added).

[36] See *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*

As a "no-action" alternative in the context of the Yucca Mountain EIS, DOE posited two scenarios for nuclear waste over a 10,000 year period. Scenario 1 assumed institutional controls last for the entirety of the 10,000 year period. Scenario 2 assumed no effective institutional control of the storage facilities after approximately the first 100 years. Such an analysis is consistent with regulatory understandings of the efficacy of institutional controls (no reliance on them after 100 years) and, as DOE itself noted, "provide[s] a basis for evaluating an upper limit of potential adverse human health impacts to the public from the continued storage of spent nuclear fuel and high-level radioactive waste." At 7-33.

However, we also concur with the views of Dr. Arjun Makhijani on this precise subject.[37] Scenario 2 is a useful starting point for NRC as an analytical tool, but only that – a starting point. Dr. Makhijani provided several examples of assumptions in Scenario 2 that are scientifically inappropriate for a Waste Confidence EIS and examples of DOE underestimating the impacts of the no-action alternative scenarios in a number of ways. *Id.* But in any event, the probabilities and consequences of the harm that should have been subjected to a "hard look" in this Draft GEIS were at least initially examined by a federal agency several years ago, no matter the weakness of the initial analysis. Here's how DOE did the work and it could have at least served as a starting point for NRC.

a. DOE's Scenario 2.

As noted, after 100 years, Scenario 2 assumes no effective institutional control and storage facilities are essentially abandoned (but the engineered barriers remain). DOE assumes no health risks for workers during the initial century. For the remaining 9,900 years, DOE assumes spent nuclear fuel and high-level radioactive waste storage facilities at 72 commercial and 5 DOE sites would begin to deteriorate and that radioactive materials is released to the environment, contaminating the local atmosphere, soil, surface water, and groundwater. Appendix K of the EIS provides details of facility degradation, radioactive material environmental transport, and human radiological exposure and dose models. *See* discussion at 7-33. Although the size of the affected area would be impossible to predict accurately for each site, DOE believed it would involve tens to hundreds of acres at each of the 77 sites.[38]

(DOE/EIS-0250), found online in full at http://energy.gov/nepa/downloads/eis-0250-final-environmental-impact-statement; and http://energy.gov/sites/prod/files/EIS-0250-FEIS-01-2002_0.pdf.

[37] *See* Declaration of Dr. Arjun Makhijani Regarding the Scope of Proposed Waste Confidence Environmental Impact Statement, Section 8.0, pages 24-28, January 2, 2013, http://ieer.org/wp/wp-content/uploads/2013/01/WasteConfidence_EIS_Scoping_MakhijaniDeclaration2013.pdf.

[38] For its analysis (see Appendix K, Section K.2.1), DOE collected information from each of the 77 sites where spent nuclear fuel and high-level radioactive waste was located at that time and then divided

b. Impacts of Scenario 2.

DOE's environmental impacts analysis, while inadequate as Dr. Makhijani describes, speaks for itself and make clear why NRC should have at least endeavored to use it as a starting point for examining the environmental impacts of nuclear waste in the event of never developing a repository:

> During the early period (200 to 400 years after the assumed loss of institutional control), acute exposures to external radiation from the spent nuclear fuel and high-level radioactive waste material could result in prompt fatalities. In addition, after a few thousand years onsite shallow aquifers could be contaminated to such a degree that consumption of water from those aquifers could result in severe adverse health effects, including premature death. Uncertainties about these localized impacts are related primarily to the inability to predict accurately how many individuals could be affected at each of the 77 sites over the 10,000-year analysis period.

See FEIS at 7-41. DOE went also noted:

> In addition to the 3,300 potential cancer fatalities under Scenario 2, more than 20 major waterways of the United States that currently supply domestic water to about 31 million people (for example, the Great Lakes; the Mississippi, Ohio, and Columbia Rivers; and many smaller rivers along the Eastern Seaboard) could be contaminated with radioactive material. Under this scenario, the shorelines could be contaminated with long-lived radioactive materials (for example, plutonium, uranium, and americium), resulting in exposures to individuals who came in contact with the sediments and, potentially, an increase in latent cancer fatalities. Because individuals would not be in constant contact with the sediments, these impacts represent a small fraction of the impacts estimated for the drinking water pathways listed in Table 7-7.[39]

It should be noted, as Dr. Makhijani points out (Makhijani Declaration at 27), when food pathways other than drinking water are considered in Scenario 2, the radiation doses and fatalities substantially increase. Dr. Makhijani went on to note: "[t]he impact of dispersed waste on vast aquifers, areas of land, and the country's most important rivers that could not be used again because of contamination is not explored in detail. The Fukushima accident that began on

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the country into five regions. Then DOE posed a single hypothetical site in each region (see Appendix K, Section K.2.1.6), and estimated the potential release rate of the radionuclide inventory from the spent nuclear fuel and high-level radioactive waste, based on forecast interactions of the environment (rainfall, freeze-thaw cycle) with the engineered barrier (concrete storage modules). *See* discussion in FEIS at 7-45.

39 *Id*. at 7-39.

March 11, 2011, has shown that the economic, social, and ecological impacts of the spread of radiation contamination are far larger than a narrow view of latent cancer fatalities may indicate." NRDC concurs.

Summing up its view of the magnitude of potential local impacts, DOE explains:

> For Scenario 2, localized impacts to individuals from degraded facilities at the 77 sites could be severe. DOE estimated that within a few hundred years at the several sites where early concrete failure was predicted, hypothetical individuals living close to the storage facilities would receive lethal doses of external radiation [800 millirem per hour at a distance of 10 meters (33 feet)] from the exposed dry storage containers (see Appendix K, Section K.2.4.2). To evaluate impacts from ingestion of radioactive materials, the analysis assumed that individuals would live near the degraded storage facilities and would consume contaminated groundwater and food from gardens irrigated with groundwater withdrawn from the contaminated aquifer directly below their locations. DOE estimated that within 6,000 years from now a hypothetical individual living within several hundred meters of a degraded facility could receive an internal committed effective dose equivalent to several thousand rem per year from ingestion of plutonium-239 and -240 (see Appendix F for further information on committed dose equivalent). Using the National Council on Radiation Protection and Measurements risk factors (DIRS 101857-NCRP 1993, p. 112), ingestion of plutonium at this rate could increase the individual's lifetime risk of contracting a fatal cancer after only a few years of exposure.

FEIS at 7-38-40. Dr. Makhijani questions many of the scientific assumptions in Scenario 2. He notes even "estimates of latent cancer fatalities are presented in a very skewed way. Cladding degradation once the spent fuel is put into dry storage is assumed to begin after thousands of years and "less than 0.01 percent" of the cladding would fail in the first 10,000 years" – a proposition Dr. Makhijani and NRDC find implausible. Makhijani Declaration at 27. And as a final technical matter, Dr. Makhijani points out the Yucca Mountain EIS was completed before any physical evaluation of high burnup fuel that had been in dry storage for any length of time. *Id.*

Given what we know now about the myriad of technical problems with long-term storage associated with high burnup fuel, DOE's Scenario 2 is dated and deficient, useful only as a rough starting point for the "hard look" analysis NRC must conduct for a NEPA compliant draft GEIS. But the fact that it even exists demonstrates the degree to which NRC has acted in an arbitrary and capricious fashion by positing institutional controls will last forever.

v. NRC's Assertion That Loss of Institutional Controls is Speculative and Unreasonable is Arbitrary and Capricious.

NRC's suggested defense for why it failed to analyze the potential environmental impacts of spent nuclear fuel in the event no repository is ever sited can be concisely summarized —the loss of institutional control so unlikely that it is a remote and speculative occurrence. Draft GEIS at 1-14, 15, note 2. NRC provides no technical, regulatory, or historic support for this assertion. Rather, NRC dismisses DOE's approach in its 2002 EIS to the loss of institutional controls at a dry cask storage facility as "not relevant" and asserts DOE's approach was related to post-closure buried radioactive waste and not relevant to the indefinite dry cask storage of licensed spent nuclear fuel. This dismissal has no merit as, seen in Appendix K of DOE's analysis, DOE examined the loss of institutional controls at dry cask storage facilities.

More pertinent, contrary to the finding of the National Academies, the GAO, federal agency regulations, and human history, NRC's unsupported suggestion—the loss of institutional controls over thousands of years at a dry storage facility is so unlikely it is a remote and speculative occurrence—is without merit.[40] NRC must return to the drawing board and perform an analysis of extended storage of SNF with a failure of institutional controls.

10. Page 1-22. "The environmental impacts of portions of the uranium fuel cycle that occur before new fuel is delivered to the plant and after spent fuel is sent to a disposal site have been evaluated and are codified in regulation (10 CFR 51.51, Table S–3)." (See also, Figure 1-2 at 1-18).

NRDC Comment.

As noted in our February 2009 comments on NRC's last iteration of the Waste Confidence Determination, NRC has no basis for continued reliance on Table S-3, the outdated uranium fuel cycle rule—which itself was contingent upon the now

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[40] It should also be noted NRC has asserted active maintenance and security will continue for centuries, and has made this assertion in a timeframe where the federal government shut down for several weeks. *See, White House Puts Price on Government Shutdown*, New York Times, Annie Lowrey, November 8, 2013, http://www.nytimes.com/2013/11/08/us/politics/white-house-puts-price-on-government-shutdown.html. ("The report said that the government had not calculated the costs of actually shutting the government down and reopening it. But it described them as significant. "Disruptions at nuclear cleanup sites associated with the shutdown will cost two to three weeks of productivity," it said. The shutdown "may cause the Department of Energy to miss cleanup milestones agreed to with the states where cleanup is underway.'"). During that shutdown period, much of the NRC staff stayed on duty as a result of carryover funding. However, near the end of the shutdown, much of NRC staff was furloughed. NRDC makes no suggestion government shutdowns will be more or less frequent, more or less damaging to the public health, or more or less meaningful to the proper management of nuclear waste. We merely subscribe to the observation of the National Academies —institutional controls will fail.

vacated Waste Confidence Rule—that depends on assumptions long since proven wrong or, simply, no longer applicable by virtue of current law. We detail the reasons for Table S-3's inadequacy in Appendix B to these comments.

And we remind the agency to the DC Circuit's direction regarding the relationship between Table S-3 and its new iteration of the TSR and its Waste Confidence obligations:

> The Commission argues that its "Table S–3" already accounts for the environmental effects of the nuclear fuel cycle and finds no significant impact. Not so. Table S–3, like the Commission itself, presumes the existence of a geologic repository. Therefore, it cannot explain the environmental effects of a failure to secure a permanent facility. The Commission also complains that conducting a full analysis regarding permanent storage would be an "abstract exercise." Perhaps the Commission thinks so because it perceives the required analysis to be of the effects of the permanent repository itself. *But we are focused on the effects of a failure to secure permanent storage*. The Commission apparently has no long-term plan other than hoping for a geologic repository. If the government continues to fail in its quest to establish one, then SNF will seemingly be stored on site at nuclear plants on a permanent basis. The Commission can and must assess the potential environmental effects of such a failure.

New York et al., at 479.

NRDC agrees Table S-3 attempts to evaluate the environmental impacts after spent fuel is sent to a disposal site—not the environmental effects of a failure to secure permanent storage that must be analyzed here (and later incorporated into the fuel cycle rule). But it is a rule that depends on assumptions long since proven wrong are no longer applicable simply by virtue of current law. NRC should immediately commence a draft rulemaking process to rectify its deficiencies.

11. <u>Page 1-23.</u> "1.8.5 Significance of Environmental Impacts."

NRDC Comment

As noted above, the Draft GEIS is a deficient presentation that fails a federal agency's basic duties to both define the scope of a major federal action and take a "hard look" at the significant environmental impacts associated with that action.[41] Indeed, NEPA is

[41] NEPA directs NRC take a "hard look" at the environmental impacts of its proposed program and compare them to alternative means of fulfilling the same purpose and need for agency action that may avoid or mitigate environmental harms or risks posed by the proposed action. "What constitutes a 'hard

clear in its well-established mandates. NEPA characterizes environmental impacts broadly to include not only ecological effects, such as physical, chemical, radiological and biological effects, but also aesthetic, historic, cultural, economic, and social effects. 40 CFR § 1508.8. NEPA requires an agency to consider both the direct effects caused by an action and any indirect effects which are reasonably foreseeable. Effects include direct effects caused by the action and occurring at the same time and place and indirect effects caused by the action, but later in time or farther removed in distance, but still reasonably foreseeable. 40 CFR § 1508.8.

Rather than comply with these well-established NEPA requirements, the Draft GEIS submits a set of quantitatively baseless set of environmental conclusions (that impacts will be SMALL) about an arbitrarily and generically presented set of broad assumptions, without any integration of meaningful site specific data. While the NRC's taxonomy (small, moderate, or large impacts) for classifying and characterizing environment impacts has been established for some time, the way it has evolved in its use is inadequate and the Draft GEIS illustrates these problems. This Draft GEIS is clearly not in conformity with the agency's own NEPA regulation requiring that "the analysis for all draft environmental impact statements will, *to the fullest extent practicable*, *quantify* the various factors considered." Slapping vague qualitative labels on impacts is only permitted "to the extent that there are important qualitative considerations or *factors that cannot be quantified*..." 10 CFR 51.71 (d). Indeed, this Draft GEIS simply abandons any effort to quantify "the environmental effects of the proposed action; the environmental impacts of alternatives to the proposed action; and alternatives available for reducing or avoiding adverse environmental effects," [*Id.*] because its analysis of reasonable alternatives *is entirely divorced from its consideration* of environmental consequences, which are themselves quantified in vague terms that do not conform to any reasonable interpretation of the phrase "to the fullest extent practicable." Specifically, such terms are no longer tied to any consistent set of quantitative or otherwise objectively ascertainable metrics for assessing and comparing the impacts of indefinite storage of SNF activities on groundwater or any other environmental resource, or on human health.

12. <u>Pages 2-7 and 2-8</u>. "For purposes of analysis in this Draft GEIS, the NRC relies for impact analysis on the larger reactor lifetime amount of spent fuel discharged at low burnups (i.e., 1,600 MTU), unless otherwise stated in the description of environmental impacts. This is because many of the environmental impacts (e.g., land use, geology and soils, and terrestrial resources) will depend upon the greater amount of space needed to store the larger amounts of spent fuel that would be generated at low burnups. In cases

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look' cannot be outlined with rule-like precision, but it at least encompasses a thorough investigation into the environmental impacts of an agency's action and a candid acknowledgement of the risks that those impacts entail." *Nat'l Audubon Soc. V. Dept of the Navy*, 422 F.3d 174, 185 (4th Cir. 2005).

where high-burnup fuel is a consideration in the impact determination, which is the case with spent fuel pool fires, this is explained in the supporting analysis."

NRDC Comment

There are several problems posed by high-burnup fuel and NRC must provide a detailed environmental analysis. The National Academy of Engineering of the National Academy of Sciences has expressed concern regarding the viability of long term storage and management of high-burnup fuel. The Academy noted: "the technical basis for the spent fuel currently being discharged (high utilization, burnup fuels) is not well established… the NRC has not yet granted a license for the transport of the higher burnup fuels that are now commonly discharged from reactors. In addition, spent fuel that may have degraded after extended storage may present new obstacles to safe transport.[42]

Further, Mr. Robert Alvarez, at the Institute for Policy Studies, has authored a recent report in which he criticized the NRC for taking a "leap of faith with respect to the safe operation of reactors and the storage and disposal of spent nuclear fuel" with higher burnup fuel.[43] With the higher burn rates, Mr. Alvarez notes nuclear fuel rods undergo significant changes meriting more study and treatment under this Draft EIS. Such changes include: increasing oxidation, corrosion and hydriding (i.e., hydrogen absorption) of the fuel cladding; oxidation reduces cladding thickness, while hydrogen (H3) absorption of the cladding to form a hydrogen-based rust of the zirconium metal from the gas pressure inside the rod can cause the cladding to become brittle and fail; higher internal rod gas pressure between the pellets and the inner wall of the cladding leading to higher fission gas release; pressure increases are typically two to three times greater; elongation or thinning of the cladding from increased internal fission gas pressure; structural damage and failure of the cladding caused by hoop (circumferential) stress; increased debris in the reactor vessel, damaging and rupturing fuel rods; cladding wear and failure from prolonged rubbing of fuel rods against grids that hold them in the assembly as the reactor operates (grid to rod fretting); a significant increase in radioactivity and decay heat in the spent fuel; a potentially larger number of damaged spent fuel assemblies stored in pools; upgraded pool storage with respect to heat removal and pool cleaning; and requiring as much as 150 years of surface storage before final disposal. *Id.*

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[42] *See* National Academy of Engineering, *Managing Nuclear Waste*, Summer 2012, pp 21, 31. http://www.nae.edu/File.aspx?id=60739.

[43] *See Reducing the Hazards of High-Level Radioactive Waste in Southern California: Storage of Spent Power Reactor Fuel at the San Onofre Nuclear Station*, Robert Alvarez, (June 25, 2013) at 12. Commissioned by Friends of the Earth; http://libcloud.s3.amazonaws.com/93/22/3/3024/SONGS_Spent_Fuel_FINAL.pdf.

(citations found in report and omitted here).

In short, there is significant evidence that with higher burn-ups nuclear fuel cladding may be inadequate as a primary barrier to prevent escape of radioactivity, especially during dry storage, and therefore the NRC needs to include these problems specific to high burnup fuel in the impact analysis in the draft GEIS.

Further, with respect to a potential fire in a spent fuel pool containing high burnup fuel, please see NRDC's Appendix C, authored by Mr. Mark Leyse on high burnup fuel cladding, fuel cladding deformation, such as ballooning, fuel fragmentation, relocation, and dispersal, and hydrogen explosions which could occur in the event of a spent fuel pool ("SFP") accident (and possible concurrent reactor core accident). The NRC's "Waste Confidence Generic Environmental Impact Statement: Draft Report for Comment," NUREG-2157, Appendix F, "Spent Fuel Pool Fires," does not consider a number of phenomena that would increase the probability of a SFP fire in the event of either: 1) a complete SFP loss-of-coolant accident ("LOCA"), 2) a partial SFP LOCA, or 3) a SFP boil-off accident.

13. Pages 2-11 and 12. Spent Fuel Pools

NRDC Comment

See our comments on Appendix E, Analysis of Spent Fuel Pool Leaks, below.

14. Page 2-14. Assumption of ability to move and no dual purpose dry casks have been certified.

NRDC Comment

With the acknowledged absence of licensed dual purpose casks or canisters and no operational experience with the moving and management challenges raised by high burnup SNF, we suggest the agency has significant research for the final GEIS to provide any meaningful support for an impacts analysis.

15. Page 2-18. "In January 2013, DOE published its response to the Blue Ribbon Commission recommendations titled, "Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste" (DOE 2013). This strategy implements a program over the next 10 years that, with congressional authorization, will: • site, design, construct, license, and begin operation of a pilot interim storage facility by 2021 with an initial focus on accepting spent fuel from shutdown reactor sites; • advance toward the siting and licensing of a larger interim storage facility to be available by 2025 with sufficient capacity to provide flexibility in the waste-management system and allow for acceptance of enough spent fuel to reduce expected government liabilities; • make

demonstrable progress on the siting and characterization of repository sites to facilitate the availability of a geologic repository by 2048. The Federal government's support for interim storage supports the NRC's decision to consider this type of facility as one of the reasonably foreseeable interim solutions for spent fuel storage pending ultimate disposal at a repository."

NRDC Comment

The history of the nuclear waste repository program is a series of failures and demonstrates, as the DC Circuit found, there should be no assurance there will be sufficient mined geologic repository capacity.[44] NRDC further suggests the failure of efforts to site interim storage facilities have been at least as problematic as the failed efforts to develop a final repository solution. S*ee* NRDC's Testimony on S. 2140, the current proposed legislation before the United States Senate Committee on Energy & Natural Resources (http://www.nrdc.org/nuclear/gfettus-13073001.asp). In that testimony, we noted current legislation pending before a Senate Committee (S.1240) risks sending the nation down another dead-end road by severing the link between storage and disposal and thereby allowing for a storage site to become a *de facto* repository. NRDC Testimony at 3.

16. Page 2-19. Discussion of Dry Transfer System

NRDC Comment

One of the fundamental linchpins of the conclusion of "small" environmental impacts in this Draft GEIS is reliance on institutional controls in perpetuity, and in particular, on the robust viability of the Dry Transfer System (DTS) discussed here. The DTS which does not, as far as NRDC is aware exist in actual form at any commercial operating reactor in this country. Further, there is not a licensed prototype in the country nor has NRC conducted any analysis to establish the ability of the DTS to isolate waste or protect public health in the event of any loss of institutional controls. NRDC has no doubt such a DTS can be constructed but we have no belief it will necessarily isolate the waste in perpetuity and to rely on such an assumption is arbitrary and capricious.

17. Page 2-21. "This draft GEIS considers the environmental impacts of constructing a reference DTS to provide a complete picture of the environmental impacts of continued storage."

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[44] *See* Appendix A of these comments on the failure of the efforts to manage and dispose of nuclear waste and *How Safe is Yucca Mountain*, Remarks of Thomas B. Cochran, Senior Scientist, NRDC, At the Symposium: Uncertainty in Long-Term Planning- Nuclear Waste Management, a Case Study, Vanderbilt University, January 7, 2008; http://docs.nrdc.org/nuclear/files/nuc_08010701A.pdf..

NRDC Comment

This Draft GEIS does nothing of the sort and fails provide a complete picture of the environmental impacts of continued storage. See discussion (at comment #4) of failure of institutional controls and DOE's Scenario 2 as a starting point for the area NRC should have covered to being providing a complete picture of the environmental impacts of failing to secure permanent storage.

18. Page 2-28. "As described in Section 2.1.4, the NRC assumes a DTS, or its equivalent, would be used to transfer fuel as needed for inspection or repackaging. For purposes of this draft GEIS, the NRC assumes the reference DTS would be constructed, operated, and replaced once during the long-term storage timeframe, and every 100 years thereafter … As shown in Figure 2-3, receiving casks and source casks enter the preparation area and exit the DTS on rail-mounted trolleys. To begin spent fuel transfer operations, a receiving cask (i.e., the cask into which fuel will be transferred) is transported to the DTS. The receiving cask is positioned and loaded on a receiving cask transfer trolley at the DTS and rolled into the preparation area. Next, the receiving cask lid and outer and inner canister lids are removed. Finally, the receiving cask is moved into the lower access area and mated to the transfer confinement area. A source cask (i.e., the cask from which fuel will be transferred) follows a similar path as the receiving cask into the lower access area and is mated to the transfer confinement area. *No personnel are present in the lower access area for the transfer operations; all transfer operations are controlled remotely.* The lids on both the receiving cask and source cask are removed to prepare for spent fuel transfer. The fuel-assembly-handling subsystem in the transfer confinement area is used to grab and lift a spent fuel assembly from the source cask. The spent fuel assembly is lifted inside a transfer tube and then moved over an empty position in the receiving cask. The spent fuel assembly is lowered into the receiving cask and detached from the lifting device. When spent fuel transfers are complete, both casks are closed, detached from the transfer confinement area, and ultimately removed from the lower access area back to the preparation area." (emphasis added).

NRDC Comment

Construction and operation of a DTS, while within the capacity of current technology, is a complicated business where operations are managed and performed remotely. Presuming this ability to remotely operate equipment for the thousands and tens of thousands of years flies directly in the face of the intergenerational justice concerns at the heart of the national consensus for geologic disposal. Further, and more important, such a conception of constantly increasing technological prowess runs directly contrary to history and the theory of appropriate reliance on institutional controls. See our discussion above in comment #9 on the failure of institutional controls.

19. Page 3-1 to 3-37. Discussion of ISFSIs and need for site specific reviews.

NRDC Comment

While NRDC has no quarrel with a broad treatment of the affected environment in the an initial generic or programmatic environmental analysis, the description of the affected environment from 3-1 to 3-37 is so cursory so as to be meaningless in terms of the hard look necessary under NEPA. This is especially true for an action of the magnitude of examining the impact of storing spent nuclear fuel in place for potentially long periods of time, past that which one might reasonably rely on the viability of institutional controls.

As we explained *supra* at comment #5 in our proposed matrix of reasonable alternatives that could lead to a compliant NEPA analysis, there could be a meaningful examination of environmental impacts at a site specific level or at least a regional level.

Once the agency has presented and commenced an evaluation of the diverse range of actual alternatives in terms of snf amounts, storage configurations, spent fuel classes, cask options and institutional control scenarios, the agency can then commence examination of quantitative impacts on realistically portrayed affected environments. It should suffice to say regional and local environments differ – differing climates, peak and average temperatures, moisture content, salinity, natural environment. The cursory descriptions in the Draft GEIS don't reach this important differences and the way the proposed rule is structured, those important differences would never be examined. Thus, the cursory nature of this section illustrates the need for a tiered process, at least on a regional or site-specific level. Only then could then could decision-makers have the proper information before them.

20. Pages 4-1 and 4-2

NRDC Comment

See comment #9 on the inappropriateness of reliance on institutional controls for thousands of years.

21. Page 4-21 – 91

NRDC Comment

Consistent with comments #5, #9, and #19 above, the conclusory treatment of the environmental impacts to the affected environment are so NRC's presentation of generic treatment of the affected environment and the reliance on the arbitrary assumption that institutional controls will last forever ensures the conclusions regarding environmental impact from 4-20 (Geology) to 4-91 fail NEPA's hard look requirement.

There are repeated problems and assumptions of no environmental impact where the NRC has provided no basis that challenges DOE's analysis of the environmental effects of failing to develop a repository or even a basis that supplies common sense. Examples include 4-77, DTS, 4-54 (land use), 4-24 surface water quality, 4-28, groundwater quality, etc.

22. Pages 4-84 to 4-91 Potential acts of sabotage or terrorism.

NRDC Comment

NRC has failed to consider the environmental impacts of terrorism related to storage and transportation at both a generic and site-specific level." Notably, NRC planned to do so, at least generically, in its 2011 Report for the Long Term Storage EIS. *See* LTR at 13. Given the long timeframe covered by the Draft GEIS, provisions should be made for periodic updating of the terrorism and sabotage analyses to address: (1) advances in the technology of terrorism and counter-terrorism; (2) changes in population density near storage facilities and shipment routes; and (3) changes in understanding and definition of the design basis events and design basis threats.

23. Page B-1 to B-21. Appendix B *Technical Feasibility of Continued Storage and Repository Availability*

NRDC Comment

Appendix B is the closest NRC comes to addressing its responsibilities under the AEA. But the NRC's assertion its "underlying conclusions regarding the technical feasibility for continued storage and repository availability … continue to undergird its environmental analysis" has little merit. *See* Draft GEIS at B-1.

NRC asserts repository capacity will be available to dispose of spent fuel. *Id*. at B-2. The last few years alone should be enough to persuade NRC not to put such deep faith or confidence in the availability of a repository and we recommend close scrutiny of Appendix A to these comments. We are far from a publicly accepted process of developing repositories, much a publicly accepted site. Further, generalizations about the technical feasibility of "a" repository do not answer the question of whether repository capacity will be sufficient to accommodate the spent fuel that will be generated in the future by reactors that have not yet been licensed or re-licensed. And the technical feasibility of some repository provides no comfort or guarantee there will be a repository with sufficient capacity available at the necessary time. Thus, the D.C. Circuit directed NRC to comply with NEPA in *New York et al.* In Appendix A to this set of comments, we detail the sad history of failure in attempts to develop repository and storage sites. Such a story should ensure the agency commits to do the work necessary to both develop better storage options and do a substantially better job of analyzing the environmental impacts of potentially permanent surface spent fuel storage.

Turning to more specifics in the section, sections B.3.1.1.-2, *Technical Feasibility of Wet Storage*, and B.3.3 *Regulatory Oversight of Wet and Dry Spent Fuel Storage*, have little support in light of the Mr. Lochbaum's declaration, submitted this day and referenced above. And with respect to NRC's B.3.4., *Summary of Technical Feasibility of Continued Storage*, particularly its reliance on the proposition institutional controls can exist is perpetuity, has no evidentiary support and runs counter to the regulatory structure of every federal agency and the findings of independent observers such as the NAS. See our comment #6.

24. <u>Pages E-1 to E-26</u>. Appendix E Analysis of Spent Fuel Pool Leaks

NRDC Comments

NRDC's concern with spent fuel pool leaks are not whether spent nuclear fuel "can" be stored safely for some period of time appropriately cooling in a pool. The issue is whether spent fuel "will" be stored safely for extended periods of time and whether applicable regulatory controls are adequate. There is little in Appendix E to allay our substantive concerns and even less here to satisfy the directions of the D.C. Circuit. *See, New York et al.* at 481. For a thorough treatment of the concerns of NRDC and many others in the environmental and safety community, we recommend and concur with the concerns and observations expressed by Mr. David Lochbaum of the Union of Concerned Scientists with respect to NRC's analysis of spent fuel pool leaks in this Draft GEIS.[45]

The task the DC Circuit set for NRC with respect to the analysis of spent fuel pool leaks was straightforward. In discussing what the agency had before it with the last iteration of the Waste Confidence Decision, the Court wrote:

> The WCD Update seeks to extend the period of time for which pools are considered safe for storage; therefore, a proper analysis of the risks would necessarily look forward to examine the effects of the additional time in storage, as well as examining past leaks in a manner that would allow the Commission to rule out the possibility that those leaks were only harmless because of site-specific factors or even sheer luck. The WCD Update has no analysis of those possibilities other than to say that past leaks had "negligible" near-term health effects. Id. A study of the impact of thirty additional years of SNF storage must actually concern itself with the extra years of storage.

Id. Specifically, the Court was concerned with a "*proper analysis of the risks would necessarily look forward to examine the effects of the additional time in storage, as well as examining past leaks in a manner that would allow the Commission to rule out the*

[45] *See Critique of the Analysis of Safety and Environmental Risks Posed by Spent Fuel Pool Leaks in the NRC's Draft Waste Confidence Generic Environmental Impact Statement*, December 13, 2013, Declaration of David Lochbaum, Director, Nuclear Safety Project, Union of Concerned Scientists.

possibility that those leaks were only harmless because of site-specific factors or even sheer luck." As Mr. Lochbaum makes clear, while the Draft GEIS concedes long-term, low-volume spent fuel pool leaks could exceed public health regulatory limits and impact groundwater resources, it fails to provide meaningful support such leaks are unlikely to happen.[46] Indeed, to the contrary, Mr. Lochbaum presents numerous examples NRC has failed to include in its analysis.[47]

Next, Mr. Lochbaum notes the Draft GEIS relies on the availability of spent fuel pool leakage detection system and a regulatory system for groundwater monitoring measures, but the Draft GEIS omits any meaningful discussion that spent fuel pool water level instrumentation is not required to be functioning except when irradiated fuel is being moved within the pool and that groundwater monitoring measures are entirely voluntary.

In direct contradiction of the direction from the DC Circuit, NRC fails to identify how the spent fuel pool leaks listed in Table E-4 were detected. By not identifying the means of detecting these past leaks, the WC DGEIS fails support its assumption that leaks will be readily detectable. Instead, the WC DGEIS leaves open the possibility that the leaks were only detected through sheer luck. The WC DGEIS must explicitly identify the means by which past leaks were detected and ensure that regulatory requirements will retain these means throughout the 60-year short-term storage period. Otherwise, the NRC has no basis for a finding of reasonable assurance that the methods on which it relies will detect future leaks.

Most important, Mr. Lochbaum observes NRC fails to recognize that both regulatory requirements and its oversight regime are significantly scaled back when nuclear power reactors cease operation. For example, the aging management measures supporting renewal of reactor operating licenses only apply during the period of extended reactor operation—not the six decades of spent fuel pool storage that follow. And Mr. Lochbaum submits significant evidence that NRC's inspection effort in the shut-down period is drastically reduced.

In short, NRC has serious gaps in its analysis and has failed to present evidence supporting its conclusion spent fuel pool leaks will be detected or have little impact on the environment.

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46 *See* Sections IV and VIII of Mr. Lochbaum's Declaration.

47 *See* discussion in Lochbaum Declaration from 10-18 and "NRC did not consider the leaks that occurred from the spent fuel pools at the Brookhaven National Laboratory and the Yankee Rowe nuclear plant. The BNL spent fuel pool leaked radioactively contaminated water into the ground for up to 12 years. Four tests for leakage from the spent fuel pool over a seven year period failed to detect the leak. And numerous monitoring wells already existing or added to the site failed to detect the leaked water for many years or attributed leak indications other sources. But this event was not included among the past events NRC considered for the WC DGEIS. Likewise, the NRC failed to consider in the WC DGEIS the two million gallons that leaked from the Yankee Rowe nuclear plant." Lochbaum Declaration at 46.

25. <u>Page F-1- F-16</u>. Appendix F, *Spent Fuel Pool Fires*.

NRDC Comments

We append the comments of Mr. Mark Leyse. Mr. Leyse states Appendix F "does not consider a number of phenomena that would increase the probability of a spent fuel pool (SFP) fire in the event of either: 1) a complete SFP loss-of-coolant accident ("LOCA"), 2) a partial SFP LOCA, or 3) a SFP boil-off accident.

Conclusion

We appreciate the opportunity to comment. If you have any questions, please do not hesitate to contact us.

Sincerely,

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Appendix A: The Failure of the Repository Program.

The history of the nuclear waste repository program is replete with failures and demonstrates, as the DC Circuit found, there should be no assurance there will be sufficient mined geologic repository capacity.

1. The first failed efforts.

In 1957-1958, the Atomic Energy Commission (AEC) conducted the first site specific study of the disposal of high-level radioactive waste in salt at Hutchinson, Kansas. Between 1961 and 1963, the AEC conducted experiments at the Cary salt mine at Lyons, Kansas. In 1970 the AEC, along with the Kansas governor, announced tentative selection of the Cary salt mine for a demonstration high-level waste repository. Opposition, primarily by the Kansas Geological Survey, and concerns over conditions in the mine, the presence of numerous oil and gas well in the vicinity, and the fact that there was solution mining at an operating adjacent salt mine operated by American Salt Company forced the AEC to abandoned the site by 1972.

Following the demise of the Lyons repository effort, the AEC announced in 1972 that it intended to develop a 100-year Retrievable Surface Storage Facility (RSSF). This proposal was opposed by the Environmental Protection Agency (EPA) and others because in their view it would divert attention and resources from efforts to find a permanent means of geologic disposal. As a consequence of this opposition the Energy Research and Development Agency (ERDA) gave up its plans for a RSSF in 1975. Between 1975 and 1982, ERDA and the DOE continued to search for potential repository sites in various rock types in the states of Michigan, Ohio, New York, Utah, Texas, Louisiana, Mississippi, Washington, and Nevada. Various degrees of resistance from state and local representatives combined with geological and technical problems stalled efforts to find a repository site. In 1976 President Gerald Ford halted the reprocessing of commercial nuclear fuel. In the following year President Jimmy Carter reinforced the ban on commercial reprocessing and tried to halt the development of commercial breeder reactor development. These actions reinforced the need for prompt development of a geologic repository. In 1977 ERDA also announced that it would accept custody of commercial spent fuel and store it at Away From Reactor (AFR) storage facilities. It never happened.

2. The IRG Process

In the mid-1970s it became clear that commercial spent fuel reprocessing was uneconomical, environmentally unsound, and represented a serious proliferation risk. President Gerald Ford refused to subsidize the completion of the Barnwell reprocessing plant, and then President Jimmy Carter pulled the plug on reprocessing. The actions by Presidents Ford and Carter gave a new urgency to finding a site suitable for geologic disposal of both spent fuel and high-level radioactive waste. In the late 1970s President Carter initiated an Interagency Review Group (IRG) process to solve once and for all the nuclear waste problem in the United States. The IRG process involved numerous scientists, extensive public involvement, and a consultation and concurrence role for the states. The outcome of the IRG effort was a two-track program. The DOE was tasked with the responsibility for identifying the best repository site in the country, and the EPA and the NRC were tasked with developing nuclear waste disposal criteria against which the selection and development of the final repository site would be judged.

3. The Nuclear Waste Policy Act

In 1982, Congress enacted the NWPA, which embodied in law the principal recommendations that grew out of the IRG process, including a commitment to geologic disposal, two repositories, and characterization of three sites before final selection of the first repository. The NWPA established a comprehensive program for the disposal of spent nuclear fuel and high-level radioactive waste (HLW) from the nation's commercial reactors and nuclear weapons complex. At the time the NWPA was passed nearly 25 years ago, the U.S. Government enjoyed fairly widespread support from within the Congress, the environmental community and state governments for the site selection and development process proposed by the IRG. Now, decades later, the U.S. Government has little, if any, support from the State of Nevada, and virtually no public support from the environment and public health community for the proposed Yucca Mountain project.

4. What else went wrong?

A whole host of things, but suffice to say that over the last twenty years, a substantial segment of the environmental community believes the process of developing, licensing, and setting environmental and oversight standards for the proposed repository have been, and continue to be rigged or dramatically weakened to ensure the licensability of the site rather than provide safety for the length of time the waste is dangerous. The site selection process and the radiation standards are examples that illuminate this perspective and conclusively demonstrate that the NRC has no basis for finding reasonable assurance that sufficient mined geologic repository capacity can reasonably be expected to be available at any time, even within 50-60 years beyond the licensed life for operation (which may include the term of a revised or renewed license) of any reactor to dispose of the commercial high-level nuclear waste and spent fuel originating in such reactor and generated up to that time.

a. Site Selection

First, DOE and then the Congress corrupted the site selection process. The original strategy contemplated DOE choosing the best four or five geologic media, then selecting a best candidate site in each media alternative, then narrowing the choices to the best three alternatives, and then picking a preferred site for the first of two repositories. Site selection guidelines were strongly criticized as DOE was accused of selecting sites that they had previously planned to pick. In May of 1986 DOE announced that it was abandoning a search for a second repository, and it had narrowed the candidate sites from nine to three, leaving in the mix the Hanford Reservation in Washington (in basalt), Deaf Smith Co., Texas (in bedded salt), and Yucca Mountain in Nevada (in unsaturated volcanic tuff). All equity in the site selection process was lost in 1987, when the Congress, confronted with a potentially huge cost of characterizing three sites, amended the

NWPA of 1982, directing DOE to abandon the two-repository strategy and to develop only the Yucca Mountain site. At the time, Yucca Mountain was DOE's preferred site. The abandonment of the NWPA site selection process led directly to the loss of support from the State of Nevada, diminished Congressional support (except to ensure that the proposed Yucca site remains the sole site), and less meaningful public support for the Yucca Mountain project. The situation has only deteriorated since that time.

b. Radiation Standards

The second track of the process has, if possible, fared worse. Section 121 of the NWPA of 1982 directs EPA to establish generally applicable standards to protect the general environment from offsite releases from radioactive materials in repositories and directs the NRC to issue technical requirements and criteria. Unfortunately, it has been clear for years that the projected failures of the geologic isolation at Yucca Mountain are the determining factor in EPA's standards. EPA repeatedly issued standards that are concerned more with licensing the site than establishing protective standards. EPA's original 1985 standards were vacated in part because the EPA had failed to fulfill its separate duty under the Safe Drinking Water Act, 42 U.S.C. §300h, to assure that underground sources of water will not be "endangered" by any underground injection. *Natural Resources Defense Council v. Environmental Protection Agency* (NRDC v. EPA), 824 F.2d 1258 (1st Cir. 1987).

EPA's second attempt to at setting standards that allow for a projected failure of geological isolation was again vacated, this time by the United States Court of Appeals for the D.C. Circuit. The D.C. Circuit found that EPA's Yucca Mountain rule (and the corresponding NRC standard), which ended its period required compliance with the terms of those rules at 10,000 years was not "based upon or consistent with" the recommendations of the National Academy of Sciences ("NAS") as required by the 1992 Energy Policy Act and therefore must be vacated. *Nuclear Energy Institute, Inc. v. EPA*, 373 F.3d 1251 (2004). Giving significant deference to the agency, the D.C. Circuit did not vacate EPA's strangely configured compliance boundary for the Yucca Mountain site. See Appendix A to these comments for a map of EPA's compliance boundary (inside the oddly drawn line, the repository need not protect water quality and radiation can leak in any amount). The dramatically irregular line that represents the point of compliance has little precedent in the realm of environmental protection, and its shape is perhaps more reminiscent of gerrymandered political districts. Rather than promulgate protective groundwater standards, EPA pieced together a "controlled area" that both anticipates and allows for a plume of radioactive contamination that will spread several miles from the repository toward existing farming communities that depend solely on groundwater and perhaps through future communities closer to the site. EPA's next proposed and revised rule, issued in 2005, retained the 15 millirem/year and groundwater standards for the first 10,000 years, but then establishes 350 millirem/year standard for the period after 10,000 years and does away with the groundwater standard entirely. This two-tiered standard failed to comply with the law and fails to protect public health, especially if the repository's engineered barriers were to fail earlier than DOE predicts. On October 15, 2008, EPA published the final version of its revised Yucca Mountain rule in the Federal Register ("2008 Yucca Mountain rule," 73 Fed. Reg. 61255-61289). The 2008 Yucca Mountain rule's two-tiered individual protection annual dose standard establishes an initial 15 millirem first-tier limit, but weakens that limit to 100 millirem in the period after 10,000 years, when EPA projects peak dose to occur. Peak dose could occur significantly earlier if engineered barriers fail earlier than DOE and EPA have projected.

The final status of EPA's most recent two-tiered rule remains fundamentally uncertain. In an action pending in the District of Columbia Circuit (*State of Nevada v. Environmental Protection Agency*, No. 08-1327, consolidated with No. 08-1345), Nevada has challenged EPA's 2008 Yucca Mountain rule as once again failing to honor EPA's statutory duty to protect public health and safety, and to proceed consistently with the National Academy of Science's recommendations.

c. Limits of the repository and a potential need for a second repository

Even more troubling, any continued confidence in a reasonable assurance of a repository being available 50 or 60 years after license expiration of any commercial reactor is contingent entirely upon Congress revising (1) the current law that limits the United States to one repository, the proposed Yucca Mountain site; and (2) the spent fuel and high-level waste stored at this one repository will be limited to 70,000 metric tons of heavy metal equivalent. Therefore, the current, and only repository under review in this country, could not even accommodate all of the spent fuel from existing reactors without new legislation, much less spent fuel from any new reactors that might be built. A second repository would also require new legislation and, as the proposals acknowledge, such a situation would almost certainly require new NRC regulations. Moreover, the NRC has failed to analyze the impact on future repository requirements of this proposed decision which would potentially place no limits on the total inventory of spent fuel generated by existing and future reactors.

Appendix B: Table S-3

1. The Uranium Fuel Cycle Rule

Contemporaneous with NRC's initial efforts at a Waste Confidence policy, NRC performed an analysis of the environmental impacts of the uranium fuel cycle in WASH-1248, Environmental Survey of the Reprocessing and Waste Management Portion of the LWR Fuel Cycle, a Task Force Report (October 1976). The NRC's initial Waste Confidence policy concluded spent fuel could be disposed of in a bedded salt repository without causing any radioactive releases after the repository was sealed. Based on that assumption, NRC concluded in WASH-1248 that radioactive releases from a repository, after it was sealed, would be zero. The NRC codified this finding in the *Uranium Fuel Cycle Rule and Table S-3. Final Rule, Licensing and Regulatory Policy and Procedures for Environmental Protection; Uranium Fuel Cycle Impacts From Spent Fuel Reprocessing and Radioactive Waste Management*, 44 Fed. Reg. 45,362 (August 12, 1979). Table S-3 also estimated negligible releases from other forms of radioactive waste in the uranium fuel cycle. The table was incorporated into NRC regulation 10 C.F.R. § 51.51(a), which provides that:

> Under § 51.50, every environmental report prepared for the construction permit stage or early site permit stage or combined license stage of a light-water-cooled nuclear power reactor, and submitted on or after September 4, 1979, shall take Table S-3, Table of Uranium Fuel Cycle Environmental Data, as the basis for evaluating the contribution of the environmental effects of uranium mining and milling, the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, transportation of radioactive materials and high-level wastes related to uranium fuel cycle activities to the environmental costs of licensing the nuclear power reactor. Table S-3 shall be included in the environmental report and may be supplemented by a discussion of the environmental significance of the data set forth in this table as weighed in the analysis for the proposed facility.

The Uranium Fuel Cycle Rule's finding of no significant health impacts fundamentally supports the Waste Confidence Decision because its estimate of zero radioactive releases from a repository is based on the Commission's then-current Waste Confidence finding, that "a suitable bedded-salt repository site or its equivalent will be found." 44 Fed. Reg. at 45,332. As the Commission explained in a subsequent policy statement, it based that finding on its "confidence" in the integrity of a repository:

> As the Commission noted in promulgating the [final uranium cycle rule], events which might lead to major releases from the bedded-salt repository used as the model for the S-3 rule appear remote in probability while any releases which might reasonably be expected eventually to occur appear very small. Accordingly, the Commission found that the staff's assumption that the integrity of the repository would be maintained after sealing was a reasonable description

> of the performance of a properly sealed repository and, when taken together with the staff's highly conservative assumption that all volatile fission products in reactor spent fuel would be released to the atmosphere prior to repository sealing, left Table S-3 overall a conservative description of fuel cycle impacts. *See* 44 FR 45369, col. 2. Considering the rule's limited purpose and taking into account the Commission's "waste confidence" proceeding, the Commission continues to believe that the record of the final S-3 rulemaking contains adequate information on waste disposal uncertainties to support continued use of the fuel cycle rule.

Policy Statement, Licensing and Regulatory Policy and Procedures for Environmental Protection; Uranium Fuel Cycle Impacts, 47 Fed. Reg. 50,591, 50,593 (Nov. 11, 1982). In the 1990 update to the Waste Confidence Rule, the Commission also acknowledged that if it were to change its waste confidence decision, it would have to revisit the adequacy of Table S-3. 55 Fed. Reg. at 38,490.

The NRC has not meaningfully updated Table S-3 or WASH-1248 for decades. As the Commission explained, a planned update:

> [w]as delayed because, by the mid-1980's, there were no new applications for construction of nuclear power plants, nor, at that time, were any future ones predicted. Consequently, there was no regulatory need to update Table S-3 and competing priorities for rulemaking resources eventually resulted in the cessation of activities on the table. Since the mid-1980's, the NRC has revisited the issue of revising the value for radon-222 in Table S-3 on more than one occasion, but in each case higher priority rulemakings led to a halt in these efforts.

New England Coalition on Nuclear Pollution; Denial of Petition for Rulemaking, 73 Fed. Reg. 14,946, 14,947 (March 20, 2008).

2. The Baltimore Gas & Electric Decision

As described above, in 1979, NRC published its final Table S-3 rule. 44 Fed. Reg. 45362 et seq. (1979). Table S-3 is, in brief, a numerical compilation of the NRC's estimates of resources used and effluents released by fuel cycle activities supporting a year's operation of a typical light water reactor. From this, the NRC decided that NRC Licensing Boards should assume, for the purposes of NEPA review, that permanent storage of nuclear waste would have no significant environmental impact (the so-called "zero release assumption"), reactor operations would have no significant impact on the environment, and thus none of these issues should affect the decision whether to license nuclear power plants. NRDC and the State of New York challenged Table S-3 as a violation of NEPA and the Administrative Procedures Act (APA), the proceedings were combined, and ultimately, the Supreme Court ruled on the issue. At the "heart of the dispute" was the viability of Table S-3, 44 Fed. Reg. 45362 et seq. (1979). *Baltimore Gas & Electric v. NRDC*, 462 U.S. 87 (1983).

The Supreme Court reversed a Court of Appeals ruling for NRDC and New York, finding that the NRC, in its final S-3 Table, "summarized the major uncertainties of long-term storage of nuclear wastes, noted that the probability of intrusion was small, and found the evidence 'tentative but favorable' that an appropriate storage site could be found." Id. at 87. The central holding of BG&E is straightforward – the NRC complied with NEPA's requirements of consideration and disclosure of the environmental impacts of its licensing decisions. Id. at 88. But as discussed in comments below, the fundamental bases upon which the Supreme Court relied to find the NRC's actions lawful are no longer valid or applicable, and such a situation has a significant impact on the NRC's NEPA obligations for the relicensing of existing facilities and licensing of new facilities.

3. There is no basis for continued reliance on an outdated uranium fuel cycle rule – which itself is contingent upon the Waste Confidence Rule – that depends on assumptions long since proven wrong or, simply, no longer applicable by virtue of current law

Finally, the NRC's lack of a basis for any determination that there is "confidence" in a final disposal option for some or all of the nation's spent fuel fatally undermines Table S-3 of the NRC's Uranium Fuel Cycle Rule, which depends on the assumption that radioactive releases from a repository will be zero. Final Rule, Licensing and Regulatory Policy and Procedures for Environmental Protection; Uranium Fuel Cycle Impacts From Spent Fuel Reprocessing and Radioactive Waste Management, 44 Fed. Reg. 45,362 (August 12, 1979).

a. The rationale for the BG&E decision no longer spares NRC from having to perform a GEIS/NEPA review for addressing the environmental impacts of the storage of nuclear waste

In 1983, the Supreme Court found that the NRC, in its final S-3 Table, "summarized the major uncertainties of long-term storage of nuclear wastes, noted that the probability of intrusion was small, and found the evidence 'tentative but favorable' that an appropriate storage site could be found." BG&E v. NRDC, 462 U.S. at 87. The central holding of BG&E is straightforward – the NRC complied with NEPA's requirements of consideration and disclosure of the environmental impacts of its licensing decisions." Id. at 88. But in dicta, the Supreme Court explained that the zero-release assumption and, indeed, the entirety of Table S-3 rule was made for a limited purpose, and that it would be supplemented with an explanatory narrative. Id. at 101. Also, a separate and comprehensive set of programs has been undertaken to serve the broader purposes of long-term waste disposal technology and site selection. Id. See note 1, supra. Second, the Court emphasized that the zero-release assumption is but a single figure in an entire Table, which the Commission expressly designed as a risk-averse estimate of the environmental impact of the fuel cycle. Id. at 102 and 103. And third, the Court was careful not to tread into the area of the NRC's special expertise. Id.

The crucial bases for the Supreme Court's decision to uphold the NRC's defense of the validity of Table S-3 are no longer valid, and the NRC must revisit this decades-old Table S-3 and all associated decisions regarding the environmental impacts of the uranium fuel cycle with new, "hard look" NEPA review. As the Court itself noted, "no one suggests that the uncertainties are trivial or the potential effects insignificant if time proves the zero-release assumption to have been seriously wrong**.** After confronting the issue, though, the Commission has determined that the uncertainties concerning the development of nuclear waste storage facilities are not sufficient to affect the outcome of any individual licensing decision." Id. at 98 (emphasis added).

b. The bases for Table S-3, including the zero release assumption, are no longer technically supportable, accurate or consistent with policy

At the time of BG&E decision, the NRC considered bedded salt as suitable for disposal either of reprocessed high-level waste or un-reprocessed spent fuel. Yet, the Proposed Waste Confidence rule of 2008 states that salt formations are not being considered for spent fuel disposal for technical reasons. Hence, the technical underpinning of Table S-3 is inconsistent with current law and the NRC's own understanding of salt repositories. Indeed, disposal in salt, which was the original basis for the S-3 Table in estimating the environmental impact of high-level waste or spent fuel disposal, is only considered suitable for high-level waste resulting from reprocessing, but reprocessing is not the current policy, and nor should it be.[48] Rather, direct disposal of spent fuel, for which the NRC would not consider salt formation, is now the current policy.

More pointedly, presuming "zero release" of radioactivity when disposing of spent fuel runs directly counter to all established scientific understanding of the expected performance of any geologic setting. One glance at Appendix A to this filing demonstrates this fact. Radioactivity will be released from a repository – the dose and timing of such release is a matter for standards and licensing, but the point remains. Radioactive dose is the result of positive releases of radionuclides into the human environment. As far back as 1983, the report on geologic isolation prepared for the DOE by the National Research Council shows positive doses attributable to both fission products as well as actinides in un-reprocessed spent fuel as well as from fission products in reprocessed high-level waste in all settings other than salt that were evaluated – tuff, granite, and basalt. The Supreme Court's concerns – that the problems would be neither trivial nor insignificant if the zero-release assumption turned out to be wrong – were well taken. Where, for example, is the Commission's analysis of the estimated range in the collective dose from the proposed Yucca Mountain repository, and what is the basis for concluding that the Table S-3 is still valid in light of this collective dose range?

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[48] Spent-fuel reprocessing and plutonium-fueled fast reactors are well-proven commercial disasters. The United States, Europe, and Japan spent tens of billions of dollars in the 1970s and 1980s trying to develop plutonium fast-breeder reactors (like the proposed Global Nuclear Energy Partnership "advanced burner reactors," but with uranium "blankets" added to "breed" more plutonium than is consumed in the reactor). These fast reactors proved to be uneconomical, highly unreliable, and prone to fires due to leaking liquid sodium coolant, which burns spontaneously when it comes in contact with air or water. For a full discussion, see http://www.nrdc.org/nuclear/gnep/agnep.asp.

Moreover, the original scope of Table S-3 (and the underlying document in WASH-1248) is inadequate and outdated. Along with failing to address the environmental impacts of spent fuel disposal, the table looks only at the health impacts of an individual plant licensing decision. The Table fails to account for the cumulative impacts of licensing many plants, the economic costs of disposing of all waste generated by the uranium fuel cycle, or even adding those costs to the other costs of a nuclear power plant. Nor does the Table compare the total costs of building and operating a new nuclear facility (and ultimately disposing of associated waste and funding the decommissioning costs) with the costs of the no action alternative or with other alternative sources of energy.

Appendix C: Leyse Report

Included as separate attachment.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

DECLARATION OF MARK LEYSE ON BEHALF OF NATURAL RESOURCES DEFENSE COUNCIL

I. INTRODUCTION

I, Mark Leyse, declare that the following statements are true and correct to the best of my knowledge.

1. Natural Resources Defense Council has contracted my services to supply technical analysis and comments on the Nuclear Regulatory Commission's (NRC) "Waste Confidence Generic Environmental Impact Statement: Draft Report for Comment," NUREG-2157, Appendix F, "Spent Fuel Pool Fires."[1]
2. My expert opinions and comments in this declaration are based both on my professional experience and on my review of relevant portions of the NRC's "Waste Confidence Generic Environmental Impact Statement: Draft Report for Comment," NUREG-2157, Appendix F, "Spent Fuel Pool Fires," and other documents listed in the References Cited section of this declaration.
3. My declaration focuses on technical issues regarding high burnup fuel, high burnup fuel cladding, fuel cladding deformation, such as ballooning, fuel fragmentation, relocation, and dispersal, and hydrogen explosions which could occur in the event of a spent fuel pool ("SFP") accident (and possible concurrent reactor core accident).
4. The NRC's "Waste Confidence Generic Environmental Impact Statement: Draft Report for Comment," NUREG-2157, Appendix F, "Spent Fuel Pool Fires," does not consider a number

[1] NRC, "Waste Confidence Generic Environmental Impact Statement: Draft Report for Comment," NUREG-2157, September 2013, (ADAMS Accession No. ML13224A106), Appendix F, "Spent Fuel Pool Fires."

of phenomena that would increase the probability of a SFP fire in the event of either: 1) a complete SFP loss-of-coolant accident ("LOCA"), 2) a partial SFP LOCA, or 3) a SFP boil-off accident.

Contention 1 – Phenomena Regarding How High Burnup Fuel and High Burnup Fuel Cladding Would Affect the Progression of a SFP Accident Are Not Considered in NUREG-2157, Appendix F, "Spent Fuel Pool Fires."

5. SFPs store fuel assemblies (essentially bundles of fuel rods, comprised of zirconium alloy cladding sheathing uranium dioxide (UO_2) fuel pellets) after they are discharged from the reactor core. If there were a loss of SFP cooling, the water in the pool would be heated by the fuel assemblies' decay heat (heat generated by the radioactive decay of the fuel's fission products) until it reached the boiling point; then the water would boil away, uncovering the fuel assemblies.

6. Fuel assemblies that had a higher burnup[2]—whose enriched-uranium fuel had been converted into energy to a greater extent in the reactor core—would produce greater quantities of decay heat; "[i]n general, the higher the burnup, the higher the heat load generated and the more heat rejection [cooling] capability is required."[3]

7. In the U.S. and elsewhere, the trend is to increase the burnup of fuel assemblies; this is done by extending the length of time the assemblies spend producing energy in the reactor core and/or by increasing the power levels of nuclear power plants ("NPP"). Some power uprates—"[t]he process of increasing the licensed power level at a commercial [NPP]"[4]—in the U.S. have been

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[2] Burnup is the thermal energy produced per unit mass of enriched-uranium in the fuel.

[3] IAEA, "Impact of High Burnup Uranium Oxide and Mixed Uranium-Plutonium Oxide Water Reactor Fuel on Spent Fuel Management," No. NF-T-3.8, 2011, p. 18.

[4] NRC, "Review Standard for Extended Power Uprates," RS-001, Revision 0, December 2003, Background.

substantial; in 2006, the NRC approved a 20 percent power uprate for Vermont Yankee Nuclear Power Station.

8. In 1999, burnup levels for spent pressurized water reactor ("PWR") fuel and spent boiling water reactor ("BWR") fuel were approximately 45 gigawatt-days thermal per metric ton[5] of enriched uranium ("GW·d/t U") and 37 GW·d/t U, respectively; in the U.S., by 2021, "[b]urnup levels for spent PWR fuel are anticipated to rise to ~55 GW·d/t U [and] burnup levels for spent BWR fuel will likely increase to over 40 GW·d/t U."[6]

9. When high burnup (and other) fuel rods are discharged from the reactor core and loaded into the SFP, the fuel cladding can have local zirconium dioxide (ZrO_2) "oxide" layers that are up to 100 microns ("µm") thick (or greater);[7] there can also be local crud layers on top of the oxide layers, which can sometimes also be up to 100 µm thick.[8]

10. Local heavy oxide and/or crud layers would partly impede the local steam or air "coolant" flow through the spent fuel assemblies in a SFP boil-off accident or complete SFP LOCA, respectively, in at least the following aspects: 1) the amount of either steam or air "coolant" in the vicinity of the spent fuel cladding that had local heavy oxide and/or crud layers may be substantially less than if the cladding were clean; 2) the amount of either steam or air coolant flow past the vicinity of the spent fuel cladding that had local heavy crud and oxide layers may be substantially less than the flow past clean cladding; 3) if there were rapid oxidation, local

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[5] 1000 kilograms.
[6] IAEA, "Impact of High Burnup Uranium Oxide and Mixed Uranium-Plutonium Oxide Water Reactor Fuel on Spent Fuel Management," No. NF-T-3.8, 2011, p. 9.
[7] IAEA, "Impact of High Burnup Uranium Oxide and Mixed Uranium-Plutonium Oxide Water Reactor Fuel on Spent Fuel Management," No. NF-T-3.8, 2011, p. 30.
[8] IAEA, "Impact of High Burnup Uranium Oxide and Mixed Uranium-Plutonium Oxide Water Reactor Fuel on Spent Fuel Management," No. NF-T-3.8, 2011, p. 29.

growth of oxide layer thicknesses and increased degradation of the fuel cladding would further obstruct either the steam or air "coolant" flow.

11. Partly impeded local cooling, caused by local heavy oxide and/or crud layers, could cause local fuel-cladding temperatures to increase up the point at which zirconium would begin to rapidly chemically react with steam or air—at approximately 1000°C (1832°F) or 900°C (1652°F),[9] respectively. In a SFP accident, partly impeded local cooling, caused by local heavy oxide and/or crud layers, could decrease the time to the ignition of zirconium in either steam or air.

12. It is doubtful that the NRC's computer safety model MELCOR simulates how local heavy oxide and/or crud layers would partly impede the local steam or air "coolant" flow through the spent fuel assemblies in a SFP boil-off accident or complete SFP LOCA, respectively.

13. As stated above, when high burnup (and other) fuel rods are discharged from the reactor core and loaded into the SFP, the fuel cladding can have local zirconium dioxide (ZrO_2) "oxide" layers that are up to 100 μm thick (or greater); there can also be local crud layers on top of the oxide layers, which can sometimes also be up to 100 μm thick. (And medium to high burnup fuel cladding typically has a "hydrogen concentration in the range of 100-1000 wppm [weight parts per million];" "[z]irconium-based alloys, in general, have a strong affinity for oxygen, nitrogen, and hydrogen…"[10])

14. High burnup fuel rods have thinner cladding, because a higher quantity of their zirconium content has oxidized during the operation of the reactor.[11] The thermal conductivity of oxide layers and crud layers is low—especially crud layers. (It is noteworthy that an EPRI report

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[9] Allan S. Benjamin *et al*., Sandia Laboratories, "Spent Fuel Heatup Following Loss of Water During Storage," NUREG/CR-0649, March 1979, p. 47.

[10] K. Natesan, W.K. Soppet, Argonne National Laboratory, "Hydrogen Effects on Air Oxidation of Zirlo Alloy," NUREG/CR–6851, October 2004, (ADAMS Accession No. ML042870061), pp. iii, 3.

[11] IAEA, "Impact of High Burnup Uranium Oxide and Mixed Uranium-Plutonium Oxide Water Reactor Fuel on Spent Fuel Management," No. NF-T-3.8, 2011, pp. 29, 50.

states that "[i]n some instances, BWR rods have been known to dislodge so much crud when moved around in [SFPs] that diminished pool clarity occurred."[12] Tenacious crud would not become dislodged from fuel rods in this fashion.)

15. And, as the burnup of fuel rods increases, there is an increase in their total *internal* thermal resistance. There is greater internal thermal resistance in high burnup fuel, because: 1) the thermal conductivity of the fuel pellets degrades, partly due to cracking and 2) there is an increased release of fission gas that degrades the thermal conductivity of the gap between the fuel pellet and the cladding.[13] (A 2011 IAEA report states that "[t]he fission gas released from the fuel pellets to the fuel cladding gap will increase *as much as ten-fold* for high burnup fuel over lower burnup fuel"[14] [emphasis added].) A 2012 NRC document states that "[t]he gap [thermal] resistance can…increase because of pellet densification (which increases the gap size) and/or degradation of the helium-gap gas conductivity by the addition of noble fission gases (xenon and krypton) released from the fuel pellets."[15]

16. It is noteworthy that the fuel-cladding gap size does not necessarily increase in high burnup fuel; an October 2003 paper states that "[i]nner surface cladding oxidation and subsequent

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[12] Electric Power Research Institute, "Technical Bases for Extended Dry Storage of Spent Nuclear Fuel," 1003416, December 2002, p. 3-8.

[13] NRC, "Letter to GE-Hitachi Nuclear Energy Americas (GEH) Regarding Nuclear Fuel Thermal Conductivity Degradation Evaluation," March 23, 2012, (ADAMS Accession No. ML120680571), Enclosure 2, "NRC Staff Assessment of General Electric-Hitachi Nuclear Energy and Global Nuclear Fuel—Americas Codes and Methods with Regard to Thermal Conductivity Degradation," March 23, 2012, (ADAMS Accession No. ML120750001), pp. 1-2.

[14] IAEA, "Impact of High Burnup Uranium Oxide and Mixed Uranium-Plutonium Oxide Water Reactor Fuel on Spent Fuel Management," No. NF-T-3.8, 2011, p. 50.

[15] NRC, "Letter to GE-Hitachi Nuclear Energy Americas (GEH) Regarding Nuclear Fuel Thermal Conductivity Degradation Evaluation," March 23, 2012, (ADAMS Accession No. ML120680571), Enclosure 2, "NRC Staff Assessment of General Electric-Hitachi Nuclear Energy and Global Nuclear Fuel—Americas Codes and Methods with Regard to Thermal Conductivity Degradation," March 23, 2012, (ADAMS Accession No. ML120750001), pp. 1-2.

mechanical bonding between the fuel pellet and the cladding are well-known phenomena of high burnup and high duty fuels."[16]

17. During the operation of a reactor, the thermal resistance of crud and/or oxide layers on cladding increases the internal pressure of fuel rods. Regarding this phenomenon, a 2003 NRC document states:

> Clad[ding] oxidation can lead to significantly increased fuel rod internal pressures. … In addition to oxidation causing increases in rod internal pressures, crud deposition has a similar effect since crud is a poor conductor of heat. Keeping crud deposition to a minimum also reduces the impact on rod internal pressures.[17]

18. During the operation of a reactor, the fuel-cladding gap of high burnup fuel rods may reopen "when [the] internal pressure in the [fuel] rod exceeds [the] reactor coolant system pressure."[18] When the fuel-cladding gap reopens there is also thermal resistance caused by the extremely low thermal conductivity of the gases in the fuel-cladding gap. Regarding this phenomenon, the 2012 NRC document states:

> Should the gap [between the fuel pellet and the cladding] reopen, the increased thermal resistance will result in higher fuel pellet temperatures, resulting in higher fission gas release. The increased fission gas release will degrade gap conductivity while increasing the rod internal pressure, thus increasing pellet temperature and widening the gas gap further. The onset of gap reopening results in a runaway process of increasing gap opening until cladding failure.[19]

[16] Sven Van den Berghe *et al.*, "Observation of a Pellet-Cladding Bonding Layer in High Power Fuel," presented at "Advanced Fuel Pellet Materials and Designs for Water Cooled Reactors: Technical Committee Meeting," 20–24 October 2003, p. 307.

[17] NRC, "Safety Evaluation by the Office of Nuclear Regulation, Topical Report WCAP-15604-NP. REV. 1, 'Limited Scope High Burnup Lead Test Assemblies' Westinghouse Owners Group, Project No. 694," 2003, (ADAMS Accession No. ML070740225 (See Section A), p. 4.

[18] NRC, "NRC Information Notice 98-29: Predicted Increase in Fuel Rod Cladding Oxidation," August 3, 1998, (ADAMS Accession No. ML003730714), p. 1.

[19] NRC, "Letter to GE-Hitachi Nuclear Energy Americas (GEH) Regarding Nuclear Fuel Thermal Conductivity Degradation Evaluation," March 23, 2012, (ADAMS Accession No. ML120680571), Enclosure 2, "NRC Staff Assessment of General Electric-Hitachi Nuclear Energy and Global Nuclear Fuel—Americas Codes and Methods with Regard to Thermal Conductivity Degradation," March 23, 2012, (ADAMS Accession No. ML120750001), p. 8.

19. Regarding the heating of the fuel cladding *in a complete SFP LOCA*, a 1979 Sandia Laboratories report states that "[v]ariations in temperature from rod to rod in an assembly might occur as a result of variations in decay heat or *differences in the thickness of the oxide coating*, but these factors are difficult to predict and have not been accounted for"[20] [emphasis added]. And, discussing research and development priorities regarding the dry storage of spent fuel assemblies, which would also pertain to SFP accidents, a 2012 Pacific Northwest National Laboratory ("PNNL") report states that "[d]etermining actual clad emissivities[21] as a function of oxide and crud layer thicknesses under dry storage conditions is necessary to calculate actual temperature profiles…"[22] The PNNL report observes that this would be a "difficult and expensive task."[23]

20. In a boil-off accident, the thermal resistance of crud (corrosion products) and/or oxide layers on fuel-cladding would slightly decrease the radial heat losses of fuel assemblies to the external environment—slightly impeding the local cooling of the fuel assemblies. The thermal resistance of crud and/or oxide layers would primarily serve to decrease radial heat losses at the outer perimeters of the fuel assemblies; this effect would not be significant because the heat flux (rate of heat transfer from the fuel rods) would be relatively low. In fact, a 1979 Sandia Laboratories report states that "[a] calculation was made to determine whether a 100 micron

[20] Allan S. Benjamin *et al*., Sandia Laboratories, "Spent Fuel Heatup Following Loss of Water During Storage," NUREG/CR-0649, SAND77-1371, March 1979, (ADAMS Accession No. ML120960637), p. 40.
[21] Emissivity is "[t]he ratio of the power per unit area radiated by a surface to that radiated by a black body at the same temperature. A black body therefore has an emissivity of 1 and a perfect reflector has an emissivity of 0." A black body is "[a] hypothetical body that absorbs all the radiation falling on it. … While a true black body is an imaginary concept, a small hole in the wall of an enclosure at uniform temperature is the nearest approach that can be made to it in practice." See Alan Isaacs *et al*., "A Concise Dictionary of Physics," Oxford Reference, 1990, pp. 22, 88.
[22] Brady Hanson *et al*., "Gap Analysis to Support Extended Storage of Used Nuclear Fuel." PNNL-20509, Rev. 0, Pacific Northwest National Laboratory, January 31, 2012, p. 88.
[23] *Id*.

[crud] Fe_2O_3 coating on the BWR fuel pins would affect the heatup of these pins during a pool drainage accident, and it was found that the overall effect on the fuel pin temperature was less than one degree."[24]

21. It is doubtful that the Sandia Laboratories calculation used the lowest possible value that the thermal conductivity of crud layers can have; the morphology of crud plays more of a role than its chemical content does in determining the degree of its thermal resistance[25] (this was not necessarily known in 1979). It is also doubtful that a calculation done in 1979 or earlier would have accurately modeled (or attempted to model) the internal thermal resistance of spent fuel rods. (In fact, today, in 2013, the computer safety model the NRC uses for SFP accident analyses—MELCOR—does not model the gap between the fuel cladding and fuel pellets. MELCOR also replaces the thermo-physical properties of UO_2 fuel with properties of compacted magnesium oxide (MgO). In SFP-fire experiments conducted at SNL—used to benchmark MELCOR—zirconium cladding is packed with solid magnesium oxide filler.[26]) Furthermore, the burnups of spent fuel assemblies were far lower in 1979 than they are today. Nonetheless, the Sandia Laboratories calculation results are instructive: the overall effect of the degraded thermal conductivity of high burnup fuel rods in a SFP accident would be slight (unless such fuel rods were involved in a criticality accident[27]).

22. If high burnup fuel rods (or other spent fuel rods) were involved in a criticality accident as the water boiled away in the pool, any degraded thermal conductivity of such fuel rods would play

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[24] Allan S. Benjamin *et al*., Sandia Laboratories, "Spent Fuel Heatup Following Loss of Water During Storage," NUREG/CR-0649, SAND77-1371, March 1979, (ADAMS Accession No. ML120960637), p. 78.

[25] NRC, Advisory Committee on Reactor Safeguards, Reactor Fuels Subcommittee Meeting Transcript, September 30, 2003, (ADAMS Accession No. ML032940295), p. 240.

[26] Jeffrey Cardoni, Sandia National Laboratories, "MELCOR Model for an Experimental 17x17 Spent Fuel PWR Assembly," SAND2010-8249, November 2010, p. 4.

[27] Fission—the splitting of atoms in the nuclear fuel—occurs in a criticality accident.

a *significant role* in increasing local fuel and fuel-cladding temperatures, because the heat flux would be high.

Contention 2 – Phenomena Regarding How Fuel Rod Ballooning and Bursting, which Would Impede Local Cooling of the Fuel Assemblies, Would Affect the Progression of a SFP Accident Are Not Considered in NUREG-2157, Appendix F, "Spent Fuel Pool Fires."

23. Heat produced by the radioactive decay heating of the fuel rods would cause the SFP's water to boil away; the fuel rods would become uncovered by water and heat up, increasing their local temperatures. When local fuel-cladding temperatures reached approximately 677°C (1250°F) the fuel rods would start to balloon and burst,[28] "releasing noble gases, such as xenon and krypton," into the environment.[29] This would occur because the fuel rods that are used in reactor cores are pre-pressurized: at higher temperatures, the internal gas pressure increases to points at which the fuel cladding balloons and bursts.

24. Creep failure of the fuel cladding could occur from incurring stress for approximately 10 hours at cladding temperatures between approximately 565°C (1049°F) and 600°C (1112°F) or greater.[30] The NRC's NUREG-1738 states that "[w]hile failure of the cladding at these lower temperatures will lead to fission product release, such release is considerably smaller than that assumed for the cases where the temperature criterion is exceeded and significant fuel heatup and damage occurs."[31]

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[28] The fuel rods would balloon and burst between approximately 677°C (1250°F) and 877°C (1610°F). See S. Güntay, J. Birchley, "MELCOR Further Development in the Area of Air Ingress and Participation in OECDNEA SFP Project to Be Performed in the Time Frame 2009-2012," April 2009, p. 14.

[29] Zachary I. Franiewski *et al*., Pennsylvania State University, "Spent Fuel Pool Analysis of a BWR-4 Fuel Bundle Under Loss of Coolant Conditions Using TRACE," NucE431W S2013, May 2013, p. 2.

[30] NRC, "Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants," NUREG-1738, February 2001 (ADAMS Accession No. ML010430066), Appendix 1B, p. A1B-5.

[31] NRC, "Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants," NUREG-1738, February 2001 (ADAMS Accession No. ML010430066), Appendix 1B, p. A1B-5.

25. It is noteworthy that the NRC computer safety model "MELCOR does not have a fuel cladding deformation and strain model. It uses a value of 900°C for widespread cladding failure."[32]

26. In a SFP boil-off accident, ballooning of the fuel cladding would most likely be in the form of sausage-type balloons, as occurred in the fuel-cleaning-tank accident at the Paks Nuclear Power Plant Unit 2 ("Paks-2"), in Hungary, in 2003.[33] In the Paks-2 accident, 30 fuel assemblies were severely damaged and their fuel rods ballooned—"long sausage balloons"[34] with "very long ballooned areas."[35] At a 2003 Advisory Committee on Reactor Safeguards ("ACRS") Reactor Fuels Subcommittee meeting, at least one participant thought that such long balloons would occur in reactor large-break loss-of-coolant accidents ("LOCA"). (*This is pertinent to the characteristics of the fuel-cladding ballooning that would occur in SFP accidents*, because, in both types of accidents, fuel rods would heat up to the point at which their internal-pressure increases caused them to balloon; in both types of accidents, the external pressure would be far less than the internal pressure of the fuel rods.)

27. In the ACRS meeting, Dr. Dana Powers (the lead author of "Cladding Swelling and Rupture Models for LOCA Analysis"[36]) stated: "If you're trying to persuade me that we'll never see long sausage balloons in reactor accidents, give up now while you're ahead;" and "where I run

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[32] NRC, "Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark I Boiling Water Reactor: Draft Report," June 2013, (ADAMS Accession No. ML13133A132), p. 26.

[33] In 2003, at the Paks Unit 2 plant in Hungry, there was a fuel cleaning tank accident in which 30 fuel assemblies incurred severe damage. In the Paks-2 accident, the fuel rods ballooned—"long sausage balloons"[33] with "very long ballooned areas."[33] See Advisory Committee on Reactor Safeguards Reactor Fuels Subcommittee, September 29, 2003, located at: http://www.nrc.gov/reading-rm/doc-collections/acrs/tr/subcommittee/2003/rf092903.pdf, pp. 212- 225.; see also IAEA, "OECD-IAEA Paks Fuel Project: Final Report," 2009, p. 12.

[34] Advisory Committee on Reactor Safeguards Reactor Fuels Subcommittee, September 29, 2003, located at: http://www.nrc.gov/reading-rm/doc-collections/acrs/tr/subcommittee/2003/rf092903.pdf, pp. 212- 225.

[35] IAEA, "OECD-IAEA Paks Fuel Project: Final Report," 2009, p. 12.

[36] D. A. Powers, R. O. Meyer, "Cladding Swelling and Rupture Models for LOCA Analysis," NUREG-0630, April 1980, (ADAMS Accession No. ML053490337).

into trouble is saying x or y can never happen. Simply because you've never seen it in an experiment you've done with one foot sections [of fuel cladding]; that's where I have real trouble."[37]

28. Experiments at Argonne Laboratories with segments of high burnup fuel rods—discussed in the same 2003 ACRS Subcommittee meeting—were conducted with 12 and 15 inch segments of fuel rods, with a "relatively uniform heating zone" *that was approximately five inches long*; hence, the ballooned locations of the fuel rods were not longer than five inches.[38]

29. In a SFP boil-off accident, it is highly probable that the ballooned sections of the fuel rods would be coplanar (at the same elevation); with coplanarity, there would also likely be some degree of local rod-to-rod contact. When local cladding temperatures reached the point at which the fuel rods ballooned, such temperatures would tend to be at approximately the same elevation. Additionally, in SFP boil-off accident, the fuel assemblies that were most recently loaded into the SFP (the hottest assemblies) would be first ones to incur fuel-cladding ballooning.

30. In addition to the Paks fuel cleaning tank accident there is further evidence that there could be long sausage-like ballooned areas of the fuel cladding in a boil-off SFP accident. (The experiments discussed in this paragraph are not SFP accident experiments; however, they apply to SFP accidents, because they are experiments in which fuel rod simulators were heated up to the point at which their internal pressure increases caused them to balloon.) For example: 1) the JAERI loss-of-accident tests had "axially extended contacts between rods (over more than

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[37] Advisory Committee on Reactor Safeguards Reactor Fuels Subcommittee, September 29, 2003, located at: http://www.nrc.gov/reading-rm/doc-collections/acrs/tr/subcommittee/2003/rf092903.pdf, pp. 217-218.
[38] Advisory Committee on Reactor Safeguards Reactor Fuels Subcommittee, September 29, 2003, located at: http://www.nrc.gov/reading-rm/doc-collections/acrs/tr/subcommittee/2003/rf092903.pdf, pp. 113, 181, and 195.

20 cm [7.9 in]) in [49-rod[39]] bundle configurations;"[40] 2) in the Materials Test 3 (MT-3), which had 12 full-length pre-pressurized fuel rods, "[t]he active strain [ballooned] region was spread over [a] ~2-[meter] (80-[in]) length" of the fuel rods[41] (this does not mean that there was a continuous ballooned length of about 80.0-in; however, it indicates that there was excessive ballooning); 3) an Oak Ridge National Laboratory (ORNL) report states that for the CORA-16 experiment that there was *estimated* cladding strain (ballooning) on one of the fuel rods at the 550, 750, and 950 mm elevations, which indicates that the rod was estimated to have a ballooned length of at least 400 mm (15.75 in)[42] (the CORA experiments, which simulated meltdown accidents, were conducted with zirconium alloy multi-rod bundles that were two meters long);[43] 4) a second ORNL report states that for the CORA-33 experiment "the computed cladding strain [ballooning] was significant over 400 mm [15.75 in] of the rod length;"[44] and 5) the cladding balloons that occurred in the middle sections of the bundles from PWR FLECHT runs 2443 and 2544, which had unintended internal gas pressure increases, [45] were substantially longer than a few inches.

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[39] European Commission: Nuclear Safety and the Environment, "Fuel Cladding Failure Criteria," September 1999, p. 88.
[40] Claude Grandjean, Institut de Radioprotection et de Sûreté Nucléaire (IRSN), "Coolability of Blocked Regions in a Rod Bundle after Ballooning under LOCA Conditions: Main Findings from a Review of Past Experimental Programmes," 2007.
[41] C. L. Wilson, G. M. Hesson, J. P. Pilger, L. L. King, F. E. Panisko, Pacific Northwest Laboratory, "Large-Break LOCA, In-Reactor Fuel Bundle Materials Test MT-6A," 1993, p. x.
[42] L. J. Ott, W. I. van Rij, "In-Vessel Phenomena—CORA: BWR Core Melt Progression Phenomena Program, Oak Ridge National Laboratory," CONF-9105173-3-Extd.Abst., Presented at Cooperative Severe Accident Research Program, Semiannual Review Meeting, Bethesda, Maryland, May 6-10, 1991.
[43] P. Hofmann, S. Hagen, G. Schanz, G. Schumacher, L. Sepold, Idaho National Engineering Laboratory, EG&G Idaho, Inc., "CORA Experiments on the Materials Behavior of LWR Fuel Rod Bundles at High Temperatures," in NRC "Proceedings of the Nineteenth Water Reactor Safety Information Meeting," NUREG/CP-0119, Vol. 2, 1991, (ADAMS Accession No. ML042230460), p. 77.
[44] L. J. Ott, Siegfried Hagen, "Interpretation of the Results of the CORA-33 Dry Core Test," 1993.
[45] F. F. Cadek, D. P. Dominicis, R. H. Leyse, Westinghouse Electric Corporation, WCAP-7665, "PWR FLECHT (Full Length Emergency Cooling Heat Transfer) Final Report," April 1971, (ADAMS Accession No. ML070780083), p. 3-95.

31. Regarding assembly blockage in reactor LOCAs, resulting from newer zirconium fuel-cladding alloys like ZIRLO and M5, a 2004 OECD Nuclear Energy Agency report states that "[n]ew alloys have the tendency of being more ductile, which can increase ballooning size and thus increase blockage."[46] Furthermore, the same report states that "it can be anticipated, due to this better ductility that, for modern alloys, *the rod balloons will be bigger and the resulting flow blockage geometry at burst higher with more radial and axial extension* than for Zy4 [an older zirconium fuel-cladding alloy] rods when experiencing the same conditions at burst"[47] [emphasis added]. (As stated above, reactor LOCA fuel-cladding ballooning phenomena are pertinent to SFP accidents, because, in both types of accidents, fuel rods would heat up to the point at which their internal-pressure increases caused them to balloon; in both types of accidents, the external pressure would be far less than the internal pressure of the fuel rods.)

32. Interestingly, the 2004 OECD Nuclear Energy Agency report states that, *in a reactor LOCA*, "[t]here is a more uniform cladding temperature at high burn-up, which can lead to much larger cladding deformations and thus more pronounced flow blockage."[48] It is plausible that these same phenomena would occur in a SFP boil-off accident, because the fuel rods in the SFP would not have the pronounced *chopped-cosine axial heat flux distribution*[49] that the fuel rods have in operating reactor cores; the axial heat flux, albeit far less, would be far more evenly distributed in the fuel rods stored in the SFP.

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[46] OECD Nuclear Energy Agency, "Summary Record of the Experts meeting on the proposed OECD-IRSN STLOC Project," NEA/CSNI/R(2004)1, January 13, 2004, p. 5.
[47] *Id*., p. 17.
[48] *Id*., p. 5.
[49] The locations of the active length of the fuel rods are much hotter at the mid-elevation than at the upper and lower ends. The active length of a fuel rod is the length of the cladding containing the fuel pellets; it is approximately 12-feet long.

33. The coplanar blockage of sausage-like fuel-cladding balloons (sections with a substantial axial extension), and any points of local rod-to-rod contact, would impede the local cooling of the fuel assemblies; and local blockage-section surface temperatures could increase up the point at which the zirconium fuel-cladding began to rapidly chemically react with steam or air at approximately 1000°C (1832°F) or 900°C (1652°F),[50] respectively.

34. Ballooning and bursting would also cause the fuel-cladding to lose the protection of preexisting oxide layers, as clean surface locations opened up, facilitating exothermic (heat-generating) oxidation and hydriding of zirconium (both of these reactions are discussed below).

35. Additionally, local ballooning and bursting of zirconium fuel cladding at grid spacers will augment the cladding-to-grid contact. The NRC report, NUREG-2121, states that "[g]rid spacers may 'pin' rod ballooning… In bundle geometries, ballooning tends to occur such that all the balloons are coplanar, but ballooning is largely suppressed in the sections of fuel rods that cross a grid spacer."[51]

36. Regarding how fuel rod ballooning could *decrease* the time to the ignition of zirconium *in air* in a SFP accident, a 2009 paper about an OECD Nuclear Energy Agency SFP safety analysis project states:

> Fuel rod ballooning is an important phenomena expected to occur prior to ignition [of the zirconium fuel cladding in a SFP accident]. Rod ballooning has been shown to occur in the temperature range of 950 K to 1150 K [1250°F to 1610°F]. In the BWR 1×4 ignition test a peak clad temperature of 1050K [1430°F] was reached at 2.75 hrs and the rapid escalation to ignition began at 4.75 hrs at a peak clad temperature of 1200 K [1700°F]. Thus fuel rod ballooning is expected to occur

[50] Allan S. Benjamin *et al*., Sandia Laboratories, "Spent Fuel Heatup Following Loss of Water During Storage," NUREG/CR-0649, March 1979, p. 47.

[51] Patrick A.C. Raynaud, "Fuel Fragmentation, Relocation, and Dispersal During the Loss-of-Coolant Accident," NUREG-2121, March 2012, (ADAMS Accession No. ML12090A018), p. 75.

> during the crucial period prior to ignition *and could be expected to decrease the time to ignition by an hour or more*[52] [emphasis added].

37. It can be extrapolated that because fuel rod ballooning could decrease the time to the ignition of zirconium *in air* in a SFP accident, ballooning could also decrease the time to the ignition of zirconium *in steam* in a SFP accident.

38. It is noteworthy that the NRC claims that "rod ballooning has a low impact on the timing to breakaway oxidation and the impact on the peak cladding temperature response was relatively insignificant."[53]

Contention 3 – Phenomena Regarding How Fuel Fragmentation, Relocation, and Dispersal Would Affect the Progression of a SFP Accident Are Not Considered in NUREG-2157, Appendix F, "Spent Fuel Pool Fires."

39. A March 2012 NRC report, NUREG-2121, states that "[f]uel fragmentation refers to any separation of the fuel pellet into more than one piece, regardless of when or why it occurred." In the reactor core, during typical operation, the uranium dioxide (UO_2) "fuel pellets develop many cracks because of thermal stresses."[54] A 2011 IAEA report explains that "[d]ue to thermal gradients, fuel pellets tend to fragment early in life,"[55] which can occur at fuel burnups "as low as a few megawatt days per metric ton uranium (MWd/MTU)."[56] It is likely that some

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[52] S. Güntay, J. Birchley, "MELCOR Further Development in the Area of Air Ingress and Participation in OECD NEA SFP Project to Be Performed in the Time Frame 2009-2012," April 2009, p. 14.
[53] NRC, "Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark I Boiling Water Reactor: Draft Report," June 2013, (ADAMS Accession No. ML13133A132), p. 26.
[54] Patrick A.C. Raynaud, "Fuel Fragmentation, Relocation, and Dispersal During the Loss-of-Coolant Accident," NUREG-2121, March 2012, (ADAMS Accession No. ML12090A018), p. 3.
[55] IAEA, "Impact of High Burnup Uranium Oxide and Mixed Uranium-Plutonium Oxide Water Reactor Fuel on Spent Fuel Management," No. NF-T-3.8, 2011, p. 37.
[56] Patrick A.C. Raynaud, "Fuel Fragmentation, Relocation, and Dispersal During the Loss-of-Coolant Accident," NUREG-2121, March 2012, (ADAMS Accession No. ML12090A018), p. 75.

degree of additional fuel fragmentation would occur in a reactor LOCA; a SFP accident would perhaps incur a lesser degree of additional fuel fragmentation than a reactor LOCA.

40. NUREG-2121 states that "[a]t higher values of burnup, fission gas production and migration is postulated to generate a 'rim' region in fuel pellets that is highly porous;" and that "[t]he size of fuel fragments is not uniform but tends to become smaller with increasing burnup."[57]

41. It is noteworthy that a 2012 paper, "Oxidation Studies on Irradiated UO_2 Fuels," states that "[f]uel fragmentation would result in larger surface areas available for corrosion processes and radionuclide release."[58]

42. Defining fuel relocation, NUREG-2121 states that "fuel relocation can be described as any physical movement of fuel pellets or fuel fragments within the cladding. … *Radial* fuel relocation is the movement of the fuel outward toward the fuel cladding. … *Axial* fuel relocation is the vertical movement of fuel fragments or particles within the cladding"[59] [emphasis not added].

43. Regarding *radial* fuel relocation, NUREG-2121 states that "fuel pellet cracking promotes an outward relocation of the pellet fragments that causes additional gap closure. This process is widely recognized in fuel performance analysis. It starts at beginning of life and quickly reaches equilibrium—by 5 GWd/MTU."[60] And regarding *axial* fuel relocation, NUREG-2121 states that "[u]nder normal operation, this process is usually limited by the fuel pellet immediately above or below the pellet in question." In experiments simulating reactor LOCAs,

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[57] Patrick A.C. Raynaud, "Fuel Fragmentation, Relocation, and Dispersal During the Loss-of-Coolant Accident," NUREG-2121, March 2012, (ADAMS Accession No. ML12090A018), pp. 3, 75.

[58] D. Papaioannou *et al*., "Oxidation Studies on Irradiated UO_2 Fuels" Top Fuel 2012 Transactions, European Nuclear Society, September 2-6, 2012, p. 5.

[59] Patrick A.C. Raynaud, "Fuel Fragmentation, Relocation, and Dispersal During the Loss-of-Coolant Accident," NUREG-2121, March 2012, (ADAMS Accession No. ML12090A018), p. 3.

[60] Patrick A.C. Raynaud, "Fuel Fragmentation, Relocation, and Dispersal During the Loss-of-Coolant Accident," NUREG-2121, March 2012, (ADAMS Accession No. ML12090A018), p. 3.

"voided regions of the cladding rod" and "additional fuel material [with]in the enlarged volume of the balloon region, or both" have been observed.[61]

44. Additionally, regarding the potential for the accumulation of relocated fuel fragments at the elevations of the spacer grids, NUREG-2121 states:

> Grid spacers may "pin" rod ballooning, potentially acting as choke points for fuel relocation. In bundle geometries, ballooning tends to occur such that all the balloons are coplanar, but ballooning is largely suppressed in the sections of fuel rods that cross a grid spacer.[62]

45. Regarding the fuel relocation which could occur in high burn-up fuel, in a reactor LOCA, a 2004 OECD Nuclear Energy Agency report states that "ANL [Argonne National Laboratory] tests have shown [the] potential for greater relocation at high burn-up due to increased fuel fragmentation. It is unknown if fuel-cladding bonding[63] delays relocation."[64] (This information is pertinent to the characteristics of the fuel-cladding ballooning and fuel relocation that could occur in SFP accidents, because, such phenomena could occur in both types of accidents.) The same report observes that larger fuel-cladding balloons—caused by "[n]ew alloys [that] have the tendency of being more ductile, which can increase ballooning size"—would be likely to facilitate a greater extent of fuel relocation and "the associated power generation increase."[65] (In a SFP accident any power generation increases caused by fuel relocation within fuel-

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[61] Patrick A.C. Raynaud, "Fuel Fragmentation, Relocation, and Dispersal During the Loss-of-Coolant Accident," NUREG-2121, March 2012, (ADAMS Accession No. ML12090A018), p. 3.

[62] Patrick A.C. Raynaud, "Fuel Fragmentation, Relocation, and Dispersal During the Loss-of-Coolant Accident," NUREG-2121, March 2012, (ADAMS Accession No. ML12090A018), p. 75.

[63] Regarding fuel-cladding bonding an October 2003 paper states: "Inner surface cladding oxidation and subsequent mechanical bonding between the fuel pellet and the cladding are well-known phenomena of high burnup and high duty fuels." See Sven Van den Berghe *et al*., "Observation of a Pellet-Cladding Bonding Layer in High Power Fuel," presented at "Advanced Fuel Pellet Materials and Designs for Water Cooled Reactors: Technical Committee Meeting," 20–24 October 2003, p. 307.

[64] OECD Nuclear Energy Agency, "Summary Record of the Experts meeting on the proposed OECD-IRSN STLOC Project," NEA/CSNI/R(2004)1, January 13, 2004, p. 5.

[65] OECD Nuclear Energy Agency, "Summary Record of the Experts meeting on the proposed OECD-IRSN STLOC Project," NEA/CSNI/R(2004)1, January 13, 2004, p. 5.

cladding balloons would not be significant because the heat flux (rate of heat transfer from the fuel rods) would be relatively low.)

46. As stated above, the 2004 OECD Nuclear Energy Agency report states that "it can be anticipated, due to this better ductility that, for modern alloys, the rod balloons will be bigger and the resulting flow blockage geometry at burst higher with more radial and axial extension than for Zy4 [an older zirconium fuel-cladding alloy] rods when experiencing the same conditions at burst."[66]

47. The coplanar blockage of sausage-like fuel-cladding balloons (sections with a substantial axial extension) that had relocated fuel fragments, would impede the local cooling of the fuel assemblies; and local blockage-section surface temperatures could increase up the point at which the zirconium fuel-cladding began to rapidly chemically react with either steam or air at approximately 1000°C (1832°F) or 900°C (1652°F), respectively.

48. Defining fuel dispersal, NUREG-2121 states that "[f]uel dispersal is the ejection of fuel fragments or particles through a rupture or opening in the cladding."[67] Rapid reactor LOCA transient phenomena, such as rapid external depressurization, could enhance the dispersal fuel fragments from ruptured locations of the fuel cladding; external depressurization would not occur in SFP accidents.

49. Fuel dispersal during a reactor LOCA could occur with fuel that had a burnup lower than 62 GWd/MTU; previously it was believed that *significant* fuel dispersal during a reactor LOCA

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[66] OECD Nuclear Energy Agency, "Summary Record of the Experts meeting on the proposed OECD-IRSN STLOC Project," NEA/CSNI/R(2004)1, January 13, 2004, p. 17.

[67] Patrick A.C. Raynaud, "Fuel Fragmentation, Relocation, and Dispersal During the Loss-of-Coolant Accident," NUREG-2121, March 2012, (ADAMS Accession No. ML12090A018), p. 3.

would not occur if the fuel had burnups lower than 62 GWd/MTU (average for the peak rod).[68] It seems probable that some degree of fuel dispersal would also occur in a SFP accident if the burnup were lower (or greater) than 62 GWd/MTU.) NUREG-2121 states that “[s]ome fuel dispersal has been observed in every case in which (1) rod rupture occurs, and (2) the fuel fragments are small enough to get through the rupture opening.” And states that “[t]he amount of fuel that is dispersed can vary widely, from a puff of dust to large amounts of fragmented and pulverized fuel. Although evidence points to likely fuel dispersal in many tests, this phenomenon was not systematically investigated nor documented in the majority of test programs.”[69]

Contention 4 – Phenomena Regarding How Hydrogen Combustion Would Affect the Progression of a SFP Accident Are Not Considered in NUREG-2157, Appendix F, “Spent Fuel Pool Fires.”

50. Radiological releases resulting from core damage would contaminate the nuclear power plant (“NPP”) site and impede efforts to mitigate the accident, especially if radioactive debris were propelled throughout the site by hydrogen explosions, as occurred in the Fukushima Dai-ichi accident.[70] After the Fukushima Dai-ichi site was contaminated, workers had to wear additional protective clothing and limit the time they spent, working to mitigate the accident.[71]

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[68] Patrick A.C. Raynaud, “Fuel Fragmentation, Relocation, and Dispersal During the Loss-of-Coolant Accident,” NUREG-2121, March 2012, (ADAMS Accession No. ML12090A018), p. 1.
[69] Patrick A.C. Raynaud, “Fuel Fragmentation, Relocation, and Dispersal During the Loss-of-Coolant Accident,” NUREG-2121, March 2012, (ADAMS Accession No. ML12090A018), p. 75.
[70] Institute of Nuclear Power Operations (“INPO”), “Special Report on the Nuclear Accident at the Fukushima Dai-ichi Nuclear Power Station,” INPO 11-005, November 2011, pp. 9, 12, 21, 24, 25, 32, 37, 79, 85, 86, 96.
[71] Institute of Nuclear Power Operations (“INPO”), “Special Report on the Nuclear Accident at the Fukushima Dai-ichi Nuclear Power Station,” INPO 11-005, November 2011, p. 9.

Efforts to mitigate a SFP accident would also be impeded (or possibly entirely prevented for significant time periods) by the radiologically-contaminated environment.

51. In BWR Mark I and Mark II designs, SFPs are typically located at the level of the operating floor, approximately 100 to 150 feet above ground level,[72] in the reactor building (secondary containment). If either a BWR Mark I or Mark II reactor core melted down and the total amount of the zirconium in the core—approximately 76,000 kg—were to chemically react with steam, approximately 3360 kg of hydrogen would be generated.[73] In the event of a severe accident at either a BWR Mark I or BWR Mark II, the Fukushima Dai-ichi accident scenario of hydrogen leaking from over-pressurized primary containments and/or hardened vent systems should be considered as likely to occur again. In the Fukushima Dai-ichi accident, BWR Mark I reactor buildings—essentially industrial buildings with design pressures of approximately 3.0 psig[74]—were compromised by hydrogen explosions. BWR Mark II reactor buildings also have low design pressures.

52. Hence, BWR Mark I and Mark II SFPs are vulnerable to the hydrogen explosions that can occur in reactor buildings. A June 2013 NRC report on how earthquakes could affect BWR Mark I SFPs states that "[t]he occurrence of a hydrogen combustion event from a concurrent reactor accident has the potential to generate debris which could impair SFP natural circulation air or steam cooling (should the fuel in the SFP become uncovered) for conditions in which the

[72] NRC, "Regulatory Analysis for the Resolution of Generic Issue 82, 'Beyond Design Basis Accidents in Spent Fuel Pools'," NUREG-1353, April 1989, (ADAMS Accession No. ML082330232), p. 4.6.
[73] IAEA, "Mitigation of Hydrogen Hazards in Severe Accidents in Nuclear Power Plants," IAEA-TECDOC-1661, July 2011," p. 10 (hereinafter "Mitigation of Hydrogen Hazards in SA").
[74] Sherrell R. Greene, Oak Ridge National Laboratory, "The Role of BWR Mark I Secondary Containments in Severe Accident Mitigation," Proceedings of the 14th Water Reactor Safety Information Meeting at the National Bureau of Standards, Gaithersburg, Maryland, October 27-31, 1986, Exhibit 6.

fuel might otherwise be cooled by means of these passive cooling modes."[75] Furthermore, if either a BWR Mark I or Mark II SFP were compromised by a hydrogen explosion, it could cause large radiological releases.

53. If a BWR Mark I or Mark II reactor building were breached by a hydrogen explosion there would be more available oxygen to facilitate oxidation of the zirconium cladding of the fuel assemblies. A June 2013 NRC report on how earthquakes could affect BWR Mark I SFPs states that if there were a hydrogen explosion in the reactor building, "damage could breach structures that would retain radioactive material, along with allowing more oxygen into the building, potentially increasing the severity of the spent fuel fire."[76] The accelerated zirconium oxidation would contribute additional heat, causing a quicker fuel-cladding temperature escalation, releasing yet more heat, causing a more rapid axial and radial propagation of the SFP fire. This would cause increased radiological releases from the SFP.

54. If the fuel assemblies were uncovered in either a SBO boil-off accident or a partial SFP LOCA, explosive hydrogen gas would be generated by the reaction of steam with the zirconium cladding of fuel rods. If enough hydrogen were generated, it could detonate.[77] Computer analyses conducted at ORNL with the MELCOR computer safety model found that in a *hypothetical* scenario if Fukushima Dai-ichi Unit 4's SFP had boiled dry, a total of 1800 to 2050 kilograms ("kg") of hydrogen could have been generated. A 2012 ORNL paper states that "[i]n theory, it [would be] possible to generate up to 3.4 kg of hydrogen per assembly (from

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[75] NRC, "Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark I Boiling Water Reactor: Draft Report," June 2013, (ADAMS Accession No. ML13133A132), p. 25.

[76] NRC, "Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark I Boiling Water Reactor: Draft Report," June 2013, (ADAMS Accession No. ML13133A132), p. ix.

[77] Juan J. Carbajo, Oak Ridge National Laboratory, "MELCOR Model of the Spent Fuel Pool of Fukushima Dai-ichi Unit 4," 2012, p. 1.

oxidation of [zirconium] in the fuel cladding and box), or *a total of 4,525 kg* from the hot 1331 assemblies stored in [Unit 4's SFP]. The hydrogen generated from oxidation of steel and B_4C [boron carbide] in the racks [would] be additional"[78] [emphasis added].

55. It is noteworthy that in MELCOR BWR Mark I "SFP calculation[s], [hydrogen] ignition is assumed to occur in the reactor building when the hydrogen concentration exceeds 10 percent by volume. In addition, MELCOR checks to determine whether there is sufficient oxygen. The minimum oxygen mole fraction for ignition is 5 percent."[79]

56. MELCOR SFP calculations of hydrogen combustion do not consider that significant deflagrations[80] of hydrogen can occur when local hydrogen concentrations are lower than 10 percent by volume. For example, in the Three Mile Island Unit 2 ("TMI-2") accident, a hydrogen deflagration occurred when the hydrogen concentration was 8.1 volume percent;[81] the deflagration caused a rapid pressure increase of approximately 28 pounds per square inch ("psi") in the containment.[82] Of course, the volume of a PWR large day containment, such as TMI-2 had, is different than that of a BWR Mark I reactor building; however, it is clear that a significant hydrogen deflagration would compromise a BWR Mark I reactor building, which has a relatively low design pressure.

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[78] Juan J. Carbajo, Oak Ridge National Laboratory, "MELCOR Model of the Spent Fuel Pool of Fukushima Dai-ichi Unit 4," 2012, pp. 1-2.

[79] NRC, "Consequence Study of a Beyond-Design-Basis Earthquake Affecting the Spent Fuel Pool for a U.S. Mark I Boiling Water Reactor: Draft Report," June 2013, (ADAMS Accession No. ML13133A132), p. 103.

[80] A deflagration is a combustion wave traveling at a subsonic speed (less than the speed of sound) relative to the unburned gas.

[81] Kahtan N. Jabbour, NRC, letter regarding Turkey Point Units 3 and 4, Exemption from Hydrogen Control Requirements, December 12, 2001, Attachment 2, "Safety Evaluation by the Office of Nuclear Reactor Regulation, Turkey Point Units 3 and 4," available at: www.nrc.gov, NRC Library, ADAMS Documents, Accession Number: ML013390647, p. 4.

[82] W. E. Lowry *et al*., Lawrence Livermore National Laboratory, "Final Results of the Hydrogen Igniter Experimental Program," NUREG/CR-2486, February 1982, p. 4.

57. PWR and BWR Mark III SFPs are typically located at ground level.[83] In the event of a severe *reactor* accident, PWR and BWR Mark III SFPs would not be as vulnerable to the potential consequences of explosive hydrogen gas—generated from oxidized zirconium and other core materials—as BWR Mark I and Mark II SFPs. However, if the fuel assemblies were uncovered in either a SBO boil-off accident or a partial SFP LOCA, PWR and BWR Mark III SFPs, would be vulnerable to the explosive hydrogen gas that would be generated by the reaction of steam with zirconium and other materials in the SFP.

58. For example, Indian Point Energy Center is located less than 25 miles north of New York City; more than 17 million people live within a 50-mile radius of Indian Point.[84] On August 26, 2013, Indian Point Unit 2's SFP, which has a storage capacity of 1374 fuel assemblies, contained 1104 fuel assemblies (80 percent of capacity); and Indian Point Unit 3's SFP, which has a storage capacity of 1345 fuel assemblies, contained 1199 fuel assemblies (89 percent of capacity).[85] (The fuel assemblies in a typical PWR core have approximately 26,000 kg of zirconium that, if completely oxidized, would generate a total of approximately 1150 kg of hydrogen.[86] The cores of pressurized-water reactors, like Indian Point's, typically contain between 150 and 200 fuel assemblies.[87])

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[83] NRC, "Regulatory Analysis for the Resolution of Generic Issue 82, 'Beyond Design Basis Accidents in Spent Fuel Pools'," NUREG-1353, April 1989, (ADAMS Accession No. ML082330232), p. 4.6.

[84] Edwin S. Lyman, Union of Concerned Scientists, "Chernobyl on the Hudson?: The Health and Economic Impacts of a Terrorist Attack at the Indian Point Nuclear Plant," September 2004, p. 23.

[85] NRC, "Summary of August 26, 2013, Meeting with Entergy Nuclear Operations, Inc. and Netco on Indian Point Unit 2 Spent Fuel Pool Management," September 24, 2013, (ADAMS Accession No. ML13256A086), p. 1.

[86] IAEA, "Mitigation of Hydrogen Hazards in Severe Accidents in Nuclear Power Plants," IAEA-TECDOC-1661, July 2011," p. 10 (hereinafter "Mitigation of Hydrogen Hazards in SA").

[87] NRC, "Pressurized Water Reactors," (available at: http://www.nrc.gov/reactors/pwrs.html : last visited on 10/15/13).

59. Indian Point's owner, Entergy, touts the safety of Indian Point Unit 2 and 3's SFPs, explaining that "[t]hey are constructed with concrete walls 4 to 6 feet wide and with a half-inch stainless steel inner liner" and that "the fuel pool for Indian Point 2 is completely underground and Indian Point 3['s] is nearly 100% underground, so they are protected on all sides by rock and gravel."[88] However, if there were a SFP fire at either unit (or at both), *thousands of kilograms of explosive hydrogen gas* could be generated by the oxidation (burning) of the tens of thousands kilograms of zirconium—the cladding material of the fuel rods—in storage. It is almost inevitable that hydrogen gas would detonate, breaching the barriers that are supposed to protect the public; releases of radiation could far exceed the quantity released by the Chernobyl Unit 4 accident. More land could be contaminated than the area encompassing the Chernobyl Exclusion Zone, with higher concentrations of radioactive cesium-137. The number of premature deaths from cancer and economic damages would perhaps be incalculable.

60. An October 2011 Natural Resources Defense Council ("NRDC") report, "Nuclear Accident at Indian Point: Consequences and Costs," with analyses of the potential radiological consequences of *one full reactor core melt* at Indian Point, would perhaps help provide insight regarding the magnitude of the damages and suffering that would ensue from a SFP fire at Indian Point.

61. The NRDC report states:

> An accident at Indian Point Unit 3 involving a full reactor core melt approaching the scale of Chernobyl could put people in New York City at risk for receiving a whole-body radiation dose greater than 25 rem, resulting in a 7 percent increase in risk of premature death from cancer for an average individual. An accident of this scale would require the administration of stable iodine throughout the New York City metropolitan area, and put thousands at risk for radiation sickness in and near the Hudson Valley. …

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[88] Entergy, "Safe, Secure, Vital: Indian Point Energy Center," website, "Spent Fuel," (located at http://www.safesecurevital.com/safe-secure-vital/spent-fuel.html: last visited on October 12, 2013)

> A release of radiation on the scale of Chernobyl's would make Manhattan too radioactively contaminated to live in if the city fell within the plume.[89]

/s/ Mark Edward Leyse

Dated: December 10, 2013

[89] Matthew McKinzie, NRDC, "Nuclear Accident at Indian Point: Consequences and Costs," October 17, 2011, Cover Sheet, p. 1.

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