No. 16-1275

IN THE

Supreme Court of the United States

VIRGINIA URANIUM, *et al.*,

Petitioners,

v.

JOHN WARREN, IN HIS OFFICIAL CAPACITY AS DIRECTOR OF THE VIRGINIA DEPARTMENT OF MINES, MINERALS, AND ENERGY, *et al.*,

Respondents.

ON WRIT OF CERTIORARI TO THE UNITED STATES COURT OF APPEALS FOR THE FOURTH CIRCUIT

BRIEF OF *AMICI CURIAE* FORMER NUCLEAR REGULATORS IN SUPPORT OF PETITIONERS

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INTEREST OF *AMICI CURIAE*[1]

Amici curiae are fourteen former senior nuclear regulators for the United States Nuclear Regulatory Commission ("NRC" or "Commission"). Collectively, *amici curiae* have over 350 years of knowledge of and experience with the regulation of radiological health, safety, and environmental issues, including those associated with uranium milling and long-term tailings management.

The *amici curiae* offer their knowledge and experience as former NRC regulators to address the concerns and common misconceptions about uranium and its byproducts that appear to have led to Virginia's continued moratorium on uranium mining[2], and to explain how NRC's current licensing requirements, dose limits, and regulatory oversight and enforcement authority ensure that there will be no significant harm to health, safety, or the environment from a licensed uranium milling operation or tailings disposal and management.

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1. No counsel for a party authored this brief in whole or in part. *Amici curiae* advise that *amicus* Dr. Malcolm Knapp was engaged as an expert witness on behalf of Petitioner Virginia Uranium in a Virginia state court action against the Commonwealth of Virginia related to the Coles Hill project, in which Virginia Uranium was represented by counsel for Petitioners here. Dr. Knapp was not compensated by Petitioners (or anyone else) for his participation in this brief. No person made a monetary contribution to or intended to fund the preparation or submission of this brief, other than the *amici*, or their attorneys.

By filing statements of consent with the Court, the parties have consented to the filing of this *amicus curiae* brief.

2. *See* Pet.Br. at 15-19.

Amici curiae include former NRC officials **L. Joseph Callan**, former Executive Director for Operations[3]; **Francis X. "Chip" Cameron**, former Assistant General Counsel; **Dr. Nils J. Diaz**, former NRC Commissioner and Chairman; **John T. Greeves**, former Director, Division of Waste Management; **Joseph R. Gray**, former Associate General Counsel for Licensing and Regulation; **Dr. Malcolm R. Knapp**, former Deputy Executive Director for Regulatory Effectiveness; **James Lieberman**, former Director of Enforcement; **Jeffrey S. Merrifield**, former NRC Commissioner; **Ellis W. Merschoff**, former Deputy Executive Director for Operations; **C. William Reamer**, former Director, High-Level Waste Repository Safety Division, Office of Nuclear Materials Safety and Safeguards; **Luis Reyes**, former Executive Director for Operations; **Hugh L. Thompson, Jr.**, former Deputy Executive Director for Regulatory Programs; **Dr. William D. Travers**, former Executive Director for Operations; and **Martin Virgilio**, former Deputy Executive Director for Operations.

Summaries of the *amici curiae*'s relevant background and experience are in the Appendix to this brief.

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3. The Executive Director for Operations is NRC's chief operating officer, discharging the operational and administrative functions of the Commission, supervising and coordinating policy development, managing operational activities, and implementing policy directives. Program offices reporting to the Executive Director of Operations ensure the safe commercial production, use, and disposal of nuclear materials; one of these, the Office of Nuclear Material Safety and Safeguards, regulates activities related to uranium recovery, including waste disposal and management. NRC's four regional offices conduct the inspection, enforcement, and emergency response programs for licensees located within their borders.

BACKGROUND: THE ATOMIC ENERGY ACT AND NRC'S MISSION AND AUTHORITY TO PROTECT PUBLIC HEALTH & ENVIRONMENT

Congress adopted the Atomic Energy Act of 1954 ("AEA"), 42 U.S.C. § 2011 *et seq.*, "to encourage widespread participation in the development and utilization of atomic energy for peaceful purposes to the maximum extent consistent with the common defense and security and with the health and safety of the public[.]" 42 U.S.C. § 2013(d). Because nuclear safety is critical to the development of the civilian nuclear industry, Congress designed the AEA "to insure that nuclear technology be safe enough for widespread development and use[.]" *Pacific Gas & Elec. Co. v. State Energy Res. Conservation & Dev. Comm'n*, 461 U.S. 190, 213 (1983).

With the enactment of the National Environmental Policy Act of 1969, 42 U.S.C. § 4321 *et seq.*, the Atomic Energy Commission's regulatory mandate was explicitly expanded to cover the environmental impact of the activities regulated by the Commission. *Vermont Yankee Nuclear Power Corp. v. Natural Resources Defense Council, Inc.,* 435 U.S. 519 (1978).

The Energy Reorganization Act of 1974, 42 U.S.C. § 5801 *et seq.*, established the NRC as an independent agency responsible for nuclear licensing and related regulatory functions, and increased the number and range of NRC's safety responsibilities over those of its predecessor, the Atomic Energy Commission. *English v. General Elec. Co.* 496 U.S. 72, 81 (1990).

Congress further expanded the NRC's jurisdiction, with specific attention to uranium milling and tailings management, with the passage in 1978 of the Uranium Mill Tailings Radiation Control Act ("UMTRCA"), Pub. L. No. 95-604, 42 U.S.C. § 7901 *et. seq.*

NRC protects the health and safety of the public and the environment by licensing and regulating civilian use of radioactive materials, including source material (uranium and thorium), enriched uranium and plutonium, and byproduct material, including mill tailings. NRC employs over 3,000 people at five primary locations, and has an annual budget of about $1 billion. Approximately 90% of NRC's budget authority is recovered from licensees and license applicants.

SUMMARY OF ARGUMENT

The Virginia legislature's "radiological safety concerns" about "uranium milling and uranium tailings management," Pet.App.26a-27a (Traxler, J., dissenting), such as possible contamination of the drinking water supply by tailings piles, are based on common misconceptions about uranium, radiation, and the federal regulatory process. While radioactive materials must be managed with due care, the NRC is chartered, funded, and staffed to ensure that all aspects of the nuclear fuel cycle are executed safely, and are protective of public health and the environment.

Uranium milling and tailings management, as licensed and regulated by NRC today, do not pose any significant risk to public health or the environment. NRC has exercised its Congressionally-mandated authority to develop and implement comprehensive regulations and effective oversight over these activities.

NRC's layered approach to protect public health and safety and the environment employs carefully crafted regulations incorporating a conservative margin of safety, comprehensive review of license applications and renewals to ensure licensees meet all regulatory criteria, detailed guidance for licensees and prospective licensees, mandatory monitoring, reporting, and on-site inspections and investigations of licensee operations, and enforcement action by NRC if necessary to assure compliance.

ARGUMENT

NRC's regulations and oversight of the uranium milling and tailings management processes provide a high margin of safety for workers, the public, and the environment—both during the operational life of the facility and afterward. NRC's regulations and oversight program have developed through the agency's expertise and experience, and are in line with modern international standards and practices for conventional uranium mining and tailings disposal, which have proven effective.

NRC's radiological safety standards require licensed uranium milling and tailings disposal facilities—like all NRC-licensed facilities—to maintain radiation dose levels as low as reasonably achievable, and in no case higher than NRC's numerical standards, which are set far below levels likely to cause harm.

Before construction of uranium milling facilities and mill tailings impoundments can even begin, prospective licensees must demonstrate to NRC that the planned facilities will meet regulatory requirements designed to ensure the operational safety of the mill and the safe disposal and effective containment of mill tailings for the long term without the need for active maintenance. NRC inspects and monitors licensees throughout construction and active operations, and at decommissioning, the licensee must return the site and the tailings impoundments to levels similar to the natural surroundings. Ownership of the land on which tailings impoundments are located is then transferred to the Federal or state government for long-term surveillance.

I. The Uranium Recovery Process and the Commission's Regulatory Authority

A. Uranium in the Natural Environment

Uranium is a naturally-occurring element with an average concentration of 2.8 parts per million in the Earth's crust. While large deposits like the Coles Hill orebody are rare, traces of uranium are found almost everywhere on Earth—it is about 500 times more abundant than gold, and about as common as tin. Uranium is commonly found in bedrock materials such as granite and limestone, and trace amounts from natural sources are commonly found in air and water. Vast amounts of uranium are in the world's oceans, although in very low concentrations.

Uranium, whether before or after it is mined and milled, emits radiation, but at levels that are not considered hazardous. For example, a handful of natural uranium ore emits about as much radiation as 10 bananas.[4]

4. Canadian Nuclear Association, How Radioactive Is Uranium Ore?, http://talknuclear.ca/2014/08/just-how-radioactive-is-uranium-ore/ (last visited July 24, 2018). Bananas contain the naturally-occurring radioactive isotope potassium-40.

Natural uranium is primarily (>99%) composed of U-238, an isotope with very low radioactivity and a half-life of over 4 billion years, meaning that it emits radiation at a very slow rate. Natural uranium also has minute quantities of more radioactive isotopes U-235 and U-234; the enrichment process increases the U-235 concentration to create nuclear fuel.

Uranium's radioactive decay produces radon, a radioactive gas. While exposure to high levels of radon over an extended period may be harmful, everyone on Earth is exposed to radon from natural sources, accounting for most of the background dose.[5]

B. Uranium Mining, Milling, and Tailings Management

Uranium recovery involves three stages: mining, milling, and tailings management. After mining, uranium ore goes to a milling facility to be crushed and put through a chemical leaching process to extract the uranium oxide (principally U_3O_8), known as "yellowcake," as a first step in the production of nuclear fuel.[6] Yellowcake is then transported to conversion and enrichment facilities, for fabrication into nuclear fuel.[7]

5. *See infra* notes 29-36 and accompanying text.

6. NRC, Uranium Recovery, https://www.nrc.gov/materials/uranium-recovery.html (last visited July 24, 2018).

7. NRC, Uranium Conversion, https://www.nrc.gov/materials/fuel-cycle-fac/ur-conversion.html (last visited July 24, 2018).

Uranium at the yellowcake stage has the same radioactivity as it did when it was underground. The milling process extracts most of the uranium from the ore, but does not alter the proportions of the uranium isotopes, which remain at their natural concentrations. In this form, it is barely more radioactive than the granite used in buildings.[8] There is no nuclear criticality hazard and little fire or explosive risk. Radiological hazards are also low, as uranium has little penetrating radiation and only moderate non-penetrating radiation. The primary industrial hazards associated with uranium milling are the occupational hazards found in any metal milling operation that uses chemical extraction, as well as the chemical toxicity of the material itself.

The primary radiological hazard is from radium in the fine-grained, sandy waste byproduct material known as "mill tailings," which remains after the milling process extracts and concentrates the uranium from the ore. Tailings are deposited in an impoundment or "mill tailings pile," which is carefully regulated, monitored, and controlled because of the remaining amounts of uranium and other metals, as well as radium produced by uranium's radioactive decay, which further decays to produce radon.

8. World Nuclear Association, Radioactive Waste Management, http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-wastes/radioactive-waste-management.aspx (last visited July 24, 2018).

C. NRC's Regulatory Authority and Obligation to Ensure Safety of Uranium Milling and Tailings Management

NRC licenses are required to "transfer or receive in interstate commerce, manufacture, produce, transfer, acquire, own, possess, import, or export" any radioactive "source material," including natural uranium after it has been removed from nature, and "byproduct material," one form of which is uranium milling tailings. 42 U.S.C. §§ 2092; 2111; 2014(z); 2014(e)(2).[9] The NRC's licensing authority for the uranium recovery process begins at the milling stage,[10] and includes both the milling of uranium ore and mill tailings management.

Until 1978, uranium mill tailings were not federally regulated and sometimes were even used as building materials.[11] As a result, large quantities of tailings accumulated at milling sites, particularly in Western states, and there were several incidents involving breaches of poorly designed tailings impoundments.[12]

Congress added uranium mill tailings to AEA's definition of licensable "byproduct material" in the

9. NRC may delegate by agreement its licensing and regulatory authority to states, provided the state's regulation is at least as strict as NRC's. 42 U.S.C. § 2021. Virginia's agreement with NRC does not cover uranium milling or tailings disposal.

10. Virginia would have regulatory control over the mining component.

11. *See* H.R. REP. No. 1480, pt. I, 95th Cong., 2d Sess.

12. *Id.*

Uranium Mill Tailings Radiation Control Act of 1978, which requires NRC to prevent such problems in future milling operations. UMTRCA requires NRC to protect public health by ensuring that mill tailings are stabilized and controlled in a safe and environmentally sound manner to minimize or eliminate radiological and non-radiological health hazards to the public. 42 U.S.C § 2114. UMTRCA also requires NRC to ensure the licensee's financial capability to meet decontamination, decommissioning, and reclamation obligations, and that title to the tailings disposal site is transferred to the Federal or state government for long-term surveillance and management. *Id.* §§ 2113; 2201(x).

These provisions authorize the NRC to use its regulatory authority to assure that the problems resulting from uranium mill tailings and uranium milling operations that led to the passage of UMTRCA would not recur. And they have not reoccurred.

II. NRC Regulation of Uranium Milling and Tailings Management

NRC regulates uranium milling and disposal of the resulting waste materials by (1) setting and enforcing radiation protection standards, and (2) establishing and overseeing a licensing and inspection program that requires uranium milling and mill tailings operations to control industrial hazards and address waste and decommissioning concerns as a condition of licensing.

Consistent with its mission, NRC focuses its regulatory actions on protecting the health and safety of workers, the public, and the environment in reviewing license applications and amendments for uranium recovery facilities, developing and releasing for public comment safety evaluations, environmental assessments and environmental impact statements documenting the agency's licensing reviews; inspecting active uranium recovery facilities; and reviewing and overseeing decommissioning plans and activities.

NRC's comprehensive regulations, developed through extensive public comment and reference to international standards and practices, provide a strong foundation to ensure that NRC's licensing, oversight, and enforcement of uranium milling and mill tailings disposal effectively promote safety and protect public health and the environment.

A. NRC's Regulatory Standards for Protection Against Radiation Establish a Substantial Margin of Safety for Workers and the Public

The protective standards that NRC established in Title 10, Part 20 of the Code of Federal Regulations ("Part 20") are designed to keep radiation doses to workers and members of the public within specified limits that provide "a very substantial margin of safety for exposed individuals … in accordance with present knowledge[.]"[13] By requiring all NRC licensees to also make every reasonable effort to maintain radiation exposures and releases of radioactive materials to unrestricted areas "as low as is reasonably

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13. Standards for Protection Against Radiation (1957 Final Rule), 22 Fed. Reg. 548, 549 (January 29, 1957) (noting that "the standards are subject to change with the development of new knowledge.").

achievable (ALARA)," 10 C.F.R. § 20.1101(b), "the degree of protection could be significantly greater than from relying upon the dose limits alone."[14]

At the relatively low levels of radiation exposure in the United States, it is difficult to demonstrate a relationship between exposure and any health effects.[15] The dose limits in Part 20 are therefore based upon what NRC considers an acceptable level of risk to the exposed individual, and are well below dose levels likely to cause harm, with a considerable margin of safety.[16]

NRC generally follows the radiation protection recommendations of the International Commission on Radiological Protection ("ICRP"), an independent, non-governmental organization, which issues widely-followed recommendations and guidance on radiation protection, and its U.S. counterpart, the National Council on Radiation Protection and Measurements ("NCRP").[17] The initial 1957 Part 20 standards substantially agreed with standards NCRP set in 1953 (and later adopted by ICRP), and Part 20 was amended in 1960 to reflect NCRP's revised 1959 standards.[18]

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14. Standards for Protection Against Radiation (1991 Final Rule), 56 Fed. Reg. 23360 (May 21, 1991).

15. *See* NRC, *ALARA Levels for Effluents from Materials Facilities,* Regulatory Guide 8.37 (July 1993), p.2.

16. *See id.*; *see also* 56 Fed. Reg. at 23360-23361.

17. 22 Fed. Reg. at 549; 56 Fed. Reg. at 23361.

18. *See* 79 Fed. Reg. 43284, 43285-43286 (July 25, 2014) (recounting regulatory history of Part 20).

NRC comprehensively revised Part 20 in 1991 to reflect standards issued by the ICRP in 1977 and 1978 and NCRP's 1987 recommendations, including an ALARA requirement.[19] Accordingly, in practice, and by regulatory design, NRC licensees inevitably maintain levels well below Part 20's regulatory limits.[20]

1. Maximum Radiation Dose Levels and Effluent Concentration Limits

All NRC licensees—including uranium mills and tailings disposal sites—must maintain radiation exposures below Part 20 annual dose limits and effluent concentration limits, and demonstrate compliance through routine radiation monitoring and reporting. The current dose limits are consistent with NCRP's current standards, which set a dose limit for which the probability of injury is so low that the risk would be readily acceptable to the average individual and that competent medical authorities would not find deleterious to health.

i. Occupational Workers

The maximum annual dose to workers at a licensed facility is 5,000 millirem[21] per year. 10 C.F.R. § 20.1201(a). Airborne concentrations to which radiation workers may

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19. *See* 56 Fed. Reg. at 23360-23363.

20. *See id.* at 23363; 81 Fed. Reg. 95410, 95411 (Dec. 28, 2016).

21. A millirem ("mrem") is one one-thousandth of a rem, a standard unit of measure for radiation. It is equivalent to 0.01 sievert, a more commonly used standard measurement for radiation outside the United States.

be exposed must also meet strict concentration limits. *Id.* § 20.1201(d).[22] Workers exceeding 10% of the occupational dose limit must receive an annual dose report. *Id.* § 20.2206.[23]

NRC continues to evaluate whether the dose limits should be further reduced.[24] NRC has so far determined that no change is necessary, given the already very high margin of safety of the current standard and the fact that even licensees with the highest exposure levels in the nuclear industry continue to report levels below the ICRP's current occupational dose recommendations.[25]

ii. Members of the Public

The annual dose limit to members of the public from an NRC-licensed operation must be below 100 millirem per year. 10 C.F.R. § 20.1301. Both airborne and liquid effluents released to the accessible environment must meet strict concentration limits to demonstrate compliance

22. *See also* Part 20, subpart H; NRC, *Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations*, Regulatory Guide 3.59 (March 1987).

23. *See also* NRC, *Health Physics Surveys in Uranium Recovery Facilities*, Regulatory Guide 8.30 (Rev. 1, May 2002).

24. *See, e.g.,* 79 Fed. Reg. 43284 (advance notice of proposed rulemaking).

25. *See* 81 Fed. Reg. at 95411 (finding that nuclear industry's current operating procedures and practices protect both occupational workers and members of the public and go beyond the applicable regulatory requirements, such that further reduction of dose limits "would result in little, if any, improvement in occupational or public radiological safety").

with this requirement. *See id.* § 20.1302.[26] NRC requires licensees to use these conservative assumptions in demonstrating compliance with this standard in order to assure that the doses to actual populations in the vicinity of any licensed facility are small fractions of the public dose limit.

iii. Compliance and Reporting

Licensees must conduct surveys and monitoring to assess radiation levels and concentrations of effluents in air and water, such as may be necessary to comply with Part 20 regulations. 10 C.F.R. § 20.1501. Records of routine surveys and monitoring are reviewed at least yearly by NRC.

Licensees must promptly report any significant incidents, exposures, and doses in excess of regulatory limits to allow NRC to assess and coordinate a response. *Id.*, subpart M. If necessary, NRC has authority to enforce dose limits through civil and criminal penalties. *Id.*, subpart O.

All licensees must also maintain a formal radiation protection program "sufficient to ensure compliance" with Part 20 limits and requirements, using procedures and engineering controls "to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable (ALARA)." *Id.* § 20.1101.[27] The

26. Part 20, Appendix B, Table 2 shows air and water concentrations for various effluents at which continuous exposure over the course of a year would result in a total dose of 50 millirem.

27. Regulatory Guide 8.37, *supra* n.15, addresses the design and implementation of radiation safety program in materials facilities.

ALARA philosophy assumes that any level of radiation exposure carries a commensurate risk, and thus exposures should be minimized when practical.[28]

Licensees must review their radiation protection program content and implementation at least annually, *Id.* § 20.1101(c), and maintain written records of program audits and implementation. *Id.* § 20.2102.

2. Maximum Dose Limits in Perspective

To put the annual maximum dose limits in perspective, it is first important to recognize that everyone on Earth is—and always has been—exposed to some level of naturally-occurring cosmic and terrestrial radiation, and radioactive isotopes naturally present in human bodies.[29] Even extraordinarily high background doses—10,000 millirem or more—do not appear to result in increased cancers or other health problems.[30]

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28. NRC, *Operating Philosophy for Maintaining Occupational and Public Radiation Exposures as Low as Is Reasonably Achievable,* Regulatory Guide 8.10, (Rev. 2, Aug. 2016), p.5. *See also* NRC, *Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will be ALARA*, Regulatory Guide 8.31 (Rev. 1, May 2002).

29. *See* NRC, Natural Background Sources of Radiation, https://www.nrc.gov/about-nrc/radiation/around-us/sources/nat-bg-sources.html (last visited July 24, 2018).

30. World Nuclear Association, Nuclear Radiation Health Effects, http://www.world-nuclear.org/information-library/safety-and-security/radiation-and-health/nuclear-radiation-and-health-effects.aspx (last visited July 24, 2018) (natural levels in some areas of more than 100 millisieverts (10,000 millirem) do not appear to cause harm).

The average person in the U.S. receives an annual average dose of about 620 mrem from all background sources, of which about half (310 mrem) is from naturally-occurring radiation,[31] mostly from radon produced by the decay of uranium in the natural environment[32], although radon levels vary widely by location.[33] By far, most of the average American's radiation exposure comes from cosmic radiation, the Earth, naturally occurring radon, medical procedures, and computer and television screens—*not* from nuclear energy or uranium mining.[34]

Uranium mines and nuclear facilities together account for only about 0.1% of the average American's annual radiation exposure due to man-made sources.[35] Most man-made radiation exposure is from nuclear medicine and medical procedures (*e.g.*, chest x-ray, 10 mrem; mammogram, 72 mrem; full-body CT scan, 1,000 mrem),

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31. NRC, Doses in Our Daily Lives, https://www.nrc.gov/about-nrc/radiation/around-us/doses-daily-lives.html (last visited July 24, 2018).

32. Natural Background Sources, *supra* note 29.

33. For example, the average annual dose from radon is 260 mrem for a person living in Virginia, but 610 mrem for someone living in Colorado. *See* S. Cohen & Assoc., (for EPA Office of Radiation and Indoor Air), *Assessment of Variations in Radiation Exposure in the United States*, (July 15, 2005), p.4, *available at* https://www.orau.org/ptp/PTP%20Library/library/Subject/Environmental/radiationbackground.pdf.

34. *See* NRC, Sources of Radiation, https://www.nrc.gov/about-nrc/radiation/around-us/sources.html (last visited July 24, 2018).

35. *Id.*

accounting for about 48% of the average American's total annual exposure; consumer products (*e.g.*, televisions, computer screens) make up about 2 percent.[36]

And one's proximity to the source greatly affects the dosage. For example, the annual dose due to radon at **100 meters** downwind of a uranium tailings pile that complies with the NRC regulatory standard has been projected as 140 mrem/year, at **2 kilometers** away from the tailings pile it is 1.4 mrem/year, [37] or less than the radiation dose from a cross-countryc flight (3.5 mrem)[38].

Many studies have estimated that the health risks posed by low doses of radiation, such as those from mill tailings impoundments, are so low that they cannot be directly measured, even with studies looking at very large populations. For example, *Health Effects of Exposure to Low Levels of Ionizing Radiation*,[39] also known as the "BEIR V," found that a dose of 1 millirem results in a calculated increased risk of cancer of less than 1/1,000,000.[40]Even this may overestimate the actual cancer risk due to radiation at the very low doses

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36. *Id.*; *see also* Doses in Our Daily Lives, *supra* note 31.

37. Calculated from NRC, *Final Generic Environmental Impact Statement*, NUREG-0706 (Sept. 1980) ("Final GEIS"), p.329 Table 12.2. *See also infra* note 44.

38. Centers for Disease Control and Prevention, Radiation from Air Travel, https://www.cdc.gov/nceh/radiation/air_travel.html (last visited July 24, 2018).

39. National Research Council, The National Academies Press (1990)(cited in 1991 Final Rule, 56 Fed. Reg. at 23362-23363).

40. *Id.* p.172.

associated with uranium mill tailings, given that there is no evidence of direct human health effects below a dose of 10 millisieverts, or 1,000 millirem.[41] Although NRC follows very conservative international regulatory guidance out of an abundance of caution, there is in fact no direct evidence of a health risk from exposures at or below the low public and occupational standards established in Part 20.[42]

B. NRC's Licensing, Regulation, and Oversight of Uranium Milling and Mill Tailings Disposal Protects Workers, the Public, and the Environment from Potential Hazards

NRC licenses and regulates conventional uranium milling operations (such as the kind being proposed by Petitioners in this case), including tailings management, under 10 C.F.R. Part 40 ("Part 40"), "Domestic Licensing of Source Material," especially Appendix A to Part 40 ("Part 40 Appendix A"), *Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Wastes*. Appendix A's specific criteria ensure that UMTRCA's statutory mandates are met, and that uranium milling operation and tailings management complies with regulatory dose and effluent limits.

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41. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), Frequently Asked Questions, http://www.unscear.org/unscear/en/faq.html (last visited July 24, 2018).

42. *See* Nuclear Radiation Health Effects, *supra* note 30.

1. Licensing Criteria for Operation of Uranium Mills and Disposition of Tailings or Wastes

Part 40 Appendix A, developed with extensive public involvement[43], reflects NRC's conclusions regarding the best and most practical safety measures and technology to contain the hazards associated with milling and tailings management for the very long term at radiation levels similar to those found in the natural environment. It establishes "technical, financial, ownership, and long-term site surveillance criteria relating to the siting, operation, decontamination, decommissioning, and reclamation of mills and tailings or waste systems and sites at which such mills and systems are located"[44]

NRC amended Part 40 Appendix A in 1985, to incorporate EPA's groundwater protection standards contained in 40 C.F.R. Part 192, *Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings*, promulgated in 1983 pursuant to UMTRCA.[45]

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43. NRC received and considered approximately 1,500 substantive comments from private individuals, state and Federal agencies, uranium mining companies, trade associations, and public interest groups on proposed rule changes to implement UMTRCA's requirements and the related draft Generic Environmental Impact Statement (GEIS).

44. Uranium Mill Licensing Requirements (Final Rule), 45 Fed. Reg. 65521 (Oct. 3, 1980) (adopting Part 40 Appendix A). NRC's three-volume Final GEIS (*supra* note 37) reflects the data and analysis supporting the Part 40 Appendix A criteria.

45. Final Rule, 50 Fed. Reg. 41852 (Oct. 16, 1985).

i. Planning, Siting, and Design of Mill Tailings Impoundments

The primary consideration driving planning, siting, design, and construction of mill tailings retention is the prevention of contamination and environmental damage over the very long term. Successful site selection and design for uranium recovery retention systems requires a detailed assessment of local conditions, including climate, ground-water and surface-water hydrology, geology, and seismology, and their impacts.[46]

The goal is permanent isolation of tailings and associated contaminants by minimizing disturbance and dispersion by natural forces and to do so without the need for ongoing maintenance. To accomplish this, applicants must optimize (i) remoteness from populated areas, (ii) hydrologic and other natural conditions as they contribute to continued immobilization and isolation of contaminants from groundwater sources; and (iii) potential for minimizing erosion, disturbance, and dispersion by natural forces over the long term. Part 40 Appendix A, Criterion 1.

Because below-grade disposal reduces the risk of catastrophic collapse or breach, and eliminates or reduces to very low levels the effects of natural weathering and erosion which could disrupt the tailings isolation, it is the "prime option" for tailings disposal. *Id.*, Criterion 3.

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46. NRC, *Design, Construction, and Inspection of Embankment Retention Systems at Uranium Recovery Facilities*, Regulatory Guide 3.11 (Rev. 3, Nov. 2008), p.4.

ii. Durability and Effectiveness of Containment System

Tailings facilities must limit releases of radon to 20 picocuries per square meter per second (pCi/m^2s), and reduce direct gamma exposure from the tailings or wastes to natural background levels. Part 40 Appendix A, Criterion 6.

Because "[t]ailings impoundments constitute large, diffuse, and essentially permanent area sources,"[47] tailings disposal facilities must be designed to control radiological hazards for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years. Part 40 Appendix A, Criterion 6. To help applicants and licensees develop siting and design choices that will meet this requirement, NRC has issued guidance describing acceptable methods for calculating radon fluxes through earthen covers and the resulting minimum cover thickness needed to meet NRC's and EPA's standards.[48]

Part 40 Appendix A's siting and design criteria anticipate and mitigate erosion and other natural forces, including extreme weather or geological events, for the long term. For example, tailings impoundments must also withstand a maximum credible earthquake based upon an evaluation of earthquake potential considering the regional and local geology and seismology; below-grade disposal sites (*see* Criterion 4) will typically meet these

47. Final GEIS p.21.

48. NRC, *Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailings Covers*, Regulatory Guide 3.64 (June 1989)

criteria.[49] Tailings impoundments must also "be designed very conservatively to avoid flood damage," in order to meet Criterion 6 durability requirements.[50]

While some have suggested that "tailings piles will eventually become uncovered and tailings widely dispersed," it is just as likely that "the erosion which might uncover tailings piles will eventually uncover natural ore bodies as well," and thus mining and milling of uranium has no significant net impacts over leaving the ore body in place.[51]

iii. Groundwater and Air Protection

Caps and liners enclosing the tailings storage cells reduce the risk of air or water-borne dispersion of radiological material to negligible levels, and methods such as dewatering tailings reduce seepage of toxic materials into groundwater to the maximum extent reasonably achievable. Any seepage which might occur must not result in the deterioration of the quality of existing affected groundwater.[52] Part 40 Appendix A, Criterion 5.

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49. *See also* Final GEIS, *supra* note 37, at p.287 ("For tailings buried below-grade, there should be no adverse effect … the most likely result would be further settlement of the tailings and cover.").

50. *Id.* p.287; *see also* 50 Fed. Reg. at 41857.

51. Final GEIS, *supra* note 37, at p.23.

52. Criterion 5 also addresses restoration of groundwater contaminated by seepage of toxic materials from mill tailings sites. Criterion 13 lists constituents for which NRC must set standards for compliance, if the constituent is reasonably expected to be in

Milling operations must be conducted so that all airborne effluent releases are reduced to levels as low as is reasonably achievable, primarily by means of emission controls. *Id.*, Criterion 8. Strict emissions controls also avoid site contamination.[53] Uranium byproduct materials effluent levels must also be managed so as to conform to EPA regulations.[54] NRC guidance provides methods, models, data, and assumptions acceptable for estimating airborne emissions of radioactive and toxic materials from various steps in uranium milling, to assist applicants and licensees in preparing required environmental reports.[55]

or derived from the byproduct material and has been detected in groundwater. These criteria incorporate EPA's basic groundwater protection standards in 40 C.F.R. § 192, subparts D & E.

53. NRC explains in *Minimization of Contamination and Radioactive Waste Generation: Life Cycle Planning*, Regulatory Guide 4.21 (June 2008), "how facility design and procedures for operation will minimize … contamination of the facility and the environment, facilitate eventual decommissioning, and minimize … the generation of radioactive waste." *See* 10 C.F.R. § 20.1406. This guidance was drawn from nuclear industry experience and lessons learned from decommissioning.

54. 40 C.F.R. Pt. 440, *Ore Mining and Dressing Point Source Category: Effluent Limitations Guidelines and New Source Performance Standards*, subpart C, *Uranium, Radium, and Vanadium Ores.*"

55. Regulatory Guide 3.59, *supra* note 22.

2. License Application Review and Renewal Process

An NRC source and byproduct material license is required to recover uranium from ore. 10 C.F.R. § 40.31. NRC performs a thorough, public review of all new license applications and license renewals. NRC bills applicants and licensees for costs associated with licensing and oversight. 10 C.F.R. § 170.31.[56]

New license applicants for a uranium milling facility operating license and renewing licensees "must clearly demonstrate how the requirements and objectives set forth in [A]ppendix A have been addressed," 10 C.F.R. § 40.31(h). Indeed, construction cannot begin until NRC confirms the applicant's proposed plans meet these requirements. *Id.* §§ 40.14, 40.32(e).[57]

Applicants address these criteria in a technical report submitted with their application. NRC also requires licensees to prepare an environmental report that serves as the basis for NRC's environmental assessment or Environmental Impact Statement ("EIS"). Applicants must also make financial assurances as to their ability to fund decontamination and decommissioning of the site, to surrender title to the land on which tailings impoundments are sited, and to fund long-term monitoring of tailings impoundments by the government. *See* Section II.B.4, *infra*.

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56. *See also* NRC, Cost Projections for Uranium Licensing Actions, https://www.nrc.gov/materials/uranium-recovery/cost-projections-license-apps.html (last visited July 20, 2018).

57. *See also* 45 Fed. Reg. at 65529.

NRC licensing proceedings are public; notices regarding license applications and renewals are published in the Federal Register, and license applications are made available online.[58] Public hearings may be held, and comments from the public regarding license applications and review are welcomed and considered. Any person whose interest may be affected by a proceeding and who desires to participate as a party may file a request for a hearing, or to intervene in an existing hearing. 10 C.F.R. § 2.309.

i. Technical Report Assessment

License applications include a detailed technical report addressing the effects of the proposed operations on public health and safety. For license renewals and amendments, the licensee must also address changes in proposed operations that NRC has not previously reviewed and operational history since its last license issuance.

The NRC's review determines whether the applicant's application complies with Part 40 Appendix A and other regulatory requirements. NRC reviews the applications according to a standard review plan to ensure consistency of review and acceptance criteria for the applicant's proposed activities; site characterization; design of the proposed facility; management plans and controls, staff qualifications, radiation safety training, security and

58. *See* NRC, License Applications for New Uranium Recovery Facilities, Expansions, Restarts, and Renewals, https://www.nrc.gov/materials/uranium-recovery/license-apps.html (last visited Jul. 24, 2018).

quality assurance; operational monitoring, radiation safety controls, reclamation and decommissioning plans, and accident management, including radiological accident procedures and training programs.[59]

ii. Environmental Assessment and NRC's Environmental Impact Statement

In carrying out the NRC's obligations under the National Environmental Policy Act, NRC requires applicant to include as part of its application a report addressing the environmental impact of the mill, adverse environmental effects that cannot be avoided should the mill be licensed, alternatives to the mill, and any irreversible and irretrievable commitments of resources involved. 10 C.F.R. § 51.45.[60]

The applicant must address ore-body locations, the anticipated quantity of ore to be mined and milled, mining methods, plans for overburden storage and disposal, milling processes, plans for tailings disposal and management, operating plans and schedules, expected longevity of the project, planned end use of the project areas, and surety arrangements for the eventual decommissioning of the mill and reclamation of the areas impacted. The applicant must also address the environmental effects of site preparation, mill construction and mine opening; the environmental effects of mill and mine operation, including radiological and chemical impacts on humans and radiological effects on the biosphere; effluent and

59. NRC, *Standard Review Plan for Conventional Uranium Mill and Heap Leach Facilities* (NUREG-2126) (Nov. 2014).

60. *See also* NRC, *Preparation of Environmental Reports for Uranium Mills*, Regulatory Guide 3.8 (Rev. 2, Oct. 1982).

environmental monitoring; the environmental effects of accidents; and economic and social effects.

The environmental report must provide sufficient information to support NRC's development of the EIS required when issuing a license for uranium milling. *See* 10 C.F.R § 51.20(a)(8). NRC's review and development of the EIS follows *Review Guidance for Licensing Actions Associated with NMSS Programs* (NUREG-1748) (NRC, Aug. 2003), which dictates that the EIS include a description of the affected environment and the environmental impacts of issuing a license, including land use, water resources, ecology, cultural and historic resources and public and occupational health. The EIS must also address mitigation measures and environmental monitoring and include a cost benefit analysis.

Prior to granting a license, the NRC publishes a draft EIS for public comment, typically conducting a public meeting or meetings near the site of the proposed action. Comments are taken into account in preparing the Final EIS.

3. Oversight of Active Uranium Milling and Mill Tailings Facilities

i. Regulatory Guidance

The Commission issues Regulatory Guides, reports, issue summaries, and other communications providing applicants and licensees with detailed guidance on how best to achieve compliance with NRC's regulations, from the initial design and planning stages through decommissioning. Regulatory Guides are first published in draft form for public review and comment.

For uranium milling and mill tailings management, the NRC provides extensive guidance regarding the Part 20 and Part 40 criteria and other applicable regulatory requirements, several examples of which have been cited throughout this brief.[61]

ii. Routine Monitoring, Self-inspection, and Reporting Requirements

Licensees must monitor and record radiation and effluent levels throughout construction and operation of the mill to ensure compliance with applicable standards and regulations, evaluate performance of control systems and procedures, assess environmental impacts, and detect potential long-term effects. Comprehensive monitoring of milling operations begins at least one full year prior to any major site construction, at which time the licensee must conduct a preoperational monitoring program on the milling site and its environs. Part 40, Appendix A, Criterion 7. The licensee must also establish a detection monitoring program required for NRC to set site-specific groundwater protection standards. *Id.*, Criterion 7A.

Daily inspections of tailings or waste retention systems must be conducted and documented by a qualified engineer or scientist during the facility's operational phase. Any failures or concerning issues identified must be immediately reported to the regional NRC office. *Id.*, Criterion 8A.

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61. *See* NRC, Uranium Recovery Regulations, Guidance, and Communications, https://www.nrc.gov/materials/uranium-recovery/regs-guides-comm.html (last visited July 24, 2018).

NRC requires uranium recovery licensees to report semiannually on radioactive effluents, and to report any other information NRC needs to estimate potential radiation doses to the public. NRC may require licensees to take corrective actions based on these reports.

Escalated reporting is required for serious or significant accidents or contamination. 10 C.F.R. §§ 20.2202; 30.50. NRC operates a 24/7 emergency response center in order to rapidly evaluate and respond to abnormal conditions or accidents that occur at licensed nuclear facilities.

iii. Facilities Inspections

NRC inspectors observe licensed facilities first-hand to confirm radioactive materials are properly controlled, areas containing radiation or radioactive contamination are properly restricted, and radiological monitoring equipment is operational. Inspectors review the licensee's monitoring records to confirm that required monitoring is being conducted and recorded, and to note any overexposures or effluent releases in excess of regulatory thresholds. Inspectors also review records of any events involving contamination, releases, equipment malfunctions, or other similar events. They review training records to confirm employee training is being conducted in accordance with the licensee's commitments, and interview workers and managers to affirm that they understand and comply with radiological safety standards, and to hear any concerns they may have.

Inspectors issue reports addressing all concerns identified, and follow up to ensure that necessary corrections are made. If necessary, NRC has the authority to suspend or revoke a license or to order temporary or permanent termination of operations. *See* 10 C.F.R. § 40.71.

iv. Corrective and Enforcement Actions

In addition to inspections conducted by technical trained inspectors, the NRC oversight process uses experienced investigators to evaluate allegations of willful misconduct.

If the results of NRC's oversight actions identify violations, NRC takes enforcement action in accordance with its Enforcement Policy such as issuance of notices of violations, civil penalties, orders suspending, modifying, or revoking licenses, and makes referrals to the Department of Justice for consideration of criminal prosecution.[62] The public may also petition the NRC to take enforcement action. 10 C.F.R. § 2.206. NRC notifies the public of all significant enforcement actions.[63]

Whether or not compliance issues are identified, pursuant to Sections 161 and 186 of the AEA, as amended, the Commission may issue orders requiring a licensee to

62. *See* NRC, *Enforcement Policy* (May 15, 2018); *see also* NRC, Enforcement Guidance, https://www.nrc.gov/about-nrc/regulatory/enforcement/guidance.html (last visited July 24, 2018).

63. *See* NRC, Escalated Enforcement Actions Issued to Materials Licensees, https://www.nrc.gov/reading-rm/doc-collections/enforcement/actions/materials/ (last visited July 24, 2018) (listing. all significant enforcement actions that NRC has issued to materials licensees since 1996).

take action as may be necessary or desirable to protect the public health and safety. *See* 10 C.F.R. § 2.202(a)(1).

4. Decontamination, Decommissioning and Long-Term Site Surveillance

Each licensed mill operator must make sufficient financial surety arrangements before the commencement of operations to assure that funds will be available to carry out the eventual decontamination and decommissioning of the site and for the reclamation of any tailings or waste disposal areas. Part 40 Appendix A, Criterion 9. Owners must also yield title to the land used for the disposal of uranium mill tailings to the United States or the state in which the site is located, at the option of the state. *Id.*, Criterion 11. To cover the cost of long-term surveillance, each licensee must pay a fee substantial enough to yield interest in an amount sufficient to cover the annual costs of site surveillance. *Id.*, Criteria 10 & 12.

If all of the Part 40 Appendix A licensing requirements have been met, the final disposition of tailings should not require ongoing active maintenance to preserve isolation. The government agency responsible for long-term care of the disposal site will conduct annual inspections to confirm its integrity and to determine the need, if any, for maintenance and/or further monitoring. *See id.,* Criterion 12.

III. The NRC's Regulation and Oversight Program Prevents Contamination and Protects Public Health and the Environment

Although critics of the Coles Hill uranium recovery project proposed by Petitioners have raised the specter of problems and incidents that arose prior to the enactment of the UMTRCA at older mill tailings disposal sites in the Western U.S. and elsewhere, those problems arose precisely because mill tailings disposal was unregulated.[64]

In fact, these were the very problems UMTRCA and NRC's Part 40, Appendix A were specifically designed to address. A "worst case scenario" such as the 1979 Church Rock uranium mill tailings spill, in which an earthen dam built on geologically unsound ground failed, releasing over 1,000 tons of mill tailings and 93 million gallons of tailings solution[65] is no longer a realistic possibility under today's regulatory system. Indeed, because the Church Rock incident occurred during NRC's development of Part 40 Appendix A, it underscored for all stakeholders the urgency and importance of developing a regulatory framework that will ensure safe and effective mill tailings management for the very long term.[66]

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64. *See, e.g.,* J.A.154-55.

65. *See Mill Tailings Dam Break at Church Rock, New Mexico: Hearing Before the Subcomm. on Energy and the Environment, H. Comm. on Interior and Insular Affairs*, 96th Cong, 1st Sess. (October 22, 1979), p.19-24.

66. *Id.* at 171-198 (testimony of NRC Director of Nuclear Material Safety and Safeguards referencing 44 Fed. Reg. 50012-50025 (Aug. 24, 1979) (proposed rule)).

Today, nothing resembling the Church Rock spill is possible at an NRC-licensed mill site, because NRC's licensing and regulation of mill tailings disposal and management following Congress's passage of UMTRCA ensures the safe disposal and long-term storage of mill tailings and associated waste products. *See* Section II, *supra.* Church Rock and incidents like it have served as a lesson for NRC regulators on the potential costs of failing to ensure full compliance.[67]

NRC is also part of the international nuclear regulatory community, which has collectively developed effective practices and expertise in regulating uranium milling and tailings disposal over the past four decades. In a 2014 report, the Nuclear Energy Agency (NEA) of the Organization for Economic Co-Operation and Development (OECD), a cooperative international organization of which the United States is a member, "compar[ed] currently leading approaches" for the management of the environment and health impacts of uranium mining with "outdated practices."[68] The OECD report found that "[u]ranium mining and milling has evolved significantly over the years" and that the review

67. *See, e.g.,* NRC, *Operational Inspection and Surveillance of Embankment Retention Systems for Uranium Mill Tailings*, Regulatory Guide 3.11.1 (Rev. 1, Oct. 1980), p.2 and Table 1 (listing tailing accidents from 1959 through 1979, noting while that modern geotechnical engineering and technology would prevent most such accidents, cautious and regular surveillance is also necessary to assure accident prevention).

68. OECD, National Energy Agency, *Managing Environmental and Health Impacts of Uranium Mining*, NEA-7602 (2014), available at http://www.oecd-nea.org/ndd/pubs/2014/7062-mehium.pdf.

of current practices "demonstrates how uranium mining can be conducted in a way that protects workers, the public and the environment." Today,

> [i]nnovative, modern mining practices combined with strictly-enforced regulatory standards [that] are geared towards avoiding past mistakes committed primarily during the early history of the industry when maximising uranium production was the principal operating consideration. Today's leading practices in uranium mining aim at producing uranium in an efficient and safe manner that limits environmental impacts to acceptable standards.[69]

While no industrial operation (and no human activity) is entirely without risk, uranium milling and tailings management, as currently regulated and practiced, is protective of the public health and safety and of the environment. It is reasonable to assume that the comprehensive and effective regulatory standards and practices developed by NRC and the international community will sufficiently manage the risks involved and protect the health and safety of Virginia's citizens and its environment, should Virginia's current moratorium be overturned.

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69. *Id.*

CONCLUSION

Radiological safety is NRC's regulatory mission and area of expertise, and *amici curiae,* based on their knowledge and experience of the effectiveness of NRC's comprehensive licensing and oversight program, have full confidence that the Virginia legislature's concerns regarding the radiological safety of mill tailings disposal are unfounded. *Amici* therefore respectfully request that the Court reverse the judgment of the Fourth Circuit.

Respectfully submitted,

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APPENDIX

APPENDIX — RELEVANT BACKGROUND AND EXPERIENCE OF *AMICI CURIAE*

L. Joseph Callan is a former NRC Executive Director for Operations. During his 19-year NRC career, Mr. Callan also served as Regional Administrator of NRC Region IV (Western United States), which provides regulatory oversight of most existing U.S. uranium mill and uranium mill tailings sites. He has a B.S. from the U.S. Naval Academy and undertook graduate studies in nuclear engineering at North Carolina State University.

Francis X. "Chip" Cameron is a former NRC Assistant General Counsel. During his 27-year career at NRC, Mr. Cameron also served as a Senior Attorney in the Office of the General Counsel, and as Deputy Director of the Office of the Licensing Support System. As Assistant General Counsel, Mr. Cameron advised NRC staff and the Commission on radioactive materials licensing issues, including the regulation of uranium mills and mill tailings, and the Agreement States program. Mr. Cameron has a B.A. and J.D. from University of Pittsburgh and a Masters of Natural Resources Management from University of Rhode Island.

Dr. Nils J. Diaz is a former NRC Commissioner and Chairman. He was appointed to the Commission in 1996 by President Bill Clinton, and by President George W. Bush to serve as Chairman of the Commission in 2003. During his two terms on the Commission, Dr. Diaz strongly promoted transparency for safety-significant issues, timelier decision-making, and a streamlined and effective regulatory processes. Prior to serving on the Commission, Dr. Diaz was Professor of Nuclear Engineering Sciences at the University of Florida. Dr. Diaz holds a Ph.D. and M.S. in Nuclear Engineering Sciences from the University of Florida, and a B.S. in Mechanical Engineering from the University of Villanova, Havana. He has received formal training and practice in Nuclear Medicine and Health Physics and was licensed as a Senior Reactor Operator for 12 years by the NRC. He has published more than 70 refereed papers on national and international journals. He is a Fellow of the American Nuclear Society, the American Society of Mechanical Engineers and the American Association for the Advancement of Science.

John T. Greeves is a former Director of NRC's Division of Waste Management. During his 30-year NRC career, Mr. Greeves also served as Chief of the Uranium Recovery and Mill Tailings Branch and directed NRC's program for licensing, inspection, and regulation of the management, treatment, and commercial disposal of low-level nuclear waste, uranium recovery mill tailings sites remediation, and material facility and power reactor decommissioning. He also ensured that NRC developed consistent criteria for acceptable radioactive waste disposal, uranium recovery activities, and decommissioning. Mr. Greeves has a B.S. in Civil Engineering from University of Maryland.

Joseph R. Gray is a former NRC Associate General Counsel for Licensing and Regulation. During his 32-year NRC career, Mr. Gray managed the Office of General Counsel's Rulemaking and Fuel Cycle Division, responsible for the legal aspects of rulemaking and regulation for uranium mills and mill tailings and State-NRC involvement in the oversight of uranium processing. He has a B.S. in nuclear engineering from Pennsylvania State University, an M.S. in nuclear engineering from Carnegie Mellon University, and a J.D. from Dickinson School of Law.

Dr. Malcolm R. Knapp is a former NRC Deputy Executive Director for Regulatory Effectiveness. During his 20-year NRC career, Dr. Knapp was also Deputy Director of the Office of Nuclear Materials Safety and Safeguards, where he was a founding co-chair of the Federal Government's Interagency Steering Committee on Radiation Standards, and Director of the Waste Management Division, where he oversaw all NRC headquarters activities for the regulation of uranium mills and mill tailings. Since retiring from NRC, Dr. Knapp has been an independent consultant in nuclear safety and management for clients including NRC, the U.S. Department of Energy, and the International Atomic Energy Agency. Dr. Knapp has B.E.S. and M.S.E. degrees from Johns Hopkins University and a Ph.D. in Chemical Engineering from Carnegie-Mellon University.

James Lieberman is a former NRC Director of Enforcement. During his 30-year NRC career, Mr. Lieberman also served as Assistant General Counsel for Enforcement and Regional Operations responsible for legal advice on issues relating to inspection and enforcement associated with uranium mills, processing, and waste management activities, and as Special Counsel for Decommissioning and Waste Management. He has a B.S. in Mechanical Engineering from the University of Rhode Island, an M.S. in Thermal Engineering from Cornell University, and a J.D. from George Washington University.

Jeffrey S. Merrifield served two terms as an NRC Commissioner, from 1998 through 2008, appointed for his first term by President Bill Clinton and for his second term by President George W. Bush. Mr. Merrifield previously served as majority counsel and staff director of the Senate Subcommittee on Superfund, Waste Control, and Risk Assessment. He is currently a partner in Pillsbury Winthrop Shaw Pittman's Washington, DC office and co-leader of the firm's Energy practice. Mr. Merrifield has a B.A. from Tufts University and a J.D. from Georgetown University.

Ellis W. Merschoff is a former NRC Deputy Executive Director for Operations. During his 25-year NRC career, Mr. Merschoff also served as Region IV Regional Administrator, responsible for safety oversight of all uranium recovery, milling, and mill tailing management in the Western United States. He has a B.S. in Aerospace Engineering from the U.S. Naval Academy and an M.S. in Mechanical Engineering from the Massachusetts Institute of Technology. He is a registered professional engineer.

C. William Reamer is a former Director of the High-Level Waste Repository Safety Division of NRC's Office of Nuclear Materials Safety and Safeguards. During his 25-year NRC career, Mr. Reamer also served as Deputy Director of the Division of Waste Management, responsible for regulating uranium recovery activities, including mill tailings management, and as an attorney in the Office of the General Counsel. He has a B.A. from Ohio University, a J.D. from Duke University, and an LL.M. from University of California at Berkeley.

Luis Reyes is a former NEC Executive Director for Operations. Mr. Reyes's 33-year NRC career covered multiple technical areas of nuclear regulation. He has a B.S. in Electrical Engineering and a M.S. in Nuclear Engineering from University of Puerto Rico.

Hugh L. Thompson, Jr. is a former NRC Deputy Executive Director for Regulatory Programs. Mr. Thompson's 25-year NRC career included over 10 years of direct-line oversight of uranium mills and mill tailings regulation. As Deputy Executive Director for Regulatory Programs, he was responsible for the inspection and enforcement activities of the uranium mills and mill tailings sites activities nationwide. He has a B.S. from the U.S. Naval Academy, an M.S. in Nuclear Engineering from Georgia Institute of Technology, and a J.D. from George Washington University.

Dr. William D. Travers is a former NRC Executive Director for Operations. Dr. Travers served in various positions during his 30-year NRC career. As Executive Director for Operations, he managed all technical staff activities at NRC Headquarters and four Regional Offices, was responsible for the safety and security at 103 nuclear power plants across the U.S., and regulation of uranium mills and mill tailings. Dr. Travers has B.S., M.S., and Ph.D. degrees in Science and Nuclear Health Physics from Purdue University.

Martin Virgilio is a former NRC Deputy Executive Director for Operations. During his 35-year NRC career, he served in various staff, management, and executive positions including positions responsible for the safety of uranium recovery and processing operations associated with nuclear fuel manufacturing. Mr. Virgilio is now a consultant to nuclear power operators on nuclear, industrial, environmental and radiological safety. He graduated from the U.S. Merchant Marine Academy and completed postgraduate studies in nuclear engineering at Catholic University.