Lost in Space?: The Legal Feasability of Nuclear Waste Disposal in Outer Space

Robin Dusek
LOST IN SPACE?: THE LEGAL FEASIBILITY OF NUCLEAR WASTE DISPOSAL IN OUTER SPACE

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Nuclear waste was originally billed as a form of energy that would be "too cheap to meter." Now we know that the real cost of nuclear energy is in its disposal, which has seemed impossible to accomplish effectively. The deadline of 1998 set by the Nuclear Waste Policy Act of 1982 ("NWPA") to begin accepting wastes for permanent disposal now appears to be premature by more than ten years. Permanent geologic disposal does not seem any closer to realization than it did when NWPA became law in 1983, thus making other disposal options more attractive. Waste disposal in outer space has been suggested as an alternative to disposal on earth. Space disposal appears to provide an easy way of permanently ridding ourselves of the waste without the accompanying fear that the waste will pollute the earth, and leave us with contaminated land. However, any plan for disposal in space will need to overcome more than the technical problems associated with "burial" in space. International law will affect our ability to dispose of waste in outer space and the circumstances surrounding this type of disposal must guarantee, for all practical purposes, a successful "burial." Part I of this note discusses nuclear waste disposal in the United States, the current state of which forces us to evaluate disposal in space. Part II discusses treaties, international

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1 In 1954, Lewis Strauss, then chairman of the U.S. Atomic Energy Commission, predicted, "Our children will enjoy in their homes electrical energy too cheap to meter." Dawn Stover, 50 Years After the Bomb: The Nuclear Legacy, POPULAR SCI., Aug. 1, 1995, at 52, 54.


3 See id.

agreements, and other sources of international law that would limit our ability to dispose in space to instances where our scientific knowledge adequately supports the risk to life and the potentially enormous environmental cleanup cost of a disposal accident. Because our scientific knowledge is not yet adequate to address these risks, it is unlikely that we ever will ship our waste into space.

PART I.

The world entered the nuclear era in December of 1942, when a team led by Enrico Fermi produced the world's first nuclear chain reaction. The experimental reaction soon turned into a deadly force as the world's first atomic bomb exploded in New Mexico on July 16, 1945 and the first nuclear warhead was dropped on Hiroshima on August 6, 1945. War had provided the rationale for developing nuclear power, but the “Atoms for Peace” program provided a non-war rationale for continuing to develop nuclear fission technology.

The Atomic Energy Act of 1954 ushered in the commercial phase of nuclear energy when the first commercial atomic plant in the United States opened in 1957 in Shippingport, PA. Although nuclear waste was advertised

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6 See id. at 8


as the fuel of the future, it has not lived up to these expectations due to the
danger of its by-products.

The nuclear fission process begins when uranium-235 ("U-235") is
bombarded with neutrons. During this bombardment, some of the uranium
splits (or fissions), releasing energy, along with dangerous radioisotopes such
as iodine, strontium, technetium, and cesium. Additional unstable elements
are produced at the same time and bombard the remaining U-235 nuclei,
creating a chain reaction. Eventually, the reaction reaches the stage where
more neutrons are produced than consumed. At this point, the reaction is
self-sustaining and has "gone critical." The heat generated creates steam,
which drives electric turbines.

A typical commercial nuclear reactor produces thirty metric tons of
irradiated fuel annually. Each ton contains elements with extremely long
half-lives and produces close to 180 million curies of radioactivity. For
example, the radioisotope plutonium-239, a major constituent of irradiated
fuel, has a half-life of 24,400 years, but is dangerous for a quarter of a million
years. As it decays, it becomes U-235 with a half-life of 710,000 years. The
danger posed by this radiation is in its effect on living cells. Radiation

10 See supra note 1.
11 See infra notes 20-24 and accompanying text.
12 See SHRADER-FRECHETTE, NUCLEAR POWER, supra note 5, at 12-13.
13 See NICHOLAS LENSEN, NUCLEAR WASTE: THE PROBLEM THAT WON'T GO AWAY 11
14 See SHRADER-FRECHETTE, NUCLEAR POWER, supra note 5, at 13.
15 See id.
16 See MARVIN RESNIKOFF, THE NEXT NUCLEAR GAMBLE: TRANSPORTATION AND STORAGE
17 See id.
18 See id.
19 See LENSEN, supra note 13, at 9. Approximately one-third of a reactor's fuel
is disposed of every twelve to eighteen months. See RESNIKOFF, supra note 16, at 38.
20 The half-life of an element is the time it takes for 50 percent of its radioactivity to decay.
21 See LENSEN, supra note 13, at 9.
22 See id.
can damage individual cells and cause cancer, degenerative diseases, mental retardation, chromosome aberrations, and genetic disorders.\textsuperscript{23} The damage inflicted on an individual depends upon the dose received and the age and strength of the individual.\textsuperscript{24}

Because of the damage nuclear waste can inflict, waste must be isolated until it is no longer a threat, which is at least a quarter of a million years.\textsuperscript{25} EPA has adopted public protection standards of only 10,000 years, with allowable emissions no greater than those of unmined uranium in the soil.\textsuperscript{26} The containers that the Department of Energy ("DOE") has designed to hold waste in deep geologic burial have been planned to isolate the waste for 300 to 1000 years.\textsuperscript{27} After that period, it is hoped that environmental factors will keep the waste isolated.\textsuperscript{28} An environment has yet to be found that scientists can say, with certainty, has the geologic stability needed to contain nuclear waste.\textsuperscript{29}

\textsuperscript{23} The "bundle" of energy emitted from an atom of radioactive material rips through the matter it encounters. This disrupts the electrical balance of atoms along the way and causes the disorganization of cells and tissues. Incomplete atoms, called ions, are formed as electrons are knocked out of their shells. New ions form by attracting particles from other atoms, increasing the disorganized state. See RESNIKOFF, supra note 16, at 50-51.

\textsuperscript{24} Even a relatively small amount of radiation can inflict severe damage. An amount of plutonium the size of a beach ball, if distributed appropriately, can give every person on the earth lung cancer. See R. Routley & V. Routley, Nuclear Energy and Obligations to the Future, 21 INQUIRY 133, 136 (1978).

\textsuperscript{25} See supra notes 20-24 and accompanying text.

\textsuperscript{26} See Nuclear News Briefs, NUCLEAR NEWS, Sept. 1985, available in LEXIS, News Library, Nunews File. A typical American is exposed to 100 millirems of radiation per year from natural sources. See RESNIKOFF, supra note 16, at 47. A millirem is "a unit measuring the biological effects of radiation." Id. Although the requirements set by the EPA seem to impose no greater risk on the environment than if the material had never been mined, generation of waste actually creates more of the dangerous substance than would otherwise exist in an unmined state. See SHRADER-FRECHETTE, Burying Uncertainty, supra note 9, at 194. Even when radioactive waste decays to the level of naturally occurring uranium, a greater volume of dangerous material is imposed on future generations. Thus, the total risk may be higher. See id.

\textsuperscript{27} See SHRADER-FRECHETTE, Burying Uncertainty, supra note 9, at 46.

\textsuperscript{28} See id.

\textsuperscript{29} See LENSSSEN, supra note 13, at 26.
The United States has a long history of nuclear legislation, beginning with the Atomic Energy Act of 1946. A series of Atomic Energy Acts followed, which were amended by the Price-Anderson Amendments Act. The Atomic Energy Commission established under the Atomic Energy Act of 1946 retained responsibility for promoting and regulating nuclear energy until 1975. Charges of covering up problems at nuclear facilities and problems with safety insurance plagued the Commission, and it was abolished and replaced in 1975 by the Energy Research and Development Agency (later the Department of Energy) and the Nuclear Regulatory Commission.

Beginning in 1976, various nuclear waste disposal legislation was proposed, but the Nuclear Waste Policy Act was not passed until 1983. The Act applies only to high-level radioactive waste. The date for disposal of

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32 See Atomic Energy Act of 1946 § 2, 60 Stat. at 756-58; SHRADER-FRECHETTE, NUCLEAR POWER, supra note 5, at 11-12; SHRADER-FRECHETTE, BURYING UNCERTAINTY, supra note 9, at 23.

33 See SHRADER-FRECHETTE, BURYING UNCERTAINTY, supra note 9, at 23.


35 High-level radioactive waste is defined in the NWPA as

(A) the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and

(B) other highly radioactive material that the Commission, consistent with existing law, determines by rule requires permanent isolation.


This definition characterizes waste based upon its source, rather than upon radioactivity or half-lives. Thus, waste with a high radioactivity conceivably could be
the waste has been pushed back numerous times. Due to problems in siting, in less than twenty years, the date for disposal has been pushed back a total of twenty-five years\(^{36}\) to a current date of 2010.\(^{37}\) The NWPA called for studying the need for and feasibility of a Monitored Retrievable Storage Site.\(^{38}\) The government also made a commitment to an interim storage system for those civilian nuclear power reactors that run out of room to store waste before the permanent repository is complete.\(^{39}\)

The siting of a permanent repository for nuclear waste was the central goal of the Nuclear Waste Policy Act of 1982.\(^{40}\) The government decided to

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36 The General Accounting Office considers 2010 to be an unrealistic date. See GENERAL ACCOUNTING OFFICE, GAO/RCED-94-299, NUCLEAR WASTE: COMPREHENSIVE REVIEW OF THE DISPOSAL PROGRAM IS NEEDED 3 (Sept. 27, 1994). The date has been pushed back due to problems with finding a qualified site. See id. Although the original Act called for fairly extensive studies of at least three sites in at least three different geologic materials, the Nuclear Waste Policy Amendments Act of 1987 modified this to require only the study of Yucca Mountain in Nevada. See 42 U.S.C. § 10133 (1994). Yucca Mountain has proven to be a difficult site, as discussed infra notes 59-87 and accompanying text.

37 In 1975, the United States planned for a burial site to be operable by 1985. The dated was moved to 1989, 1998, 2003, and is currently 2010. See Nicholas Lenssen, Nowhere to Hide, SACRAMENTO BEE, Mar. 29, 1992, at F1; LENSEN, supra note 13, at 21.

38 See 42 U.S.C. §§ 10161-10169 (1994). A monitored retrievable storage site is a temporary, central storage facility for waste until a permanent disposal site is prepared. See SHRADER-FRECHETTE, BURYING UNCERTAINTY, supra note 9, at 188-89.


40 The purposes of the Act were:

1. to establish a schedule for the siting, construction, and operation of repositories that will provide a reasonable assurance that the public and the environment will be adequately protected from the hazards posed by high-level radioactive waste and such spent fuel as may be disposed of in a repository;
2. to establish the Federal responsibility, and a definite Federal policy, for the disposal of such waste and spent fuel;
3. to define the relationship between the Federal Government and the State governments with respect to the disposal of such waste and spent fuel; and
4. to establish a Nuclear Waste Fund, composed of payments made by the generators and owners of such waste and spent fuel, that will ensure that
use deep geologic disposal, although the first Act did not rule out the
possibility of evaluating subseabed or space disposal. The chosen method,
deep geologic burial, attempts to replicate a naturally occurring type of
"waste" disposal. The key to deep geologic burial lies in the ability of the
gеologic medium to contain the waste long past the eventual disintegration
of the containers in which the waste is buried. The containers would be
surrounded by an impermeable material, possibly clay, in order to retard
groundwater movement, then they would be sealed with cement. When
the repository is full, it would be sealed off from the surface. Because the
containers are only designed to contain waste for 300 to 1000 years, the
quality of the geologic environment is important to containing the waste.
Granite, clay, salt, and basalt are considered potential environments for the

the costs of carrying out activities relating to the disposal of such waste
and spent fuel will be borne by the persons responsible for such waste and
spent fuel.

*Id.* § 10131.

4 The NWPA prohibited neither type of disposal. *See* Nuclear Waste Policy Act of 1982,
(1994)). The current statute expressly states a desire to explore subseabed disposal. *See* 42

42 Los Alamos National Laboratory scientists studied naturally occurring reactors at the
Oklo uranium mines in the Republic of Gabon. Natural fission reactions occurred in the
mines. The waste products were mostly contained with natural geologic barriers. *See* U.P.I.,

43 The sorption capability of the environment determines the ability of the environment to
safely contain the waste. Sorption is the generic term for a number of mediums that cause
particular elements to stick on solids rather than being carried in a solution of groundwater.
*See* ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT [OECD], GEOLOGICAL

44 *See* Lenssen, *supra* note 37, at 11.

45 *See id.;* LENSSSEN, *supra* note 13, at 23.
storage of waste. Disposal in any geologic medium must take into account the likelihood that the waste will leach into groundwater or be released into the environment in some other way. Earthquakes, tornados, floods, and volcanoes are concerns for any site. Because the waste must be isolated for a long period, any interruption in the site's integrity could be very dangerous.

Any disposal site also must keep future generations from being exposed to the waste. The inquisitive nature of humans and the extraordinary longevity of the waste's radioactivity create difficulties for any disposal. How will future generations know that a poisonous substance lies beneath the ground? DOE recognized this as a potential problem and contracted a 13-member study panel in 1980 to explore ways to communicate

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46 Each medium presents concerns. Granite generally contains groundwater that has moved through fissures and fractures in the rock. Additionally, the heating effects of the waste may cause stress fractures. Waste placed in clay formations eventually will come in contact with water, as the formation's media is porous. Salt dome structures may attract water from the heat of the waste, creating a brine that would corrode the waste containers. Finally, basalt and tuff (Yucca Mountain's medium) possess a limited ability to self-seal boreholes and fractures. OECD, supra note 43, at 17-19.

47 In one DOE study, all of the containers designed to hold nuclear waste failed and showed cracking during a one-year test when exposed to conditions simulating those to which the canisters would be exposed once disposal took place. See SHRADER-FRECHETTE, BURYING UNCERTAINTY, supra note 9, at 46.


49 When evaluating any environment for its suitability to contain waste semi-permanently, it is important to note that less than 10,000 years ago, volcanoes were erupting in what is now central France; the English Channel did not exist 7,000 years ago; and much of the Sahara was fertile just 5,000 years ago. See LENSSSEN, supra note 13, at 27.

50 Isolation from future generations presumably is more difficult with an earth-based disposal system than one based in space. With a space-based system, the waste could interfere with future exploration of space, but is unlikely to destroy the integrity of the environment on earth. A space-based system confronts the ethical consideration of interference with possible extra-terrestrial life forms. However, this remote possibility should not influence the process of deciding whether space disposal is feasible. Not only is the existence of extra-terrestrial life merely a possibility, but the effect of the waste is unknown. The waste could be benign, or even beneficial, to extra-terrestrial life forms.
to future generations the danger of the waste site. A panel suggested that
an “atomic priesthood” organization pass on the secrets of the repository. The “priests” would start a story concerning the repository to warn people to stay away. Of course, as soon as a boy scout troop camps in the area without incident, the tale would likely die. A structure of obelisks with hieroglyphics designed to warn future people has received support as a means of communicating the dangers of the repository to people who will not understand our current version of English. These structures could be thorn-like and foreboding. A sense of evil would envelope anyone who entered the area. Ensuring that the message of these structures is understood far into the future is problematic, however, because the hieroglyphics could be read in the wrong direction and misinterpreted. Additionally, the structures must survive erosion. Other suggestions have included making the site “repulsively malodorous” so people would not want to approach it, or genetically encoding a warning message in human genes. Both these suggestions are beyond the current state of scientific ability, but may be

51 See Warning Signals: Symbols for 10,000 Years, TIME, Nov. 26, 1984, at 44.
52 See id.
53 See id.
54 The likelihood of the priesthood’s continued existence presents another concern with this method of communicating to future generations. Not only is the stability of such a human created institution questionable, but the desirability of this type of priesthood is lacking. Most religions provide hope for followers. A “religion” centering on the concept that the ground is poisonous lacks the appeal of more mainstream religions.
55 This idea has been suggested for the Waste Isolation Pilot Plant (“WIPP”) in New Mexico. WIPP will eventually store plutonium contaminated waste from the nuclear weapons program. Although this has been suggested for WIPP, it presumably is a possibility for any site of nuclear waste disposal. See Michael Haederle, American Album: Composing a Message for the Ages: ‘Keep Out!’ Scholars Seek a Way to Warn Future, L.A. TIMES, Oct. 5, 1992, at A5.
56 See id.
57 The difficulty in building such a structure can be seen with Stonehenge, a monument that was most likely readily understandable to its builders, but it continues to puzzle present day observers.
within the capabilities of scientists by the time a structurally sound permanent repository is built.

Currently, only one site, Yucca Mountain in Nevada, is being studied as a permanent disposal site.\(^{59}\) It was designated by the 1987 Nuclear Waste Amendment Act as the only site that would be studied for a permanent repository.\(^{60}\) Even if Yucca Mountain defies seemingly insurmountable geologic and political problems and is designated a suitable site, the site will not hold enough waste to meet our needs.\(^{61}\) Yucca Mountain will hold 70,000 metric tons of waste if completed, but an estimated 87,000 metric tons of nuclear waste will require disposal in the U.S. by 2030.\(^{62}\)

Yucca Mountain must overcome a number of hurdles before it is found suitable as a permanent disposal site. Any site in the western United States presents transportation concerns because the majority of waste generated in the United States is generated in the East.\(^{63}\) Thus, transportation of much of the waste would involve cross-country travel. Although any site must face shipping issues, multiple sites, or a site located more centrally to the production of most waste, could decrease the likelihood of a shipping accident. The shipping concern is minor compared to some of the other concerns that have been raised regarding Yucca Mountain.

Some scientists have expressed concern that radionuclides may reach

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\(^{59}\) By the end of 1996, DOE had spent approximately three billion dollars to investigate Yucca Mountain. During the lengthy studies, 17 plants spent more than $200 million to plan and build dry-cask storage systems. See Fredreka Schouten, *Idaho and a Nation is Waiting on Yucca Mountain*, IDAHO STATESMAN, Dec. 26, 1996, available in 1996 WL 14378920.

\(^{60}\) See Nuclear Waste Policy Act, 42 U.S.C. § 10133 (1994). This designation creates increased incentive for scientists to find Yucca Mountain suitable. If it is found unsuitable, the price tag for the depository will increase along with the wait for a suitable site. The final cost of the disposal site, if approved, will be close to $15 billion. See Ad Crable, *A Future Nuclear Graveyard*, LANCASTER NEW ERA, Nov. 18, 1993, available in 1993 WL 8857752.


\(^{62}\) See id.

\(^{63}\) See Blundering Over Nuclear Burial, N. Y. TIMES, Mar. 16, 1987, at A18.
the water table in less than 1,000 years. Not only is there disagreement with the rate of travel of the radionuclides to the water table, there is also concern as to a rise in the water table. Scientists do not know why this rise occurs and worry that the water table could continue to rise. Additionally, though the nuclear testing that once occurred in Nevada may have increased the political feasibility of the site, it also may have “damaged” the site. Surface water may have seeped below the site during atmospheric nuclear testing, increasing the probability of ground water intrusion into the repository. Other past and possible future activity at the site indicates that Yucca Mountain may not be suitable for long term isolation of a dangerous substance. Less than 100 miles from Yucca Mountain, geologists found ancient snail shells, indicating that parts of the desert were once underwater.

A June 1992 earthquake measuring 5.6 on the Richter scale and causing one million dollars worth of damage to a Department of Energy (“DOE”) building caused many to question the site and its thirty-two earthquake faults. A DOE geologist suggested that the depository may flood from below if earthquakes compressed flooded fissures in underlying

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64 Due to a variety of concerns about the water table at Yucca Mountain, some scientists have concluded water could reach the waste in as little as 978 years. See SHRADER-FRECHETTE, BURYING UNCERTAINTY, supra note 9, at 41.
65 See id. at 48-49.
66 See id.
67 See id.
69 See Scott Allen, If We Can’t Bury Nuclear Waste in Nevada, Where Can We?, BOSTON GLOBE, May 17, 1993, at 25, available in 1993 WL 6593407. A hydrologist from Ohio State University, Moid Ahmad, has called the Yucca Mountain studies “very sloppy from a hydrological point of view.” Ahmad believes that the climate will become wetter in the Southwest several thousand years from now. This will increase the groundwater in the region. However, with a repository at Yucca Mountain, the groundwater will be unusable. See Nuclear Waste Plan Called a Danger to Future Groundwater, ARIZ. REPUBLIC, Mar. 23, 1994, at B3, available in 1994 WL 6322811.
rock, causing radioactivity to flow into springs in Death Valley National Park.\textsuperscript{71} Several ancient volcanoes in close proximity further hamper the site.\textsuperscript{72}

Additional concerns center on the waste's stability. Physicists from the Los Alamos National Laboratory in New Mexico suggested that the dump might erupt in a nuclear explosion that would scatter radioactivity into the wind or groundwater.\textsuperscript{73} This explosion would occur when the canisters dissolved and plutonium began to disperse into surrounding rock.\textsuperscript{74} The rock may start a chain reaction by slowing down neutrons, leading to the explosion of the pile of plutonium.\textsuperscript{75} The danger of such an explosion is increased by the relatively soluble volcanic ground of Yucca Mountain.\textsuperscript{76} In a granite repository, however, this problem might be alleviated.\textsuperscript{77}

Legal challenges to the site threaten the project with more than technical issues. In 1989, Nevada attempted a legislative veto of the site by

\textsuperscript{71} See William Poole, \textit{Gambling with Tomorrow: Yucca Mountain Nuclear Waste Depository}, SIERRA, Sept. 1992, at 50, 56. Furthermore, earthquakes disrupt the water table. "As the crust snaps back into shape, rocks contract, and water that has seeped deep into fractures is forced up toward the surface." Betsy Carpenter, \textit{A Nuclear Graveyard}, U.S. NEWS AND WORLD REP., Mar. 18, 1991, at 72.

\textsuperscript{72} One of the volcanoes may be as young as 20,000 years old. See Allen, supra note 69, at 25. Although government scientists have predicted the odds of a volcano eruption in the next 10,000 years at a not-very-reassuring one in 30, a senior geologist at the Nuclear Regulatory Commission has assessed the probability at one in six. See Robert Burns, \textit{Watkins Urged to Declare Nevada Site Unsuitable for Nuclear Waste}, ASSOCIATED PRESS, July 19, 1989, available in 1989 WL 4046972.

\textsuperscript{73} See Mark Nichols, \textit{Nuclear Mausoleums: Two Scientists Fear that Buried Radioactive Fuel Might Explode}, MACLEAN'S, Mar. 20,1995, at 64.

\textsuperscript{74} See William J. Broad, \textit{Scientists Fear Atomic Explosion of Buried Waste}, N. Y. TIMES, Mar. 5, 1995, at A1. Other scientists dispute this theory. Scientists at the University of California, Berkley concluded that the possibility of such an explosion is very small. The group further found that the risk of such an explosion could be effectively reduced to zero through engineering fixes. See Gary Taubes, \textit{Yucca Blowup Theory Bombs, Says Study}, 271 Sci. 1664 (1996).

\textsuperscript{75} See Broad, supra note 74.

\textsuperscript{76} See id.

\textsuperscript{77} See id.
making illegal the permanent disposal of high-level radioactive waste in Nevada. The State of Nevada also brought suit against James D. Watkins, the Secretary of DOE. The State challenged the constitutional authority of the federal government to single out Yucca Mountain in the selection of a permanent repository. The Shoshone Indians, on whose ancestral lands the site is located, also have challenged the site, claiming that the treaty the tribe signed in 1863 did not cede full control of the land to the United States.

All of these problems have delayed the siting of a permanent depository at Yucca Mountain. Congress recently approved Yucca Mountain as an above-ground interim storage site. The House bill passed with well over the number of votes required to overrule a threatened Presidential veto; the Senate bill was two votes shy of the required veto override margin. Much of the opposition to the interim site mirrors the

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78 The Nevada Code states:

1. It is unlawful for any person or governmental entity to store high-level radioactive waste in Nevada.
2. As used in this section, unless the context otherwise requires, "high-level radioactive waste" has the meaning ascribed to that term in 10 C.F.R. § 60.2 [1997].


80 See Watkins, 914 F.2d at 1552.


82 In addition to the problems with the geologic environment of Yucca Mountain, DOE has admitted that its waste containers, which were designed to last at least 300 years, have shown stress-corrosion cracking when exposed to a year-long test in the ground water and tuff environment at Yucca Mountain at 200° Celsius (the expected temperature of the site once waste is emplaced). See SHRADER-FRECHETTE, BURYING UNCERTAINTY, supra note 9, at 46.


84 H.R. 1270 passed by vote of 307 to 120. See 143 CONG. REC. 9771 (1997). The Senate bill passed by a recorded vote of 65 to 34. See 143 CONG. REC. 3153 (1997).
resistance to turning Yucca Mountain into a permanent disposal site. In addition, opponents fear an interim site at Yucca Mountain may become a de facto permanent site. Even if Yucca Mountain should be found unacceptable as a permanent repository, the fact that it is being pursued by Congress as a temporary site may encourage lawmakers to override the cautions of scientists.

Although there is currently no permanent disposal site for nuclear waste, the federal government must begin accepting waste by January 31, 1998. Though the government tried to push this date back, a federal court held that this date must stand.

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85 See supra text accompanying notes 61-77.
PART II.

Because the difficulties associated with deep geologic burial of waste seem insurmountable, some scientists have suggested disposal of waste in outer space. Russian scientist Pyotr Kapitsa, a Nobel Prize winning physicist, suggested in 1959 that outer space may be an option for dealing with nuclear waste. Later, United States scientists discussed transporting nuclear waste into space with a space shuttle. However, this idea was set aside after the Challenger disaster. Despite the Challenger disaster, Russia continues to consider outer space disposal as an option. To reduce the weight of the cargo, Russian scientists propose treating radioactive waste to extract dangerous, long-lived isotopes. The extracted isotopes would then be transported into distant space with boosters. This process would end with one of the many types of space “disposal.”

Two basic types of space disposal possibilities have been proposed. One involves disposing of waste on the sun. The sun’s heat would act as a giant thermonuclear reactor and burn the waste. To transport waste to the

grounds that it has not yet prepared a permanent repository or interim storage facility. See id. at *23.

90 See Russia Express Briefing, supra note 4.
91 See id.
94 See Russia Express Briefing, supra note 4.
95 See id.
96 See id.
97 See id.
98 See Rayl, supra note 92.
99 See id.
sun, a two-stage chemical rocket would carry the waste to extremely high points of orbit (called libration points) where the waste would remain until moved. Then, a solar electronic propulsion system would be launched that would “push” the waste to the sun.

Another type of space disposal involves simply transporting waste into distant space areas. Advocates of this system envision leaving waste in areas that are hard to access and possess properties that make the areas impossible for man to research. With this delivery system, waste would be treated to reduce its weight, and then transported into distant space using boosters. A variation of this type of disposal is called dispersed delivery. With this method, waste would be delivered to the outer heliocentric orbit of the earth where it would be dispersed into microscopic particles that would then be put into motion by solar wind.

Although no country has begun disposing nuclear waste in space, space is far from being a pristine frontier. Debris floats through space, including an estimated ton of radioactive material. International law primarily governs our legal ability to dispose of

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100 See id.
101 See id. A basic problem with this method is the need to find a way to send the waste into orbit at speeds as high as 30 km/sec. See Russia Express Briefing, supra note 4.
102 See Russia Express Briefing, supra note 4.
103 See id. Suggestions include Jupiter, Saturn, Uranus, and Neptune. See id. One problem with this method is that it does not actually get rid of the waste. Right now, distant planets seem attractive because visiting these planets is beyond the current abilities of man. However, this view is probably short-sighted and we may be cutting off the possibility of future science missions by contaminating space with toxic substances.
104 See id.
105 See id.
106 See id. This method has the added danger that the radioactive particles could form a type of a stable radioactive zone in interplanetary space.
waste in space. International law is based on a variety of sources. Article 38 of the Statute of the International Court of Justice provides a starting point for determining the sources of international law. It is not an exhaustive list of the sources of international law, but a listing of sources for the Court to consult when hearing disputes. The most important aspect of Article 38 may be that it requires states to consider the variety of sources contributing to international law. Under Article 38, a state cannot limit its view of international law to simply one source.

The only way states can consciously enact international law is through international treaties. Treaties can be bilateral or multilateral, binding only those states that agree to be bound by the treaty. The states involved in the treaty are bound only to each other with regard to the treaty; they are not

108 See id. at 11-31.
110 Article 38 provides:

   (1) The Court, whose function is to decide in accordance with international law such disputes as are submitted to it, shall apply:
   (a) international conventions, whether general or particular, establishing rules expressly recognized by the contesting States;
   (b) international custom, as evidence of a general practice accepted as law;
   (c) the general principles of law recognized by civilized nations;
   (d) subject to the provisions of Article 59, judicial decisions and the teachings of the most highly qualified publicists of the various nations, as subsidiary means for the determination of rules of law.

   (2) This provision shall not prejudice the power of the Court to decide a case ex aequo et bono, if the parties agree thereto.

111 See DIXON, supra note 109, at 21.
112 See id. at 21-22.
113 See id.
114 See id. at 23.
115 An exception exists, in a sense, if a treaty codifies existing customary law. See DIXON, supra note 109, at 24. Only the states who sign on to the treaty are bound by the treaty, but all other states are bound by the customary law that is codified in the treaty. See id.
bound to follow the treaty in relation to states who are not signatories.\textsuperscript{116}

A major source of international law is customary law, or law which has become a common practice based on the customs of states.\textsuperscript{117} The \textit{Lotus Case} is a starting point for determining the elements of customary international law.\textsuperscript{118} Most important, in order to become customary law, a practice must be consistent.\textsuperscript{119} Absent a constant basis for the law, no customary law exists.\textsuperscript{120} Another element of customary law was set forth in the \textit{North Sea Continental Shelf Cases},\textsuperscript{121} which found that several states must have a common practice. However, the \textit{North Sea Continental Shelf Cases} also found that not all states need to participate in the practice.\textsuperscript{122} The custom of the states most affected by the practice in question carries the most weight in determining whether customary law exists.\textsuperscript{123} Furthermore, the \textit{Lotus Case} found that states must believe that the practice is binding on them as law.\textsuperscript{124}

Treaties and customary international law can contain similar or contradictory provisions. When the two contain similar legal obligations, the treaty serves to bind the states that are signatories, while customary law binds even those states that are not signatories.\textsuperscript{125} When the two sources of law conflict, the treaty will prevail over customary law if it is last in time.\textsuperscript{126} If the customary law develops after the treaty, the legal implications are unclear. One position is that the customary law should prevail because it is later in

\textsuperscript{116} See \textit{id.} at 22.
\textsuperscript{117} See \textit{id.} at 19.
\textsuperscript{118} See S.S. Lotus (Fr. v. Turk.), 1927 P.C.I.J. (ser. A) No. 10, at 4 (Sept. 7).
\textsuperscript{119} See \textit{id.} at 24-31.
\textsuperscript{120} See \textit{id.} at 31.
\textsuperscript{122} See \textit{id.} at 108, 130.
\textsuperscript{123} See \textit{id.}
\textsuperscript{124} See S.S. Lotus, 1927 P.C.I.J. at 21 (discussing "custom having the force of law").
\textsuperscript{125} See DIXON, \textit{supra} note 109, at 30-31.
\textsuperscript{126} Martin Dixon reasons that "treaties represent a deliberate and conscious act of law creation." \textit{Id.}
time and non-signatories to the treaty will be bound by the customary law.\textsuperscript{127} Another position supports the treaty continuing to govern relations between treaty signatories while the customary law regulates all other relations.\textsuperscript{128}

A third basis of international law may exist. Article 38 lists "general principles of law" as a source.\textsuperscript{129} This provision is unclear. Many believe that it is simply an exclusive principal and encompasses customary and treaty law, while ignoring some types of "primitive" law.\textsuperscript{130} Others take a wider view of the principle and see it as creating its own standards of law.\textsuperscript{131}

The United Nations Committee on the Peaceful Uses of Outer Space ("U.N. COPUOS")\textsuperscript{132} is the most important United Nations body dealing with space policy. In a sense, it is the world's space legislature, as it debates, drafts, and negotiates international law for outer space.\textsuperscript{133} Policy questions are decided by consensus, and one country's objection vetoes a provision.\textsuperscript{134} Since its inception in 1958,\textsuperscript{135} U.N. COPUOS has ratified five treaties.\textsuperscript{136} None of these treaties expressly prohibits or condones disposal of nuclear waste in outer space, but the treaties do set limits on disposal and provide general principles of law that may be important in evaluating the legality of

\begin{itemize}
  \item \textsuperscript{127} See id. at 31.
  \item \textsuperscript{128} See id.
  \item \textsuperscript{130} See \textit{Dixon, supra} note 109, at 33. Article 38's reference to "primitive" law is thought to denote underdeveloped legal systems, as opposed to the economic or political status of different countries. \textit{See id.}
  \item \textsuperscript{131} Alternative legal standards include natural law doctrines, rules and principles common to all legal systems, and principles of equality. \textit{See id.} at 33-35.
  \item \textsuperscript{133} See \textit{Nathan C. Goldman, Space Policy: An Introduction} 23 (1992).
  \item \textsuperscript{134} See \textit{id.}
  \item \textsuperscript{135} See \textit{id.}
  \item \textsuperscript{136} See \textit{General Assembly Resolutions and International Treaties Pertaining to the Peaceful Uses of Outer Space} (visited Mar. 18, 1997) <http://www.un.or.at/OOSA_Kiosk/treat/treat.html>.
\end{itemize}
nuclear disposal in outer space.\textsuperscript{137}

The Nuclear Test Ban Treaty of 1963\textsuperscript{138} prohibits the contamination of outer space by the explosion of radioactive substances.\textsuperscript{139} This treaty demonstrates the unwillingness on the part of the countries that have signed the treaty (including the United States) to contaminate the space environment with radioactive materials.\textsuperscript{140} Although the treaty does not directly ban the disposal of nuclear waste in space, it does limit the disposal to methods where the waste will not explode.\textsuperscript{141} Because some scientists believe the possibility of explosion exists for waste disposed on earth, this possibility could not be ruled out in space. If an accidental explosion did occur, the country responsible would have to confront the ethical implications of harming the environment and the added legal implications of violating the

\begin{itemize}
\item See infra notes 138-60 and accompanying text.
\item See id; Schafer, supra note 107, at 11.
\item Article I of the treaty states:
\begin{enumerate}
\item Each of the Parties to this Treaty undertakes to prohibit, to prevent, and not to carry out any nuclear weapon test explosion, or any other nuclear explosion, at any place under its jurisdiction or control:
 \begin{enumerate}
 \item in the atmosphere; beyond its limits, including outer space; or under water, including territorial waters or high seas; or
 \item in any other environment if such explosion causes radioactive debris to be present outside the territorial limits of the State under whose jurisdiction or control such explosion is conducted. It is understood in this connection that the provisions of this subparagraph are without prejudice to the conclusion of a treaty resulting in the permanent banning of all nuclear test explosions, including all such explosions underground, the conclusion of which, as the Parties have stated in the Preamble to this Treaty, they seek to achieve.
\end{enumerate}
\item Each of the Parties to this Treaty undertakes furthermore to refrain from causing, encouraging, or in any way participating in, the carrying out of any nuclear weapon test explosion, or any other nuclear explosion, anywhere which would take place in any of the environments described, or have the effect referred to, in paragraph 1 of this Article.
\end{enumerate}
\end{itemize}


\begin{itemize}
\item See id.
\end{itemize}
provisions of a treaty.

Because no other treaty discusses radioactive substances specifically, broad principles relating to disposal in space must provide the law in the area. The most far-reaching treaty on space law is the Outer Space Treaty of 1967\textsuperscript{142} which outlines four freedoms of space: exploration, use, access, and scientific investigation.\textsuperscript{143} The treaty compares space to parts of the ocean beyond any nation’s territory; space is an area common to all mankind, used by all, but never owned.\textsuperscript{144} The goal of benefitting mankind must govern the exploration and use of space. The successful use of space for nuclear waste disposal arguably benefits all of mankind, as all countries could take advantage of the technology used to achieve the disposal. Whether mankind benefits from waste disposal in space depends on the method used. If the waste is incinerated successfully, as in disposal in the sun, mankind does benefit. Any technology used in the disposal could be used by all countries.

On the other hand, although the Outer Space Treaty does not ban nuclear waste disposal outright, it does place liability on any nation that

\textsuperscript{142} Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, Jan. 27, 1967, 18 U.S.T. 2410 \textsuperscript{[hereinafter Outer Space Treaty]. This treaty is so important to space law that it is often called the Magna Carta of Outer Space Law.}

\textsuperscript{143} Article I states:

\begin{quote}
The exploration and use of outer space, including the moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind.

Outer space, including the moon and other celestial bodies, shall be free for exploration and use by all States without discrimination of any kind, on a basis of equality and in accordance with international law, and there shall be free access to all areas of celestial bodies.

There shall be freedom of scientific investigation in outer space, including the moon and other celestial bodies, and States shall facilitate and encourage international cooperation in such investigation.
\end{quote}

\textit{Id.} at 2412.

\textsuperscript{144} Article II states “Outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any means.” \textit{Id.} at 2413.
disposes of waste in space if the waste causes harm to another country.\textsuperscript{145} Depositing nuclear waste in outer space would leave a country potentially responsible for billions of dollars in damages.\textsuperscript{146} Where successful “burial” would most likely benefit all of mankind by fulfilling the positive requirements of the Outer Space Treaty, unsuccessful “burial” could cause the United States substantial liability under the Liability Convention of 1972.\textsuperscript{147} For a country to engage in nuclear waste disposal in space, the disposal would have to make sense economically.\textsuperscript{148} Even if the waste could be transported to space at a reasonable cost, the possibility of liability damages from the waste may make such disposal impractical.

\textsuperscript{145} Article VII places the burden:

> Each State Party to the Treaty that launches or procures the launching of an object into outer space, including the moon and other celestial bodies, and each State Party from whose territory or facility an object is launched, is internationally liable for damage to another State Party to the Treaty or to its natural or juridical persons by such object or its component parts on the Earth, in air space or in outer space, including the moon and other celestial bodies.

\textit{Id.} at 2415; see also James P. Lampertius, Note, \textit{The Need For an Effective Liability Regime for Damage Caused by Debris in Outer Space}, 13 \textit{Mich. J. Int’l L.} 447, 450-51 (1992). With any type of disposal that does not actually involve the disintegration of the waste (as on the sun), harm is a real danger. Various space objects have had “near misses” with debris in space, and even some hits. The chance that nuclear waste could destroy a satellite or a manned space mission needs to be weighed heavily, for both ethical and monetary reasons. \textit{See id.}

\textsuperscript{146} See The Convention on International Liability for Damage Caused by Space Objects, Mar. 29, 1972, 24 U.S.T. 2389 [hereinafter Liability Convention of 1972], which places absolute liability on the launching party if damage occurs on earth or with aircraft. It places liability on the launching state if it is at fault for an accident in space. \textit{See id.} at 2392.

\textsuperscript{147} \textit{See id.}

\textsuperscript{148} If the savings and safety of disposal of nuclear waste in outer space appears to greatly outweigh those of disposal on earth, the risk involved may be worth the pay-off. Science has not determined that geologic disposal of waste makes sense from either an economic or a safety perspective, so it is possible that a country may determine that the potential risk of waste disposal in outer space is worth the benefit.
The Rescue and Return Agreement of 1968\textsuperscript{149} adds to the Outer Space Treaty and states that if a hazardous object is discovered in an area of outer space where another nation is conducting space operations, the finder can demand that the owner do what is necessary to eliminate the problem.\textsuperscript{150} Like the problems associated with disposing of waste in space under the Outer Space Treaty, the Rescue and Return Agreement places a heavy financial responsibility on any country that places harmful debris in space, whether or not the placement was intentional.\textsuperscript{151} The United States has signed both the Outer Space Treaty and the Rescue and Return Agreement.

The Liability Convention of 1972\textsuperscript{152} completes the survey of possible treaty law liability for mishaps with nuclear waste disposal in outer space. The Liability Convention provides an absolute liability standard for space activities that cause harm to an aircraft in flight or on the surface of the

\textsuperscript{149} Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, Apr. 22, 1968, 19 U.S.T. 7570 [hereinafter Rescue and Return Agreement of 1968].

\textsuperscript{150} Article 5 provides in part:

[a] Contracting Party which has reason to believe that a space object or its component parts discovered in a territory under its jurisdiction [including an area of space that is being utilized by that country], or recovered by it elsewhere, is of a hazardous or deleterious nature may so notify the launching authority, which shall immediately take effective steps, under the direction and control of the said Contracting Party, to eliminate possible danger of harm.

Id. at 7575.

\textsuperscript{151} See id. at 7575. The elimination of the danger from the hazardous object could be quite expensive.

\textsuperscript{152} Liability Convention of 1972, supra note 146.
In space, liability is based on a fault standard. If an accident occurred during the disposal of the waste, the launching country would most likely be found at fault and would be liable under either standard. If an accident occurred after "disposal," the particular circumstances would determine liability. It is likely that a country would be responsible for tracking any floating debris in order to ensure that another country does not encounter this waste during a space mission. Any mishaps in launching the waste not only would be traumatic because of the injuries produced, but also because the costs of cleanup would be enormous. Under the Liability Convention of 1972, compensation is paid in accordance with international

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153 See id. at 2392. Article II provides that "[a] launching State shall be absolutely liable to pay compensation for damage caused by its space object on the surface of the earth or to aircraft in flight."

154 Article III states:

In the event of damage being caused elsewhere than on the surface of the earth to a space object of one launching State or to persons or property on board such a space object by a space object of another launching State, the latter shall be liable only if the damage is due to its fault or the fault of persons for whom it is responsible.

Id.

155 See id.

156 The launching and emplacement of space objects is far from guaranteed. The Cosmos 954 incident, see infra notes 214-17 and accompanying text, may be the most serious radiological accident related to a space object. Besides the danger that something will go wrong in space and the waste will return to Earth, a more serious concern may be that an accident will occur during the launch, spreading the waste on Earth. In 1986, the space shuttle Challenger exploded a mere 74 seconds after liftoff. See William J. Broad, The Shuttle Explodes: 6 in Crew and High-School Teacher are Killed 74 Seconds After Liftoff, N.Y. TIMES, Jan. 29, 1986, at A1. The booster rockets which exploded in the accident were considered "not susceptible to failure" at the time of the accident. John Noble Wilford, NASA Considered Shuttle Boosters Immune to Failure, N.Y. TIMES, Feb. 3, 1986, at A1. This misplaced confidence demonstrates the fragility of scientific certainty. Problems with space launches have not been solved. In November 1996, a Russian space probe failed in its launch, due to the lack of ignition in a rocket booster, and fell back to Earth. See Russia's Mars Probe Drops Back to Earth, N.Y. TIMES, Nov. 18, 1996, at A1. If such a mishap occurred on the launch of nuclear waste into space, the effects would be catastrophic.
law, but its prime purpose is to restore the victim to its original condition. In the case of a nuclear mishap, the original condition may never be restored and the costs could be unending.

The last space-related treaty that the United States has signed is the Registration Convention of 1976. This convention would impede disposal from a political, rather than a legal, basis. Under this treaty, the Secretary-General of the United Nations must be notified of objects launched into outer space and of the general function and locations of the space objects. This treaty does not specifically prohibit any material from being launched into space, but it does provide a forum for international inquiry from which a country cannot escape. Manned space missions and satellites are fairly common, but no country has yet attempted to dispose of nuclear waste in outer space. If the United States became the first country to attempt disposal in this manner, it could not do so absent inquiry. Pursuant to this treaty, it would have to call political attention to itself.

Because no space law treaty defines "safe" waste disposal in outer space, customary law must be examined to determine the legality of disposal. A number of treaties provide an analogous framework for assessing the legality of nuclear waste disposal in outer space.

The Antarctic Treaty limits future claims of sovereignty over

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157 Article XII states:

The compensation which the launching State shall be liable to pay for damage under this Convention shall be determined in accordance with international law and the principles of justice and equity, in order to provide such reparation in respect of the damage as will restore the person, natural or juridical, State or international organization on whose behalf the claim is presented to the condition which would have existed if the damage had not occurred.

Liability Convention of 1972, supra note 146, at 2397.

158 Convention on Registration of Objects Launched into Outer Space, Mar. 29, 1972, 28 U.S.T. 695 [hereinafter Registration Convention].

159 See id. at 698-99.

160 Article III requires that the Secretary-General of the United Nations maintain a register where launched objects are recorded. It also provides that "[t]here shall be full and open access to the information in this Register." Id. at 699.

Antarctica. Its approach approximates the common view of space expressed in the Outer Space Treaty. A key provision of the Antarctic Treaty is its ban on exploiting Antarctica for military or nuclear purposes. The Agreement Governing the Activities of States on the Moon and Other Celestial Bodies expresses a similar concern for the exploitation of an environment owned in common. This treaty expresses a common heritage of mankind principle, as it forbids private property rights in space resources. Resources may only be exploited by an international authority that apportions its profits in such a way as to give less developed countries a substantial portion of such profits, even if those countries do not play a role in creating

162 Article IV does not take away rights asserted to Antarctica prior to the Treaty; however, it does deny the right of asserting sovereign rights to Antarctica while the Treaty is in force. See Antarctic Treaty, 12 U.S.T. at 796; 19 I.L.M. at 860.
163 See Outer Space Treaty, supra note 142.
164 Article I prevents the use of Antarctica for anything other than peaceful purposes and Article V prevents nuclear explosions and the disposal of radioactive waste. See Antarctic Treaty, supra note 161.
166 Article XI of the Moon Treaty provides in part:

1. The moon and its natural resources are the common heritage of mankind, which finds its expression in the provisions of this Agreement and in particular in paragraph 5 of this article.
2. The moon is not subject to national appropriation by any claim of sovereignty, by means of use or occupation, or by any other means.
3. Neither the surface nor the subsurface of the moon, nor any part thereof or natural resources in place, shall become property of any State, international intergovernmental or non-governmental organization, national organization or non-governmental entity or of any natural person. The placement of personnel, space vehicles, equipment, facilities, stations and installations on or below the surface of the moon, including structures connected with its surface or subsurface, shall not create a right of ownership over the surface or the subsurface of the moon or any areas thereof. The foregoing provisions are without prejudice to the international regime referred to in paragraph 5 of this article.

Moon Treaty, supra note 165; 18 I.L.M. at 1438.
Furthermore, the Moon Treaty requires any activities to take into account the interests of future generations. However, no major space power has signed the Moon Treaty, including the United States. The importance of the Moon Treaty rests in its assertion that space is not something to be used to benefit one country or a relatively small group of people. If its resources are used, all should benefit. Because this treaty was signed by a small group of countries, its principles alone cannot be

167 Article 4 provides in part:

1. The exploration and use of the moon shall be the province of all mankind and shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development. Due regard shall be paid to the interests of present and future generations as well as to the need to promote higher standards of living and conditions of economic and social progress and development in accordance with the Charter of the United Nations.

Moon Treaty, supra note 165; 18 I.L.M. at 1435.

Additionally, Article 11, section 7 states:

7. The main purposes of the international regime to be established shall include:

(d) An equitable sharing by all States Parties in the benefits derived from those resources, whereby the interests and needs of the developing countries, as well as the efforts of those countries which have contributed either directly or indirectly to the exploration of the moon, shall be given special consideration.

Moon Treaty, supra note 165; 18 I.L.M. at 1438.

168 See Moon Treaty, supra note 165; 18 I.L.M. at 1435.

169 Only Austria, Chile, France, Guatemala, India, Morocco, the Netherlands, Peru, the Philippines, Romania, and Uruguay have signed the treaty. In contrast, the 1967 Principles Treaty has been signed by 85 states. The Rescue and Return Agreement binds 78 states, 69 states are bound by the 1972 Convention on the International Liability for Damage Caused by Space Objects, and the 1975 Convention on Registration of Objects Launched into Outer Space binds 34. See Carl Q. Christol, Current Developments: The Moon Treaty Enters Into Force, 79 AM. J. INT’L L. 163, 163-64 (1985).

170 This provision is expressed in Articles 4 and 11. See Moon Treaty, supra note 165, arts. IV, XI; 18 I.L.M. at 1435, 1438-39.
considered customary law.\textsuperscript{171} However, in light of other sources of law prohibiting exploitation of areas considered common, this treaty sheds light on customary law principles.

For example, the International Convention on Civil Liability for Oil Pollution Damage\textsuperscript{172} reflects the principle that no one may spill oil into the res communes of the sea.\textsuperscript{173} A system of liability and compensation for harms exists for offenders.\textsuperscript{174} The Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft prohibits the dumping of wastes in oceans by vessels and aircraft,\textsuperscript{175} unless the dumping is part of a domestically-created permit program.\textsuperscript{176} Article 9 of this treaty does provide for help from an advisory Commission established by the treaty\textsuperscript{177} in circumstances where a country does not feel it can store safely a substance on

\textsuperscript{171} See supra text accompanying notes 117-28.
\textsuperscript{173} Article III places liability on the owner of a ship for any pollution damage caused by oil that escaped from the ship. See 973 U.N.T.S. at 5; 9 I.L.M. at 47-48.
\textsuperscript{174} Articles IV through X set out the system. See 973 U.N.T.S. at 5-9; 9 I.L.M. at 48-57.
\textsuperscript{175} The Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft, Feb. 15, 1972, 932 U.N.T.S. 3, \textit{reprinted in} 11 I.L.M. 262 (1972). The United States is not a signatory. Article 4 provides:

The Contracting Parties shall harmonize their policies and introduce, individually and in common, measures to prevent the pollution of the sea by dumping by or from ships and aircraft.

932 U.N.T.S. at 7; 11 I.L.M. at 263.

\textsuperscript{176} Article 6 provides:

No waste containing such quantities of the substances and materials listed in Annex II to this Convention as the Commission established under the provisions of article 16, hereinafter referred to as "the Commission," shall define as significant, shall be dumped without a specific permit in each case from the appropriate national authority or authorities. When such permits are issued, the provisions of annexes II and III to this Convention shall be applied.

932 U.N.T.S. at 7; 11 I.L.M. at 263.

\textsuperscript{177} See 932 U.N.T.S. at 7; 11 I.L.M. at 263.
This may indicate a willingness to use questionable methods of disposal in circumstances where a safe method of disposal does not seem to be available. The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter provides a similar view of the responsibilities of the states. This Convention prohibits the dumping of some wastes altogether, while other wastes can only be dumped with a permit.

178 Article 9 provides:

If a Contracting Party in an emergency considers that a substance listed in annex I to this Convention cannot be disposed of on land without unacceptable danger or damage, the Contracting Party concerned shall forthwith consult the Commission. The Commission shall recommend methods of storage or the most satisfactory means of destruction or disposal under the prevailing circumstances. The Contracting Party shall inform the Commission of the steps adopted in pursuance of its recommendation. The Contracting Parties pledge themselves to assist one another in such situations.

932 U.N.T.S. at 7; 11 I.L.M. at 263.

Annex I lists the following substances:

1. Organohalogen compounds and compounds which may form such substances in the marine environment, excluding those which are non-toxic, or which are rapidly converted in the sea into substances which are biologically harmless;
2. Organosilicon compounds and compounds which may form such substances in the marine environment, excluding those which are non-toxic, or which are rapidly converted in the sea into substances which are biologically harmless;
3. Substances which have been agreed between the Contracting Parties as likely to be carcinogenic under the conditions of disposal;
4. Mercury and mercury compounds;
5. Cadmium and cadmium compounds;
6. Persistent plastics and other persistent synthetic materials which may float or remain in suspension in the sea, and which may seriously interfere with fishing or navigation, reduce amenities, or interfere with other legitimate uses of the sea.

932 U.N.T.S. at 17; 11 I.L.M. at 265.

179 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, Final Documents, Dec. 29, 1972, 26 U.S.T. 2403. The United States was a member of this conference.

180 See id. art. IV, at 2408.
The Conference specifically condemns the dumping of radioactive material at sea. The sea, like outer space, is commonly considered an area used by all but owned by none; therefore, common uses of the sea shed light on how other countries will view disposal in space. Because disposal at sea is not allowed in most circumstances, a treaty likely would be enacted banning disposal of radioactive waste in outer space, assuming technology made such a practice feasible. Although, if treaties are read more narrowly as to apply only to the oceans, disposal in space may continue to be a legal possibility. Space differs from oceans, however, in an important way. Disposal in space, if done safely, will not make any part of the earth toxic. Ocean disposal, however, even when safely executed, inevitably poisons a portion of the earth.

The Agreement on Cooperation in the Field of Environmental Protection Between the United States and the Union of Soviet Socialist Republics may also limit the United States in its ability to dispose of waste in outer space. In this treaty, both parties agreed to cooperate to prevent pollution and develop new technologies that do not pollute the

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181 Article XII provides, in part:

The Contracting Parties pledge themselves to promote, within the competent specialised agencies and other international bodies, measures to protect the marine environment against pollution caused by:

(d) radioactive pollutants from all sources, including vessels;

Id. at 2411.

environment. A broad reading would imply that disposing of waste in space would be safer to the environment than, for example, deep geologic disposal. A narrow reading focuses on the lack of attention given to the space environment. A list of environmental concerns appears in Article 2 of the treaty, yet none relate to anything broader than earth’s environment. Therefore, it seems possible that the United States could dispose of nuclear waste in space without violating this agreement.

Environmental protection is emphasized in the Convention on the Prohibition of Military or Any Other Hostile Use of Environmental

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183 Article 2 of the treaty provides:

This cooperation will be aimed at solving the most important aspects of the problems of the environment and will be devoted to working out measures to prevent pollution, to study pollution and its effect on the environment, and to develop the basis for controlling the impact of human activities on nature.

It will be implemented, in particular, in the following areas:
- air pollution;
- water pollution;
- environmental pollution associated with agricultural production;
- enhancement of the urban environment;
- preservation of nature and the organization of preserves;
- marine pollution;
- biological and genetic consequences of environmental pollution;
- influence of environmental changes on climate;
- earthquake prediction;
- arctic and subarctic ecological systems;
- legal and administrative measures for protecting environmental quality.

In the course of this cooperation the Parties will devote special attention to joint efforts improving existing technologies and developing new technologies which do not pollute the environment, to the introduction of these new technologies into everyday use, and to the study of their economic aspects.

The Parties declare that, upon mutual agreement, they will share the results of such cooperation with other countries.

Agreement on Cooperation in the Field of Environmental Protection Between the United States of America and The Union of Soviet Socialist Republics, supra note 182, at 847-48.

184 See id.
Modification Techniques. This treaty expresses a need to cooperate in preserving, improving, and peacefully utilizing the environment. The purpose of the convention is closely aligned in theory with the Nuclear Test Ban Treaty, as it bans environmental modification through hostile uses of the environment. The Convention does not prohibit modification of the environment through peaceful means. Because the definition of

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186 Article I provides:
   1. Each State Party to this Convention undertakes not to engage in military or any other hostile use of environmental modification techniques having widespread, long-lasting or severe effects as the means of destruction, damage or injury to any other State Party.
   2. Each State Party to this Convention undertakes not to assist, encourage or induce any State, group of States or international organization to engage in activities contrary to the provisions of paragraph 1 of this article.

Id. at 336.
187 See id.
188 Article II defines “environmental modification techniques” as “any technique for changing through the deliberate manipulation of natural processes - the dynamics, composition or structure of the earth, including its biota, lithosphere, hydrosphere and atmosphere, or of outer space.” Id.
189 Article III provides:
   1. The provisions of this Convention shall not hinder the use of environmental modification techniques for peaceful purposes and shall be without prejudice to the generally recognized principles and applicable rules of international law concerning such use.
   2. The States Parties to this Convention undertake to facilitate, and have the right to participate in, the fullest possible exchange of scientific and technological information on the use of environmental modification techniques for peaceful purposes. States Parties in a position to do so shall contribute, alone or together with other States or international organizations, to international economic and scientific cooperation in the preservation, improvement and peaceful utilization of the environment, with due consideration for the needs of the developing areas of the world.

Id.
environmental modification includes outer space, and the Convention does not prohibit the modification of the environment through peaceful means, the Convention actually may permit the disposal of nuclear waste in outer space, provided the rationale for the disposal was peaceful.

Although considered "soft law," principles and declarations of international law provide a basis for customary law and give insight into the politically acceptable treatments of space. The Principles Relevant to the Use of Nuclear Power Sources in Outer Space was adopted in 1992 by U.N. COPUOS. Although it only considers the use of nuclear fuel as it relates to nuclear power sources, it does show a commitment to the "safe" use of nuclear materials in space. The principles require that safety measures be taken with nuclear power sources, but these sources of power are not banned outright, as U.N. COPUOS realizes the essential usefulness of these

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190 "Soft law" principles are not legally binding, but give insight to customary international law and general principles of international law. See Mark Allan Gray, The International Crime of Ecocide, 26 CAL. W. INT'L L.J. 215, 247 (1996).


193 Principle 3, Guidelines and Criteria for Safe Use, provides in part:

1. General goals for radiation protection and nuclear safety
   (a) States launching space objects with nuclear power sources on board shall endeavor to protect individuals, populations and the biosphere against radiological hazards. The design and use of space objects with nuclear power sources on board shall ensure, with a high degree of confidence, that the hazards, in foreseeable operational or accidental circumstances, are kept below acceptable levels as defined in paragraphs 1 (a) and (c).

Such design and use shall also ensure with high reliability that radioactive material does not cause a significant contamination of outer space.

Principles Relevant to the Use of Nuclear Power Sources in Outer Space, supra note 191, at 26.
sources.\textsuperscript{194} If the disposal of nuclear waste in outer space is looked at in terms of these principles, it is possible that nuclear waste could be disposed in a "safe" way if disposal in space is the best, or only, type of disposal.

United Nations General Assembly Resolution 3281 of the Charter of Economic Rights and Duties of States\textsuperscript{195} addresses some pollution issues that may affect the legality of disposal in outer space. Article 29 declares that the seabed ocean floor and subsoil of the ocean are the common heritage of mankind,\textsuperscript{196} a distinction also given to space.\textsuperscript{197} Article 30 of this resolution requires states to take responsibility for preserving and enhancing the environment for future generations.\textsuperscript{198}

\textsuperscript{194} The preamble to the Principles states: "[r]ecognizing that for some missions in outer space nuclear power sources are particularly suited or even essential due to their compactness, long life and other attributes." \textit{Id.} at 25.


\textsuperscript{196} Article 29 provides:

The sea-bed and ocean floor and the subsoil thereof, beyond the limits of national jurisdiction, as well as the resources of the area, are the common heritage of mankind. On the basis of the principles adopted by the General Assembly in resolution 2749 (XXV) of 17 December 1970, all States shall ensure that the exploration of the area and exploitation of its resources are carried out exclusively for peaceful purposes and that the benefits derived therefrom are shared equitably by all States, taking into account the particular interests and needs of developing countries; an international regime applying to the area and its resources and including appropriate international machinery to give effect to its provisions shall be established by an international treaty of a universal character, generally agreed upon.

\textit{Id.}

\textsuperscript{197} See \textit{supra} notes 142-44 and accompanying text.

\textsuperscript{198} Because the Moon Treaty also provides that future generations should be protected, this idea may become an element of customary international law. Although an ethical obligation, the United States government has proven, with its lack of a workable nuclear waste plan, that absent legal enforcement, future generations will be protected only minimally. Article 30 of the Charter on Economic Rights and Duties of States provides:

The protection, preservation and enhancement of the environment for the present and future generations is the responsibility of all States. All States shall endeavour to establish their own environmental and
The Stockholm Declaration of the United Nations Conference on the Human Environment provides insight into the views of the 113 countries that signed the declaration on the preservation of the environment. Principles 6 and 7 indicate that states should dispose harmful substances into the seas only to the extent that the oceans can absorb the substance and render it harmless. Principles 21 through 24 discuss the responsibility of states to ensure that territories beyond a state's sovereignty remain free from damage. Any damage that a state causes to areas beyond its jurisdiction developmental policies in conformity with such responsibility. The environmental policies of all States should enhance and not adversely affect the present and future development potential of developing countries. All States have the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction. All States should co-operate in evolving international norms and regulations in the field of the environment.


Principles 6 and 7 provide:

Principle 6 provides:

The discharge of toxic substances or of other substances and the release of heat, in such quantities or concentrations as to exceed the capacity of the environment to render them harmless, must be halted in order to ensure that serious or irreversible damage is not inflicted upon ecosystems. The just struggle of the peoples of all countries against pollution should be supported.


Principle 7 provides:

States shall take all possible steps to prevent pollution of the seas by substances that are liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea.

Id., supra note 199; 11 I.L.M. at 1420-21.
shall be compensated by the state doing the damage. This treatment of the environment can be expanded to space. When these principles are extended to space, however, it seems unlikely that nuclear disposal in outer space could be accomplished with any certainty that these principles would not be violated.

Principles that add to the understanding of the legality of space disposal are seen in a few international decisions. The Trail Smelter Case was an arbitration decision where air pollution from a Canadian smelting operation caused damage in the United States. The tribunal found that, under the principles of international law and the law of the United States, Canada could be prevented from causing environmental injury to the United States. The key principle enunciated by the court was that no state could use its territory in a way that injures another state.

The Corfu Channel Case, decided by the International Court of Justice, centered on the international responsibility for the laying of mines by Albania within its territorial waters. These mines exploded, damaging British warships and causing the loss of human life. The International Court of Justice found that every state has an obligation to refrain from knowingly using its territory for acts contrary to the rights of other states.

The Lake Lanoux Case found that France could change the flow of a river, provided that the change in the flow of the river did not injure a downstream state. This case may indicate that nuclear waste disposal in

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205 See id. at 692-93.
206 See id. at 716.
207 See id.
209 See id. at 9-15.
210 See id. at 12.
211 See id. at 35.
213 See id. at 170.
space is allowed but only to the extent that altering the environment of space does not damage any other portion of the environment.

The *Cosmos 954 Case*\(^{214}\) is the only time the Liability Convention has been invoked.\(^{215}\) In this case, a Soviet satellite made an uncontrolled reentry into the atmosphere and crashed in Canadian territory.\(^{216}\) Canada eventually settled with the U.S.S.R. for three million Canadian dollars.\(^{217}\) This case demonstrates the potential effectiveness of international treaties in dealing with space based pollution.

The international treaties, cases, and principles do not seem to indicate a clear answer to the question of whether disposal of nuclear waste in outer space is permissible. They do indicate, however, that the country that disposes the waste would be liable for any harm that is caused by such disposal. This principle is seen in treaty and customary law. If waste could be disposed of without harming another country, the law is less clear. Certainly no treaty expressly forbids the disposal, and because no country has used space as a disposal site, international custom has not been set. Customary law seems to ban disposal of harmful substances in common areas on earth, but whether this applies to space is, again, unclear. Hence, customary law probably does not prohibit the disposal. If the U.S. did dispose of waste in this manner, it might set custom to allow such disposal. The U.S. is one of a handful of countries that have the technology for such disposal, and therefore, the practice of the U.S. will have a substantial impact on customary law in this area.

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\(^{214}\) Department of External Affairs, Canada, Claim Against the U.S.S.R for Damage Caused by Soviet Cosmos, Note No. FLA-268 (Jan. 23, 1979), *reprinted in* 18 I.L.M. 899 (1979) [hereinafter Department of External Affairs].

\(^{215}\) See Schafer, *supra* note 107, at 25.

\(^{216}\) See Department of External Affairs, *supra* note 214; 18 I.L.M. at 902.

CONCLUSION

The problem of nuclear waste presents no easy or clear choices. Therefore, in any attempts to address its disposal, potential "solutions" should not be dismissed without recognizing the lack of options that exist. The prospect of disposing nuclear waste in outer space is not beyond technical or legal reach. Legally, the United States could dispose of the waste, but it must be willing to risk both international liability for any damages and international scorn for what may be seen as a violation of the res communes of space.

Although the United States may be risking both monetary and political loss by disposing waste in outer space, the benefits may be worth the cost. Nuclear waste will not disappear. It will be with us far longer than the 10,000 years the Department of Energy has determined is the appropriate isolation period. If an option exists through which the waste is permanently destroyed, such as incineration on the sun, the option may save the lives of entire future generations. However, if the gamble is wrong, and the waste returns to the earth, or contaminates the environment in another way, earth's residents will suffer. If science can formulate a safe way for waste to be disposed in space, it should be done. Legal harm will result only from a failed attempt, and would be minor compared to the damage that would occur to the environment and to humans.