United States Government Accountability Office

Report to the Chairman of the Committee on Environment and Public Works, U.S. Senate

January 2024

NUCLEAR WASTE

Changing Conditions May Affect Future Management of Contamination Deposited Abroad during U.S. Cold War Activities

Accessible Version

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GAO Highlights

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Highlights of GAO-24-104082, a report to the Chairman of the Committee on Environment and Public Works, U.S. Senate
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Why GAO Did This Study

The United States conducted defense activities in many countries during the Cold War. These activities resulted in radioactive contamination in three countries: Greenland, Spain, and RMI. During the 1960s, the United States buried radioactive liquid in Greenland's ice while operating the experimental Camp Century base to study the feasibility of installing nuclear missiles there. In 1966, in Spain, two U.S. defense aircraft collided, dispersing radioactive debris over the town of Palomares. From 1946 to 1958, the United States conducted 67 nuclear weapons tests in RMI, and the resulting radioactive fallout contaminated several atolls.

This report examines (1) the amount and type of radioactive contamination in Greenland, Spain, and RMI; and (2) how conditions have changed at these sites, and the extent to which the environment and inhabitants have been affected by these changed conditions. GAO reviewed key literature on the contamination and interviewed U.S. and foreign government officials.

What GAO Recommends

The Secretary of Energy, as a part of the agency's ongoing efforts to address the legacy of U.S. nuclear testing in RMI, should develop and document a strategy for communications on radioactive contamination that is sustained, understandable, transparent, engages the RMI government, and builds on lessons learned. DOE concurred with GAO's recommendation.

What GAO Found

U.S. Cold War activities resulted in radioactive contamination in three locations: Greenland (part of the Kingdom of Denmark), Spain, and the Republic of the Marshall Islands (RMI) (see fig.). In Greenland, radioactive liquid—generated by a small nuclear reactor that powered the U.S. Camp Century base—remains entombed under ice. In Spain, a mid-air collision resulted in radioactive contamination around Palomares. The United States and Spain cleaned up much of the radioactive material and have monitored the remaining material since. In RMI, contamination from nuclear weapons tests and the resulting fallout remains measurable on several atolls, some of which are still uninhabitable.

Figure: Locations of Radioactive Contamination from U.S. Cold War Activities Abroad

Sources: GAO analysis of U.S. government documents; Republic of the Marshall Islands: National Museum of Nuclear Science and History; Greenland: Bryan Ambrust/U.S. Army Corps of Engineers, Engineer Research and Development Center; Spain: National Museum of Nuclear Science and History (images); and Map Resources. | GAO-24-104082

Conditions have changed in all three locations since the original contamination. Most affected are the environment and inhabitants of RMI, where the Department of Energy (DOE) has ongoing responsibilities. Specifically:

- **Greenland**. At Camp Century, Denmark instituted permanent ice sheet monitoring to address concerns that climate change could release contamination. However, a 2021 study reported that contamination likely would remain immobile through 2100.
- **Spain**. In Palomares, Spanish officials reevaluated the radioactive contamination in the 1990s and found it exceeded European Union standards. In 2015, U.S. and Spanish authorities signed a statement of intent to further remediate Palomares but have not reached a final agreement.
- **RMI**. In RMI, people are concerned that climate change could mobilize radiological contamination, posing risks to fresh water and food sources. DOE assesses human radiation exposure and monitors environmental contamination in RMI. DOE considers human health risk to be low, but RMI officials believe DOE has downplayed the risk. This and other disagreements fuel distrust of DOE's information. By implementing a sustainable communication strategy in RMI, DOE could improve the Marshallese people's access to, and trust in, information on contamination as environmental conditions change.

Contents

Abbreviations

Bq	Becquerel
Ci	Curie
CIEMAT	Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (Center for Energy, Environmental and Technological Research)
COFA	Compact of Free Association
DOE	U.S. Department of Energy
Euratom	European Atomic Energy Community
mSv	Millisievert
REM	Roentgen equivalent man
RMI	Republic of the Marshall Islands
Sv	Sievert

U.S. GOVERNMENT ACCOUNTABILITY OFFICE
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January 31, 2024

The Honorable Tom Carper
Chairman
Committee on Environment and Public Works
United States Senate

Dear Mr. Chairman,

During the Cold War, the United States conducted nuclear-related activities, such as defense-related research and nuclear weapons testing, in many countries. In three locations—Greenland, the Republic of the Marshall Islands (RMI), and Spain—U.S. activities, including an aircraft accident, resulted in radioactive contamination. Some of that contamination remains in those locations today (see fig. 1).

Figure 1: Radiation Deposited in Three Foreign Countries as a Result of U.S. Nuclear-Related Activities during the Cold War

Sources: GAO analysis of U.S. government documents; Republic of the Marshall Islands: National Museum of Nuclear Science and History; Greenland: Bryan Ambrust/U.S. Army Corps of Engineers, Engineer Research and Development Center; Spain: National Museum of Nuclear Science and History (images); and Map Resources. | GAO-24-104082

Contamination in Greenland occurred between 1959 and 1967 during construction and operation of a U.S. military base called Camp Century, which the United States used to assess the feasibility of placing nuclear-armed ballistic missiles within the ice sheet. The United States powered the base for several years with a small, portable nuclear reactor and disposed of radioactive liquid waste from routine operations and testing of the reactor in the ice sheet. It also disposed of chemical waste from the camp's daily operations and biological waste from wastewater and general sewage. After determining that maintaining nuclear missiles in

Greenland's ice sheet was not feasible, the United States closed the base in 1967, leaving the waste in the ice sheet.

Contamination in RMI occurred from 1946 to 1958 when the United States conducted 67 nuclear weapons tests in the Pacific Ocean. Blasts and radioactive fallout from the weapons tests, which mostly consisted of atmospheric and underwater detonations, caused significant contamination to land and marine environments of several northern atolls—which are rings of islands. The U.S. Department of Defense conducted some cleanup operations. In one operation, the United States deposited radioactive soil and debris that it collected into an unlined crater, which itself was created by a weapons test, on Runit Island on the Enewetak Atoll. In the late 1970s, to protect the waste pile from erosion, the United States covered the crater with a concrete cap, known as Runit Dome.

Contamination in southern Spain occurred in 1966 when two U.S. defense aircraft carrying four thermonuclear bombs collided in midair. There was no nuclear explosion, but the collision dispersed radioactive debris over a wide area near the town of Palomares. Following the accident, the U.S. Department of Defense and Spain remediated the area in accordance with decontamination levels and methods mutually agreed upon at the time. Cleanup activities at the site included removing aircraft wreckage, burning contaminated vegetation, and removing some contaminated soil that the United States disposed of at a facility in South Carolina. However, some radioactive contamination remains in Palomares.

You asked us to review what is known about radioactive contamination deposited as a result of U.S. nuclear-related activities overseas. This report examines (1) the amount and type of contamination in Greenland, RMI, and Spain and what the United States has done to address the contamination at these sites, and (2) how conditions have changed at these sites and the extent to which the environment and inhabitants have been affected by these changed conditions.

To obtain information about the amount and type of radioactive contamination at the three sites and what the United States has done to address the contamination, we conducted two literature searches from November 2022 to December 2022. The first search collected data on the amount and type of past and current radioactive contamination in Greenland, RMI, and Spain. The second collected data on pertinent international guidance and standards on radiation. Both searches included peer-reviewed studies, government reports, conference papers, and similar documents spanning contemporaneous accounts to the present. We then performed a content analysis of the collected literature using a software program that allowed us to sort the material and summarize results. We also reviewed documents from the U.S. Departments of Defense, Energy, the Interior, and State. We obtained and reviewed applicable legal requirements, including international agreements and diplomatic exchanges between the United States and Denmark, RMI, and Spain.[1] We also reviewed documents and interviewed foreign government officials from Denmark, RMI, and Spain.

To describe how conditions have changed at sites contaminated by U.S. nuclear activities since initial cleanup efforts and the extent to which the environment and inhabitants of these sites have been affected by changed conditions, we reviewed and analyzed relevant summaries of our literature search, as well as documents from the U.S. Departments of Energy, the Interior, and State. We also reviewed applicable U.S. legislation to determine relevant requirements and guidance for U.S. agencies at these sites. We reviewed documents and interviewed foreign government officials from Denmark, RMI, and Spain. We reviewed publicly available information on agreements being negotiated between the United States and RMI and the United States and Spain. We also obtained and reviewed documents from the European Union related to the contamination in Spain. In addition, we interviewed academics with expertise in nuclear waste in Greenland and RMI and we reviewed documents that they provided. For more details about our objectives, scope, and methodology, see appendix I.

We conducted this performance audit from March 2020 to January 2024 in accordance with generally accepted government auditing standards.[2] Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that

[1]Greenland was a colony of Denmark from the early 18th century until the 1950s, when Greenland was integrated into Denmark. Greenland remains part of the Kingdom of Denmark today. While Greenland has gained various rights to home rule and self-government over the years, the Danish government retains authority over Greenland's foreign affairs, defense, and security policy.

[2]We suspended this work from April 2020 through October 2022 because the COVID-19 pandemic limited our ability to carry out aspects of our methodology.

the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

This section describes radiation health risks to humans, the legacy of waste at Camp Century in Greenland, the history of nuclear weapons testing in RMI and the Compact of Free Association, and the U.S. aircraft collision over Palomares, Spain.

Radiation Health Risks to Humans

The human health risks posed by any given type of radioactive material depend on its intensity, or ionizing effects; radiation type; length of exposure; and means of exposure—typically inhalation, ingestion, or external contact. The complex interplay of these factors causes health effects ranging from death, severe injury, and chronic illness to no discernable damage. Our report addresses two types of radiation that pose a threat to human health.[3]

- **Alpha radiation.** Alpha radiation poses little threat to human health from external exposure because material such as clothing can easily block it. However, inhaling or ingesting alpha radiation poses considerable health risks. Once ingested, alpha emitters expose internal organs to ionizing radiation. Heavy radioactive elements such as plutonium, radium, and uranium emit alpha radiation as they decay and some radioactive elements, such as plutonium, tend to remain in the body for a long time exposing human tissue to continuous ionizing radiation.
- **Gamma radiation.** Gamma radiation is penetrative and can cause injury through external exposure if not properly shielded. Radionuclides that emit gamma radiation can also be ingested if they

[3]In addition to alpha and gamma radiation, there are also beta and neutron radiation. Our report focuses on alpha and gamma radiation because these types of radiation have the most significant human health effects from radioactive material deposited in other countries as a result of U.S. Cold War activities.

are in food products. Gamma radiation is emitted during decay of elements such as cobalt-60, iridium-192, and barium-137 metastable.[4]

Activity is used to measure the level of radioactive decay and emission for a radiological source and is measured in units of becquerel (Bq) or curie (Ci).[5] For example, under U.S. Environmental Protection Agency regulations, the maximum allowable level of combined radium-226 and -228 in drinking water is 5 picocuries/liter, which is equivalent to 0.185 Bq/liter.[6] Conversely, when assessing radiation risks to humans, scientists use a different unit of measurement: the effective dose, or the amount of ionizing radiation absorbed in human tissue adjusted for the radiation type and organ sensitivity. According to the U.S. Environmental Protection Agency, assessing the effective dose allows the agency to set regulatory limits to protect humans and to project risk in different exposure situations. Effective dose cannot, however, be used to assess the risk to a single individual because risk estimates are based on population-based analyses. Effective dose is measured by sievert (Sv) or roentgen equivalent man (rem).

For example, the U.S. Nuclear Regulatory Commission has established effective dose limits for certain workers exposed to occupational radiation. While those limits vary depending on the affected part of the body, the annual total effective dose limit is 5 rems, which is equivalent to 50 millisieverts (mSv).[7] Figure 2 shows the units of measurement of radiation.

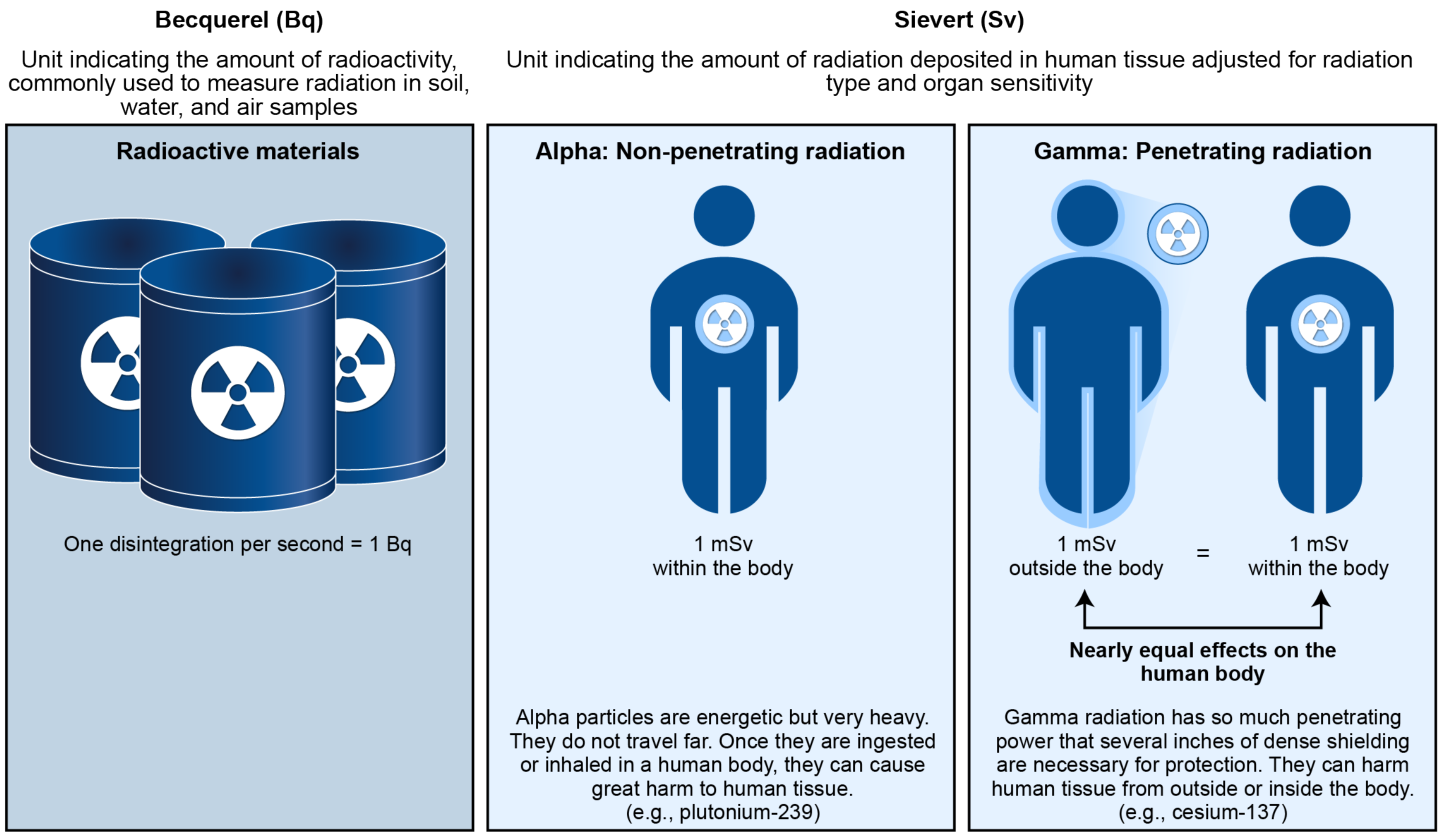
[4]Cesium-137 decays in the environment by emitting beta radiation, but it also decays to barium-137 metastable, which emits gamma radiation. Barium-137 metastable decays to a stable form of barium.

[5]One Bq is equivalent to one disintegration per second, and one Ci is equivalent to 37 billion Bq, or 37 billion disintegrations per second.

[6]40 C.F.R. § 141.66(b).

[7]10 C.F.R. § 20.1201(a).

Figure 2: Units Used to Measure Radiation



Source: GAO analysis of documents from the U.S. Department of Energy and he U.S. Environmental Protection Agency; and GAO (icons). | GAO-24-104082

Accessible text for Figure 2: Units Used to Measure Radiation

- Becquerel (Bq)
  - Unit indicating the amount of radioactivity, commonly used to measure radiation in soil, water, and air samples
  - Radioactive materials
  - One disintegration per second = 1 Bq
- Sievert (Sv)
  - Unit indicating the amount of radiation deposited in human tissue adjusted for radiation type and organ sensitivity
  - Alpha: Non-penetrating radiation

- Alpha particles are energetic but very heavy. They do not travel far. Once they are ingested or inhaled in a human body, they can cause great harm to human tissue. (e.g., plutonium-239)

- Gamma: Penetrating radiation
    - Gamma particles have so much penetrating power that several inches of dense shielding is necessary for protection. They can harm human tissue from outside or inside the body. (e.g., cesium-137)

Source: GAO analysis of documents from the U.S. Dept. of Energy and the U.S. Environmental Protection Agency, and GAO (icons). | GAO-24-104082

Figure 3 shows the effect of radiation on the human body. Low doses of radiation have uncertain health effects on humans. The higher the dose, the more is known about negative health effects.

Figure 3: The Health Effect of Radiation on the Human Body Depends on Dose

Sources: U.S. Environmental Protection Agency (data); GAO (icons). | GAO−24−104082

Note: The U.S. National Academies of Sciences, Engineering, and Medicine consider low-dose radiation to be a dose of less than 100 millisieverts and a dose-rate of less than 5 millisieverts per hour. Millisieverts are a measure of the effectiveness ofg radiation to induce biological damage. This figure is a simplified illustration of example exposures and does not reflect variability in uncertainty over health outcomes for specific exposures.

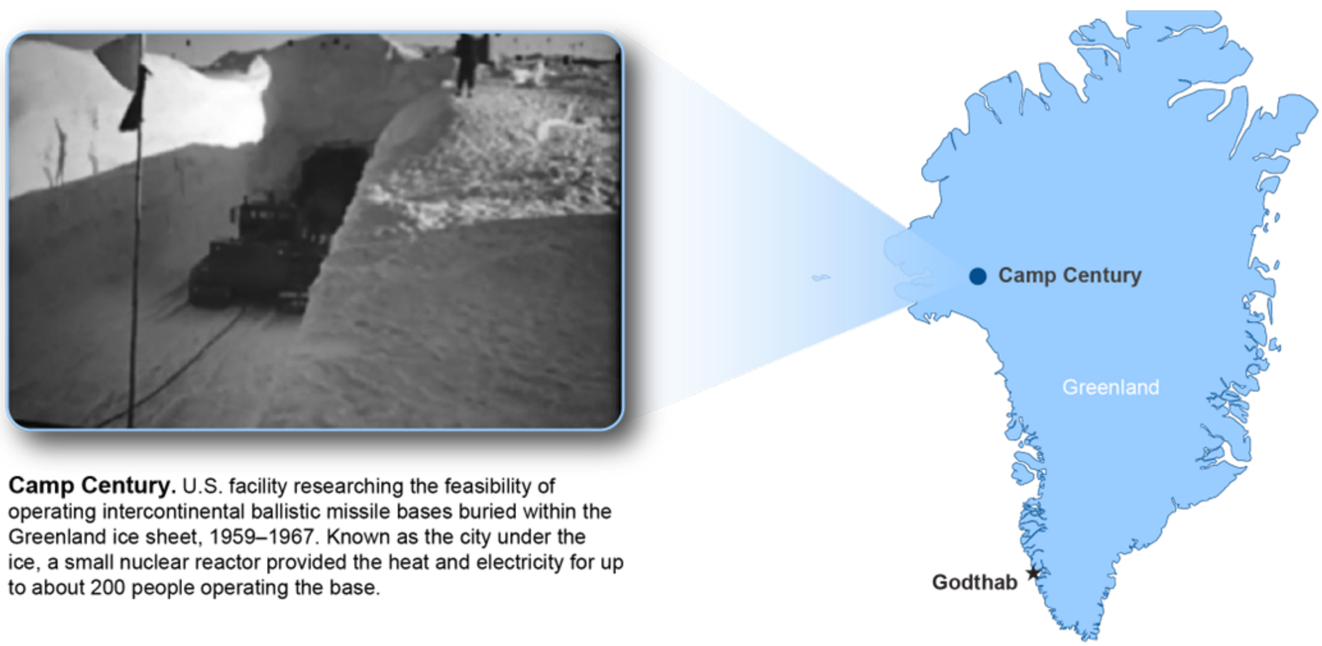
Camp Century's Legacy Waste in Greenland

During World War II, the United States established military bases in Greenland as part of mutual defense, leading to an enduring presence after the war.[8] In 1951, the United States and Denmark—Greenland's governing authority at the time—signed an agreement giving the United States access to establish new defense facilities in certain areas of

[8]On April 9, 1941, the anniversary of the day German troops invaded Denmark, the United States signed an agreement with Denmark to assist in the defense of Greenland. The agreement allowed the United States to construct, maintain, and operate certain defense facilities in Greenland that were important in protecting trans-Atlantic convoys.

Greenland.[9] Among other defense objectives, the United States was interested in researching the feasibility of operating a base under the ice in Greenland. Specifically, the United States wanted to study a subsurface facility that would be relatively unaffected by adverse surface weather, could remain hidden, and would be less vulnerable to attack. It tested this concept at Camp Century. Figure 4 shows the origin of radioactive contamination in Greenland resulting from U.S. Cold War activities.

Figure 4: Origins of Radioactive Contamination in Greenland Resulting from U.S. Cold War Activities



Camp Century. U.S. facility researching the feasibility of operating intercontinental ballistic missile bases buried within the Greenland ice sheet, 1959–1967. Known as the city under the ice, a small nuclear reactor provided the heat and electricity for up to about 200 people operating the base.

Sources: GAO analysis of U.S. government documents and scientific literature; Bryan Armbrust/U.S. Army Corps of Engineers, Engineer Research and Development Center (image); and Map Resources. | GAO-24-104082

Camp Century also served as a secret effort—codenamed Project Iceworm—to conduct research on the feasibility of deploying nuclear missiles under the ice sheet. As part of its Cold War strategy, the United States investigated establishing nuclear missile bases near the Arctic Circle for the shortest air routes from the moment of launch to the

[9]The United States, Denmark, and other allies chartered the North Atlantic Treaty Organization in 1949. In 1951, the United States and Denmark signed an agreement regarding the defense of Greenland, which gave the United States the right to establish and outfit certain areas in Greenland for military use to assist Denmark in defending Greenland and the North Atlantic Treaty area. Defense of Greenland Agreement signed at Copenhagen April 27, 1951, June 8, 1951, T.I.A.S. 2292.

moment of impact in the Soviet Union. The concept of an ice-sheet base did not advance past the research stage at Camp Century.

While Camp Century was operational, providing power for base operations was difficult. Resupply of liquid fossil fuels was burdensome and renewables such as solar, wind, or hydropower were too seasonal or intermittent to support uninterrupted operations. However, the Army Nuclear Power Program had been designing small, portable nuclear reactors to serve such austere environments, leading to the Portable Mobile-2A nuclear power reactor for Camp Century. The reactor could produce 10 megawatts of thermal energy and 1.5 megawatts of electrical energy.[10] It was the first small portable reactor ever deployed in the world, according to the U.S. Department of Defense. Routine operations and testing of the portable nuclear power reactor resulted in some radioactive liquid with a small amount of radioactivity. After the United States abandoned Camp Century in 1967, it left this liquid in the ice under Camp Century, resulting in contamination that remains today.

History of Nuclear Testing in RMI and the Compact of Free Association

Following World War II, the United States conducted 67 nuclear weapons tests at northern atolls in RMI between 1946 and 1958 (see fig. 5).[11] At the time of testing, the Marshall Islands were part of the Trust Territory of the Pacific Islands, a United Nations trust territory administered by the United States. The weapons tests, which mostly consisted of atmospheric and underwater detonations, caused significant radiological contamination to land and marine environments of several atolls. Prior to testing, the United States relocated residents of Bikini and Enewetak, which were expected to receive radioactive fallout during the testing program. Furthermore, a March 1, 1954, test, termed Castle Bravo,

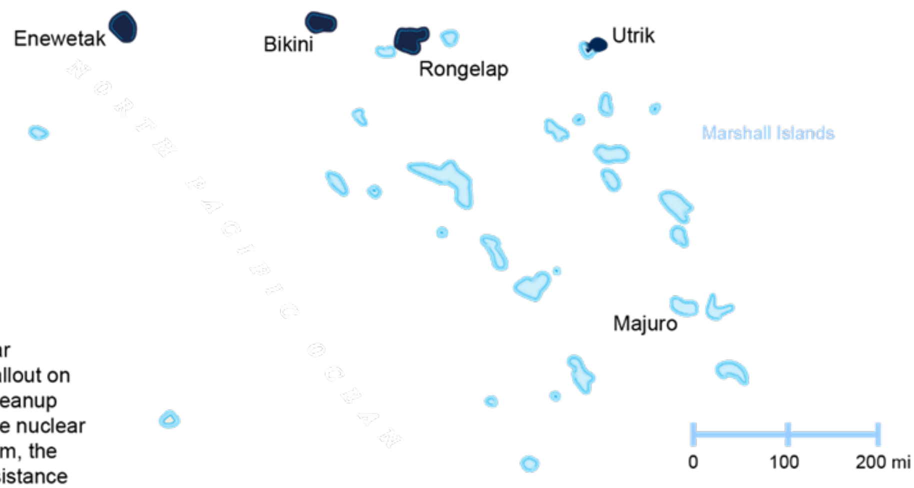
[10]Megawatt, or 1 million watts, is a term used to describe the generating capacity of an electrical power plant over the course of 1 year. For comparison, the U.S. Energy Information Administration reported that the average U.S. household purchased 10,000 watts of electricity over the course of 2021. According to the administration, the average household likely consumes more electricity than this amount because many households consume solar energy that is not purchased.

[11]The U.S. Atomic Energy Commission, which developed the RMI nuclear testing program, was a predecessor federal agency to the present-day U.S. Nuclear Regulatory Commission and U.S. Department of Energy.

caused radiological contamination on Rongelap and Utrik Atolls, both of which were inhabited when fallout from the test reached the atolls.

Figure 5: Origins of Radioactive Contamination in the Republic of the Marshall Islands Resulting from U.S. Cold War Activities

Republic of the Marshall Islands. U.S. nuclear weapons tests from 1946 to 1958 caused nuclear fallout on certain atolls. The United States conducted some cleanup activities on the affected atolls in the aftermath of the nuclear testing program. Since the end of the testing program, the United States has provided economic and other assistance for certain medical surveillance and environmental monitoring activities related to the nuclear fallout under the auspices of various U.S. statutes and a Compact of Free Association with the Republic of the Marshall Islands.



Atolls the United States considers as having been affected by the Nuclear Testing Program.

Sources: GAO analysis of U.S. government documents; Leonard P. Schultz/Smithsonian Libraries and Archives (image); and Peter Hermes Furian/stock.adobe.com (map). | GAO-24-104082

Note: Majuro is the capital of the Republic of the Marshall Islands. The U.S. government considers the four atolls highlighted in dark blue as the only Republic of the Marshall Islands atolls affected by radiological contamination from the nuclear testing program. The Republic of the Marshall Islands government maintains that more than these four atolls were affected by radiological contamination from the nuclear testing program. The Republic of the Marshall Islands covers about 750,000 square miles, but its land area only consists of about 70 square miles, about the size of Washington, D.C.

The Marshall Islands remained a part of the Trust Territory of the Pacific Islands until 1986, when the United States and RMI entered into a Compact of Free Association.[12] From 1999 to 2003, the United States and RMI negotiated an amended compact that entered into force in 2004.[13] Under the original and amended compact, the United States has provided financial assistance for defined time periods and has responsibility for defense and security matters. These include the right to establish military

[12]Compact of Free Association Act of 1985, Pub. L. No. 99-239, 99 Stat. 1770 (1986).

[13]Compact of Free Association Amendments Act of 2003, Pub. L. No. 108-188, 117 Stat. 2720.

facilities and to foreclose access to or use of RMI by other countries' militaries.[14]

In Section 177 of the compact, the United States accepted responsibility for compensation owing to RMI citizens for loss or damage to people or property caused by the nuclear testing program. The United States and RMI also agreed in Section 177 to set forth a separate agreement providing for the just and adequate settlement of all claims which had not yet been compensated or might arise in the future, among other things. Accordingly, in the mid-1980s, the United States and RMI entered into the Agreement for the Implementation of Section 177 of the Compact of Free Association (Section 177 agreement). Under the Section 177 agreement, the United States provided $150 million to RMI to establish a nuclear claims fund and an independent Nuclear Claims Tribunal to adjudicate all claims resulting from the nuclear testing program. Article X of the Section 177 agreement states it constitutes the full settlement of all claims past, present, and future related to the nuclear testing program. The Section 177 agreement remains in effect, and the long-standing position of the U.S. government is that, pursuant to the provisions of the agreement, RMI bears full responsibility for its lands, including those used for the nuclear testing program.

Article IX of the Section 177 agreement allows RMI to petition the U.S. Congress to request further compensation for losses and damages arising out of "changed circumstances" that were not and could not have reasonably been identified as of the effective date of the agreement and which would render the provisions of the agreement manifestly inadequate. In 2000, RMI submitted to Congress a petition under Article IX claiming the original settlement agreement did not provide adequate funds to address personal injury claims, property damage claims, or the health consequences of the testing program and making several other arguments for "changed circumstances."[15] In November 2004, the U.S.

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[14]We reported on United States' assistance to RMI and other freely associated states through the compacts of free association in 2022. GAO, *Compacts of Free Association: Implications of Planned Ending of Some U.S. Economic Assistance*, GAO-22-104436 (Washington, D.C.: Feb. 14, 2022).

[15]As a part of that petition, RMI requested, among other things, that the U.S. Congress authorize and appropriate over a $1.1 billion so the Nuclear Claims Tribunal could pay personal injury and property damage awards that exceeded funding provided under the Section 177 Agreement. RMI also requested that the U.S. Congress replenish the Nuclear Claims Trust Fund so the tribunal could continue to make personal injury and property damage awards in the future. According to RMI government officials, the tribunal has issued property damage awards for over $3 billion that remain unpaid.

Department of State, on behalf of an interagency group, released a report evaluating the legal and scientific basis of the petition. The report concluded that the evidence provided in the petition did not qualify as changed circumstances within the meaning of the Section 177 agreement. Congress held a series of hearings following RMI's petition, but the petition remains pending.[16]

Under the amended compact, certain U.S. economic assistance to RMI was set to end after fiscal year 2023. In 2019, the United States announced that it was negotiating with the government of RMI regarding agreements related to the expiring provisions for economic assistance and certain federal programs and services. In September 2022, RMI broke off compact-related agreement negotiations, stating that the proposed financial assistance was not adequate given the damage inflicted, according to news reports. In January 2023, the United States signed a memorandum of understanding with RMI in which both countries affirmed a shared understanding on levels and types of future U.S. assistance to be requested for RMI. According to July 2023 congressional testimony, that memorandum reflects the understanding that the United States would offer future assistance to RMI totaling $2.3 billion. In October 2023, the U.S. Department of State announced that the United States and RMI had signed an agreement to amend the compact, as well as a new fiscal procedures agreement and a new trust fund agreement. The U.S. Congress and RMI Parliament must approve the agreements before they are brought into force.

[16]In 2006, a group of Marshallese brought class action lawsuits in the U.S. Court of Federal Claims on behalf of the people of Bikini and Enewetak Atolls at the time of the testing program and their descendants. Those cases sought, among other things, just compensation for deprivation of property rights under the Fifth Amendment of the United States Constitution's takings clause. The plaintiffs based their takings claims on inadequate funding of the Nuclear Claims Tribunal's award fund and the deprivation of their land during the testing program. In 2000 and 2001, the Nuclear Claims Tribunal awarded the People of Bikini and the People of Enewetak $563,315,500 and $385,894,500 respectively for property damage and restoration costs, among other things, resulting from the testing program. However, due to insufficient funds, the Tribunal was able to pay less than 1% of those awards. The 2006 lawsuits sought compensation in the amounts awarded by the Tribunal, but the U.S. Court of Federal Claims dismissed the suits for lack of jurisdiction, and the U.S. Court of Appeals for the Federal Circuit affirmed. In doing so, the Federal Circuit concluded that the Section 177 agreement—which constitutes "the full settlement of all claims, past, present and future, of the Government, citizens and nationals of the Marshall Islands which are based upon, arise out of, or are in any way related to the Nuclear Testing Program"—withdrew the jurisdiction of U.S. courts to hear such claims related to the testing program. *People of Bikini v. United States*, 77 Fed. Cl. 744 (2007) & *John v. United States*, 77 Fed. Cl. 788 (2007), *consolidated on appeal People of Bikini v. United States*, 554 F.3d 996 (Fed. Cir. 2009).

Four federal departments engage in activities related to the legacy of nuclear testing in RMI:

- **U.S. Department of Defense.** From the 1970s to the 2000s, the U.S. Department of Defense, with assistance from the U.S. Departments of Energy (DOE) and the Interior, conducted cleanup operations on Bikini, Enewetak, and Rongelap Atolls. This included the construction of Runit Dome, a containment structure storing over 100,000 cubic yards of radioactively contaminated soil and debris from six islands in northern Enewetak Atoll. DOE sponsored a 1983 report to document the radiological conditions of northern atolls, and radiological contamination remains to this day in varying amounts. The combined federal cleanup effort cost about $100 million (about $395 million adjusted for inflation in August 2023) and required a task force of almost 1,000 people.
- **DOE.** DOE conducts radiological monitoring—such as dose assessments and radioecology programs—on Bikini, Enewetak, Rongelap, and Utrik Atolls through various memorandums of understanding with the RMI government. DOE also provides medical care through the RMI Special Medical Care and Logistics Program. This program provides medical examinations and treatment for potential radiation-related cancers for members of the populations of Rongelap and Utrik who were exposed to fallout from the Castle Bravo test.[17] In addition, the Insular Areas Act of 2011 requires DOE to periodically (but not less than every four years) conduct a visual study of and report on the exterior of Runit Dome and conduct a radiochemical analysis of the groundwater surrounding it.[18] According to DOE officials, DOE has requested and received about $6.3 million each fiscal year since 2001 to conduct programmatic work in RMI.
- **U.S. Department of the Interior.** Interior's Office of Insular Affairs provides funding to DOE for the Runit Dome groundwater monitoring program, which DOE implements. The Office of Insular Affairs also funds the restoration of Enewetak's natural vegetation program and provides funding to the RMI Ministry of Health and Human Services for the Four Atoll Health Care Program. This program provides health care services for the people from Bikini, Enewetak, Rongelap, and Utrik Atolls who were affected by the nuclear weapons testing program and for their descendants.

[17]DOE reported that 91 individuals were eligible for the Special Medical Care and Logistics Program as of October 2019.

[18]Insular Areas Act of 2011, Pub. L. No. 112-149, 126 Stat. 1144 (2012).

- **U.S. Department of State.** The U.S. Department of State engages with RMI federal government officials, RMI local governments, and the people of RMI, including through the U.S. embassy in RMI. The U.S. embassy coordinates U.S. government activities in RMI.

U.S. Aircraft Collision over Palomares, Spain

During the 1950s and 1960s, the U.S. Air Force's Strategic Air Command flew continuous international flights of nuclear-armed U.S. military aircraft as part of its airborne alert program, known as Operation Chrome Dome. The operation was intended to deter Soviet aggression by maintaining a 24-hour airborne bomber presence in positions from which the aircraft could quickly reach targets in the Soviet Union. In 1953, the United States and Spain signed a defense agreement, which allowed the United States to use areas and facilities in Spain in support of mutual defense.[19] Under the auspices of this agreement, the United States conducted nuclear-armed flights and refueling operations within Spanish airspace.

Operation Chrome Dome relied upon midair refueling procedures with one refueling point over the coastal town of Palomares, Spain. While refueling on January 17, 1966, a U.S. Air Force B-52 bomber transporting four nuclear weapons collided with a KC-135 refueling tanker aircraft. The aerial accident resulted in the destruction of both aircraft, the deaths of seven U.S. military personnel, and the dispersal of radioactive materials across the terrain of Palomares because the conventional explosives on two bombs detonated, breaking apart the bomb casings. However, no nuclear detonation occurred. Figure 6 shows the origin of radioactive contamination in Spain resulting from U.S. Cold War activities.

[19]Defense Agreement Between the United States of America and Spain, Sept. 26, 1953, T.I.A.S. 2850.

Figure 6: Origins of Radioactive Contamination in Spain Resulting from U.S. Cold War Activities

Palomares, Spain. In 1966, a U.S. B-52 bomber carrying four thermonuclear weapons collided with a U.S. refueling tanker in midair over Palomares. The accident scattered radioactive debris over a wide area. The U.S. recovered the weapons and conducted cleanup operations, but some contamination still remains.

Sources: GAO analysis of U.S. government documents and scientific literature; Sandia National Laboratories (image); and Map Resources. | GAO-24-104082

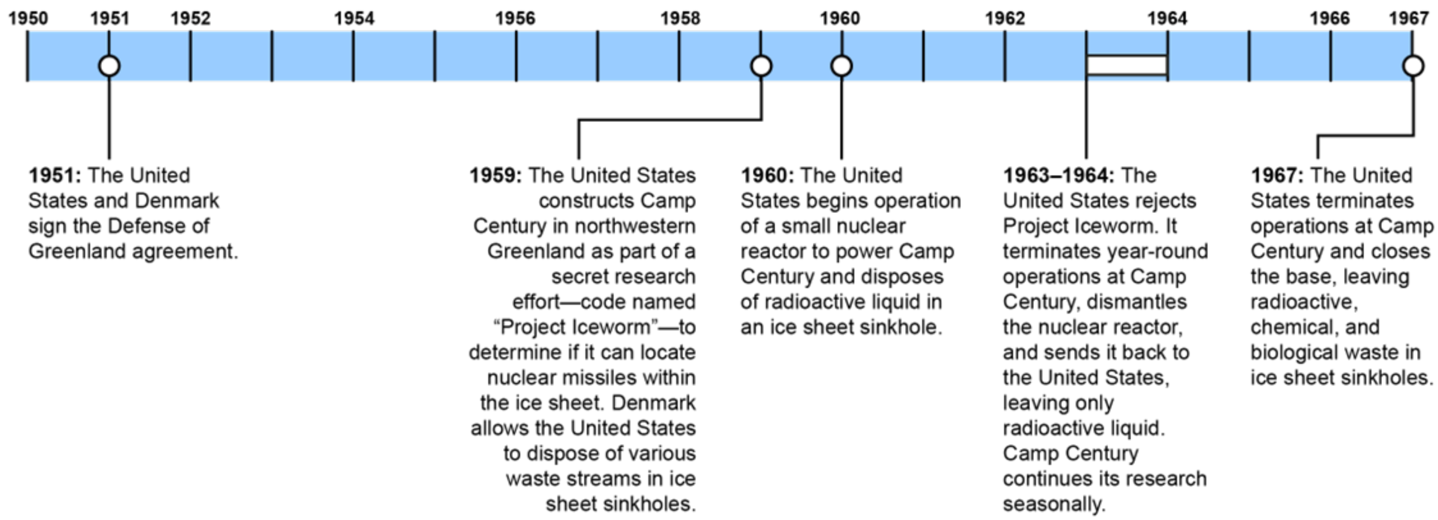
Radioactive Contamination Deposited during U.S. Cold War Activities Remains in Greenland, RMI, and Spain

Radioactive contamination resulting from nuclear-related activities that the United States conducted during the Cold War remains in Greenland, RMI, and Spain. In Greenland, radioactive coolant from a small nuclear reactor, and chemical and biological waste lie entombed several dozen meters below the ice at Camp Century. In RMI, radioactive fallout from nuclear weapons tests remains measurable at various levels. In Palomares, Spain, the United States and Spain cleaned up much of the dispersed radioactive material according to mutually agreed-upon limits and procedures after the two U.S. aircraft collided. The United States and Spain have monitored the effect of remaining radioactive material since then.

Contamination Remains Entombed in the Greenland Ice Sheet

As discussed above, in the 1960s, the United States disposed of thousands of gallons of radioactive liquid waste and millions of gallons of chemical waste in unlined pits underneath its research base at Camp Century in Greenland. That waste remains entombed in the ice sheet today. Figure 7 chronicles key events from the time Camp Century was constructed to when it was dismantled, showing that some radioactive waste was left behind.

Figure 7: Timeline of Events Related to the Construction and Termination of Camp Century in Greenland, 1951–1967



Source: GAO analysis of documents from the U.S. Department of Defense, the Kingdom of Denmark, and scientific journals. | GAO-24-104082

Accessible Text of Figure 7: Timeline of Events Related to the Construction and Termination of Camp Century in Greenland, 1951–1967

Year	Event
1951	The United States and Denmark sign the Defense of Greenland agreement.
1959	The United States constructs Camp Century in northwestern Greenland as part of a secret research effort—code named "Project Iceworm"—to determine if it can locate nuclear missiles within the ice sheet. Denmark allows the United States to dispose of various waste streams in ice sheet sinkholes.
1960	The United States begins operation of a small nuclear reactor to power Camp Century and disposes of radioactive liquid in an ice sheet sinkhole.
1963–1964	The United States rejects Project Iceworm. It terminates year-round operations at Camp Century, dismantles the nuclear reactor, and sends it back to the United States, leaving only radioactive liquid. Camp Century continues its research seasonally.
1967	The United States terminates operations at Camp Century and closes the base, leaving radioactive, chemical, and biological waste in ice sheet sinkholes.

Source: GAO analysis of data from the U.S. Department of Defense, the Kingdom of Denmark, and scientific journals.

The United States installed the portable PM-2A nuclear power reactor at Camp Century in 1960 to provide heat and electricity to the research base. In discussions between U.S. and Danish officials, U.S. officials said they expected at the time that operating the PM-2A reactor would create 7,500 gallons per year of radioactive liquid waste from reactor operations, reactor service, and laboratory sampling.[20] U.S. and Danish officials agreed this liquid waste would be cumbersome to deal with. The officials agreed that the radioactive liquid waste could be disposed of in the ice sheet as long as it did not exceed agreed-upon limits. A Danish government document stated that the United States and Denmark agreed that the radioactive liquid waste could be discharged directly to a dedicated wastewater well in the ice sheet but would be limited to 0.05 curies (50 millicuries) annually.[21] The United States shut down the reactor in 1964 and removed it. According to a Danish government document citing documentation from 1964, the total radioactivity of the radioactive liquid waste discharged was 72.3 millicuries, placing it within the total allowance of 150 millicuries for the 3 years the reactor operated.

According to Danish documentation, after the United States no longer needed the reactor at Camp Century, the United States agreed to return the reactor, radioactive ion exchange filters, and the highly radioactive spent nuclear fuel rods to the United States. When the United States terminated full-time operations at Camp Century in 1963, it began dismantling the reactor, returning 136 drums of solid reactor waste, three water purification plants for the reactor, all 37 spent fuel elements, and all other parts of the reactor plant to the United States.

[20]One Danish academic with expertise on Camp Century told us that the radioactive liquid waste came from routine operations. For example, in talks with Danish officials, the United States agreed to monitor its radioactive emissions and routinely test the water from the reactor to ensure the reactor operated according to international norms. Other routine operations, such as cleaning the ion exchange filters, also resulted in radioactive liquid waste.

[21]The Danish document stated that the actual composition of radioactive isotopes in the liquid waste are not known, but that based on discussions during the initial planning stages, U.S. officials said the following isotopes were likely to be contained in the radioactive liquid waste: cesium-137, strontium-90, chromium-51, nickel-65, manganese-54, manganese-56, iron-59, cobalt-58, and cobalt-60. Danish officials told us that in their assessment of radioactivity at Camp Century, they assumed all activity was represented by cesium-137 and cobalt-60. The half-life of cesium-137 is 30 years, meaning that after 30 years, only half of it will remain with the rest decaying into another material. Cobalt-60 has a half-life of 5.27 years, but most of the remaining isotope half-lives are measured in hours or days.

In addition to the radioactive liquid waste, the United States disposed of other liquid waste resulting from base operations in similar unlined waste wells. This waste included uncertain amounts of polychlorinated biphenyls, diesel fuel, and wastewater, including sewage.[22]

At the time the United States proposed Camp Century to Denmark, both Danish and U.S. officials believed the liquid wastes would remain perpetually entombed in the ice sheet. As a result, there were no efforts to retrieve any of the liquid wastes for disposal elsewhere when the United States abandoned Camp Century in 1967. There have also not been any efforts to remediate the site since Camp Century was closed, although some radioactive waste remains. U.S. State Department officials told us they were not aware of any Danish or Greenlandic government requests for the United States to clean up Camp Century.

U.S. Nuclear Weapons Tests Contaminated Numerous Atolls in RMI, Some Parts of Which Remain Uninhabitable Despite Resettlement Efforts

Several RMI atolls, and the islands within those atolls, remain affected by varying ranges of radioactive contamination. Of the 67 nuclear weapons tests conducted by the United States, Castle Bravo—an experimental thermonuclear test conducted on Bikini Island in 1954—caused the most widespread regional fallout contamination to RMI. This was because of a high explosive yield produced by the weapon, as well as a shift in wind direction in the time period surrounding the test.

As a result of Castle Bravo and other tests, the United States recognizes four atolls—Bikini, Enewetak, Rongelap, and Utrik— as having been affected by radioactive contamination. However, in our review of scientific literature, we found one scientific article that reported evidence of radiological contamination on Bikar and Bokak Atolls at a level

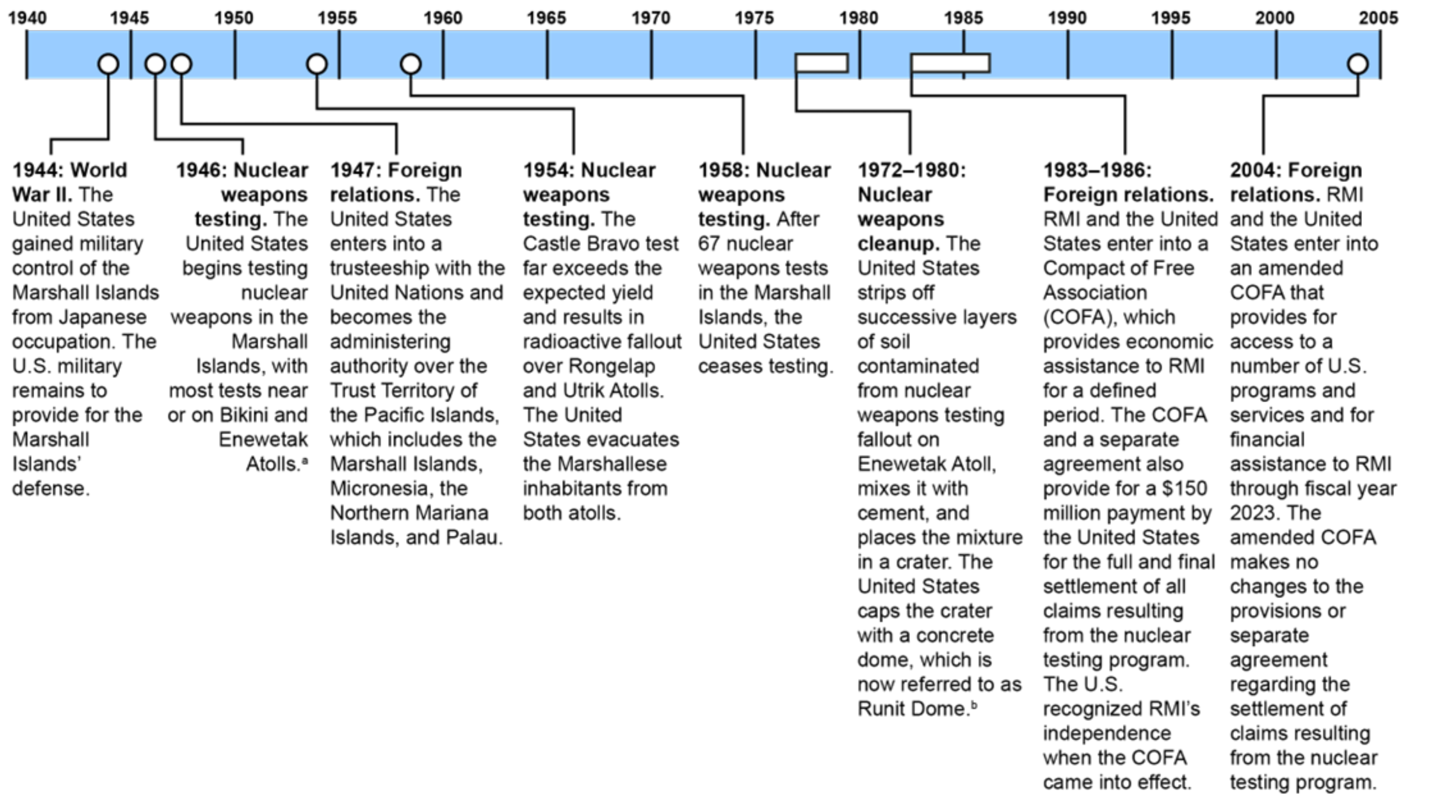
[22]The Department of Defense did not have documentation of the exact amounts of the chemical waste it left behind at Camp Century. Researchers had to make certain assumptions about the waste left under the ice. A journal article about Camp Century reported the there was a “non-trivial quantity” of polychlorinated biphenyls, about 53,000 gallons of diesel fuel, and 6.3 million gallons of wastewater. See William Colgan, Horst Machguth, Mike MacFerrin, Jeff D. Colgan, Dirk van As, and Joseph A. MacGregor, “The abandoned ice sheet base at Camp Century, Greenland, in a warming climate,” *Geophysical Research Letters*, vol. 43, no. 15 (Aug. 4, 2016), https://doi.org/10.1002/2016GL069688.

comparable to Utrik Atoll.[23] In addition, a senior Marshallese official told us that at least six additional mid-level atolls have also been affected by fallout. As stated above, in 2004, the U.S. Administration responded to a petition from RMI regarding changed circumstances arising from the nuclear testing program that RMI had submitted pursuant to the Section 177 agreement. The U.S. Administration's report noted, among other things, that the scientific data did not indicate significant direct radiological contamination from nuclear testing on these additional atolls.[24] However, in July 2023, a Marshallese government official testified to the U.S. Congress that the amount of radioactive fallout in RMI was the equivalent of detonating 1.7 Hiroshima-sized bombs every day for the entire 12-year testing period. Figure 8 chronicles key events from World War II to the amended compact between the United States and RMI.

[23]José A. Corcho-Alvarado, Candice Guavis, Paul McGinnity, Stefan Röllin, Tuvuki Ketedromo, Hans Sahli, Isabelle N. Levy, et al, " Assessment of Residual Radionuclide Levels at the Bokak and Bikar Atolls in the Northern Marshall Islands," *Science of the Total Environment*, vol. 801 (2021): 149541.

[24]In its report evaluating RMI's petition, the U.S. Administration stated that the facts regarding radioactive fallout do not support a request under the changed circumstances provision of the Section 177 settlement agreement, in part because the weight of scientific evidence indicates that the then-present impact of radioactive fallout was limited to the more northerly atolls and islands. The report cited several studies, including a 1978 aerial radiological survey of 11 atolls and two islands, and a Nationwide Radiological Survey completed in 1994 that surveyed 432 islands. U.S. Department of State, *Report Evaluating the Request of the Government of the Republic of the Marshall Islands Presented to the Congress of the United States of America*, accessed Dec. 14, 2022, https://2001-2009.state.gov/p/eap/rls/rpt/40422.htm#exec.

Figure 8: Timeline of Events Pertaining to Radioactive Contamination in the Republic of the Marshall Islands



Sources: GAO analysis of documents from the U.S. Department of Defense, the U.S. Department of Energy, the U.S. Department of the Interior, the U.S. Department of State, the Republic of the Marshall Islands, scientific journals, and legal agreements. | GAO-24-104082

Accessible text for Figure 8: Timeline of Events Pertaining to Radioactive Contamination in the Republic of the Marshall Islands

Year	Event
1944	World War II. The United States gained military control of the Marshall Islands from Japanese occupation. The U.S. military remains to provide for the Marshal Islands' defense.
1946	Nuclear weapons testing. The United States begins testing nuclear weapons in the Marshall Islands, with most tests near or on Bikini and Enewetak Atolls.[a]
1947	Foreign relations. The United States enters into a trusteeship with the United Nations and becomes the administering authority over the Trust Territory of the Pacific Islands, which includes the Marshall Islands, Micronesia, the Northern Mariana Islands, and Palau.
1954	Nuclear weapons testing. The Castle Bravo test far exceeds the expected yield and results in radioactive fallout over Rongelap and Utrik Atolls. The United States evacuates the Marshallese inhabitants from both atolls.

Year	Event
1958	Nuclear weapons testing. After 67 nuclear weapons tests in the Marshall Islands, the United States ceases testing.
1972 - 1980	Nuclear weapons cleanup. The United States strips off successive layers of soil contaminated from nuclear weapons testing fallout on Enewetak Atoll, mixes it with cement, and places the mixture in a crater. The United States caps the crater with a concrete dome, which is now referred to as Runit Dome.[b]
1983 - 1986	Foreign relations. RMI and the United States enter into a Compact of Free Association (COFA), which provides economic assistance to RMI for a defined period. The COFA and a separate agreement also provide for a $150 million payment by the United States for the full and final settlement of all claims resulting from the nuclear testing program. The United States recognized RMI's independence when the COFA came into effect.
2004	Foreign relations. RMI and the United States enter into an amended COFA that provides for access to a number of U.S. programs and services and for financial assistance to RMI through fiscal year 2023. The amended COFA makes no changes to the provisions or separate agreement regarding the settlement of claims resulting from the nuclear testing program.

Source: GAO analysis of documents from the U.S. Department of Defense, the U.S. Department of Energy, the U.S. Department of the Interior, the U.S. Department of State, the Republic of the Marshall Islands, and scientific journals. GAO-104082

[a]The United States relocated Marshallese people from Bikini and Enewetak Atolls prior to nuclear weapons testing.

[b]Cactus Crater was created by a nuclear weapons test and contains over 100,000 cubic yards of radioactively contaminated material within Runit Dome.

The three key radionuclides, or radioactive isotopes, of concern that resulted from fallout across the affected atolls in RMI are cesium-137, plutonium-239, and plutonium-240. In about 120 years, the cesium in RMI will decay to safer levels, while the plutonium will remain a concern.

- **Cesium.**[25] As discussed above, gamma radiation emitters are a radiation hazard for the entire body. Gamma radiation can easily penetrate barriers such as skin and clothing, causing negative health effects by close external proximity and consumption. Gamma radiation from cesium-137 in the soil contributes the largest external radiation dose to the people living in RMI. In addition, locally grown food crops can absorb cesium-137 from the soil. As a result, consumption of cesium-137 in contaminated food contributes the largest internal radiation dose to people who consume potentially contaminated foods in RMI. A diet composed of mostly locally grown

[25]Cesium-137 emits beta particles as it decays, but its decay product is a barium isotope that emits gamma radiation. The barium isotope decays into a stable form of barium.

food in contaminated areas results in higher exposure to radiological contamination than a diet of predominantly imported food.

Cesium-137 has a physical half-life of about 30 years. A physical half-life represents the time it takes for half the radioactive material to decay into another form—in this case, a stable form of barium. This means that after one 30-year half-life, half of the cesium-137 will have decayed into barium. After 10 half-lives—300 years—about one-thousandth of the original amount of cesium-137 will remain. However, research shows that local environmental factors naturally cause concentrations of cesium-137 to diminish in the environment at a higher rate than the physical half-life would imply. This is referred to as an effective half-life. According to Lawrence Livermore National Laboratory, RMI's local environmental factors, such as rain flushing contaminants from the soil, make the effective half-life of cesium-137 in RMI about 12 years. At this rate, one-thousandth of the original amount of cesium-137 will be left after 10 half-lives, or about 120 years.

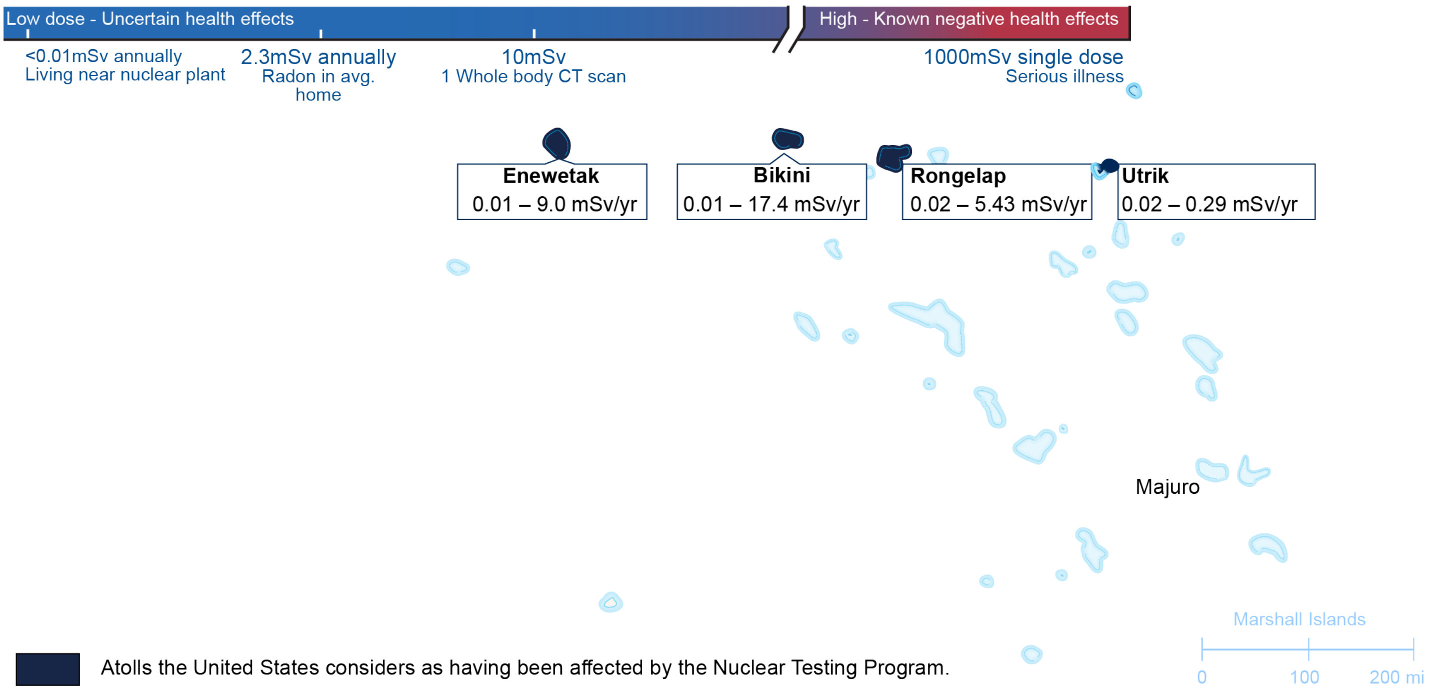
- **Plutonium.** As discussed above, alpha particle emitters, such as those emitted by plutonium, cannot penetrate even the outer layer of skin, so exposure to the outside of the body is not a major concern. However, plutonium-239 and plutonium-240 can contribute to radiation dose when inhaled or ingested. Plutonium becomes suspended in air with dust particles when contaminated soil is disturbed, leading to inhalation or ingestion if the particles contaminate food and water. Plutonium can remain a health hazard for centuries given that the physical half-life of plutonium-239 is about 24,000 years. Figure 9 shows scientists collecting soil in RMI to study the level of contamination.

Figure 9: U.S. Department of Energy Scientists Study Contaminated Soil in the Republic of the Marshall Islands in 1978

Source: U.S. Department of Energy. | GAO-24-104082

The radiological contamination at each affected atoll varies by amount, type, and location, according to scientific studies we reviewed (see figs. 10 and 11). For example, the interior of an island tends to have the highest concentrations of radiation, while the exterior tends to have lower concentrations. These variables affect each atoll's population and prospects for resettlement in different ways.

Figure 10: Minimum and Maximum Range of Radioactive Fallout Doses from Nuclear Weapons Testing on Four Affected Atolls in the Republic of the Marshall Islands in Millisieverts (mSv) per Year



Sources: GAO analysis of scientific studies (data); U.S. Environmental Protection Agency (health effects); and Peter Hermes Furian/stock.adobe.com (map). | GAO-24-104082

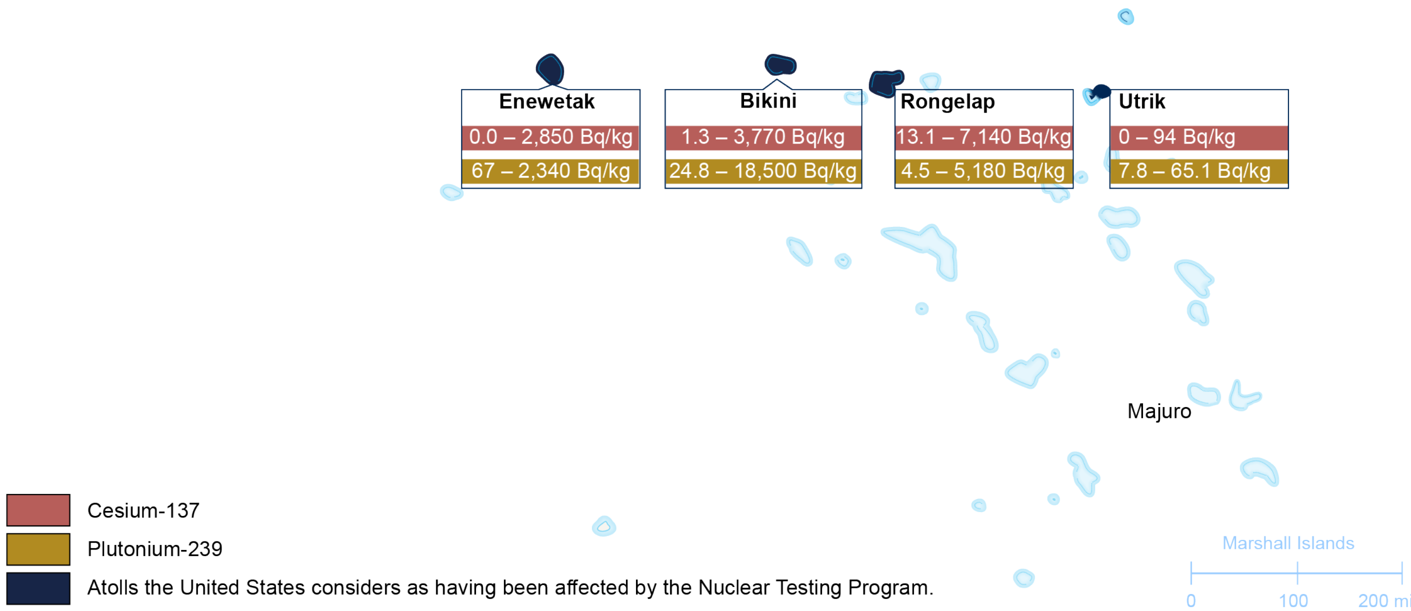
Data table for Figure 10: Minimum and Maximum Range of Radioactive Fallout Doses from Nuclear Weapons Testing on Four Affected Atolls in the Republic of the Marshall Islands in Millisieverts (mSv) per Year

Island	Min. and Max Range of fallout doeses
Enewetak	0.01 – 9.0
Bikini	0.01 – 17.4
Rongelap	0.02 – 5.43
Utrik	0.02 – 0.29

Source: GAO analysis of scientific studies (data); U.S. EPA (health effects); and Peter Haermes Furian/stock.adobe.com (map). | GAO-24-104082

Note: This map illustrates radiological information collected from our review of scientific studies on the four atolls recognized by the United States as having been affected by the Nuclear Testing Program. We did not include information on Runit Dome and the adjacent lagoon on Enewetak Atoll in our analysis because it would have skewed the data. The U.S. Department of Energy reported that the concentration of radiation in Runit Dome was dwarfed by the amount of radiation in Enewetak Lagoon. This map illustrates data published from 1983 to 2022 and does not represent current radiological conditions.

Figure 11: Minimum and Maximum Amount of Radioactive Fallout from Nuclear Weapons Testing on Four Affected Atolls in the Republic of the Marshall Islands in Becquerel per Kilogram (Bq/kg)



Sources: GAO analysis of scientific studies (data) and Peter Hermes Furian/stock.adobe.com (map). | GAO-24-104082

Data table for Figure 11: Minimum and Maximum Amount of Radioactive Fallout from Nuclear Weapons Testing on Four Affected Atolls in the Republic of the Marshall Islands in Becquerel per Kilogram (Bq/kg)

Cesium-137

Island	Min. and Max radioactive fallout levels
Enewetak	0.0 – 2,850
Bikini	1.3 – 3,770
Rongelap	13.1 – 7,140
Utrik	0 – 94

Plutonium-239

Island	Min. and Max radioactive fallout levels
Enewetak	67 – 2,340
Bikini	24.8 – 18,500
Rongelap	4.5 – 5,180
Utrik	7.8 – 65.1

Source: GAO analysis of scientific studies. | GAO-24-104082

Note: This map illustrates radiological information collected from our review of scientific studies on the four atolls recognized by the United States as having been affected by the Nuclear Testing Program. We did not include information on Runit Dome and the adjacent lagoon on Enewetak Atoll in our analysis because it would have skewed the data. The U.S. Department of Energy reported that the radiation encapsulated in Runit Dome is 545,000,000,000 Bq, but that was less than 1 percent of the amount of radiation in Enewetak Lagoon. This map illustrates data published from 1983 to 2022 and does not represent current radiological conditions.

Below is a summary of contamination at the four affected atolls recognized by the United States:

- **Bikini Atoll.** Some parts of Bikini Atoll have high levels of radiological contamination, according to the scientific studies in our review. Currently, no residents live on Bikini Atoll. The United States relocated people living on Bikini Atoll to Rongerik Island in 1946 prior to nuclear weapons testing. From 1968 to 1969, the United States cleaned up debris from testing, planted food crops, and completed a radiological survey and dose assessment. Some families and construction workers had moved back to Bikini Island by 1972. However, according to scientific articles in our review, Brookhaven National Laboratory conducted whole-body counting and confirmed in 1978 that cesium-137 exposure in people on Bikini increased by 75 percent over the course of one year.[26] Consequently, in August 1978, people who had resettled on Bikini Island relocated to Kili Island with DOE assistance.

  Permanent resettlement of Bikini Atoll without remedial measures is not recommended by the scientific studies we reviewed. For example, according to a 2016 *Proceedings of the National Academy of Sciences* article, gamma radiation levels on Bikini Island remain more than 100 millirem (1 mSv) per year above natural background.[27] Background radiation in RMI, according to this article, is about 9.5 millirem (0.095 mSv) per year.

[26]The whole-body counting systems installed in RMI contain large-volume sodium iodide radiation detectors that measure gamma rays, like cesium-137, coming from radionuclides deposited in the body.

[27]This article used Majuro Atoll as a control, since it received very low levels of fallout from the nuclear testing program. A.S. Bordner, et al, "Measurement of background gamma radiation in the northern Marshall Islands," *Proceedings of the National Academy of Sciences of the United States of America,* vol. 113, no. 25 (2016).

Figure 12: Commodore Ben H. Wyatt Addresses the Bikini Atoll Community before Nuclear Testing

Source: Carl Mydans/National Museum of American History. | GAO-24-104082

Note: A few months before nuclear testing began in 1946, Commodore Ben H. Wyatt, commander of the nearby Kwajalein Naval Air Base and military governor of the Marshall Islands, spoke with the Bikini Atoll community. He reportedly asked the community if they would be willing to leave Bikini Atoll temporarily so that the United States could test atomic bombs for “the good of mankind and to end all wars.”

- **Enewetak Atoll.** Some parts of Enewetak Atoll have high levels of radiological contamination, according to the scientific studies in our review. We reported in May 1979 that in late 1947, the United States moved all 142 Marshallese inhabitants of Enewetak to a smaller, less desirable atoll to clear the area for nuclear testing.[28] People from Enewetak returned to southern Enewetak Atoll islands in 1980 following cleanup and rehabilitation of the atoll; however, Runit Island has remained uninhabited. In addition, RMI officials told us that in addition to Runit Island, Enjebi Island—also in the northern part of Enewetak Atoll and culturally distinct from the southern part—remains uninhabited because of radioactive fallout. The people of Enjebi have had to settle in the southern part of Enewetak Atoll.

[28]GAO, *Enewetak Atoll – Cleaning Up Nuclear Contamination*, PSAD-79-54 (Washington, D.C.: May 8,1979).

People living in the southern islands are not likely to receive significant exposure to radiation from nuclear weapons testing, according to a 1995 RMI Radiological Survey of Enewetak and Ujelang Atolls. However, the more northern Runit Island—which contains a capped crater, called Runit Dome, where the United States deposited radioactive debris and soil—has high levels of contamination and cannot be safely resettled. As discussed above, the United States built Runit Dome in the late 1970s as a containment structure for over 100,000 cubic yards of radioactively contaminated soil and debris from six islands in northern Enewetak Atoll as part of an effort to permit people from Enewetak to return. The United States scraped off successive layers of contaminated soil to reduce the level of plutonium in six islands' surface soils within Enewetak Atoll. This waste soil and other radiologically contaminated debris was mixed with a concrete-like mixture, called grout, then encapsulated inside an unlined nuclear test crater, called Cactus Crater, on the north end of Runit Island. The waste was then covered by an exterior concrete cap—the Runit Dome itself—to help protect it from natural erosion. The U.S. Department of Defense, DOE, the U.S. Department of the Interior, and the people of Enewetak determined in 1980 that Runit Island should remain indefinitely quarantined due to the possibility of subsurface levels of plutonium. In July 2023, a senior RMI government official testified to the U.S. Congress that the site remains a concern to people from Enewetak and their leadership. DOE reported that the total inventory of contamination—consisting of mostly transuranics—was 545 billion Bq for Runit Dome and 67.8 trillion Bq for the Enewetak lagoon (approximately 100 times more than Runit Dome).[29]

- **Rongelap Atoll.** Some parts of Rongelap Atoll have some radiological contamination, according to the scientific studies in our review. Rongelap Atoll received significant radioactive fallout hours after the Castle Bravo test in 1954. The United States had not expected radioactive fallout to reach Rongelap and moved to relocate the population of Rongelap 3 days after the test. The United States returned the relocated Marshallese people to Rongelap Atoll in 1957. In 1985, volunteers from the nongovernmental organization Greenpeace evacuated the Rongelap population to Mejatto Island at

[29]"Transuranic" is used to describe elements that have atomic numbers greater than that of uranium. Transuranic waste is, without regard to its form or origin, a waste that is contaminated with alpha-emitting transuranic radionuclides with half-lives greater than 20 years and concentrations greater than 3,700 Bq/gram.

the request of Rongelap leadership due to concerns that DOE had been misleading them about the levels of radiological contamination. The Compact of Free Association Act of 1985—the U.S. implementing legislation for the 1986 compact—stated that "[b]ecause Rongelap was directly affected by fallout from a 1954 United States thermonuclear test and because the Rongelap people remain unconvinced that it is safe to continue to live on Rongelap Island, it is the intent of Congress to take such steps (if any) as may be necessary to overcome the effects of such fallout on the habitability of Rongelap Island, and to restore Rongelap Island, if necessary, so that it can be safely inhabited."[30]

Throughout the 1990s, the United States undertook various efforts to help return Marshallese people to Rongelap Atoll, providing technical assistance to develop radiation monitoring programs for resettlement workers and to verify the effectiveness of resettlement measures. A small number of Marshallese people resettled Rongelap Island around 2008, although most residents left around 2018 and then more left during the COVID-19 pandemic, according to DOE officials. In a 1992 memorandum of understanding regarding the possible resettlement of Rongelap Atoll, the U.S. Department of the Interior and RMI decided that resettlement would not begin unless the maximum whole-body radiation dose equivalent would not exceed 100 millirem per year above natural background.[31] According to a 2019 *Proceedings of the National Academy of Sciences* study, some islands located in Rongelap Atoll exceed the radiological exposure limit of 100 millirem (1 mSv) per year referenced in the 1992 memorandum of understanding.[32]

[30]Compact of Free Association Act of 1985, Pub. L. No. 99-239, 99 Stat. 1770, 1783-84 (1986). The act further noted Congress's expectation that RMI use a portion of the funds provided as a part of the Section 177 agreement to contract with a qualified scientist or group of scientists to review data collected by DOE relating to radiation levels and other conditions on Rongelap Island resulting from the thermonuclear test. Moreover, the act referenced Congress's intent that any necessary steps to restore Rongelap Island's habitability and return its people to their homeland would be taken by the United States in consultation with the RMI government and Rongelap local government council.

[31]Later, in 1998, the RMI Nuclear Claims Tribunal accepted 15 millirems per year as the annual safe dose for the cleanup of radiation-contaminated land in RMI.

[32]Maveric K.I. L. Abella, Monica Rouco Molina, Ivana Nikolic´-Hughes, et al, "Background gamma radiation and soil activity measurements in the northern Marshall Islands," *Proceedings of the National Academy of Sciences of the United States of America,* vol. 116, no. 31 (2019): 15425-15434.

Indirect Consequences of Radiological Contamination in the Republic of the Marshall Islands (RMI)

The nuclear legacy in RMI is indirectly correlated to other health and social difficulties for the Marshallese people. In part because of the loss of land from nuclear testing and rapid population growth since the 1960s, the vast majority of the Marshallese people in RMI live on Majuro Atoll and Ebeye Island on Kwajelein Atoll. According to officials from the U.S. Department of State, concerns about employment opportunities and access to healthcare and education have also driven migration from outer islands in the RMI to population centers. This has resulted in severe overcrowding. According to a 2009 *Californian Journal of Health Promotion* article, population growth has outpaced facilities for safe water and sanitation, leading to an increase in transmissible disease outbreaks such as cholera. Rising sea levels further threaten to decrease livable land.

The migration provision of the amended Compact of Free Association allows eligible RMI citizens to enter, lawfully work, and reside in the United States indefinitely. The Census Bureau’s 2013-2017 Survey estimated about 20,545 Marshallese citizens born in RMI were living in the United States.

Additionally, some Marshallese are hesitant to consume certain traditional and locally harvested foods—such as fresh fish, breadfruit, coconut, and pandanus—because of the perceived radiological contamination risks. Instead, the Marshallese people have added imported food from outside of RMI to their diets. Increased consumption of imported foods—such as white rice and highly processed packaged foods—has contributed to health problems such as hypertension, obesity, and diabetes in the population.

According to a 2019 University of Hawai‘i at Mānoa study, the Marshallese people have increasing difficulty sustaining their connection to their environment and their unique set of customs, beliefs, and language as a result of these second- and third-order effects of the nuclear legacy.

Source: GAO analysis of scientific studies. | GAO-24-104082

- **Utrik Atoll.** According to recent scientific literature in our review, Utrik Atoll has little lasting measurable radiation. However, Utrik Atoll contains islands that received enough fallout from nuclear tests to force evacuation of the population during the Castle Bravo test, according to scientific studies in our review. The United States evacuated the Utrik population 2 days after the test and returned them to Utrik Atoll 3 months later. Among the four affected atolls recognized by the United States, Utrik Atoll is located the farthest from the nuclear test sites. Utrik has been continuously inhabited since that time, and several hundred people currently reside there.

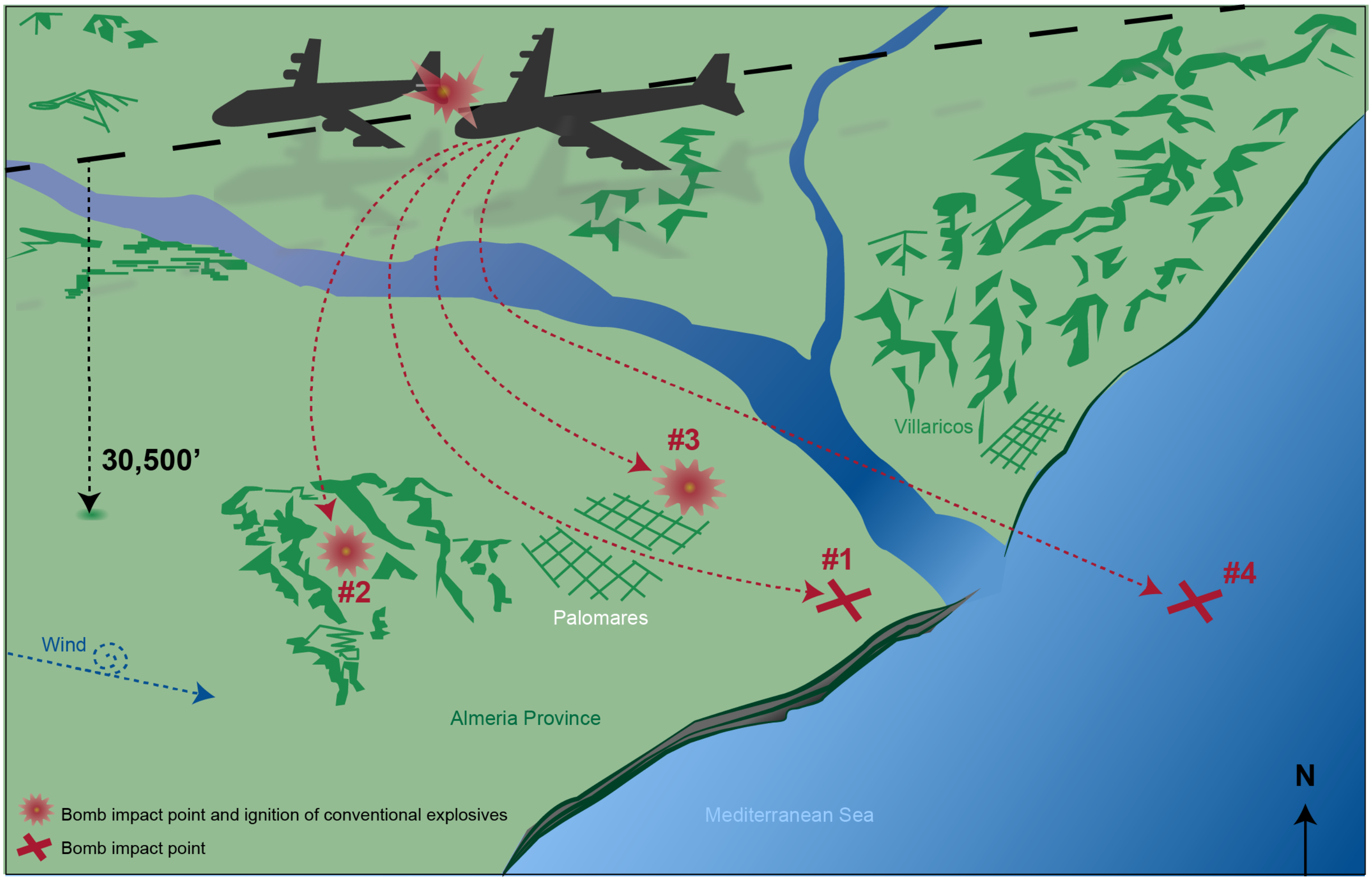
In comparison, Majuro Atoll, the capital of RMI and about 500 miles south of Bikini Atoll, has very little measurable radiological contamination, according to scientific studies that we reviewed.

Some Radioactive Contamination Remains in Palomares after Agreed-Upon Cleanup Procedures

Following the midair collision of two U.S. aircraft, the United States and Spain cleaned up radioactive contamination dispersed in and around Palomares, but some contamination remains to this day. Specifically, in 1966, a KC-135 tanker aircraft and a B-52 bomber carrying four Mk28 thermonuclear bombs collided in a refueling operation, and 250 tons of debris and four nuclear bombs fell from the sky. While none of the nuclear warheads detonated, two of the bombs suffered enough damage during the accident and subsequent ground impact that the conventional explosives cased within the bombs ignited, resulting in chemical detonations.[33] The explosions dispersed approximately 20 pounds (9 kilograms) of oxidized isotopes of plutonium, uranium, and americium across 0.9 square miles (2.3 square kilometers) of Palomares. No local residents or animals were harmed because of the accident. Figure 13 illustrates the aircraft collision and the resulting release of four nuclear bombs on or near Palomares.

[33]At the time of the accident, nuclear bombs relied on conventional high explosives to compress the nuclear core, creating a nuclear reaction. Seen as inherently dangerous, DOE has been replacing conventional high explosives in nuclear weapons with insensitive high explosives to limit accidental detonation.

Figure 13: 1966 Aerial Accident over Palomares, Spain, Resulting in the Release of Nuclear Bombs



Source: GAO adaptation of 1966 Artist's Rendering of Palomares Accident, courtesy of the National Museum of Nuclear Science and History. | GAO-24-104082

The Spanish Civil Guard was first to arrive at the scene of the accident and began securing the site prior to the arrival of U.S. military forces. According to a 1975 federal report on the Palomares incident, the United States had primary responsibility for removing the airplane wreckage and recovering the missing weapons, under the cooperative military agreements signed by the United States and Spain.[34] Immediately following the accident, U.S. military personnel identified the area affected by radioactive contamination—called the zero line—which encompassed

[34]Department of Defense/Defense Nuclear Agency, *Palomares Summary Report* (Kirtland Air Force Base, NM: Jan. 15, 1975).

a total of 650 acres after initial assessments were recorded and wind-spread contamination was taken into account.

Recovery operations following the accident spanned 81 days, utilized over 650 U.S. military personnel, and involved activities on land and at sea. The first missing weapon was discovered about 900 feet from the beach, southeast of the main village of Palomares. It had sustained only slight damage on impact and did not show any signs of radiation leakage. The second weapon was found in a small valley the following day, having sustained substantial damage from the fall after its parachute failed to deploy. The damage to the weapon caused its conventional high explosives to detonate, creating a crater over 20 feet in diameter and releasing radioactive contaminants, such as plutonium, into the area. Shortly after the second weapon was located, the third weapon was found in a ravine on the eastern edge of Palomares. The third weapon sustained considerable damage and its conventional explosives detonated as well, creating a crater and dispersing radioactive contamination. The fourth weapon fell into the Mediterranean Sea and was subsequently found at a depth of 2,550 feet and recovered by U.S. military personnel on April 7, 1966—80 days after the accident. This weapon was recovered intact, and no radioactive contamination was found to be leaking from it.

At the time of the accident, the Spanish government had yet to establish criteria for permissible levels of radioactivity in the country, since nuclear weapons and plutonium producing facilities were nonexistent in 1966 in Spain, according to a report from the U.S. Department of Defense. Over the following weeks, the U.S. Atomic Energy Commission and Spain’s Nuclear Energy Board engaged in negotiations regarding the methods and cleanup levels to decontaminate the area.[35] Initial cleanup proposals included constructing a burial pit for contaminated soil and vegetation to be deposited. However, a U.S. Department of Defense report stated that U.S. and Spanish officials did not want to leave a “monument” to the accident in the form of a burial pit and therefore decided that contaminated earth with readings above agreed-upon thresholds would be removed from Spain and transported to the United States.

On February 28, 1966, the United States and Spain settled on certain criteria for cleanup of the contamination, which included (1) contaminated

[35]Spain’s Nuclear Energy Board was the agency in charge of advising the Spanish government on issues related to security and protection against the harmful effects of radiation.

soil producing readings of 60,000 counts per minute or greater was to be scraped and removed from Spain; (2) contaminated soil producing readings between 10,000 and 60,000 counts per minute was to be washed or dug up and raked; (3) contaminated soil producing readings less than 10,000 counts per minute was to be watered down where practical; and (4) vegetation producing readings of 400 counts per minute or greater was to be removed from Spain.[36]

After establishing the cleanup criteria and defining the areas of contamination, U.S. authorities started the process of remediating the contamination at Palomares. The contaminated areas were divided into 844 plots of land, spanning 385.68 acres, with contamination readings ranging from zero counts per minute to over 100,000 counts per minute, according to a U.S. Department of Defense report. Removal of contaminated soil and vegetation was carried out according to the decontamination criteria agreed upon by United States and Spanish authorities. Cleanup operations culminated in 285 acres of soil being plowed and watered down, 3,700 dump truck loads of vegetation being incinerated, and 1,400 tons of soil and vegetation debris being deposited in 55-gallon barrels and sent to the United States. Over 4,800 barrels of contaminated soil and vegetation were sent to the Savannah River Facility in Aiken, South Carolina, for final disposition on April 8, 1966. Figure 14 shows barrels of soil from Palomares awaiting shipment to the United States.

[36]According to a U.S. Department of Defense report, a PAC-IS was used to measure the radiation levels of contaminated soil and vegetation in Palomares after the accident in 1966. Radiation surveys at the time were conducted in units of counts per minute.

Figure 14: Barrels Contaminated with Radioactive Soil from Palomares, Spain, Await Shipment to the United States, 1966

Source: National Museum of Nuclear Science & History. | GAO-24-104082

In succeeding years, the United States and Spain continued to collaborate on monitoring and analyzing contamination levels at the Palomares accident site. This cooperation began following an exchange of letters between the U.S. Atomic Energy Commission and Spain's Nuclear Energy Board in February 1966; these letters became known as the Hall-Otero Agreement. Under this agreement, the U.S. Atomic Energy Commission and Spain's Nuclear Energy Board initiated a formal cooperative research program. According to DOE, the major goals of the Hall-Otero Agreement are to (1) evaluate the associated radiological impact on the community and its livelihood; (2) update radiological inventories for further land recovery; and (3) improve knowledge on the environmental behavior of transuranic elements in an arid rural environment.[37] The research program was designed to obtain information in several areas, including the uptake and excretion of plutonium and

[37]DOE Office of Environment, Health, Safety & Security, *International Health Studies and Activities*, accessed Dec. 12, 2023, https://www.energy.gov/ehss/international-health-studies-and-activities.

uranium by a population group and the temporal migration and redistribution of plutonium oxide in soil, according to DOE documents.[38]

According to DOE, the Hall-Otero Agreement acknowledges that Spain's Center for Energy, Environmental and Technological Research (CIEMAT) (formerly Spain's Nuclear Energy Board) is the principal investigator, with DOE serving as the secondary investigator providing technical advice and partial funding of the research activities.[39] In 1997, DOE and Spain's Ministry of Industry and Energy entered an Implementing Arrangement to continue and advance the research effort initiated following the Hall-Otero Agreement. According to a joint statement between the United States and Spain in 2015, the United States and Spain continued to collaborate on cooperation related to the Palomares site, consistent with the Implementing Arrangement.

Changing Conditions in Greenland, RMI, and Spain May Affect Future Management of Radioactive Contamination Deposited during U.S. Cold War Activities

Climate change in Greenland and RMI, which have raised concerns about the potential release of radiation into their environments, and a push for economic development among locals in Palomares amid changing European Union radiation requirements may affect future management of radioactive contamination deposited in these areas from U.S activities during the Cold War.

Concerns that Climate Change Could Release Radioactive Waste from the Greenland Ice Sheet Have Led to Continuous Monitoring of the Waste

The contamination under Camp Century has lain entombed in the ice sheet since the 1960s, but climate scientists have raised recent concerns

[38]DOE, "Information Memorandum: Palomares (Project Indalo), Spain" (Washington, D.C.: Apr. 8, 1978), accessed Dec. 12, 2023, https://www.osti.gov/opennet/detail?osti-id=16169273.

[39]In this report, we refer to Spain's Center for Energy, Environmental, and Technological Research as its Spanish acronym: CIEMAT (*Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas*).

that the Greenland ice sheet could begin to melt in the near future, which could release the contamination into the environment. For example, the Intergovernmental Panel on Climate Change, consisting of contributing experts throughout the world, has reported that the cumulative ice sheet loss in Greenland is billions of tons since at least 1990. In 2016, *Geophysical Research Letters* reported that net ablation of the ice sheet—the point at which the ice sheet loses more mass due to melting, evaporation, or sublimation than it accumulates—at Camp Century could occur within 75 years under a business-as-usual scenario in greenhouse gas emissions. Net ablation, the report stated, would guarantee the eventual release of the contaminants into the environment.[40]

[40]See Colgan, et al., "The abandoned ice sheet base at Camp Century."

Greenland Climate Studies

Many climate studies on Greenland focus on projecting future rates of mass loss from the Greenland ice sheet because the ice sheet is so large that it could have enormous effects on sea level rise.

In studying the Greenland ice sheet, scientists assess the net accumulation of precipitation that adds to the ice sheet, less the net loss. Accumulation is mass added to the ice sheet, typically as snow. Net loss occurs due to melting, evaporation, or sublimation, which occurs when warm temperatures turn frozen snow and ice directly into a vapor.

In addition to studying net accumulation and net loss, scientists have also studied analogues—that is, something similar or comparable to the subject being studied—related to the Greenland ice sheet to better project future rates of mass loss. For example, the U.S. Army succeeded in drilling an ice core to the bottom of the ice sheet at Camp Century between 1961 and 1966, including recovering 3.44 meters of subglacial sediment that included multimillion-year records of glacial and vegetative history. The glacial and vegetative sediments of the ice core showed that Greenland was ice free about 400,000 years ago. If Greenland was ice free then, scientists reason, it could be ice free again in the future.

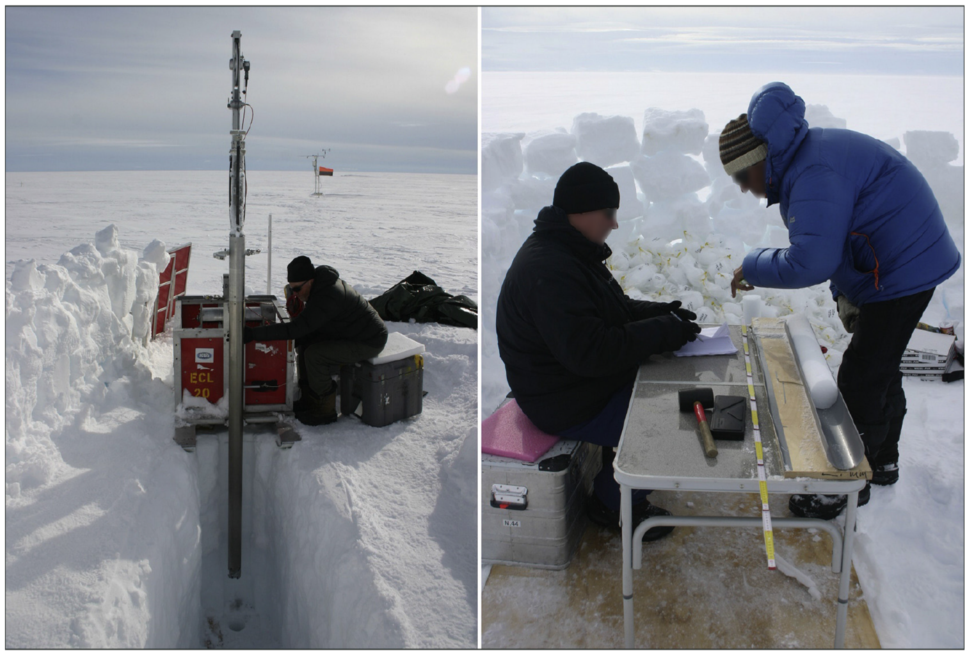
Source: GAO analysis of scientific literature. | GAO-24-104082

After the release of the 2016 *Geophysical Research Letters* report, Greenland officials raised concerns about potential release of the contaminants with the government of Denmark. In response, Denmark established a program for long-term climate monitoring and organized a one-time survey of the debris field at Camp Century. In particular, the long-term climate monitoring, which evaluates net accumulation and net ablation of the ice sheet, also assesses the effect of meltwater percolating through the ice sheet and whether it can potentially mobilize the Camp Century contaminants.

The Geologic Survey of Denmark and Greenland leads the Camp Century Climate Monitoring Program. The Survey plans to continuously conduct monitoring at the Camp Century site by emplacing and maintaining equipment and by applying data collected into climate models. The Survey conducted its first site visit in July and August 2017, during which the team emplaced monitoring instruments and conducted ice-penetrating radar surveys. The upper horizon of the Camp Century debris field was found buried at 32 meters during the radar survey in

2017, much deeper than the 8-meter depth of some of the trench floors soon after construction. Figure 15 depicts scientists studying ice near Camp Century during their 2017 survey.

Figure 15: Scientists from the Geological Survey of Denmark and Greenland Study the Ice near Camp Century in Greenland during a 2017 Survey



Source: Geological Survey of Denmark and Greenland. | GAO-24-104082

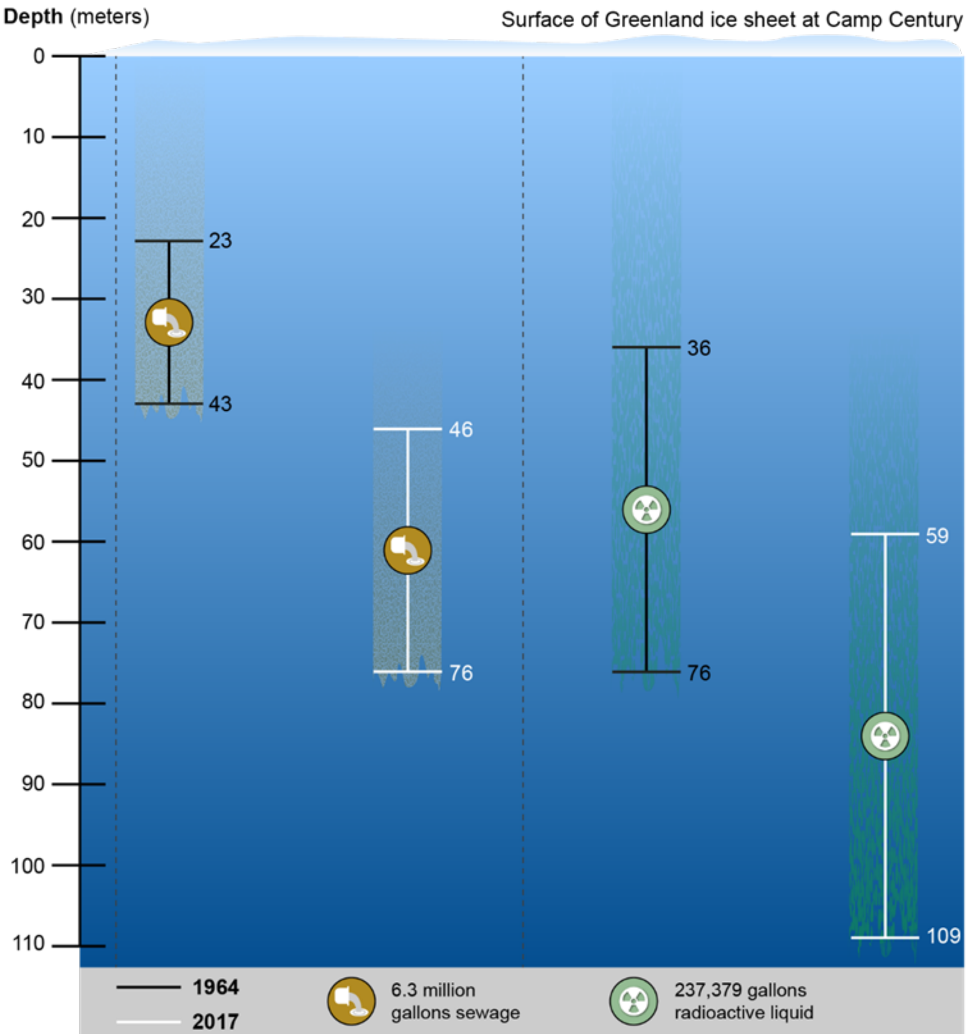
The scientists reported on their findings developed from their collected data in a 2021 report.[41] The report concluded that temperatures at the Camp Century location would continue to warm, but that net accumulation would continue because as melting snow percolates, it will refreeze within the annual snowpack. Figure 16 shows that, according to a report on an ice-penetrating radar survey of Camp Century completed in 2017, the liquid wastes were deeper under the surface in 2017 than in 1964.[42] As a result, the scientists concluded that the contaminants should remain

[41]Baptiste Vandecrux, William Colgan, Anne M. Solgaard, Jørgen Peder Steffensen, and Nanna B. Karlsson, "Firn Evolution at Camp Century, Greenland: 1966-2100," *Frontiers in Earth Science,* vol. 9 (Mar. 22, 2021), https://doi.org/10.3389/feart.2021.578978.

[42]Nanna B. Karlsson, William T. Colgan, Daniel Binder, Horst Machguth, Jakob Abermann, Karina Hansen, Allan Ø. Pedersen, "*Ice-penetrating radar survey of the subsurface debris field at Camp Century, Greenland*," Cold Regions Science and Technology, Volume 165 (September 2019), https://doi.org/10.1016/j.coldregions.2019.102788.

entombed in the ice at least through 2100. The radioactive isotopes will continue to decay while entombed in the ice sheet and, as a result, will be less of a threat to human health the longer they remain locked in the ice. Nevertheless, Danish officials told us that they plan to continue monitoring the ice sheet to study the long-term effects of climate change on Camp Century.

Figure 16: Cutaway of Greenland Ice Sheet Showing Approximate Depth of Liquid Contamination under Camp Century in 1964 and 2017



Sources: Geological Survey of Denmark and Greenland, and the Kingdom of Denmark; and GAO (icons). | GAO-24-104082

Data table for Figure 16: Cutaway of Greenland Ice Sheet Showing Approximate Depth of Liquid Contamination under Camp Century in 1964 and 2017

Waste type	1964 depth range	2017 depth range
Sewage (63 million gallons)	23–43m	46–76m
Radioactive liquid (237,379 gallons)	36–76m	59–109m

Source: Geological Survey of Denmark and Greenland, and the Kingdom of Denmark. | GAO-24-104082

Note: During the operation of the nuclear reactor at Camp Century from 1960 to 1963, Denmark limited U.S. radioactive liquid waste disposal to 50 millicuries/year. A Danish document reported that the American military left 72.3 millicuries over the 3 years the nuclear reactor operated at Camp Century, well below the maximum of 150 millicuries that would have been allowed. According to the Danish Ministry of Environment, the data on waste amounts relies on assumptions and estimations. An official from the Geological Survey of Denmark and Greenland said it would be reasonable to assume the liquid wastes could be another 30 meters deeper by 2100.

Neither Greenland nor Denmark have suggested any plans for cleaning up the contamination entombed beneath Camp Century, although they plan to continue monitoring. A Danish government document reported that the short-lived isotopes in the radioactive liquid disposed of at Camp Century have already decayed, and the long-lived isotopes have so little radioactivity that they would be diluted by melting ice. According to one scientific study, among the various wastes stored at Camp Century, persistent chemical waste—particularly the polychlorinated biphenyls—may be the most consequential waste at Camp Century.

Rising Sea Levels Could Spread Contamination in RMI, and Conflicting Risk Assessments Cause Residents to Distrust Radiological Information from the U.S. Department of Energy

RMI is vulnerable to the effects of climate change, according to U.S. government and scientific studies we reviewed. Specifically, climate change in RMI could cause large-scale flooding, as well as the potential migration of radioactive contamination. In addition, rising sea levels could push up groundwater levels under Runit Dome, potentially creating a pathway for leaking radiation (see fig. 17). DOE and RMI disagree on the radiological dangers posed by Runit Dome. Moreover, people in RMI are generally wary of radiological information originating from DOE for a variety of reasons discussed below.

Figure 17: Runit Dome after Construction in 1979 on Runit Island, Enewetak Atoll

Source: U.S. Department of Energy. | GAO-24-104082

Rising sea levels from climate change pose an existential threat for RMI because it is a low-lying atoll nation. In 2008, large waves damaged structures in Majuro and forced roughly 300 people into shelters. Rising sea levels could introduce increased radiological contamination through water movement on contaminated atolls. According to RMI government officials, the people in RMI are concerned that climate change will increase the risk of radiological contamination of freshwater and food sources. RMI government officials are also concerned about the potential migration of radiological contamination from affected atolls to fishing grounds through rising sea levels. In addition, we previously reported that members of Marshallese communities cited rising sea levels and frequent tidal flooding as reasons for migrating from RMI to the United States. Some Marshallese community members also noted that the legacy of U.S. nuclear testing had contributed to their decision or need to move.[43]

DOE and the RMI government disagree on the danger posed by climate change-related radiation leakage from Runit Dome. DOE reported in 2020 that it found no evidence that potential leakage from Runit Dome represented a significant source of radiation exposure relative to other

[43]GAO, *Compacts of Free Association: Populations in U.S. Areas Have Grown, with Varying Reported Effects*, GAO-20-491 (Washington, D.C.: June 15, 2020).

sources.[44] DOE reported that the main safety concern to humans associated with leakage is the uptake of fallout radioactivity in marine foods, but that the nearby lagoon was already so contaminated that any leakage from the dome would not significantly change radiation levels. DOE reported that it is conducting groundwater analysis to determine what effect leakage could have on the surrounding environment now or in the future. According to senior Marshallese government officials, however, rising sea levels could introduce additional radiological contamination to the ocean—and fishing grounds—through the movement of water through contaminated islands, such as the area around Runit Dome. According to a 2022 *National Academies of Sciences, Engineering, and Medicine* report, the Marshallese government stated that DOE has downplayed the risks and has declined to take responsibility for Runit Dome and its leaking contents.[45]

According to senior Marshallese government officials we spoke with and scientific studies we reviewed, the RMI government and people in RMI are generally wary of DOE's information on radiological contamination. According to Marshallese senior government officials, DOE's communication of radiological information is infrequent and difficult to understand. These officials also stated that DOE has not made clear efforts to translate scientific jargon into more understandable language for people in RMI. The Marshallese government has a department that educates the public about radiological studies obtained from DOE, but RMI does not have enough translators to translate the volume and complexity of the scientific information. In addition, the Marshallese language lacks the scientific terms necessary to translate some information. For example, the word "radiation" is translated as "poison" in Marshallese. Figure 18 presents an example of how people in RMI have sought answers from DOE to questions related to the health implications of radiation exposure caused by the testing program.

[44]DOE, *Report on the Status of the Runit Dome in the Marshall Islands, Report to Congress* (Washington, D.C.: June 2020).

[45]National Academies of Sciences, Engineering, and Medicine, *Leveraging Advances in Modern Science to Revitalize Low-Dose Radiation Research in the United States*, (Washington, D.C.: The National Academies Press, 2022).

Figure 18: Marshallese Women Petition the U.S. Department of Energy for Answers on the Health Effects of Radiation

In May 1979, we reported that the Marshallese people had suffered physical and psychological hardship resulting from relocation because of U.S. nuclear weapons testing. A 2021 book by Jessica A. Schwartz, an associate professor at the University of California, Los Angeles, chronicled the pervasive effects of the RMI's nuclear legacy on its culture and music. Below is an excerpt of a translated song Schwartz included in her book called "Kajjitok in aō nan kwe kiiō" (Translated: These Are My Questions for You Now, Still). According to this book, songs are an important communication tool and the Marshallese women composed this song as a "petition" to the U.S. Department of Energy to answer their questions.[a]

Kajjitok in aō nan kwe kiiō (excerpt)	These Are My Questions for You Now, Still (excerpt)
Kajjitok in ao nan kwe kiiō Komaron ke jiban ippa bukot mejlan aban kein ao kab ro nuku	These are my questions for you now, still Can you help me find a way to untangle myself and my family from these things that hinder us?
Ewor ke baj jemlokin ao idraak? Aspirin, calcium, uno in kirro, Uno kan tyroit	Will there be an end to taking pills? Aspirin, calcium, gout medicine, Synthroid
Ewi waween am lomnak problem in aō bwe etakie na jab kiki lo aenemman	What is your opinion of my problems because there are times I can't sleep peacefully

Source: GAO analysis of relevant literature. | GAO-24-104082

Accessible text of Figure 18: Marshallese Women Petition the U.S. Department of Energy for Answers on the Health Effects of Radiation

In May 1979, we reported that the Marshallese people had suffered physical and psychological hardship resulting from relocation because of U.S. nuclear weapons testing. A 2021 book by Jessica A. Schwartz, an associate professor at the University of California, Los Angeles, chronicled the pervasive effects of the RMI's nuclear legacy on its culture and music. Below is an excerpt of a translated song Schwartz included in her book called "Kajjitok in aō nan kwe kiiō" (Translated: These Are My Questions for You Now, Still). According to this book, songs are an important communication tool and the Marshallese women composed this song as a "petition" to the U.S. Department of Energy to answer their questions.[a]

These Are My Questions for You Now, Still (excerpt)

These are my questions for you now, still
Can you help me
find a way to untangle myself and my family
from these things that hinder us?
Will there be an end to taking pills?
Aspirin, calcium, gout medicine,
Synthroid
What is your opinion

of my problems
because there are times I can't sleep
peacefully

Source: GAO analysis of relevant literature. | GAO-24-104082

[a]Jessica A. Schwartz, *Radiation Sounds: Marshallese Music and Nuclear Silences* (Durham and London: Duke University Press, 2021).

Additionally, in testimony before the U.S. Congress in 2021 and 2023, senior Marshallese government officials stated that the United States has not taken into account new information that was not known at the time of the original 1986 compact. For example, Marshallese officials said that the effect of low doses of radiation on human health is better understood now than it was in the 1980s. They also said that the United States has downplayed Marshallese concerns regarding Runit Dome, contributing to Marshallese distrust of DOE's information.

In addition to general distrust of DOE's information, lifestyle changes recommended by DOE to address possible radiation exposure for people in RMI have posed difficulties because these changes can be challenging to integrate with traditional ways of life in RMI. For example, DOE officials told us that in the late 1980s, they recommended that the Marshallese fertilize crops with potassium to reduce plant cesium-137 uptake. The officials also told us that they recommended that Marshallese limit consumption of food grown in areas known to be contaminated with cesium-137. They said that both efforts could keep radiation exposures as low as reasonably achievable. Although DOE's recommendations are scientifically supported, a United Nations Human Rights Council report noted that some Marshallese people face challenges in adapting to new lifestyles after becoming disconnected from their traditional methods of harvesting and consuming food.[46]

DOE's communications over the past several decades on radiological contamination in RMI have varied in clarity and frequency, according to DOE officials and DOE documents we reviewed. DOE officials told us that they agree that their communications in the past have not engaged senior RMI government officials and that DOE has to overcome decades of Marshallese distrust in the U.S. government. In 1985, for example, an internal DOE memo stated: "The Rongelap people have been disillusioned by what they perceive as contradictory advice from DOE."

[46]United Nations, *Report of the Special Rapporteur on the implications for human rights of the environmentally sound management and disposal of hazardous substances and wastes*, A/HRC/21/48/Add.1 (Sept. 3, 2012), accessed Jan. 8, 2024, https://www.ohchr.org/Documents/HRBodies/HRCouncil/RegularSession/Session21/A-HRC-21-48-Add1_en.pdf.

That same year, conflicting information from DOE led hundreds of Marshallese to flee Rongelap Atoll with the help of Greenpeace, as discussed above. They believed that DOE had misled them regarding the radiological safety of resettling Rongelap.

In addition, according to Marshallese officials, radiological differences among the affected atolls and islands can be confusing for local government authorities and people in RMI to understand. To address this, from 2009 to 2010, under a contract with DOE, Lawrence Livermore National Laboratory issued a quarterly newsletter called the Marshall Islands Monitor that provided an explanation of its dose assessment and radioecology program. DOE officials we spoke with did not know why the newsletter was terminated.

According to DOE officials, DOE performs routine radiological monitoring of the affected atolls at the request of the RMI government consistent with various memorandums of understanding with RMI. For example, at Bikini, Rongelap, and Enewetak Atolls, DOE performs routine monitoring on different types of potassium fertilizer applications that may reduce the uptake of cesium-137 in plants through the soil. Additionally, the Insular Areas Act of 2011 requires the DOE to monitor the exterior of Runit Dome and the groundwater surrounding it.

DOE officials told us they used several methods in recent years to improve communication and trust with the Marshallese government and people in RMI. For example, DOE has built on lessons learned from prior experiences:

- **Increased engagement with RMI's national-level agencies.** DOE increased active engagement with RMI agency counterparts at the national level, such as the RMI National Nuclear Commission, RMI Environmental Protection Authority, and RMI Health and Human Services.[47] In prior years, DOE generally had engaged Marshallese officials at the atoll government level, which effectively removed national leaders from the communication process. According to DOE officials, DOE now holds monthly meetings with national agencies, such as the RMI National Nuclear Commission, and the leaders of Bikini, Enewetak, Rongelap, and Utrik Atolls. By sharing proposals related to monitoring the radiological contamination through RMI

[47] RMI's National Nuclear Commission was established by the RMI National Nuclear Commission Act of 2017 to develop a strategy and plan of action for pursuing justice regarding the nuclear testing legacy and its effects.

government channels, DOE hopes to build trust in the scientific results. A senior RMI government official, however, said that DOE engagement has come in the form of an annual stakeholder meeting in RMI.

DOE also directs information requests to the relevant RMI agencies to help build trust. For example, when a local official requests information related to the whole-body count program, DOE directs them to contact RMI Health and Human Services for that information.[48] DOE also consulted with officials from the RMI Embassy in the United States regarding the best way to improve communication and, as a result, DOE now communicates primarily with the National Nuclear Commission and includes the RMI Embassy in the United States on those communications.

- **Increased oversight from DOE and participation from RMI on radiological research proposals.** DOE officials told us that over the last 3 years, they have taken the lead on proposing radiological monitoring research to RMI. Previously, they said that Lawrence Livermore National Laboratory scientists played a lead role in proposing research, which at times was independent of RMI government input. DOE officials said they wanted to take the lead on proposals so they could engage RMI government officials at the appropriate level and to ensure consistency in messaging.[49] In addition, DOE proposed to RMI that it could adopt the U.S. Center for Disease Control's Agency for Toxic Substances and Disease Registry Action Model to provide independent community health assessments to better inform RMI land use and resettlement decisions.[50]
- **Increased radiological study translation services.** DOE has also made an effort to better translate important reports and studies into

[48]The whole-body counting program provides a direct measure of internally deposited cesium-137 and is a reliable method for assessing the internal dose contribution from ingestion of cesium-137.

[49]The U.S. Atomic Energy Commission established Lawrence Livermore National Laboratory in 1952 as a multiprogram research laboratory. Research and support operations handle, generate, and manage hazardous materials that include radioactive wastes.

[50]The Agency for Toxic Substances and Disease Registry Action Model is a grassroots, community-level model designed to foster dialogue, communication, and vision among members of the community. The Action Model framework encourages the community to focus on broad public health topics connected to community health, such as physical and mental health, environment, education and economy, planning, safety and security, and communication and risk communication.

Marshallese. DOE officials told us that translations are difficult because there are few Marshallese translators available and, as noted above, some scientific jargon is absent in Marshallese. DOE officials also stated that there are many radiological research reports on RMI—very few of which have been officially translated—and DOE agreed that it could improve the ease of understanding on this topic.

According to decades of reports from us, federal agencies, and academia, when communicating information related to radiation and potential radioactive exposure, it is important to provide accurate, transparent, and understandable language that fosters trust. For example, in 1996, the National Research Council reported that communicating risk to a vulnerable population should emphasize accuracy, thoroughness, accessibility, and ease of understanding to enhance the decision-making capabilities of vulnerable people facing that risk.[51] In 2011, we reported that transparency demonstrates a willingness to address concerns openly and fosters the dialogue necessary to resolve differences and enhance cooperation when dealing with differences related to radiation concerns.[52]

Congress has also emphasized the importance of communicating risk effectively. In 1980, Congress passed a law that directed the U.S. Department of the Interior to work with DOE and other agencies to develop a plan for a program that would, as appropriate, provide education and information to help people from affected atolls in RMI more fully understand nuclear radiation and its effects.[53] Interior officials told us that no such program exists and that they would have deferred to DOE

[51]National Research Council, *Understanding Risk: Informing Decisions in a Democratic Society* (Washington, D.C.: The National Academies Press, 1996).

[52]GAO, *Commercial Nuclear Waste: Effects of a Termination of the Yucca Mountain Repository Program and Lessons Learned*, GAO-11-229 (Washington, D.C.: Apr. 8, 2011).

[53]Pub. L. No. 96-205, § 102, 94 Stat. 84, 84-85 (1980) directed the Secretary of the Interior to provide a program of medical care, treatment, environmental research, and monitoring in RMI for any conditions resulting from the nuclear weapons testing program. The law directed the Secretary of the Interior, in consultation with DOE and other agencies to develop a plan for implementing this program that was to set forth as appropriate and among other things, “an education and information program to enable the people of such atolls to more fully understand nuclear radiation and its effects.” *Id.* The law also provided that the costs associated with the development and implementation of this plan were to be assumed by DOE and authorized the appropriation of funds to achieve the purposes articulated in Section 102. *Id.*

because they have no expertise in low-dose radiation. DOE officials told us that they had no institutional knowledge of this program.

While current DOE officials have made several efforts to improve communication and trust, these efforts are not institutionalized or documented so that future DOE leaders will be best positioned to continue the same efforts to engage RMI government officials. Additionally, senior Marshallese government officials stated that while DOE has improved recent communication efforts, more effort is needed, as noted above. Improved communication from officials will become more important as concerns regarding climate change and the potential mobilization—perceived or actual—of radiological contaminants increases in RMI. Moreover, by DOE developing a documented strategy for communication that is sustained, understandable, transparent, engages the RMI government, and builds on lessons learned, DOE can better ensure the Marshallese government and people will have improved access to information that they could understand and trust when making decisions now or in the future regarding resettlement, climate change concerns, and lifestyle choices.

Economic Development and Revised Radiological Standards Have Led to Spain's Proposed Plans to Further Remediate Contamination at Palomares

As a result, in part, of revised European Union radiological standards and economic growth at Palomares, Spain has proposed plans to further remediate contamination at Palomares. In 1980, the Spanish government created the Nuclear Safety Council as the key organization responsible for its domestic nuclear safety and radiological protection. With respect to Palomares, the council has primary responsibility over establishing radiological criteria, including land use restrictions. In 1986, Spain joined the European Union and became party to the Treaty Establishing the European Atomic Energy Community (Euratom). A key goal of the Euratom Treaty, among others, is to establish uniform safety standards within Euratom to protect the public and workers against the dangers arising from ionizing radiation.[54] In the same year, Spain's Nuclear Energy

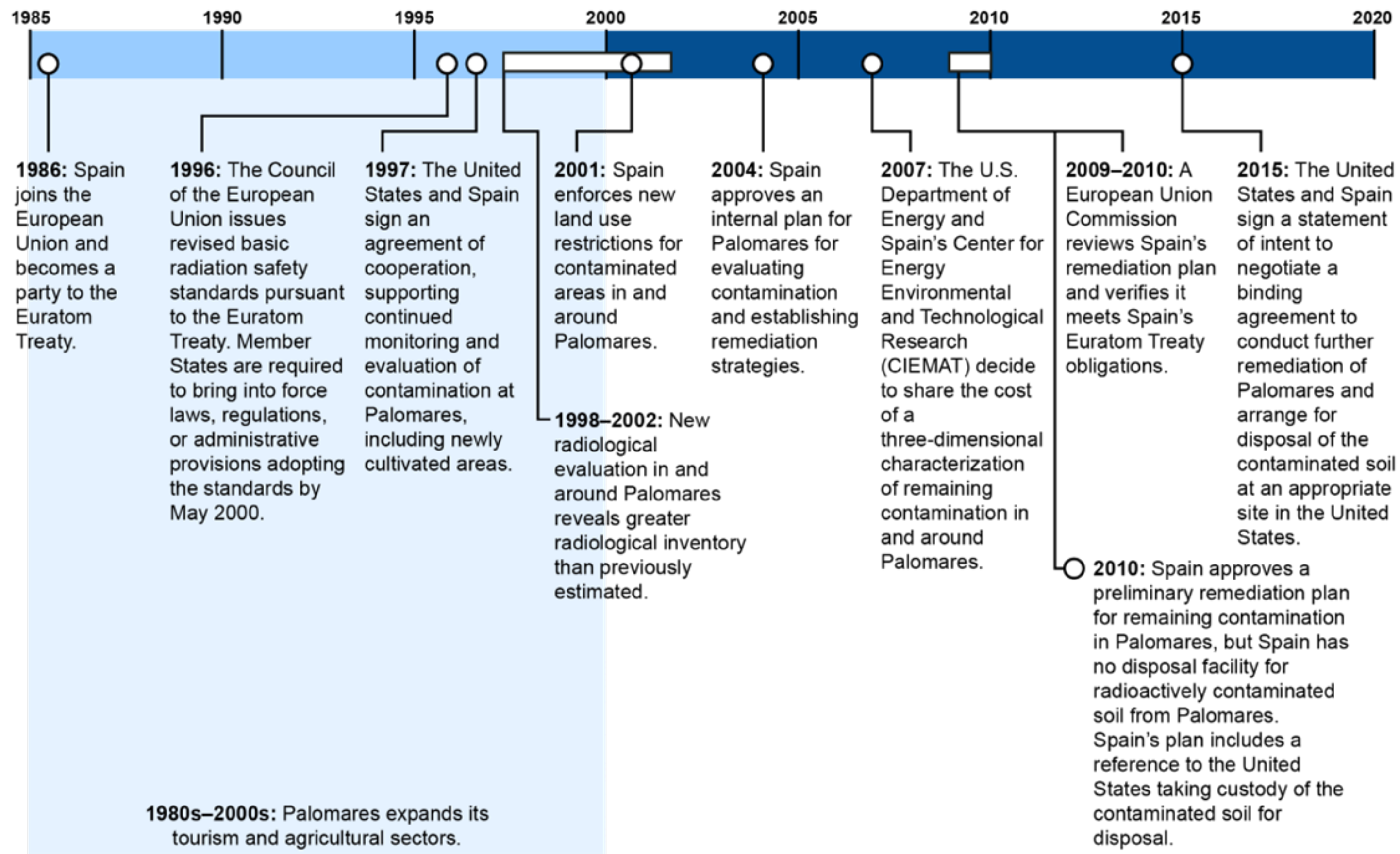
[54]The Euratom Treaty was signed on March 25, 1957, and established the European Atomic Energy Community. Key goals of the treaty include (1) promoting research and disseminating technical information, (2) setting uniform safety standards to protect the public and industry workers, and (3) ensuring civil nuclear materials are not diverted to other uses, particularly military.

Board was transformed into the Center for Energy, Environmental and Technological Research (CIEMAT) and tasked with executing surveillance programs and evaluating the radiological situation.

In the years following the accident at Palomares, the radiological monitoring and sampling activities carried out by what is now CIEMAT were viewed as sufficient for properly maintaining the remaining contamination, particularly due to the low agricultural and urban activity in the area. However, during the mid-1980s through the 1990s, Palomares underwent significant changes aimed at increasing agricultural and urban development in the region. Large water storage ponds and several cultivation terraces were built in contaminated areas to assist in extensive irrigation. Additionally, some contaminated land that had been previously designated as rural and without agricultural use was reclassified as developable land.

According to Spanish officials and documents, the desire for agricultural expansion and increased tourism in the region helped spur CIEMAT to reassess the remaining contamination inventory at Palomares to prevent a possible change in the radiological exposure to the population. Moreover, a representative from the Embassy of Spain in the United States told us that the Palomares area has had trouble selling its agricultural products because of the stigma of potential radiological contamination. Figure 19 shows a timeline of certain events from 1986 to 2015 that led to plans to further remediate Palomares.

Figure 19: Timeline of Events Affecting Radioactive Contamination at Palomares, Spain (1986–2015)



Sources: U.S. Department of State, the European Union, and the Kingdom of Spain. | GAO-24-104082

Accessible text for Figure 19: Timeline of Events Affecting Radioactive Contamination at Palomares, Spain (1986–2015)

Year	Changed Condition
1986	Spain joins the European Union and becomes a party to the Euratom Treaty.
1980s – 2000s	Palomares expands its tourism and agricultural sectors.
1996	The Council of the European Union issues revised basic radiation safety standards pursuant to the Euratom Treaty. Member States are required to bring into force laws, regulations, or administrative provisions adopting the standards by May 2000.
1998-2002	New radiological evaluation in and around Palomares reveals greater radiological inventory than previously estimated.

Year	Changed Condition
1997	The United States and Spain sign an agreement of cooperation, supporting continued monitoring and evaluation of contamination at Palomares, including newly cultivated areas.
2001	Spain enforces new land use restrictions for contaminated areas in and around Palomares.
2004	Spain approves an internal plan for Palomares for evaluating contamination and establishing remediation strategies.
2007	The U.S. Department of Energy and Spain's Center for Energy Environmental and Technological Research (CIEMAT) decide to share the cost of a three-dimensional characterization of remaining contamination in and around Palomares.
2009 - 2010	A European Union Commission reviews Spain's remediation plan and verifies it meets Spain's Euratom Treaty obligations.
2010	Spain approves a preliminary remediation plan for remaining contamination in Palomares, but Spain has no disposal facility for radioactively contaminated soil from Palomares. Spain's plan includes a reference to the United States taking custody of the contaminated soil for disposal.
2015	The United States and Spain sign a statement of intent to negotiate a binding agreement to conduct further remediation of Palomares and arrange for disposal of the contaminated soil at an appropriate site in the United States.

Source: U.S. Dept. of State, the European Union, and the Kingdom of Spain. | GAO-24-104082

Note: After Spain joined the European Union, it became a party to the Treaty Establishing the European Atomic Energy Community (Euratom).

In 1996, the Council of the European Union issued revised basic radiation safety standards under the Euratom Treaty. Under the council directive laying down the basic safety standards for ionizing radiation, member states were directed to generally limit the effective dose for public exposure at 1 mSv per year and to bring into force laws, regulations, and administrative provisions necessary to comply with the directive by May 2000. In 1997, CIEMAT and DOE signed an agreement of scientific cooperation aimed at continuing the monitoring and sampling work begun under the Hall-Otero Agreement.

From 1998 to 2002, CIEMAT reevaluated the remaining contamination in and around Palomares, finding that some of the residual contamination was higher than initially estimated. According to a Spanish document, based on CIEMAT's revised assessment and to ensure compliance with the revised European Union radiation safety standards, in 2001, Spain's Nuclear Safety Council began to propose a plan to further remediate Palomares and to redefine the restriction criteria for land use. Spain's Council of Ministers approved the plan in 2004. The approved plan aimed to more closely evaluate the residual contamination in the areas affected by the accident and establish potential environmental recovery strategies. The plan also included total and partial land use restrictions in the contaminated areas of Palomares. Total land use restriction was designated for lands that would produce a level of residual dose equal to or greater than 5 mSv per year, and partial restriction was imposed for lands that would produce a residual dose equal to or greater than 1 mSv per year.

To accomplish these objectives, in 2005, CIEMAT informed DOE of its intent to carry out a three-dimensional radiological analysis of the residual contamination at Palomares and to prepare a radiological management plan for the contaminated zones. In 2007, DOE and CIEMAT agreed to share the cost of the three-dimensional radiation analysis. The three-dimensional analysis was conducted from 2007 to 2009. The results of the analysis showed higher levels of radioactive exposure than prescribed by land use restrictions in some contaminated areas. Therefore, CIEMAT took control of these lands and restricted access to them by putting up fencing and signage. Based on the findings from the three-dimensional analysis, CIEMAT also developed a preliminary remediation plan in 2010, which aimed to remove soil from Spain that is emitting radiation levels that would produce an exposure of more than 1 mSv per year. According to Spanish documents, Spain does not have disposal facilities for the radioactive soil from Palomares, so Spain's goal is to negotiate a binding agreement with the United States to take custody of the contaminated soil for disposal.

The Euratom Treaty stipulates that, "each Member State shall establish the facilities necessary to carry out continuous monitoring of the level of radioactivity in the air, water and soil to ensure compliance with the basic standards." It also provides that the European Commission shall have the right to access these facilities to verify their operation.[55] The International Atomic Energy Agency and the European Commission launched reviews of the radiological analysis program at Palomares in 2009 and 2010, respectively.

The International Atomic Energy Agency's review concluded that the analysis program was carried out following international standards and that the sampling was representative and adequate for the characterization and contamination of the land. Similarly, the European

[55]The European Commission is the executive of the European Union. It promotes the Union's general interests, ensures the application of treaties, and oversees the application of Union law by Member States.

Commission's verification team concluded that the radiological studies and surveillance programs in Palomares were appropriate and efficient, and that the potential radiological impact to the public appeared to be very small. Additionally, the European Commission's recommendation supported CIEMAT's plan to remove contaminated soil and transport it to the United States for disposal. The European Commission's report also noted that Spain does not have facilities capable of storing the contaminated soil, and therefore the assistance of the United States is vital for producing a final storage solution to remedy the residual contamination problem at the Palomares site.

In 2015, the United States and Spain signed a statement of intent to cooperate on a program to further remediate the accident site at Palomares. Following the signing of the statement of intent, the United States and Spain initiated discussions regarding further remediation of Palomares, but no final agreement has been reached, according to State Department officials. A May 2023 White House press release about a meeting between U.S. President Biden and Spanish President Sanchez highlighted negotiations on reaching an agreement to further remediate Palomares. According to the European Commission's follow-up verification report completed in 2019, remediation activities at Palomares have paused while Spain continues to negotiate in hopes of reaching a binding final remediation agreement with the United States.[56]

Conclusions

Greenland, RMI, and Spain all have lingering effects to this day from the United States' nuclear-related activities during the Cold War. Greenland officials have raised fears of a potential future release of contamination as a result of climate change, leading to long-time monitoring of ice sheet conditions. In Spain, economic growth coupled with revised European Union radiation safety standards have spurred land-use restrictions and a plan for additional remediation. RMI remains host to significant contamination nearly 65 years after weapons testing ceased.

For people in RMI, confusing communication from DOE has contributed to distrust in scientific assessments of the contamination. Furthermore, the potential for climate change-driven sea level rise has raised concerns

[56]European Commission Directorate-General for Energy, "Technical Report: Spain, Palomares, Environmental radioactivity monitoring arrangements, Monitoring of radioactivity in foodstuffs, 18-20 June 2019," ES-19/01 (Nov. 29, 2019).

about the possible mobilization of contamination on affected atolls. While current DOE officials have made several efforts to improve communication and trust with RMI citizens, these efforts are not institutionalized and could be improved. When communicating about unseen threats such as radiation contamination, it is important to foster trust by using accurate, transparent, and understandable language. By developing a documented strategy for sustained, understandable, and transparent communication that engages the RMI government and builds on lessons learned, DOE could improve the Marshallese people's access to, and trust in, vital information on contamination as environmental conditions change.

Recommendation for Executive Action

The Secretary of Energy, as a part of the agency's ongoing efforts to address the legacy of U.S. nuclear testing in the Republic of the Marshall Islands, should develop and document a strategy for communications on radioactive contamination that is sustained, understandable, and transparent; engages the RMI government; and builds on lessons learned. (Recommendation 1)

Agency Comments

We provided a draft of this report to the U.S. Departments of Energy, the Interior, and State for review and comment. DOE, the Interior, and State provided technical comments, which we incorporated as appropriate. We also provided relevant portions of the report—specifically, sections of the report pertaining to the status of contamination in their respective countries—to foreign officials from Denmark, the Republic of the Marshall Islands, and Spain to review for technical accuracy. Officials from all three countries provided technical comments, which we incorporated as appropriate.

In its written comments, reproduced in appendix II, DOE concurred with our recommendation and stated that it plans to develop and implement in collaboration with RMI a plan to communicate on radioactive contamination that is sustained, understandable, and transparent. DOE also noted that it intends to consult with the U.S. Department of State as the plan is developed and implemented to ensure that it aligns with U.S. priorities and commitments. Furthermore, DOE stated that it will review and update this plan as needed to ensure that it evolves with stakeholder needs. DOE emphasized that it has made substantial efforts over the last three years to improve engagement with RMI officials and stakeholders, including establishing regular meetings with multiple RMI agencies to obtain feedback on current and future DOE-supported projects. We continue to believe that by developing and implementing a sustainable strategy for communicating with RMI, DOE could improve the Marshallese people's access to, and trust in, information on contamination as environmental conditions change. We also provided relevant portions of our draft report to foreign officials of each of the countries in our review to check for accuracy.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Defense, the Secretary of Energy, the Secretary of the Interior, and the Secretary of State. In addition, this report will be available at no charge on GAO's website at https://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-3841 or andersonn@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix III.

Sincerely yours,

Nathan Anderson

Nathan J. Anderson
Director, Natural Resources and Environment

Appendix I: Objectives, Scope, and Methodology

During the Cold War, the United States conducted nuclear-related activities in many countries, including defense-related research and nuclear weapons testing. In three locations—Greenland, the Republic of the Marshall Islands (RMI), and Spain—U.S. activities resulted in radioactive contamination, some of which remains in those locations today. The objectives of our review were to describe (1) the amount and type of contamination in Greenland, RMI, and Spain and what the United States has done to address the contamination at these sites, and (2) how conditions have changed at these sites and the extent to which the environment and inhabitants of these sites have been affected by these changed conditions.

To obtain background information and information on the status of contamination at the three sites, we conducted two literature searches from November 2022 to December 2022. Specifically, we conducted our first search to identify information on the amount and type of past and current radioactive contamination in Greenland, RMI, and Spain. We performed a second literature search to identify pertinent international guidance and standards on radiation. For both searches, we conducted searches of peer-reviewed studies, government reports, conference papers, and similar documents from various databases that included, but were not limited to, ProQuest, SCOPUS, EBSCO, NTIS National Technical Research Library, and Congressional Quarterly Transcripts and Testimony.

Two analysts assessed the relevance of the collected documents and identified candidates for exclusion, based on our objectives. The analysts discussed and resolved any differences in recommended exclusions. Collectively, we identified 103 studies and documents from our searches. We then performed a content analysis of these studies and documents. One analyst coded the content of documents to categorize certain information and a second analyst reviewed the coding. The two analysts discussed and resolved differences in coding. For example, we coded for categories that were likely to be found in the literature for each of the three countries, such as U.S. cleanup efforts to address the extent of contamination or new scientific information that became available since the sites were contaminated to address changed conditions. Some of the categories we coded for were unique to a specific country, such as contamination at Runit Dome in RMI. We used a document analysis program called NVivo that allowed the team to sort the coded material and summarize results. In cases when documents could not be uploaded to NVivo, the team coded them separately and included the results with the NVivo summaries. Since the nuclear-related events in Greenland, RMI, and Spain occurred many decades ago, we included studies and documents ranging from contemporaneous accounts to the present.

To describe the amount and type of contamination in Greenland, RMI, and Spain and the steps the United States has taken to address the contamination at these sites, we reviewed documents from the U.S. Departments of Defense, Energy, the Interior, and State.[1] We also reviewed applicable U.S. legislation to determine relevant requirements and guidance for U.S. agencies at these sites. We obtained and reviewed international agreements and diplomatic exchanges between the United States and Denmark, RMI, and Spain. We also reviewed documents and interviewed foreign government officials from Denmark, RMI, and Spain. In addition, through our collection of studies, we identified and interviewed academics with expertise in nuclear waste in Greenland and RMI and reviewed documents they provided.

To describe how conditions have changed at sites contaminated by U.S. nuclear activities since initial cleanup efforts and the extent to which the environment and inhabitants of these sites have been affected by changed conditions, we reviewed documents and interviewed officials from the U.S. Departments of Energy, the Interior, and State. We also reviewed applicable U.S. legislation to determine relevant requirements and guidance for U.S. agencies at these sites. We reviewed documents and interviewed foreign government officials from Denmark, RMI, and Spain. We reviewed publicly available information on agreements being negotiated between the United States and RMI and the United States and Spain. We also obtained and reviewed documents from the European Union. In addition, we interviewed academics with expertise in nuclear waste in Greenland and RMI and reviewed documents they provided.

[1]Although we reviewed documents from the Department of Defense, we did not interview agency officials because the Department of Defense no longer retains institutional knowledge of these historical events, nor is it involved in activities at these contaminated sites.

We conducted this performance audit from March 2020 to January 2024 in accordance with generally accepted government auditing standards.[2] Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

[2]We suspended this work from April 2020 through October 2022 because the COVID-19 pandemic limited our ability to carry out aspects of our methodology.

Appendix II: Comments from the U.S. Department of Energy

Department of Energy
Washington, DC 20585

January 17, 2024

Mr. Nathan Anderson
Director
Natural Resources and Environment
U.S. Government Accountability Office
441 G Street NW
Washington, DC 20548

Dear Mr. Anderson:

Thank you for the opportunity to review the Government Accountability Office Draft Report, "*NUCLEAR WASTE: Changing Conditions May Affect Future Management of Contamination Deposited Abroad During U.S. Cold War Activities (GAO-24-104082)."* This letter provides the Department of Energy's (DOE) consolidated response to the report's recommendation.

Recommendation 1.1: The Secretary of Energy, as a part of the agency's ongoing efforts to address the legacy of U.S. nuclear testing in the Republic of the Marshall Islands (RMI), should develop and document a strategy for communications on radioactive contamination that is sustained, understandable, and transparent, engages the RMI government, and builds on lessons learned.

Management Response: Concur.

Action Plan: DOE acknowledges the long-standing challenges in effectively communicating public health and environment risks associated with residual radioactive contamination in the Republic of the Marshall Islands (RMI) as a result of the former U.S. nuclear weapons testing program. Over the past three years, DOE has made substantial efforts to improve engagement with RMI officials and stakeholders including establishing regular standing meetings with multiple RMI agencies (including the National Nuclear Commission, RMI Environmental Protection Authority, Marshall Islands Marine Resources Authority, and RMI Ministry of Health and Human Services) to promote collection and consideration of feedback on current and future DOE supported projects. DOE plans to continue to expand these efforts by working with RMI officials to define their specific needs. At the request of the RMI Environmental Protection Authority, an interagency working group that includes DOE and multiple RMI agencies is planned where DOE can actively engage with the RMI to understand specific challenges and develop effective solutions. DOE expects to develop and implement in collaboration with the RMI a plan to communicate on radioactive contamination that is sustained, understandable, and transparent. Further, DOE intends to consult with the U.S. State Department as the plan is developed and implemented to ensure alignment with U.S. priorities and commitments. The plan would be reviewed and updated as needed to ensure that it evolves with stakeholder needs.

Estimated Completion Date: December 13, 2024

If you have any questions or need additional information, please contact me, at (202) 586-6740 or Kevin Dressman, Director, Office of Health and Safety at (301) 903-5144.

Sincerely,

Todd N. Lapointe
Director
Office of Environment, Health, Safety and Security

Enclosure

Accessible text of Appendix II: Comments from the U.S. Department of Energy

January 17, 2024

Mr. Nathan Anderson Director

Natural Resources and Environment

U.S. Government Accountability Office 441 G Street NW

Washington, DC 20548 Dear Mr. Anderson:

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If you have any questions or need additional information, please contact me, at (202) 586-6740 or Kevin Dressman, Director, Office of Health and Safety at (301) 903-5144.

Sincerely,

Todd N. Lapointe Director

Office of Environment, Health, Safety and Security

Enclosure

Appendix III: GAO Contact and Staff Acknowledgments

GAO Contact

Nathan J. Anderson, Director, Natural Resources and Environment, (202) 512-3841 or andersonn@gao.gov.

Staff Acknowledgments

In addition to the contact named above, Amanda K. Kolling (Assistant Director), Robert S?nchez (Analyst in Charge), Luqman Abdullah, Anna Beischer, and Eliot Fletcher made key contributions to this report. Also contributing to this report were Cindy Gilbert, Claudia Hadjigeorgiou, Matthew McLaughlin, and Sara Sullivan.

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