Grand Canyon at Risk

Uranium Mining Threatens a National Treasure

2018 Update

ENVIRONMENT AMERICA RESEARCH & POLICY CENTER

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Abigail Bradford,
Frontier Group

Christy Leavitt and Steve Blackledge,
Environment America
Research & Policy Center

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Executive Summary

Uranium mining—which can spread radioactive dust through the air and leak radioactivity and toxic chemicals into the environment—is among the riskiest industrial activities in the world. Every uranium mine ever operated in the United States has required some degree of toxic waste cleanup, and the worst have sickened generations of people, contaminated miles of rivers and streams, and required the cleanup of hundreds of acres of land.

After decades of reduced activity due to depressed prices, uranium mining began to make a comeback in the 2000s—including nearby one of America's most treasured wild places—the Grand Canyon. In response, then-Interior Secretary Ken Salazar issued a Public Land Order in 2012 that stopped mineral exploration and the staking of new claims within a one million-acre area near the Grand Canyon for 20 years.[1]

Now, the Grand Canyon is at risk again. In March 2017, President Trump issued an executive order directing federal agencies to review all actions that could potentially interfere with developing or using domestic energy resources.[2] On November 1, 2017, the U.S. Forest Service released its official report in response to this order and recommended revising the 2012 Public Land Order to reopen lands near the Grand Canyon to new uranium exploration and mining.[3]

Uranium mining has left a toxic trail across the West—including at the Grand Canyon itself. In addition to many other devastating impacts, mining in this area has contaminated tributaries of the Colorado River, which supplies drinking water to 40 million Americans.[4] The drinking supply of nearly one-eighth of Americans is too vital a resource to risk in order to access uranium, especially at a time when renewable energy sources are proving increasingly capable of meeting our energy needs.[5] **To protect the Grand Canyon, its residents, the millions of people who visit each year and the millions of Americans who drink from the Colorado River, the surrounding lands should remain closed to new uranium mines.**

Uranium mining is risky for miners, local residents, visitors, wildlife and the environment. Mines can release uranium itself—a dangerous radioactive

substance—as well as toxic chemicals used in the mining process.

- **Contaminated water** can leak from mines or piles of waste rock and soil into groundwater or nearby streams, which can carry the contamination far from mining sites. Mining near the Grand Canyon threatens wildlife in the canyon, as well as the drinking water supplies of the Havasupai Tribe, who live in the canyon, and residents in cities such as Phoenix, Los Angeles and Las Vegas who receive their drinking water from the Colorado River.[6]

- **Airborne uranium dust** threatens the health of miners, local residents, visitors and residents of communities through which uranium ore is transported on its way to processing facilities. If inhaled, uranium dust can cause lung cancer.[7]

- **Tailings**—the waste rock and dirt left over once uranium extraction and milling are complete—are 85 percent as radioactive on average as the original ore and can remain radioactive for hundreds of thousands of years.[8] Tailings also contain other toxic chemicals like arsenic, can make mine sites permanently hazardous, and can leach toxic substances into the environment long after mining has finished.[9]

Uranium mining and processing have left a toxic trail across the West—including at the Grand Canyon itself.

- According to the U.S. Geological Survey (USGS), 15 springs and five wells near **Arizona's Grand Canyon National Park** contain uranium concentrations above the safe limit for drinking water.[10]

- In **New Mexico**, a 1979 dam break released radioactive wastewater from a New Mexico uranium mill into the Little Colorado River, releasing more radiation into downstream waterways than was released in the Three Mile Island nuclear power plant accident.[11]

- In **Utah**, workers are still cleaning up 16 million tons of contaminated tailings at the site of one of the nation's first mines in Moab.[12]

- In **Colorado**, residents of the Lincoln Park community have had to stop drinking well water because a nearby uranium mill's old tailings pool was leaking uranium and other toxic substances into their drinking water supply.[13] This was discovered after community members had already suffered health consequences. Between 2010 and 2017, a wastewater pipe on the same site had leaked at least seven times, leaking thousands of more gallons of contaminated water uphill of the community.[14]

- Current uranium mining near the Grand Canyon threatens the health, water and livelihood of the Havasupai Tribe, who live in the Canyon.

Grand Canyon National Park is a uniquely valuable place and ecosystem.

- The Grand Canyon is a natural wonder—one of the world's deepest and widest canyons, home to spectacular views, great biological diversity, and a unique geologic record.

- Nearly 6 million people visit Grand Canyon National Park every year, making it the second-most visited park in the National Park System, and the most visited park west of the Mississippi.[15]

- Tourism in Grand Canyon National Park contributes $904 million to northern Arizona's economy every year.[16]

- The Colorado River, which provides drinking water for 40 million people downstream, runs through the Grand Canyon and draws water from the area's springs and streams.[17]

- Uranium mining near the Grand Canyon threatens this treasured ecosystem, visitors and residents, and those that drink from the Colorado River.

Uranium mining is incompatible with the preservation of the Grand Canyon as a treasured ecosystem and natural wonder. The Trump administration should act to protect the Grand Canyon from the threat of uranium mining. The administration should:

- **Maintain the moratorium on new mining claims near the Grand Canyon.** In January 2012, Interior Secretary Ken Salazar extended a moratorium on exploration and new mining claims on public lands near the canyon, in place since 2009, through 2032.[18] The Trump administration should maintain this moratorium while pursuing permanent protections.

- **Make the moratorium on new mining claims near the Grand Canyon permanent.** The Greater Grand Canyon Heritage Monument Act, introduced in the U.S. Congress, would, for example, expand the protected area near the Grand Canyon from approximately 1 million square miles to 1.7 million square miles and would make the ban on new mining claims in this area permanent.

- **Require updated inspections and permits for new or reopened mines on existing mining claims with outdated environmental impact statements.** The moratorium on new mining claims near the Grand Canyon does not prevent companies from developing new mines or reopening old mines on existing mining claims. Updated environmental impact statements should be required for new or resumed mining projects with outdated permits that do not take into account current understanding of mining risks and conditions near the mining site.

- **Reform mining laws to allow regulators to deny permission to mine where significant natural places or human health are at risk.** The 1872 General Mining Law, which currently governs mining on federal land, is too lax in granting mining companies the right to stake and develop claims. Most federal land is considered open for mining by default and regulators lack sufficient power to weigh the costs and benefits of mining against other possible uses of the land.[19] Mining should be placed on an even footing with recreation and other land uses by allowing regulators to make a balanced evaluation of the best use of federal lands.

- **Require uranium mining companies to ensure that any contamination is cleaned up.** Uranium companies should be required to post enough financial assurance to cover the full cost of cleanup—or reclamation—at mine and mill sites before beginning operations. Costs should cover all foreseeable reclamation activities, as well as insurance against accidents that would significantly raise cleanup

costs. Additionally, companies should not be allowed to place mines on "standby" for extended periods of time without cleaning them up sufficiently to prevent the spread of contamination.

- **Require hardrock mining companies to pay royalties to operate on public lands.** Companies that extract oil, natural gas and coal are required to pay the federal government royalties to operate on public lands.[20] The federal government should also require hardrock mining companies, which extract other types of minerals and metals—including uranium—to pay royalties to mine on public lands.[21]

Introduction

The hike from the Grand Canyon National Park headquarters to the Hermit's Rest Overlook is one of the most beautiful in America. Incredible views greet hikers the entire way as the trail hugs the canyon's rim, looking out over the massive gorge down to the Colorado River.

At one point, however, the trail cuts away from the canyon. There, behind a rusty fence, sits the remnants of what was once one of the nation's biggest sources of uranium, the Orphan Mine. After sitting abandoned for decades, the mine's buildings were removed in 2009, but the ground around the site remains too contaminated for visitors to enter.

Hiking down from Hermit's Rest into the canyon, hikers can turn onto the Tonto Trail, a popular hiking trail that runs right through the middle of the canyon. Towering limestone walls line the right side of the trail, while the Colorado River passes by to the left, 1,000 feet below. Hikers using the Tonto Trail fill their water bottles from creeks that spill down from springs in the canyon walls to eventually join up with the Colorado. They don't, however, drink from Horn Creek, which emerges from the rock near the site of the Orphan Mine, because the creek is too contaminated with uranium.

Most Americans do not think of Grand Canyon National Park as a mining site. Yet, for years, uranium was mined within the park's borders—leaving scars that will remain for generations to come.

The Grand Canyon is not the only place in the West scarred by uranium mining. Uranium mines and processing facilities have left a toxic trail across the West, harming both the natural environment and human health.

With the Trump administration now considering reopening the Grand Canyon area to new uranium mining, it is an important time to review the toxic legacy of uranium mining. That legacy demonstrates that uranium mining is utterly incompatible with the preservation of the Grand Canyon as a healthy ecosystem and natural wonder.

Americans have long fought to preserve our national parks for ourselves and future generations to enjoy. The time has come once again to defend Grand Canyon National Park by keeping uranium mining activity far away from the park's boundaries.

The Grand Canyon Is a Uniquely Valuable Natural Place

The Grand Canyon is unlike anything else on earth. Its scale—277 river miles in length, over a mile deep in places, and more than 15 miles across at its widest point—places it among the largest canyons on Earth.[22] Its geological value—three of the four eras of geologic time are represented by the canyon's rocks—is unique.[23] The canyon contains remarkable biodiversity. The sharp change in elevation along its walls allows different climates and ecosystems to exist in close proximity, and the canyon and its surroundings contain three of the four types of desert that exist in North America, and five of the continent's seven ecological zones.[24] The canyon is renowned for its spectacular views and has been a tourist attraction since the late 19th century. Theodore Roosevelt, after visiting the canyon in 1903, made it a national monument in 1908 and it became a national park in 1919.[25]

Grand Canyon National Park, which contains the canyon and much of its surrounding forest and desert, is today one of the most-visited natural attractions in the world. Nearly 6 million people visited Grand Canyon in 2016, making it the second-most visited national park in the country. Only Great Smoky Mountains National Park, which sits much nearer to major population centers on the East Coast, received more visitors.[26] The park draws visitors from around the world. In 2004, a survey found that park visitors included residents from all 50 states. Additionally, 17 percent of park visitors had come from outside the United States, representing at least 41 different countries.[27]

The Grand Canyon's status as an international tourist destination draws millions of visitors to nearby towns like Flagstaff every year, creating an estimated $904 million of economic activity in the northern Arizona region.[28] Many visitors to Grand Canyon National Park make their visit part of a larger tour of attractions in Arizona and the Southwest. Other nearby national parks, as well as attractions as far away as Las Vegas, also receive a large amount of tourist traffic from visitors to the park.[29]

Beyond the value of the canyon itself, the Colorado River, which flows through it, provides drinking water for 40 million people—nearly one-eighth of the

U.S. population.[30] Any toxic releases or accidents that damage the quality of the Colorado as a drinking water source could have severe consequences for people in California, Arizona, and Nevada—a threat that is made even more severe by frequent and ongoing drought in the region.[31]

Uranium Mining Has Taken Place Near the Grand Canyon and Could Once Again

For over a century, mining and recreation have competed for use of the Grand Canyon. Military needs, energy demand and economic factors have driven demand for uranium and other minerals at the Grand Canyon—posing a deep and lasting threat to the area's ecological integrity and value as a recreational resource.

History of Uranium Mining and the Grand Canyon

Early in its history, the Grand Canyon was explored as a mining site as well as a tourist attraction. Prospectors began to visit the area soon after the 1872 General Mining Act threw open almost all federal lands to mineral exploration and extraction. The canyon and its surroundings contain a variety of mineral deposits. The first decade of the 20th century saw a few successful efforts at developing copper and asbestos mines. Most miners, however, failed to earn much money at their chosen trade. As time went on, some early miners abandoned mining and established themselves as tour guides instead, helping transform the canyon from a site of extractive industry to a tourist attraction.[32]

The last mineral to inspire major mining efforts in the Grand Canyon area was uranium. This first wave of uranium mining was driven by military development of nuclear weapons.[33] Uranium was found at the Orphan Mine—an inactive copper mine—in 1951, and that mine produced high-grade uranium ore between 1956 and 1969.[34] Other finds followed, and several mines operated outside the park in the Arizona Strip, north of the canyon. In the 1970s, the uranium extracted from these operations primarily fueled nuclear power plants.[35] Then, in the 1980s, prices on the world uranium market dropped and these mines stopped operations.[36]

The price of uranium began to rise in 2003, partially driven by speculation around the growth of nuclear energy programs in China and India and by expectations that high-grade uranium supplies were going to decrease.[43] Then, in 2006, the Cigar Lake mine in Canada—the world's largest undeveloped, high-grade uranium deposit at the time—flooded, forcing the mine to close.[44] This intensified fears that uranium was about

The 1872 Mining Law

Mining near the Grand Canyon, as on other public lands, is governed by the General Mining Law of 1872. That law was passed with the intent of speeding the settlement of the American West by encouraging individuals to prospect for minerals on federal land. More than a century later, that law is still governing the establishment of mining claims and the management of mineral deposits on public lands in America.[37]

The General Mining Law of 1872 allows anyone to establish mining rights over any suspected mineral deposit on federal land. The law also allows miners or mining companies to purchase the land surrounding a proven claim for almost nothing by modern standards—$2.50 to $5.00 per acre—a process known as patenting.[38] Congress put a moratorium on new applications to patent mining claims in 1994, but the moratorium must be renewed each year. If the moratorium is ever lifted, public lands could again be purchased for next to nothing.[39] Hardrock mining companies are also not required to pay royalties to the government while they are operating on public lands as oil, gas and coal extraction industries are required to do.[40]

Mining companies have broad discretion to carry out mining activities on land near their claims. The Bureau of Land Management (BLM) needs to approve a plan of operations before mining operations can take place, which it must do unless it finds that the plan would result in "unnecessary or undue degradation of federal lands."[41] Miners are required to post bonds to cover the expected cost of remediating mine sites, but the Government Accountability Office (GAO) has expressed concerns about this process. In 2011, the GAO found that 57 mining operations on federal lands had provided inadequate funds to cover estimated reclamation costs.[42]

to become scarce, causing prices to spike from about $30 per pound in 2006 to $136 per pound in 2007.[45]

Renewed Interest in Uranium Mining

In response to the rising uranium prices of the 2000s, mining companies rushed to resume mining. Several companies that had mines near the Grand Canyon in the 1980s applied for permits to resume those operations. Other companies filed new claims or applied for permits to explore potential mine sites near the Grand Canyon. As of January 2003, there were only 10 claims within five miles of Grand Canyon National Park—by 2007, that number had shot up to 815 claims.[46] In the larger area that would later be protected from new mining claims by the 2012 Public Land Order,

3,500 claims were staked by June 2011 and mining companies started moving to develop uranium mines at some of those locations.[47] In January 2008, the Forest Service approved a request by VANE Minerals, a British mining company, to explore 39 sites near the canyon for uranium potential.[48]

In response to this uranium mining rush near the Grand Canyon and opposition from the public, outdoor recreation industries, tribal leaders, environmental groups and others, Interior Secretary Ken Salazar imposed a halt on uranium exploration and the staking of new claims on one million acres near the Grand Canyon from 2009 to 2011 in order to study the impact of uranium mining in the area.[49]

A draft environmental impact study by the U.S. BLM in 2011 predicted that mining companies would explore 278 sites, and actually mine at 30 sites around the Grand Canyon, if the moratorium were fully lifted at that time.[50] Operating that many mines near the canyon would have required the construction of 22 miles of roads and power lines and disturbed approximately 1,350 acres of land, primarily north of the canyon.[51]

In January 2012, after two years of environmental analysis and after receiving nearly 300,000 public comments on the issue, Secretary Salazar issued an order that extended the ban for 20 years, the longest time span allowed by the Federal Land Policy and Management Act.[52]

The Kanab Creek Uranium Mine, just north of the Grand Canyon, opened in the 1980s. Photo: Don Bills, USGS, public domain.

Mining interests challenged this ban, but in December 2017, a U.S. Appeals Court held that the ban and study period were a lawful and reasonable way to study the risks of uranium mining in the area in order to make an informed decision.[53]

Arizona Congressman Raul Grijalva, with the support of several Native American tribes, introduced the Greater Grand Canyon Heritage National Monument Act in 2015 to make this ban permanent and to expand the protected land area.[54] In 2016, environmental and other groups delivered over half a million signatures and comments, including from businesses and national elected leaders, in support of the national monument.[55] The bill was most recently introduced in the U.S. House of Representatives on January 6, 2017 and then referred to the subcommittee on Federal Lands on February 10, 2017, but no action has been taken as of the time of publication.[56]

The current order does not ban companies from developing mines that were previously approved or from seeking approval for mining on valid, existing claims. In 2012, the U.S. Forest Service gave Energy Fuels Inc. permission to resume mining at the Canyon Mine, located six miles from the Grand Canyon.[57] The Havasupai Tribe and the Grand Canyon Trust filed suit against the Forest Service for allowing the mine to reopen without updating the environmental permits first issued for the mine in the 1980s, but in December 2017, the court ruled that the mine could remain open.[58]

The Canyon Mine is the only active mine in the area today.[59] There are uranium deposits elsewhere in the world of much higher-grade than U.S. deposits, so uranium prices have to be relatively high for uranium mining in the U.S. to be economically favorable.[60] The uranium price bubble burst in 2007 and prices have continued to decline since—partially driven by the Fukushima nuclear disaster in 2011, which reduced demand for uranium worldwide and decreased investments in nuclear power plants.[61] Since then, prices have remained around $20 to $25 per pound.[62]

The current administration, however, is working to increase domestic energy production. In March 2017, President Trump issued an executive order directing federal agencies to review all actions that could potentially interfere with developing or using domestic energy resources, "with particular attention to oil, natural gas, coal, and nuclear energy resources."[63]

On November 1, 2017, the U.S. Forest Service released its official report in response to this order. This report includes a recommendation that the ban on new mining claims around the Grand Canyon be revised and that the boundaries of the protected area potentially be changed.[64]

Mining companies are interested in the Grand Canyon area because it contains some of the highest-grade uranium deposits in the country, but these are still relatively low-grade compared to some foreign deposits.[65] Additionally, the Grand Canyon's uranium resources compose an insignificant portion of the nation's overall uranium resources. The lands near the canyon that are currently protected contain only 12 percent of Arizona's recoverable uranium resources.[66] Assuming all of this uranium could be extracted, it is only enough to fuel the nation's nuclear energy fleet for about 1.5 years.[67]

Dangers from Uranium Mining around the Grand Canyon

The risks of mining near the Grand Canyon are great. The impacts that uranium mining could have in the area are not adequately understood and are still being studied. In particular, the hydrologic structure of the area is very complex, consisting of a series of interconnected springs, wells and aquifers.[68] It is not yet known how the area's water supply would be impacted if a mining operation in a given area pierced a perched aquifer—as has already happened at the Canyon Mine (see page 17)—or how contamination would spread through the system in the event of an accident or just standard contamination resulting from uranium mining.[69]

The water supply in this area is important to the wildlife and plants of the area, visitors and local residents—particularly the Havasupai Tribe, who are the only people who live in the canyon. The Colorado River, which flows through the canyon, is also one of the most important water resources in the country. The health and the tourism livelihood of the Havasupai people could also be impacted by the radioactive dust, landscape alteration and other impacts associated with uranium mining.

Uranium mined near the Grand Canyon is transported long distances, threatening many more communities. Ore from the Canyon Mine, the only currently active mine in the protected area, is shipped to Blanding, Utah, for processing at the White Mesa uranium mill and the U.S. BLM has stated that ore from other mines near the Grand Canyon would most likely be shipped to Utah, as well.[70] Radioactive dust can be released as uranium ore is transported, threatening the health of the communities through which the trucks pass. In this case, uranium would be transported over 200 miles through northern Arizona and southern Utah.

Partly due to these abundant risks and limited benefits, there is widespread public opposition to uranium mining near the Grand Canyon. A 2018 poll of voters in eight western states found that 70 percent of respondents oppose mining in the protected area near the Grand Canyon.[71] A separate 2016 survey of Arizona voters found that 80 percent of respondents supported the creation of the Greater Grand Canyon Heritage National Monument, which would expand the moratorium on new mining claims near the Grand Canyon and make the protections permanent.[72]

Uranium Mining Is a Dirty, High-Risk Activity

Uranium mining is an inherently risky activity. Uranium, the chemicals used to extract it, and many of the substances commonly released through the process of mining it, are either toxic or radioactive. Rocks and dirt removed from mines and processed to extract uranium become toxic waste; tools and equipment used in the mining and milling process eventually become radioactive; water that filters through mines or tailings becomes contaminated; even dirt from the ground surrounding uranium facilities can become a toxic hazard when whipped up by the wind.

Uranium Mining Involves Dangerous Substances

Uranium mining and processing release a number of toxic substances including radioactive elements and heavy metals.

Radioactive Elements

Radioactivity comes in several forms, all of which damage cells and DNA. Electromagnetic radiation—specifically gamma rays or x-rays—can travel through the air and harm people who spend time near a radiation source.[73] Alpha and beta radiation—emitted particles—cannot travel very far but can inflict severe damage on cells if they are released from within the body, which can happen after a person drinks contaminated water or inhales contaminated dust.[74] Acute exposure—likely only the result of severe radioactive accidents—results in immediate sickness, and possibly death.[75] Longer term exposure raises the risk of cancer and other illnesses, such as anemia and cataracts.[76]

Uranium itself is radioactive, but a larger portion of the radioactivity in uranium ore comes from other elements, which means that the waste from uranium mining remains radioactive even after the uranium has been removed.[77] Radioactivity declines over time, but some elements decay so slowly that radioactivity remains a health threat for generations.

As the radioactive elements in uranium ore break down, they produce other isotopes and elements including

radon, which is the leading cause of lung cancer in non-smokers.[78] Because radon is a radioactive gas, it can escape from waste piles and travel through the air, spreading the risk of exposure over a wider area.[79] Radon exposure threatens miners and the substance can also accumulate in buildings and homes.[80]

Heavy Metals

Rock that contains uranium may also contain toxic heavy metals. The most familiar toxic heavy metal is lead, a substance that can impair the mental and physical development of young children.[81] Lead can leach out of uranium mining and milling wastes and into the water supply, as can a number of other heavy metals. Many of those metals cause problems similar to those caused by lead, as well as additional impacts. Molybdenum, for instance, causes joint and respiratory problems in adults as well as threatening the development of fetuses and children. [82]

Other Toxic Chemicals

In addition to radioactive elements and heavy metals, uranium mining and milling use and release a range of other toxic chemicals. Sulfuric acid, which is used to leach uranium out of ore, can burn skin and cause illness at high levels of exposure.[83] Selenium, which is released from uranium ore, is needed in very small doses by humans, but can accumulate in the body and cause liver damage, interfere with hormone regulation and the immune system, and even result in death in larger doses.[84] Arsenic, a poison that interferes with important cell functions—causing gastrointestinal illness, nervous system damage, cancer, and other ailments—is also released from uranium ore.[85]

Mining Damages the Environment

Producing uranium is a complicated and labor-intensive process, involving extracting and purifying ores that may contain only a tiny fraction of uranium. Large amounts of rock are excavated, soaked with chemicals, and eventually disposed of. Each step in the process creates the potential for pollution that is harmful to the environment and human health.

Water Filtration Through Mines and Tailings

Mining uranium ore exposes the ore and the rocks that surround it to the air and weather. Once exposed to the air, uranium oxidizes and becomes water-soluble, allowing it to leach into groundwater, along with other toxic substances.[100] Water filtering through tailings or mines can carry the toxic and radioactive contents of these waste materials into the broader environment, putting nearby water supplies at risk.

The risk that contamination could enter the Colorado River and threaten the drinking water supplies of 40 million people—over 12 percent of the U.S. population—has raised concern among the agencies responsible for providing water to major cities downstream.[101] The agencies responsible for the drinking water supplies of Phoenix, Las Vegas, and Los Angeles have all registered their opposition to expanded uranium mining near the canyon, noting that a worst-case scenario involving uranium contamination could threaten the water supply of the entire region.[102] This threat is even more dire as this area is already suffering from ongoing drought that is projected to continue.[103]

Case Study: Uranium Mines Continue to Harm the Health of the Navajo People

Intensive uranium mining has occurred in the Navajo Nation—in Utah, Arizona and New Mexico—for over six decades.[86] Uranium mining has impacted the health of the Navajo people—both those who have worked in mines and those who just live nearby.

Charley Colorado, a former uranium miner, told *The Arizona Republic* that he and other Navajo miners were told that uranium was safe.[87] He reported that mine overseers wore protective suits and masks, but that the Navajo miners did not and would go home with uranium powder on their clothes.[88] Chronic exposure, through ingestion or inhalation, to one type of radiation resulting from uranium mining can cause uranium to build up in the bones, damage the kidneys, and increase the risks of cancer and liver disease.[89] Gamma radiation, which exceeds safe levels at multiple mine sites on Navajo land, is more penetrating and can be harmful even without ingestion or inhalation.[90] One study found that lung-cancer rates were almost 29 times higher in Navajos who worked in the mines than in those who did not.[91]

Some Navajo people report that they used to play on abandoned mine sites and swim in the mine pits to cool off in the summer, not knowing that they were dangerous.[92] Others have found out years later that their wells are contaminated or that their homes were built with radioactive materials.[93]

Many Navajo people have died from conditions related to uranium contamination, including kidney failure and cancer. Between the 1970s and 1990s, cancer rates doubled in the Navajo Nation.[94] A 2016 CDC study even found uranium in newborn Navajo babies.[95] Local healthcare workers have expressed concern for increasing rates of respiratory diseases, including pulmonary fibrosis, in non-smoking residents.[96] And preliminary results of a current study have found uranium in every blood and urine sample collected from hundreds of Navajo mothers, fathers and infants.[97]

In 2006, the U.S. Environmental Protection Agency (EPA) won a $1 billion settlement from one company that formerly mined on Navajo lands, but that settlement only covers the reclamation of 49 of the 521 abandoned mines on Navajo lands.[98] The responsible parties for hundreds of those mines have still not even been identified, so Navajo advocates are calling on the federal government to pay for the cleanup in the meantime, and to end the ongoing contamination and resulting impacts on the health of the Navajo people as quickly as possible.[99]

Release of Tailings

Tailings are mine or mill waste containing processed ore, chemicals used in processing, and other contaminated liquids or debris. Tailings are stored in piles or ponds near uranium facilities. Because uranium accounts for such a small portion of the material in ore, uranium mines can generate extremely large amounts of tailings—up to 99.9 percent of the original volume of ore. Sulfuric acid, commonly used to extract uranium from tailings, also breaks molybdenum, vanadium, selenium, iron, lead and arsenic out of the ore, enabling those substances to pollute water passing through the tailings.[104] Even after uranium extraction, mill tailings contain 5 to 10 percent of the original uranium, along with all of the other radioactive elements that were present in the original ore. In total, tailings are 85 percent as radioactive on average as the original ore from which they were derived and remain radioactive for hundreds of thousands of years.[105]

Accidents involving mine or mill tailings can result in environmental contamination and public health impacts. The Church Rock Mine disaster in 1979, in which a tailings pond at a New Mexico uranium mill broke open, left miles of river so contaminated with uranium that water in the area is still unsafe to drink, decades later. Even smaller spills can do serious damage. When a single truck carrying ore overturned in a flash flood at the Hack Canyon mine north of the Grand Canyon, the resulting spill contaminated a watershed severely enough to necessitate long-term warnings against drinking from one of the Grand Canyon's streams.[106]

Airborne Radioactive Dust

Bringing radioactive material above ground exposes it to wind as well as floods and spills. Dust from uranium mining or processing sites contains many of the hazardous materials that are present in ore, tailings, and mine debris. Uranium cleanup efforts may need dust suppression measures to prevent blown dust from becoming a health risk. At the cleanup of the Atlas tailings pile near Moab, Utah, for instance, water spraying is required to prevent dust from escaping the site.[107] Companies also build special fences around mines to prevent dust from spreading, but two studies in 2016 found elevated levels of radioactivity outside of the fenced in, inactive Pinenut Mine, which is within the currently protected area near the Grand Canyon.[108] Uranium sites that are abandoned or temporarily shut down without being fully remediated—like the Kanab North mine site near the Grand Canyon—can become large-scale sources of radioactive dust.[109] If inhaled, that dust can increase the risk of lung cancer; it can also blow into streams or onto nearby ground, spreading radioactive contamination.[110]

Land Disruption

Land disruption is one of the most visible and severe impacts of the mining process, although it is less significant for underground mines, the most likely mine type near the Grand Canyon.

Open-pit mines, from which about 25 percent of the world's uranium is drawn, require the excavation of large areas of land.[111] These mines produce large volumes of waste rock, which may contain elevated levels of uranium compared to ordinary rock and is typically stored near the mine site.[112]

Even underground mines or *in situ* leaching operations—in which chemicals

are injected into the ground to dissolve uranium and allow it to be pumped to the surface—require a substantial footprint of about 20 acres for underground mines of the sort that would be developed near the Grand Canyon.[113] Radioactive dust and debris can render the area around the mine unsafe even after the mine closes, as has occurred at the Orphan Mine on the rim of the Grand Canyon.

Ecosystem Damage

Plants and animals near uranium mines are vulnerable to several of the effects of mining—in particular, radioactive contamination and hydrological disruption.

Mines near the Grand Canyon have the potential to introduce radioactivity into the environment and food chain and to affect the water sources on which plants and animals rely. Increased levels of radioactivity in the environment could lead to diminished vitality or death for exposed plants and animals.[114]

Disruption to any of the scarce springs near the canyon could impact local plants and animals by cutting off an important source of water. Some water will be diverted for mine operations under any mining scenario. A larger, permanent impact might take place if mines pierce perched aquifers—isolated pools of groundwater elevated above the overall water table—which could sharply reduce the water available to plants and animals that rely on a particular spring.[115] Exploratory drilling for the Canyon Mine—the only currently active mine in the protected Grand Canyon area—pierced such an aquifer, draining an estimated 1.3 million gallons of water per year from area springs.[116]

Every Uranium Mining and Processing Technique Poses Risks

Every uranium mining technique damages the environment and threatens public health. Each kind of facility used to mine and process uranium carries its own risks:

- **Underground mines** extract ore from deep underground deposits and are the type of mine likely to be used near the Grand Canyon. Underground mines usually involve a deep shaft down to the level where ore is located, and a network of excavations at the depth of the ore through which uranium is removed. A mix of ore-bearing rock and ordinary rock is excavated from these mines. Because they are more expensive to build and operate, deep underground mines are likely to be used only for relatively high-grade ore deposits.[117]

- **Open-pit mines** are mines where uranium-bearing ore is extracted from a large pit, in a fashion similar to quarrying stone. These mines have the largest surface footprint of any uranium operation, both from the mine itself and from the land required to store the ore and land removed from the mine.[118]

- **In situ leaching mines** are low-cost mines that extract uranium from underground deposits. Leaching fluid is circulated through a uranium deposit through wells drilled down into the deposit, extracting uranium from the rock. Uranium is recovered by pumping the fluid back to the surface. If fluid escapes from a well or from the underground deposit, groundwater can be contaminated.[119]

- **Heap leaching** is a method for extracting uranium from low-grade ore by running sulfuric acid or another chemical through piles of ore at a mine site to extract the uranium. These heaps become large tailings piles once leaching ends; they contain many of the toxic substances often found in tailings and can contaminate the land and water under them.[120]

- **Uranium mills** are used to process higher-grade ores by grinding up the rock and using sulfuric acid or another chemical to extract uranium. Mills produce large amounts of tailings—and, in fact, often centralize the tailings from multiple mines at a single location, leading to potentially very large tailings piles. Mill equipment also requires special handling when the facilities are decommissioned; the equipment is radioactive and poses health risks without proper disposal.[121]

Uranium Mining Has a Track Record of Environmental Contamination

In four decades of heavy mining—from the 1950s through the 1980s—the U.S. uranium industry left a toxic trail of contaminated sites across the American West. Contaminated sites include mines, mills, tailings piles, and the sites of accidental spills. Some of the first sites used by the uranium industry are still contaminated today. The Atlas Uranium Mill near Moab, Utah, for example, which was built to process ore from one of the country's first major uranium strikes, left behind a tailings pile that still threatens the Colorado River.

In the 1950s and 1960s, the uranium industry came into existence to produce bomb-making material to meet the needs of the U.S. military's nuclear program. In the 1970s, as the military stepped down its uranium purchasing, uranium mines and mills found a new market as fuel providers to the civilian nuclear power industry. By the 1980s, though, worldwide demand for newly extracted uranium had fallen, as reprocessed reactor fuel and repurposed uranium from decommissioned nuclear weapons supplied a large portion of the civilian nuclear industry's needs. Mine and mill closures swept through the U.S. uranium industry.

Every uranium site is hazardous while in use (as discussed in the previous section) and needs to be cleaned up afterward. Uranium itself, the chemicals used to extract it, and many of the byproducts that emerge from ore alongside it, are toxic. These contaminants can do lasting damage to the land and water around uranium sites. Sick families, poisoned streams, and lasting threats to the drinking water of millions have been among the results of uranium mining in the past. The case studies below describe a range of sites and incidents—in multiple states, at multiple types of uranium facilities, across multiple decades—that illustrate the risks uranium mining has posed in the past and will continue to pose in the future.

Several of these sites closely resemble potential new mines near the Grand Canyon. The incidents described in Arizona and New Mexico both affected the Grand Canyon area, and those in Arizona actually took place at mines near the canyon. The other case studies below illustrate the risks that uranium extracted from any mine poses to the areas where ore is processed and waste is stored, and the overall risk that the uranium

industry poses to human health and the environment.

Arizona: Fouled Streams, Damaged Aquifers, and Toxic Dirt Piles

If uranium mining companies are allowed to develop new mines near the Grand Canyon, it won't be the first time that the canyon has hosted uranium mining activities. Nor will the impacts of any new mining be the first damage uranium has done to the canyon; the park already bears the scars of a previous round of extraction

During the mid-century uranium boom, a handful of uranium mines operated near the Grand Canyon—in one case, right up to the canyon's edge. These mines have left an indelible mark on the canyon and its surroundings, from fouled streams and damaged aquifers to lingering piles of radioactive debris. According to the U.S. Geological Survey (USGS), 15 springs and five wells near Arizona's Grand Canyon National Park contain uranium concentrations above the safe limit for drinking water.[122]

Every year, millions of park visitors head west from Grand Canyon Village toward the historic El Tovar Hotel and the popular Hermit Overlook; on the way, they detour away from the canyon's rim to avoid the Orphan Mine, an abandoned uranium mine surrounded by fences and warning signs to keep park visitors away.

The Orphan Mine—a 1,500-foot deep underground mine that produced high-grade uranium ore from 1956 to 1969—began its life as an unsuccessful

Abandoned equipment and structures for the Orphan Mine on the rim of the Grand Canyon in 2007, decades after the mine closed and shortly before the National Park Service removed them from the site. Photo: Alan Levine via Flickr, public domain.

copper mine, then sat idle for decades as the mine's owners put their land to use for the more profitable tourism business. The discovery of uranium in 1951 changed their profit incentive, and the mine resumed activity shortly thereafter. The mine owners ultimately secured permission to mine uranium within the boundaries of Grand Canyon National Park. (The federal government was originally reluctant to give that permission but relented after the mine owners threatened to build an 18-story hotel descending down the rim of the canyon.)[123]

Today, the mine site is controlled by the National Park Service (NPS), and access is restricted because soil radiation is 450 times above background levels.[124] The NPS removed the mine structures from the rim in 2009—total cleanup of the contamination on the surface is estimated to cost $15 million and the Park Service has still recovered no costs from the defense contractors responsible for the mine.[125] The costs of cleaning up contamination in the underground portion of the site have not been determined.[126]

Two creeks near the mine, meanwhile, contain high quantities of uranium. Horn Creek, flowing from a spring near the mine, crosses a popular trail through the canyon, but hikers are warned not to drink the water, as its uranium content is too high for safe consumption. Nearby Salt Creek bears a similar warning.[127]

The Orphan Mine is an underground uranium mine, a series of tunnels from which miners pulled ore when the mine was active. Mines of this sort are less disruptive of the land's surface than open-pit mining, but in a landscape like the Grand Canyon they bear risks of their own. By disrupting and opening up the rock formations in which uranium is sealed underground, mines can open pathways for water from mine tunnels to enter aquifers, including the limestone from which the Grand Canyon's springs emerge.[128] If new underground mines open near the canyon's rim, more springs could be contaminated as uranium finds its way down into aquifers. Even mines that don't introduce contamination can harm local water supplies by piercing the impermeable rocks that support perched aquifers, which are the source of many of the park's springs. Exploratory drilling for the Canyon Mine—the only currently active mine in the protected Grand Canyon area—pierced such an aquifer, draining an estimated 1.3 million gallons of water per year from area springs.[129]

Another old Grand Canyon mine demonstrates a different, more direct, path to stream contamination. The Hack Canyon Mine, on the Grand Canyon's less-traveled north rim, is a deep shaft mine like the Orphan Mine.[130] The mine made its lasting radiological mark on the area in 1984, when a summer flash flood swept four tons of high grade uranium ore from the mine site into nearby Kanab Creek; the NPS still advises visitors not to drink or bathe in the creek because of its radioactivity levels.[131]

Uranium mining continues to contaminate the Grand Canyon. In December 2016, uranium levels four times higher than background levels were found in soil outside of the closed Pinenut Mine near the Grand Canyon, which is currently being cleaned up.[132] This caused the Arizona Department of Environmental Quality (ADEQ) to suspend air pollution permit renewal applications for the Pinenut Mine, the EZ uranium claim, and the Canyon Mine, which are all mines owned

by Energy Fuels Inc.[133] The ADEQ also ordered that the company improve dust control measures to keep the radioactive soils at these sites near the Grand Canyon from blowing away and threatening people and water supplies.[134]

Wet winter conditions during 2017 caused excess water to flow into a shaft of the Canyon Mine through the perched aquifer that had been pierced when the shaft was drilled.[135] To prevent the mine's holding ponds from overflowing during the following spring, the mine operator began trucking contaminated water away to be treated, but also began spraying some water into the air on site to evaporate.[136] The water in the holding ponds was found to have uranium levels three times higher than federal drinking water standards and arsenic levels 30 times higher than are considered safe.[137] Environmental groups and local Native American tribes have expressed serious concern over these practices.[138]

New Mexico: A Giant Spill and an Ongoing Cleanup

Beginning in the 1950s, uranium mines sprang up in New Mexico's Grants Mineral Belt, which spans Cibola, McKinley, Sandoval, and Bernalillo counties, as well as Navajo Tribal lands.[139] When uranium prices fell, the industry left, leaving extensive contamination behind. Of the 13,068 abandoned mines in and around New Mexico's federal lands, 11,751 have not been remediated and 8,956 have been identified as needing contamination analysis.[140]

A uranium mill that served New Mexico's mines was the site of the worst uranium accident in United States history. The Church Rock Mill, owned by the United Nuclear Corporation, operated from 1977 to 1982, processing ore from mines in the area.[141] In 1979, an earthen dam burst at the mill's tailings pond. Behind that dam were 94 million gallons of acidic water, laden with uranium tailings. The radioactive flood that resulted spilled down the north fork of the Rio Puerco and into the Little Colorado River; within days, water sources as far as 50 miles downstream in neighboring Arizona had been polluted.[142] Though less well publicized, the Church Rock Disaster was actually larger, in terms of the volume of radioactive material released, than the Three Mile Island nuclear power plant accident that occurred that same year.[143]

Aerial view of the cleanup site at the former Church Rock Uranium Mill. The former location of the tailings pond is visible in the bottom right half of the photograph. Photo: U.S. Environmental Protection Agency, public domain.

Problems extend beyond the spill; while it operated, the mine piled up waste in heaps outside the mine and pumped radioactive water out of mineshafts to evaporate in pools on the ground above. The ongoing contamination stemming from those waste heaps

and pools led the U.S. EPA to declare the mine a Superfund site, starting a cleanup process that continues today.[144]

When the United Nuclear Corporation closed the Northeast Church Rock Mine, it failed to clean all the radioactive sediments out of the pools it had used to treat radioactive mine water. Now, those pools fill with rainwater instead, creating dangerous and unhealthy surface water. Water from the final treatment pool poured out into an intermittent creek that runs between houses in the community of Church Rock; that creek, too, is contaminated.[145]

The mine waste piles, meanwhile, contain low-grade uranium, other radioactive elements, and heavy metals. Those piles—now partly covered by plants—pose a risk to people who walk through the area. Dirt blows off the piles in the wind and runs off in rainwater to spread contamination to the surrounding area.[146] People who inhale contaminated dust particles or utilize contaminated rainwater or runoff that has pooled in ponds around the site face elevated health risks from Radium-226, which is found in high concentrations on the 125-acre site. Among the health risks of Radium-226 are "anemia, cataracts, fractured teeth, cancer (especially bone cancer), and death," according to the U.S. EPA.[147]

Additionally, many homes and storage structures have been constructed from materials contaminated with radioactivity from nearby mines.[148] The U.S. EPA has removed 47 such structures since 2008.[149]

The Northeast Church Rock Mine continues to poison the land, air and water around it decades after being shut down. Even with cleanup efforts underway, the people of the community near the mine are surrounded by sources of dangerous contamination every day, which pose severe health risks not only for them, but also for future generations.

Utah: 16 Million Tons of Radioactive Rubble

Today, the town of Moab, Utah, is most famous for outdoor recreation. Rock climbers, mountain bikers, hikers, and all-terrain vehicle riders travel from all over the country to visit the area's wide-open landscapes and striking red rocks. Moab got its start, though, as one of the nation's biggest hubs of uranium mining and processing.

Uranium was discovered near Moab in 1953, and a boom started immediately. Moab's population shot from 1,200 to 6,000 in less than a year, and Charlie Steen, the impoverished prospector who made the first uranium strike, suddenly found himself rich enough to build a mill for his ore.[150]

That mill, completed in 1956 and purchased in 1962 by the Atlas Uranium Corporation, operated from 1956 to 1982. Milling uranium involves crushing ore and running sulfuric acid or another chemical through it to extract the uranium. This process produces large volumes of waste; since uranium composes only a tiny fraction of the material in ore, 99 percent or more of the rock extracted from a mine can wind up in a tailings pile. That waste retains 85 percent of the radioactivity of the original underground deposit.[151]

In 1982, the collapsing price of uranium rendered the Atlas Mill uneconomical, and it closed. Left behind was a 130-acre, 16-million-ton pile of toxic and radioactive tailings located 750 feet from the edge of the Colorado River, a source

of drinking water for 40 million downstream residents.[152]

That tailings pile remained untouched for almost three decades, from 1982 to 2009, and most of it is still in place today. Over that period, it has steadily leaked uranium and other toxic substances into the aquifer underneath it, the land between the pile and the river, and the river itself.[153] By the late 1990s, uranium concentrations beneath the pile were 31 times the safe limit, lead concentrations 20 times their limit, and ammonia concentrations 6 times their limit—to name just a few of the 20 toxic substances found at unsafe levels in the vicinity of the pile.[154] In the late 1990s, as much as 28,000 gallons of contaminated water from the pile was ending up in the Colorado River every day.[155] Should there be a flood, or if the course of the river should shift, large amounts of toxic waste could be swept into the river.[156]

Atlas Uranium, under pressure to address the risk posed by the tailings, proposed to cap the pile with a layer of rock and clay. In the midst of a regulatory battle over whether that measure would be sufficient, the company went bankrupt, leaving the government with full responsibility for the tailings pile.[157] A multi-year legal and legislative struggle ensued, as local residents and downstream water users fought to get the tailings relocated to a safer site away from the river.

The Atlas Mill tailings pile near Moab. The Colorado River is visible in the right of the photograph. The pile likely won't be fully removed until the 2030s at current funding levels. Photo: U.S. Department of Energy, public domain.

After the federal government agreed to remove the tailings, cleanup began in 2009, but the size of the pile ensures that the risk will remain for years. Based on funding approved for fiscal year 2017, the Moab Tailings Project Steering Committee members estimate that the project will not be completed until the 2030s.[158]

Colorado: Poisoned Well Water and Sick Residents

For decades, residents of Lincoln Park, a small community near the Cotter Corporation Uranium Mill outside of Cañon City, Colorado, got their drinking water from wells near the mill. Today, they rely instead on treated water from Cañon City's water system, since their groundwater is no longer safe to drink.

From 1958 to 1979, the Cañon City uranium mill stored its waste in unlined pools on the mill's grounds.[159] The result was a toxic plume in groundwater surrounding the plant—a pool of contamination that required the U.S. EPA to declare the mill and its surroundings a Superfund toxic waste site and remove tons of contaminated soil from the area.

When uranium processing takes place near residences, the wastes it produces can pose a serious threat to human health—even years after the processing is complete. Stored waste from the decades of uranium processing at the Cotter Mill was the source of contamination that led to the poisoning of Lincoln Park's water supply.

Radioactive substances were not the only threats to which Lincoln Park residents were exposed. Uranium milling both uses and releases a wide variety of toxic chemicals—from the sulfuric acid commonly used for extracting the uranium to the molybdenum and other heavy metals that leach out of the ore along with uranium. Among the chemicals found in the soil near the Cotter Mill were uranium, arsenic, molybdenum, lead, cobalt, nickel, selenium, zinc, copper and cadmium.[160]

Federal investigators found that heavy metal contamination of well water accounted for the worst of the health threats from the Cotter Mill, putting residents at particular risk of joint and respiratory problems.[161] Lincoln Park's residents switched from well water to municipal water to avoid these risks, but only after decades during which they unknowingly consumed contaminated well water. Other health risks came from the soil—scientists warned that properties near the mill might be too contaminated to develop safely as homes, and local vegetable gardens were contaminated with arsenic and other poisons.[162]

The impacts on the community were severe. Residents of the area suffered from birth defects, arthritis, and cancer, among other illnesses; medical experts have testified that contamination from the mill contributed to these health problems.[163] Residents have fought through several rounds of litigation with the Cotter Corporation, winning various settlements and awards worth millions of dollars, but facing persistent appeals and denial of responsibility from the mill company.[164] Long-term plans for cleaning up the site remain uncertain. Cotter has set aside $20 million for decommissioning the mill, but that sum is just under half of the total estimated cost of the cleanup.[165] In Colorado alone, taxpayers had already spent more than $1 billion by 2010 cleaning up past

uranium milling operations according to U.S. Department of Energy (DOE) and U.S. EPA documents.[166]

And the threat of contamination continues. Since 2010, a pipeline on the mill site has leaked at least seven times, including 7,000 gallons during one incident in August 2016.[167] In July 2015, well water around the pipeline site was found to contain uranium and molybdenum levels above safety standards.[168] In March 2017, 5,200 more gallons of wastewater were spilled while the faulty pipeline was being replaced.[169]

Policy Recommendations

The Grand Canyon is one of our most treasured natural places—visited by millions of people every year and home to spectacular views, unique geologic formations, great biodiversity, the Havasupai Tribe and the Colorado River, which supplies drinking water for nearly one-eighth of the nation's population.[170] Decades ago, uranium mining left toxic contamination in areas around the Grand Canyon that will persist for generations, harming the environment and people's health.

To properly protect the park for future generations, no new uranium mining can take place there. In the longer term, other places deserve that same protection, including other national parks and important waterways. In order to achieve this, policymakers should:

- **Maintain the moratorium on new mining claims near the Grand Canyon.** In January 2012, Interior Secretary Ken Salazar extended a moratorium on exploration and new mining claims on public lands near the canyon, in place since 2009, through 2032.[171] The Trump administration should maintain this moratorium while pursuing permanent protections.
- **Make the moratorium on new mining claims near the Grand Canyon permanent.** The Greater Grand Canyon Heritage Monument Act, introduced in the U.S. Congress, would, for example, expand the protected area near the Grand Canyon from approximately 1 million-square miles to 1.7 million square miles and would make the ban on new mining claims in this area permanent.
- **Require updated inspections and permits for new or reopened mines on existing mining claims with outdated environmental impact statements.** The moratorium on new mining claims near the Grand Canyon does not prevent companies from developing new mines or reopening old mines on existing mining claims. Updated environmental impact statements should be required for new or resumed mining projects with outdated permits that do not take into account current understanding of mining risks and conditions near the mining site.

- **Reform mining laws to allow regulators to deny permission to mine where significant natural places or human health are at risk.** The 1872 General Mining Law, which currently governs mining on federal land, is too lax in granting mining companies the right to stake and develop claims. Most federal land is considered open for mining by default and regulators lack sufficient power to weigh the costs and benefits of mining against other possible uses of the land.[172] Mining should be placed on an even footing with recreation and other land uses by allowing regulators to make a balanced evaluation of the best use of federal lands.

- **Require uranium mining companies to ensure that any contamination is cleaned up.** Uranium companies should be required to post enough financial assurance to cover the full cost of cleanup—or reclamation—at mine and mill sites before beginning operations. Costs should cover all foreseeable reclamation activities, as well as insurance against accidents that would significantly raise cleanup costs. Additionally, companies should not be allowed to place mines on "standby" for extended periods of time without cleaning them up sufficiently to prevent the spread of contamination.

- **Require hardrock mining companies to pay royalties to operate on public lands.** Companies that extract oil, natural gas and coal are required to pay the federal government royalties to operate on public lands.[173] The federal government should also require hardrock mining companies, which extract other types of minerals and metals—including uranium—to pay royalties to mine on public lands.[174]

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