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BLIGHTED HOMELAND

A peril that dwelt among the Navajos

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MARY AND BILLY BOY HOLIDAY bought their one-room house from a medicine man in 1967. They gave him \$50, a sheep and a canvas tent.

For the most part, they were happy with the purchase. Their Navajo hogan was situated well, between a desert mesa and the trading-post road. The eight-sided dwelling proved stout and snug, with walls of stone and wood, and a green-shingle roof.

The single drawback was the bare dirt underfoot. So three years after moving in, the Holidays jumped at the chance to get a real floor. A federally funded program would pay for installation if they bought the materials. The Holidays couldn't afford to, but the contractor, a friend of theirs, had an idea.

He would use sand and crushed rock that had washed down from an old uranium mine in the mesa, one of hundreds throughout the Navajo reservation that once supplied the nation's nuclear weapons program. The waste material wouldn't cost a cent. "He said it made good concrete," Mary Holiday recalled.

As promised, the 6-inch slab was so smooth that the Holidays could lay their mattresses directly on it and enjoy a good night's sleep.

They didn't know their fine new floor was radioactive.

Fifty years ago, cancer rates on the reservation were so low that a medical journal published an article titled "Cancer immunity in the Navajo."

Back then, the contamination of the tribal homeland was just beginning. Mining companies were digging into one of the world's richest uranium deposits, in a reservation spanning parts of Arizona, New Mexico and Utah.

From 1944 to 1986, 3.9 million tons of uranium ore were chiseled and blasted from the mountains and plains. The mines provided uranium for the Manhattan Project, the top-secret effort to develop an atomic bomb, and for the weapons stockpile built up during the arms race with the Soviet Union.

Private companies operated the mines, but the U.S. government was the sole customer. The boom lasted through the early '60s. As the Cold War threat gradually diminished over the next two decades, more than 1,000 mines and four processing mills on tribal



land shut down.

The companies often left behind radioactive waste piles and open tunnels and pits. Few bothered to fence the properties or post warning signs. Federal inspectors seldom intervened.

Over the decades, Navajos inhaled radioactive dust from the waste piles, borne aloft by fierce desert winds.

They drank contaminated water from abandoned pit mines that filled with rain. They watered their herds there, then butchered the animals and ate the meat.

Their children dug caves in piles of mill tailings and played in the spent mines.

And like the Holidays, many lived in homes silently pulsing with radiation.

Today, there is no talk of cancer immunity in the Navajos.

The cancer death rate on the reservation -- historically much lower than that of the general U.S. population -- doubled from the early 1970s to the late 1990s, according to Indian Health Service data. The overall U.S. cancer death rate declined slightly over the same period.

Though no definitive link has been established, researchers say exposure to mining byproducts in the soil, air and water almost certainly contributed to the increase in Navajo cancer mortality.

The government has never conducted a comprehensive study of the health effects of uranium mining on the reservation. But individual scientists working on their own have documented sharply elevated cancer rates near old mines and mills. High concentrations of uranium, arsenic and other heavy metals have been found in one out of five drinking-water sources sampled.

Particularly toxic were the "hot" houses built with radioactive debris.

In every corner of the reservation, sandy mill tailings and chunks of ore, squared off nicely by blasting, were left unattended at old mines and mills, free for the taking. They were fashioned into bread ovens, cisterns, foundations, fireplaces, floors and walls.

Navajo families occupied radioactive dwellings for decades, unaware of the risks.

Over the years, federal and tribal officials stumbled across at least 70 such homes, records show. The total number is unknown because authorities made no serious effort to learn the full extent of the problem or to warn all those potentially affected.

After years of delay, they fixed or replaced about 20 radioactive houses and then walked

away from the problem. Navajos continued to use mine waste as construction material, and the homes were passed down from one generation to the next.

Not until 2000 did the Holidays learn that their hogan was dangerous. By then, the couple had raised three children and sheltered a host of other kin while the uranium decayed. The resulting alpha, beta and gamma rays were invisible; the radon gas was odorless. But the combination greatly increased the chance of developing fatal lung cancer, according to a radiation expert who sampled air in the hogan.

"It brings chills when you're told that your house is like this," said Mary Holiday, now in her early 70s. "All the years that you've lived here," she said, her voice trailing off.

Unsuspecting, she had gone about her chores in the Navajo way, clad in the customary velveteen blouse, long skirt, thick socks and dusty shoes. She chopped wood for the stove, cooked tortillas and brewed tea. She set up her loom to weave rugs under a juniper tree while the grandchildren played dress-up for hours inside the old hogan.

By the time of the discovery that now torments her, she had lost her husband, Billy Boy, to lung cancer and congestive heart failure. He didn't smoke, but he'd worked in uranium mines by day and slept, unknowing, in the equivalent by night.

Her grandnephew, too, would soon die of lung cancer, at age 42. He had neither smoked nor mined. But he had lived in the hogan for three years as a teenager.

The dwellings in the Holiday family compound faced east toward dawn, in accordance with Navajo tradition. Behind them loomed the mesa, with a pale green uranium stain that started at the old mine and pointed down the cliff.

'Where is our guardian?'

More than 180,000 people live scattered across the region bounded by the Navajos' four sacred peaks. More than a homeland, it is their holy land. The tribe's creation stories are set here, among the painted deserts, ponderosa highlands and layered sandstone cliffs.

The U.S. government appealed to both Navajo patriotism and self-interest when it asked the tribe to open its land to uranium exploration in the 1940s. The mining would aid the American war effort and provide jobs, federal officials said.

Some of the mining companies were conglomerates like Kerr-McGee Corp. Some were small like A&B Mining, a Utah firm that was the last to mine the mesa near the Holidays' hogan.

Early on, federal scientists knew that mine workers were at heightened risk for developing lung cancer and other serious respiratory diseases in 15 or 20 years. Many did, and eventually their plight drew wide attention. In 1990, Congress offered the former miners an apology and compensation of up to \$150,000 each.

But pervasive environmental hazards remained.

Starting in the late '50s, government scientists and inspectors had written memos and journal articles calling attention to the dangers posed by open mines and exposed tailings.

But the warnings failed to spark vigorous action. Pleading lack of funds, officials at the Environmental Protection Agency and the Indian Health Service dodged responsibility, declining to study the health threats comprehensively, much less eliminate them.

Navajo leaders tried sporadically to force federal action, usually without success. On occasion, they withheld information about uranium-related dangers from their own people, reasoning that there was no point stirring up fear if there was no money for a solution.

Efforts to repair the environmental damage finally began in the 1980s but have been fitful and incomplete. Unable to agree on a thorough cleanup under the federal Superfund program, the tribe and the U.S. government settled for half-measures.

From 1984 through 1995, the Department of Energy spent \$240 million to cover tailing piles at the old uranium mills as part of a nationwide program. Tailings are the fine sand left over when ore is ground up to extract uranium. They retain most of the radioactivity and give off large quantities of radon, an odorless, cancer-causing gas.

But the tailings cleanup, though important, was limited to the mills. It did nothing to ease the hazards posed by the abandoned mines.

Over the last decade, the tribe has used money from a federal mine-reclamation fund to seal entrances and fill pits at most of the old mines. But the cleanup was incomplete. At many of the sites, radioactive rubble lies along cliffs and on hillsides.

Erosion compounds the problem. Desert winds constantly wear away the earthen caps at the mines, exposing chunks of radioactive ore. Gullies eat into buried pit mines, allowing rainwater to course through irradiated soil and contaminate groundwater.

Now, with a renewed push for nuclear power driving up uranium prices, the mining industry wants to extract more from the still-vast Navajo reserve. Tribal leaders are resisting.

By treaty and law, the United States is responsible for the tribe's welfare, Navajo President Joe Shirley Jr. noted. But the government's response to the Cold War contamination has been half-hearted, he said.

"It's an emergency that is not being treated like an emergency," he said. "Where is our guardian?"

On their own

In 1975, Joseph M. Hans Jr., an EPA radiation expert, was sent to inspect an abandoned uranium-processing plant in Cane Valley, on Navajo territory near the Arizona-Utah line.

Vanadium Corp. of America had operated the plant and an adjacent pit mine in the 1950s. A successor company, Foote Mineral, closed everything down in 1969. Federal mining inspector Howard B. Nickelson reported that the local manager had assured him that "the area would be cleaned up. No final inspection is planned."

But Foote left behind piles of tailings and mine rubble.

When Hans arrived, Congress was weighing the proposal to cover tailings at closed uranium mills across the country. The EPA was assessing the scope of the task.

As Hans worked, he noticed a small community of hand-built houses nearby. He began to worry that the residents might have used Foote's leftovers as construction material. A few months later, he and some EPA colleagues returned with hand-held radiation scanners, air samplers and other equipment.

Berlinda Cly was 9 when the inspectors visited the home where she lived with her parents and eight siblings. "The meter went BEEEEEP," she recalled.

To Hans' dismay, at least 17 of 37 homes tested contained radioactive ore or tailings.

Hans said he wrote to EPA headquarters in Washington, D.C., recommending that the agency clean up the most contaminated homes or relocate the occupants. "You've got two risks -- gamma radiation and you've got radon," he recalled. "It wasn't acceptable."

His higher-ups said no.

"I still felt uncomfortable," Hans said, so he urged the Indian Health Service to act. The response was the same.

"Finally, we got the message," said Hans, now retired and living in Las Vegas. "We didn't have the money to go decontaminating sites."

Still, he wanted to warn homeowners. Most spoke Navajo and were uncomfortable with English. So Hans went back with a translator.

"All we could say is, 'You got a problem.' "

He could offer no hope that the government would fix it.

Just 200 miles from the reservation, in Grand Junction, Colo., residents faced the same situation. But there, the government was moving with urgency to eliminate the health risk posed by homes, schools and churches made with tailings from the Climax Uranium Co.

State health authorities had armed themselves with research and demanded federal action. The local congressman, Democrat Wayne N. Aspinall, was chairman of the House Interior Committee. He held hearings and helped secure funds for a thorough cleanup, which ultimately cost more than \$500 million.

The Navajos had no such champion. Nor did they mobilize politically around the issue. In their small, widely scattered settlements, people were only vaguely aware of a radiation problem.

In Grand Junction, canvassers went door to door, checking for contamination. Contractors replaced foundations and floors, uprooted trees and cleaned tainted soil. As a bonus, they upgraded substandard electrical systems.

The Navajos were left on their own.

Hans made one more try in 1977, two years after his first visit. He recommended that the Department of Energy clean or replace the nine most-contaminated houses in Cane Valley.

More than a decade later, the department fixed three. Drawing a technical distinction, it passed over the other six for lack of proof that the building materials came from Foote Mineral's mill, as opposed to the mine.

Juanita Jackson's house was one of those six. Despite Hans' warning, she stayed put, stringing beads for jewelry and weaving rugs until she died in 1992. She was 59. The cause was lung and breast cancer, her daughter said.

Jesse Black, his wife and their eight children remained in their uranium house for 15 years. Black died of lung cancer in 2000 at age 78. A daughter was diagnosed with breast cancer at 27.

Oscar Sloan, too, hung on in Cane Valley, raising three boys. One of them, Hoskey, now 54, says that both of his parents and his grandmother developed serious respiratory disease.

"If given a different place to live, we would have, I guess," he said. "But it was the only dwelling we had."

More contamination

Similar problems soon became evident in other parts of the reservation. In 1979, employees of the tribe's newly created environmental commission escorted a television crew to the hamlet of Oaksprings, Ariz., to interview former miners.

In one house, a tribal staffer offhandedly stuck a Geiger counter against a wall. It

screamed.

By April 1980, the tribe had found 16 more Oaksprings houses with uranium. The tribal chairman, Peter MacDonald, called together representatives of Navajo agencies, the U.S. Bureau of Indian Affairs and the Indian Health Service, and "directed that the homes be replaced immediately," recalled Harold Tso, then the Navajo environmental director. "We were to work together and get a plan."

Tso cobbled together enough federal money to replace a handful of houses. The tribe evicted the other families in the spring of 1981. They were left to find shelter wherever they could.

There was no money to dismantle the condemned structures. Many still stand, including the log cabin that Clifford Frank built in the early '60s for his family of eight. He mixed cement for the foundation with rocks from the uranium mine where he worked. Then he invited a Christian Reformed minister to bless the house.

When the tribe padlocked the cabin years later, Frank was furious. But there was little he could do. Frank, a nonsmoker in his 50s, was in the Indian Health Service hospital in Shiprock, N.M., slowly succumbing to lung cancer.

A family in the dark

The Holidays had no inkling of a problem.

Their hogan in Oljato had become the center of a bustling family compound. Dogs and chickens ran between an assortment of earthen and stucco dwellings. An array of aging trucks and cars sat in the dirt.

By the late '70s, Mary and Billy Boy had moved out of the hogan and into a two-room house 15 feet away that they painted a bright teal blue.

But the old place wasn't empty. Mary allowed her niece, Elsie Begay, to move in with her seven children after Elsie's marriage broke up in 1978.

Elsie and her brood ate their meals on the floor. At night, they rolled out their sheepskins and went to sleep. After three years, they left for a smaller dwelling on the Holiday property.

The hogan wasn't vacant long. Two of the Holidays' grown children, Daisy and Robert, returned to Oljato and moved in.

Daisy had taken a husband. He'd grown up on the mesa where the old mine was. He turned the story of their courtship into family lore: He slipped one day while herding sheep, fell down the slope, found Daisy at the bottom and married her. The uranium stain on the cliff marked the path of his slide, he liked to quip.

Robert had taken a bride. Mary was a witness, signing the marriage certificate the only way she knew how, by dipping her right thumb in ink and affixing her print.

The two couples, and soon enough three children, lived together under the green-shingle roof. From the front door, they could watch the setting sun wash Monument Valley's spires of stone in red.

Members of the family took jobs catering to tourists. The paved road that had first attracted Mary and Billy Boy to the hogan led to a historic lodge. They cleaned rooms there and tended the register at the grocery store next door. They guided visitors to the rock formations and sold turquoise and silver jewelry from plywood stands.

In 1989, Elsie Begay's son Lewis died of a brain hemorrhage caused by a tumor. He was 25. The next year, Billy Boy died, suffering from lung cancer and other diseases. He was in his early 60s.

During the 1990s, touches of modernity seeped into the compound. Daisy and her husband, Frank Haycock, bought a trailer and hooked it up to electricity. They even got a TV.

Robert left the reservation to join his older brother, John, in Salt Lake City, lured by a good job installing air conditioners and heaters.

But the hogan still had its uses. The Holidays stored cans of beans, sacks of flour, extra blankets and toys there, along with garden tools and blue plastic water barrels.

The door was padlocked, but the children liked to stand on one another's shoulders and climb through the windows. They'd tear into the folded clothes and don them for long games of pretend.

Once a month, Robert's family came down from Salt Lake for the weekend. There was only one place to stay: the hogan. Everyone took to calling it "the rabbit house" because one of the toddlers pronounced "Robert" that way.

U.S. 'lack of interest'

In 1981, 10 of the reservation's local governments, called chapters, asked the tribe to inspect houses for signs of uranium contamination. But "we had our old nemesis -- money," Tso said. His appeals to federal agencies were met with "a real lack of interest."

The prevailing attitude was expressed in a December 1986 memo by Charles A. Reaux, an Indian Health Service official stationed in the Navajo region. Ticking off mining-related hazards, he wrote: "Radon in homes is another significant but resource consuming endeavor."

The tribe had surveyed 96 homes and found 37 with radon levels above the EPA's safety

threshold, he wrote to his superiors. Many areas near abandoned mines had yet to be tested, including Monument Valley-Oljato, where the Holidays lived.

But he recommended against getting involved because of the cost. The health service, he wrote, "should only monitor tribal efforts."

Reaux offered his bosses the same advice for nearly all of the environmental problems confronting the Navajos: Keep your distance. "The true risk assessment of the radiation problems may never be performed due to the vast cost," he wrote.

In a recent interview, Reaux, now a consultant in Las Vegas, said that if the same contaminants "were in the middle of Los Angeles, something would be done about it because there would be thousands of people living around them."

But Navajo shepherds moving through the desert with their herds and the locals in their far-flung hogans were not numerous enough to warrant government action. "That's life," Reaux said.

Cancer on the rise

Richard M. Auld Jr. arrived on the reservation in 1982, fresh from his residency in internal medicine at UC San Diego.

He was posted to the Indian Health Service clinic in Shiprock, N.M., at the edge of the uranium belt. Over the next two years, he treated six cases of stomach cancer. Two of the patients were women, 18 and 20 years old.

Auld thought this highly unusual. He won a two-year fellowship in gastroenterology at the Scripps Clinic and Research Foundation in La Jolla, to try to find an explanation. He worked with William S. Haubrich, a prominent gastrointestinal specialist.

Their review of Indian Health Service medical charts showed that stomach cancer on the reservation had increased sharply in 1975 -- which suggested, given cancer's latency period, that something had changed during the '50s. The increase kept up through the mid-'80s. Patients typically died within five months.

The doctors' research ruled out hereditary factors, medications, alcohol and smoking as possible causes. But when the locations of cases were plotted on a map, they clustered around the sites of uranium mines and mills.

They discovered that incidence of stomach cancer was 15 times the national average in some areas near uranium deposits and mills.

And the disease was not limited to former miners. In two western parts of the reservation filled with old pit mines, stomach cancer was 200 times the U.S. average for women ages 20 to 40.

New evidence shows that gastric cancer rates rose 50% during the '90s among Indians in two New Mexico counties salted with Navajo uranium mines.

"I don't know quite what to make of it. It's not what's happening regionally," said Charles Wiggins, director of the New Mexico Tumor Registry, who analyzed the data for the Los Angeles Times.

Diet or bacterial infections could play a role, but so could an environmental insult, Wiggins said: "All three of those things are what I would want to look at."

Uranium mining could be connected to reproductive cancers as well. In 1981, the tribe's health department reported a sharp increase in breast, ovarian and related cancers among teenage girls. Rates 17 times the national average were found.

In 2001, Navajo graduate students and reservation elders asked scientists at Northern Arizona University to investigate whether the old uranium mines might explain the increase in cancers.

Biologist Cheryl A. Dyer was intrigued but skeptical. "I didn't believe this for a long time," she said.

Dyer specializes in the female reproductive system. She and a Navajo doctoral candidate, Stefanie Raymond-Whish, fed uranium-tainted water to mice. They discovered that uranium mimics the hormone estrogen, causing changes in reproductive tissue. Increased estrogen has been linked to breast and ovarian cancers.

The findings "changed my research," Dyer said. "Now all I do is uranium." She has discovered that uranium speeds the growth of human breast cancer cells. "Instead of killing them," she said, "it makes them happy."

Closer to the truth

A helicopter rumbled low and loud across the sky over Oljato in the late summer of 1997.

Mary Holiday took little notice. She had heard that, under pressure from the tribe, the EPA was finally gathering data on potential radiation hazards throughout the reservation.

She did not know the copter's onboard scanner had picked up high levels of radiation on her property.

The helicopter was forgotten until 1999, when a filmmaker from Chicago showed up looking for Mary's niece, Elsie Begay.

Elsie, it turned out, had been featured as a young girl in a silent movie from the 1950s set in Navajo country. She had never seen it. The man from Chicago, Jeff Spitz, had come into possession of a copy and was recording her reaction to it for a documentary.

Someone mentioned the helicopter and the radiation sampling. Curious and a bit worried, Spitz called the EPA when he got home. He eventually pried a map from the agency. Unfurling it on his kitchen table, he studied the bright purple splotches marking high radiation. One of the largest and darkest spots was over the Holiday compound.

"Look at this!" he blurted. "That's Elsie's house!"

He got a message to her. She was concerned but unsure what it meant.

Around the same time, Elsie's youngest son, Leonard, learned that he had lung cancer. He was 38.

Leonard had been 16 when his mother sought refuge with her children in the Holidays' cozy hogan. He grew into a handsome man with a broad face, a dark mustache and glossy black hair. He took up carpentry and played drums at the Pentecostal church. He passed a note during services to a young woman named Sarah. She became his wife.

After the children came along, Leonard installed a trailer at the Holiday compound. Their daughter was 7 and their son 12 when Leonard was diagnosed. He sought a second opinion; the doctor concurred. He got a third with the same result.

"We were supposed to grow old together," said Sarah Begay. "He just started getting into his Bible. He told me not to tell nobody at all."

A tainted home

In January 2000, specialists from the Army Corps of Engineers showed up in Oljato to sample drinking water for the EPA. They were part of the same project that had sent the helicopter overhead.

The leader, Glynn R. Alsup, was worried by what they were finding. One in five water sources tested was polluted with dangerous amounts of uranium and other mining byproducts.

"Nobody could believe it was that bad," he said.

Alsup briefed local officials and residents about his work, and offered to screen homes for radiation. At Oljato, he visited the Holiday compound and talked to Elsie Begay. He told her he had permission from the chapter to sample anything she wanted.

She wanted a check of her aunt's hogan. She knew the history of its concrete floor.

Alsup held a radiation detector up to an outside window. The needle jumped to the top of the scale.

"I'd gotten readings that high at the entrance to uranium mines," recalled Alsup, now retired.

Leonard and Sarah Begay heard his voice quaver as he circled the hogan, calling out numbers. Inside, emissions reached 1,000 microroentgens per hour, 75 to 100 times the radiation level deemed acceptable by the EPA.

Leonard was losing weight. The pain was getting bad. A sudden suspicion struck him and his wife.

Mary Holiday and Daisy Haycock were also on hand for the radiation readings. Daisy called her brother Robert in Salt Lake City to break the news about the "rabbit house."

Reluctant to act

Navajo officials in the tribal capital of Window Rock, Ariz., did not like Alsup informing locals of the dangers he was uncovering. Alsup only wanted to help. But the tribe's environmental staff believed nothing good would come of it. There was no money to fix the problems.

"It's just a fancy, nice-looking report that's going to sit on a shelf," Derrith Watchman-Moore, then the tribe's environmental director, remembered thinking. Frightened Navajos, she said, "would be coming to us: 'What are you going to do about it?'"

The situation revived long-standing tensions. Despite years of appeals from the Navajos, the U.S. government still had not committed to pay for a comprehensive cleanup of the reservation. Alsup's visit to the Holiday hogan was the last straw, as far as the tribal government was concerned.

The Navajos demanded that the EPA pull Alsup off the reservation. He was gone within weeks, and the sampling ground to a halt.

The hogan was left standing. Six months later, in June 2000, Elsie Begay wrote to the EPA to inquire about its fate. "The kids were still going in it," she recalled.

"We recommend that people stay out of that hogan," Sean P. Hogan, an EPA official, wrote back after three more months had passed. "We also recommend that the hogan be removed from the area so that no one is exposed to those levels of radiation."

But treading carefully after the blowup with Navajo officials, he added that the EPA would not take action unless the tribe asked.

The Oljato chapter appealed to the tribal government, which in October 2000 authorized the EPA "to take the steps necessary to eliminate this risk."

It was not until April 2001 that the EPA destroyed the place, along with a radioactive

house miles away.

The grand total of government demolitions still stands at two.

Where the Holidays had lived for decades, the wrecking crew wore moon suits and radiation badges for a single day's work.

The U.S. government gave Mary Holiday a corrugated-metal shed to compensate her for the loss of storage space.

Uranium's deadly toll

On Dec. 7, 2003, two days after his lung began bleeding profusely, Leonard Begay collapsed and was flown to University Medical Center in Tucson. "This patient lives in Monument Valley, UT, near the uranium mines," the attending physician noted in his records.

Leonard knew what to expect. Sarah's father, a veteran of the mines, had died of lung cancer the month before.

"He was aware that he was going," Sarah recalled. "He would talk to me: Take care of yourself. Stay in the Word. Take the kids to church."

He kept hugging and kissing his family and asked his wife to lie beside him. Sarah said he instructed her "to build a house for the kids and then for the grandkids that he'll never see."

On Dec. 19, he died at 2:50 a.m. He was 42.

Sarah told her children that they all had something in common: She had lost her dad to uranium, and she was certain they had lost theirs to uranium too.

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Times researchers Mark Madden and Sunny Kaplan contributed to this report.

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Blighted homeland

Four articles on the legacy of uranium mining on the Navajo reservation.

Today

Families spent years in radioactive homes, unaware of the danger.

Monday

Navajos quenched their thirst at watering holes that turned out to be toxic.

Tuesday

How the tribe and the U.S. botched the chance for a thorough cleanup.

Wednesday

Uranium producers want to resume mining, with new technology.

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On the Web

For a narrated photo gallery with Navajo voices and music, visit latimes.com/navajo.*

Note on sources

The risk of lung cancer associated with the Holiday family hogan was calculated for The Times by radiation expert Andrew G. Sowder using Environmental Protection Agency models. Sowder, who took readings inside the home while on a research fellowship, said that someone who lived there for 10 years could be 32 times more likely to die of radon-induced lung cancer than someone exposed to the average U.S. residential radon level.

Internal documents of the EPA and Indian Health Service cited in this article were obtained through the Freedom of Information Act. Mine records came from the National Archives, the Bureau of Land Management and William L. Chenoweth, a former Atomic Energy Commission geologist.

GRAPHIC: Spread of radioactivity

CREDIT: Lorena Iniguez Los Angeles Times

GRAPHIC: Cold War legacy (includes map of Navajo reservation)

CREDIT: Doug Stevens Los Angeles Times

PHOTO: 'WE WERE SUPPOSED TO GROW OLD TOGETHER': Sarah Begay visits the grave of her husband, Leonard. He was diagnosed with lung cancer at 38. He had lived in a tainted hogan years earlier.

PHOTOGRAPHER: Gail Fisher Los Angeles Times

PHOTO: AMID THE RUBBLE: Old cars and contaminated debris lie near the abandoned uranium mining site in the Navajos' Cane Valley, near the Arizona-Utah line.

PHOTOGRAPHER: Gail Fisher Los Angeles Times

PHOTO: LOSS: Mary Frank's husband, Clifford, died of lung cancer. Their log cabin and other buildings in the family compound, including this one, were made with mine waste.

PHOTOGRAPHER: Gail Fisher Los Angeles Times

PHOTO: LEFTOVER: A chunk of uranium ore is one of many scattered among the debris near a reclaimed pit mine.

PHOTOGRAPHER: Gail Fisher Los Angeles Times

PHOTO: EMPTY: The two-bedroom cabin Clifford Frank built in the '60s. When the tribe later padlocked the cabin, Frank was furious. But there was little he could do. He was slowly succumbing to cancer.

PHOTOGRAPHER: Gail Fisher Los Angeles Times

PHOTO: MINING BOOM: Uranium for the U.S. arms race with the Soviet Union was chiseled and blasted from a desert reservation that spans parts of Arizona, New Mexico and Utah.

PHOTOGRAPHER: Gail Fisher Los Angeles Times

PHOTO: 'IT MADE GOOD CONCRETE': In the 1960s, a friend of Mary Holiday's suggested using sand and rock from an old uranium mine to make a new floor for her hogan.

PHOTOGRAPHER: Gail Fisher Los Angeles Times

PHOTO: HOGAN ON THE RANGE: Elsie Begay believes a hogan that stood near this one caused her sons' deaths. Here on the Utah-Arizona line, and across the Navajo reservation, many hogans were built with uranium waste.

PHOTOGRAPHER: Gail Fisher Los Angeles Times