



BUREAU OF BUSINESS  
& ECONOMIC RESEARCH



# THE ECONOMIC OPPORTUNITIES AND CHALLENGES OF URANIUM MINE CLEANUP IN NEW MEXICO

Prepared for the New Mexico Legislature Indian Affairs Committee

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We take full responsibility for any errors or oversights that may be contained within this report.

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# Executive Summary

New Mexico was a principal site of uranium mining in the US from the 1940s until the collapse of demand in the 1990s. Much of the mining activity was in northwestern New Mexico, on and neighboring Native American tribal lands, particularly those of the Navajo Nation.

A legacy of uranium mining is severe environmental contamination, including approximately 1100 mining, milling, and exploratory drilling sites in northwest New Mexico, as well as extensive groundwater contamination. Native, especially Navajo, communities have suffered the majority of the consequences of this contamination. Native populations, many of whom were employed in uranium mining operations, also suffered severe economic dislocation following the collapse of the industry.

Significant measures to address the environmental impacts of past uranium mining have emerged only recently. Remediation has been complicated by the difficulty of identifying the parties who are legally responsible for the environmental damage, as control of mining operations and attached leases frequently changed hands during repeated cycles of boom and bust. Moreover, processes necessary to fund and oversee remediation work have been established only over the past two decades. A hopeful development was the 2015 Tronox settlement, under which the US Environmental Protection Agency (EPA) secured more than \$1 billion to fund the cleanup of 56 sites on or near territory of the Navajo Nation, including the Quivira mine sites and the Shiprock Uranium mill site in northwestern New Mexico.

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## Advantages and Challenges of Focusing on Uranium Mine Remediation

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BBER conducted over 75 interviews with unique individuals, agencies, or companies working in fields related to uranium mine remediation, regionally. In these interviews, professionals commonly described a willing, able workforce with only piecemeal employment opportunities available. The mismatch of opportunities with skills is a key challenge the state will face when engaging in uranium mine remediation activities. However, from a New Mexico economic development perspective, given the significant levels of expertise in this state concerning nuclear materials, mining, engineering, health, and legal and legislative matters, developing a model for bringing all these resources together to address the various issues surrounding uranium mine cleanup could represent not only immediate benefit to residents and businesses in New Mexico but could also parlay this model into a significant new business sector. As we continue to see fluctuations in the extractive energy economy's stability, it is essential to diversify our economic development priorities. In those regions, such as northwestern New Mexico, most dependent on energy resource development, planning for environmental remediation work would also reposition our already experienced workforce for possible economic shifts.

As mines move into remediation and reclamation, work will need to occur on a potentially massive scale. Many of the individuals previously employed by the mining industry already have labor skills that could transition to environmental remediation work but may need reorientation or training to complete that transition. Working in uranium mine cleanup requires specific training, but some of the base-level skills developed across the mining industry could be transitioned to work in environmental remediation.

Mining jobs fluctuate with the market for natural resources, but environmental remediation jobs have the potential to endure over time. We know that cleanups for even the fraction of assessed mines will require multiple years of intensive labor in addition to follow-up monitoring into the foreseeable future. Beyond what we already know, hundreds of mines in New Mexico remain unassessed for remediation actions. Work will

depend on the intensity and speed of cleanup actions, which depends on the funding of cleanup efforts, but has the potential to last generations addressing New Mexico's mines alone.

Beyond New Mexico, a sector focused specifically on environmental remediation with specialized expertise in radioactive cleanup could export its industry nationally and internationally. Uranium mine sites exist all around the world. Further, there are active uranium mines that someday will close--either because demand and economics don't justify the continuation of the mines or because the deposits are sufficiently depleted as to render these mines uneconomic, compared to other sites with greater reserves. With the inclusion of environmental remediation as a priority industry, New Mexico could develop a skills list for businesses and individuals trained in uranium mine cleanup work and help increase our educational programs alongside in-state corporate growth. This focus could also make New Mexico a place for international education, attracting students from other countries to learn from our professionals at our state institutions.

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## Limitations of the Study

This report is limited in three regards.

- ▼ The economic impact analysis (EIA) is an exercise to illustrate how cleanup funds would be distributed throughout the New Mexico economic system. It is not predictive of funds secured under current or future settlements or those spent by responsible parties under other consent decrees. The EIA is presented in this document in a manner that allows the findings to be applied to new settlements.
- ▼ Funding for uranium cleanup is not always consistently available, nor is it always usable by state agencies. Further, available funding may cover multiple states and mine sites. For example, the current funding from the Tronox settlement covers uranium cleanup sites on or near the Navajo Nation not only in New Mexico, but in Arizona as well, and is being managed by the EPA. The analysis included in this document is limited to sites located in New Mexico, though again it is presented in a way that allows for application to other sites.
- ▼ Most importantly, this document addresses only the immediate or direct economic impacts of uranium waste cleanup and does not address longer term and/or broader impacts of contamination, such as provision of community health services or the benefits of a healthier workforce.

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## Recommendations to Develop Future Opportunities

In all, the findings of this report are based on more than 75 in-depth interviews, cost-estimate and invoice data from government agencies conducting uranium mine cleanups, geographic, geologic, and historical information about the nature and scope of uranium mining in New Mexico. In the report, we present twelve recommendations to systematically address challenges the State currently faces in tackling uranium mine remediation. They are presented not necessarily in order of priority but as a logically structured program to promote the cleanup of uranium sites.

Addressing these challenges will require the involvement of *all* stakeholders: federal, State and local governments, Native nations, private landowners, private sector firms, educational institutions, and community organizations; however, the recommendations here are designed for State action, as the State of



New Mexico sponsored this research project. Recommendations are presented not necessarily in order of priority but as a logically structured program to promote the cleanup of uranium sites.

Specifically, based on the findings of this comprehensive study BBER offers four categories of interrelated policy recommendations that may be undertaken by the State of New Mexico:

1. Overall planning recommendations
  - Create a central repository for all documentation related to uranium mining, employment, remediation, ownership, and land status.
  - Identify and engage key stakeholders who will be most impacted by uranium mine remediation activities.
  - Develop a unified plan with key stakeholders, creating a culture of communication and collaboration among the various entities impacted.
  
2. Addressing challenges faced by state businesses may include:
  - Establishing a specialized small business assistance center to maintain an up-to-date listing of contracting opportunities in environmental remediation and assist in navigating the paperwork and certification processes both before and while managing federal contracts.
  - Creating a shared workspace or workspaces for business networking and coordination. These spaces could also serve as a repository for contact information, both for businesses able to do remediation work in New Mexico and individuals with certifications and skill sets appropriate for the industry. They would provide centralized locations for notification of upcoming RFPs and potential subcontracting opportunities.
  - Creating a facility to provide support or guarantee for bonding and capital requirements for small New Mexico businesses.
  
3. Addressing challenges faced by the state's workforce may include:
  - Advancing consistent safety certification training programs for qualified workers.
  - Facilitating collaboration among higher education institutions to ensure research is being shared and institutional overlap is minimized.
  - Creating opportunities for worker placement locally, including the development of increased networking events.
  
4. A focus on the development of future opportunities
  - Prioritize environmental remediation as a target industry, focusing specifically on specialized expertise in radioactive cleanup.
  - Generate pathways for greater innovation by bringing together creative experts across industries.
  - Continue research on the effects of unremediated uranium mines beyond economic impacts, including, but not limited to cultural impacts, health impacts, and validity of metrics used for cleanup standards.

New Mexico's uranium mine issues may seem too big to tackle, but with the proper support, the State has the ability to leverage existing expertise in environmental remediation; thus, utilizing our existing resources for economic development and creating an industry to address this seemingly insurmountable problem.

# Introduction

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## 1.1 Background

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In 2019, the New Mexico legislature appropriated funds for FY 2020 to The University of New Mexico's Bureau of Business and Economic Research (BBER) to investigate the potential economic impact of uranium mine cleanup and assess the workforce capacity for conducting the cleanup work. The funding was first proposed in HB233, as introduced by Rep. D. Wonda Johnson, and later authorized in HB548 (Section 27.A.4). The work was conducted with oversight by the New Mexico Legislature's Indian Affairs Committee. This report summarizes the results of the study.

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## 1.2. Purpose of the Study

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New Mexico was a principal site of uranium mining in the US from the 1940s until the collapse of demand in the 1990s. Much of the mining activity was in northwestern New Mexico, on and neighboring Native American tribal lands, particularly those of the Navajo Nation.

A legacy of uranium mining is severe environmental contamination, including approximately 1100 abandoned mining, milling, and exploratory drilling sites in northwest New Mexico as well as extensive groundwater contamination. Native, especially Navajo communities have suffered the majority of the consequences of this contamination. Native populations, many of whom were employed in uranium mining operations, also suffered severe economic dislocation following the collapse of the industry.

Significant measures to address the environmental impacts of past uranium mining have emerged only recently. Remediation has been complicated by the difficulties of identifying the parties legally responsible for the environmental damage, as control of mining operations and attached leases frequently changed hands during repeated cycles of boom and bust. Moreover, processes necessary to fund and oversee remediation work have been established only over the past two decades. A hopeful development was the 2015 Tronox settlement, under which the US Environmental Protection Agency (EPA) secured more than \$1 billion to fund the cleanup of 56 sites on or near territory of the Navajo Nation, including the Quivira mine sites and the Shiprock Uranium mill site in northwestern New Mexico.

It is crucial that the communities most impacted by legacy of uranium mining in the state, especially Native communities, benefit economically as well as environmentally from remediation efforts, including those to be funded by the Tronox



*Image 1 – The Mount Taylor mine site recently announced official closure. It will now enter into the remediation phase.*

settlement. This would include participation of Native-owned firms and employment of Native workers. Support of this goal is the principal intention of legislators sponsoring the funding of this study.

However, there are significant constraints to the participation of these communities in the cleanup of uranium contamination sites in New Mexico. Without targeted efforts, there is a risk that economic benefits associated with environmental remediation will pass by the very communities that for decades have incurred the greatest costs, with wages and profits accruing to companies and workers not principally located in the region.

The purpose of this document is to:

- ▲ Estimate potential economic benefits of uranium mine cleanup in New Mexico;
- ▲ Identify the challenges that local businesses and the local workforce face in participating in the cleanup; and
- ▲ Recommend actions that the State of New Mexico may take to support the full participation of local communities in remediation work.

This report is limited in three regards.

- ▼ The economic impact analysis (EIA) is an exercise to illustrate how cleanup funds would be distributed throughout the New Mexico economic system. It is not predictive of funds secured under current or future settlements or those spent by responsible parties under other consent decrees. The EIA is presented in this document in a manner that allows the findings to be applied to new settlements.
- ▼ Funding for uranium cleanup is not always consistently available, nor is it always usable by state agencies. Further, available funding may cover multiple states and mine sites. For example, the current funding from the Tronox settlement covers uranium cleanup sites on or near the Navajo Nation not only in New Mexico, but in Arizona as well, and is being managed by the EPA. The analysis included in this document is limited to sites located in New Mexico, though again it is presented in a way that allows for application to other sites.
- ▼ Most importantly, this document addresses only the immediate or direct economic impacts of uranium waste cleanup and does not address longer term and/or broader impacts of contamination, such as provision of community health services or the benefits of a healthier workforce.

# Background

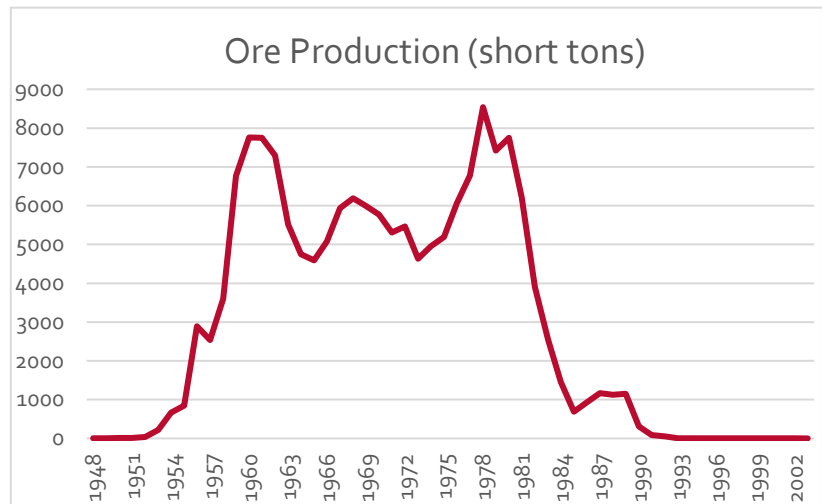
## 2.1. History of Uranium Mining in New Mexico

### 2.1.1. Uranium Mining and the Atomic Energy Commission

Many of the uranium mines in New Mexico date back to the early 1940s, when the Atomic Energy Commission was purchasing ore for defense-related purposes.<sup>1</sup> However, despite the relatively new interest in uranium at the time, many mine sites already existed, focusing primarily on extracting radium in the 1920s and vanadium in the 1930s.<sup>2</sup>

The shift to uranium extraction occurred in 1948 when the US Atomic Energy Commission (AEC) announced a guaranteed price for all US-produced uranium ore through the Atomic Energy Act (AEA). Additionally, uranium prospectors were incentivized with access to federal buying stations and the use and building of access roads to mines as the government sought to thoroughly bolster development of the industry. Many mines were established during this period and many sites were remined or remilled.

Figure 2.1. Uranium Ore Production in New Mexico 1948-2002



### 2.1.2. Commercial Mining

As the AEC's stockpile built up between 1948 and 1962, the federal government began to slow its purchase rate of uranium ore. From 1962 to the official end of the procurement program in 1971, the AEC only honored price incentives for ore discovered before 1958; during this time, uranium production declined steeply and many mines were abandoned. However, by the mid-1960s, the nuclear power industry began ramping up development and was well positioned to take over for the US government as primary purchaser of US-mined uranium ore with the procurement program's termination.

Due to economic shifts in the production of uranium ore described above, the industry saw booms and busts that led to periods of feverish mining followed by sudden abandonment. Mining companies frequently changed hands, leases were transferred or allowed to expire, and the records of historic responsibility for cleaning up a mine site were not well kept. Mine owners would also occasionally vanish alongside a mine's profitability. Various companies owned and managed uranium mines from the 1950s forward, but the large numbers of original individual prospectors and frequent ownership

<sup>1</sup> Department of Energy. 2014. "Defense-Related Uranium Mines Location and Status Topic Report." *US Department of Energy Legacy Management*.

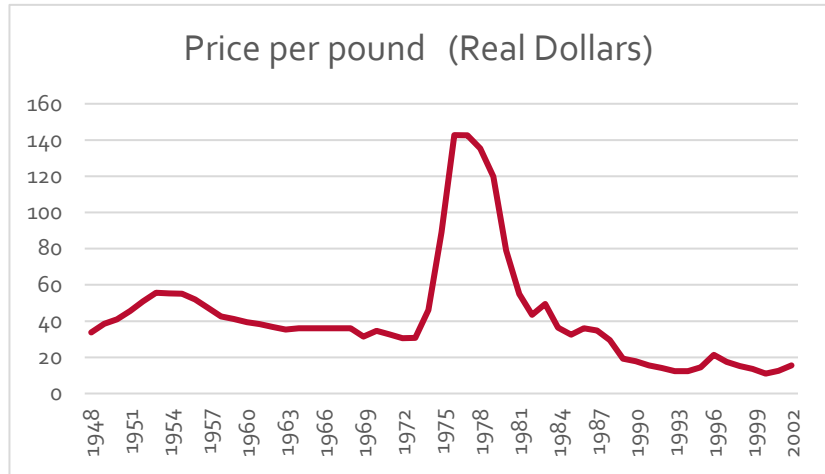
<sup>2</sup> The history of uranium mining and exploration in New Mexico has been well documented. In this section, we used information from Rautman, Christopher. 1977. "The Uranium Industry in New Mexico." *New Mexico Bureau of Mines and Mineral Resources*; Chenowith, William L. 1985. "Historical Review of Uranium Production from the Todilto Limestone, Cibola and McKinley Counties, New Mexico." *New Mexico Geology* 8:80-83.;

Chenowith, William L. 1989. "Geology and Production History of Uranium Deposits in the Dakota Sandstone, McKinley County, New Mexico." *New Mexico Geology* 11(2); and Zhu, Liping. 1995. "The Historical Statistics of the New Mexico Mining Industry." *Mining History Journal*.

changes created a cleanup situation for which Potentially Responsible Parties (PRPs),<sup>3</sup> the person or company liable for cleanup costs cannot always be found.

In the late 1970s, uranium production in the United States saw a second peak, with purchases by commercial markets, primarily focused on energy production. However, by the 1980s, Canadian and Australian uranium became favored globally as it was extracted at a lower cost and a higher grade. Additionally, The Three Mile Island (TMI) accident crystallized anti-nuclear safety concerns among activists and the general public, and resulted in new regulations for the nuclear industry.<sup>4</sup> Coupled with the Chernobyl accident in 1986, TMI has been cited as a contributor to the decline of a new reactor construction program in the US and elsewhere, a slowdown that was already underway in the 1970s.<sup>5</sup>

Figure 2.2. Uranium Ore Price per Pound over Time



Nuclear energy began to more fully fall out of favor by the 1990s and the US saw a stoppage of new nuclear power plant construction. Although demand for uranium held steady until 2003, the United States faced an oversupply and the uranium mining industry again declined.

New Mexico has approximately 1100 uranium mines and mine sites, none of which are actively producing ore, and most of which have not been producing ore in decades. However, it wasn't until the 1990s that a regulatory framework was developed within the State of New Mexico to address uranium mine remediation and contamination issues. Because of this, the state has many abandoned mines that need remediation but have no potentially responsible party available to pay for that remediation. Mines that need remediation, have a responsible party, and have undergone CERCLA classification as a Superfund Site involve the EPA working to hold them liable for some or all of the cleanup costs. For some of the mines that are not designated as Superfund Sites limited remediation may have been done on to help reduce airborne contamination or other minor safety issues; however, these efforts rarely addressed issues such as groundwater and were not necessarily permanent solutions. We discuss the CERCLA classification process in more detail in Section 2.4.1.

Tracking down which mines have had any cleanup actions taken was arduous and the information gathered was sometimes incomplete or contradictory. The most comprehensive analysis of mine sites was taken on by New Mexico Tech; BBER utilized their 2002 database of mine sites for much of this report. Unfortunately, the lack of complete long-term records means that not all hazards from mine sites are well documented and of those sites that have had actions taken, many are considered partially remediated needing more work and further analysis to become fully remediated.<sup>6</sup>

<sup>3</sup> PRP is a legal term used by the EPA to pursue the costs of cleaning up sites designated as "Superfund Sites" under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). More information can be found at <https://www.epa.gov/enforcement/superfund-liability>. We have used "PRP" to refer to any party that may be responsible for cleanup funds, whether or not the site has been designated as a Superfund Site.

<sup>4</sup> "Chernobyl Nuclear Accident". [www.iaea.org](http://www.iaea.org) - May 14, 2014

<sup>5</sup> *The Economist*. <https://www.economist.com/briefing/2011/03/24/when-the-steam-clears> March 31, 2011.

<sup>6</sup> Ulmer-Scholle, Dana S. 2019. "Uranium Legacy Issues in New Mexico." *New Mexico Bureau of Geology & Mineral Resources*.

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## 2.2. Uranium Waste Sites

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### 2.2.1. Geography and Ownership

The following map illustrates the density and jurisdictional complications involved in uranium mine cleanup efforts. In this section, we discuss the difficulty in determining mine ownership and responsibility as well as the complexity involved in undertaking multijurisdictional cleanup efforts.

Part of the reason for the sheer number of mines in the Colorado Plateau region is the small-to-moderate-sized nature of the ore bodies located in the geologic area. This compounds the issues of tracking down Potentially Responsible Parties (PRPs) as government incentives encouraged exploration and small prospecting operations were able to extract and sell uranium with less visibility than the larger mining operations. As the small pockets were emptied, the mines were often abandoned and the waste left behind. When the AEC ended its procurement program in 1971, many of the smaller sized mines had either become economically unviable or devoid of purchasable ore.

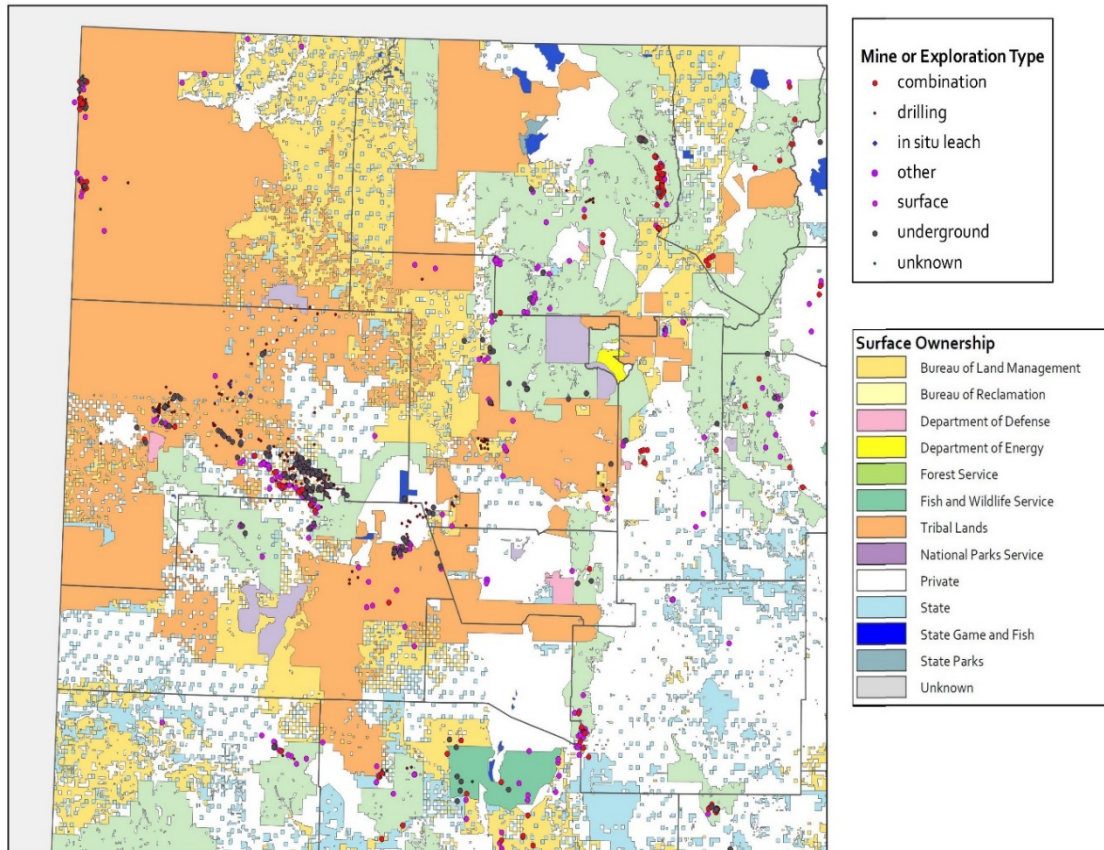
Much of the area in the Grants Mineral Belt is within the “checkerboard”. This term refers to the way in which lands are owned or managed by different entities throughout the region, such that a jurisdictional map of the region looks like a checkerboard. This complicated map of ownership developed over time beginning with attempts to assimilate the Native American population through private land ownership by the federal government’s Dawes Act in the late 1800s. Through this Act, reservation land was allotted to specific tribal members rather than the tribe as a whole. When the original person holding the deed died, the land was divided among the heirs legally, but not physically. As this continued through time, it created a situation known as “fractionated ownership,” often with hundreds or thousands of Native owners having legal claims to the same original plot of land.<sup>7</sup>

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<sup>7</sup> Environmental Protection Agency. 2006. “Technical Report on Technologically Enhanced Naturally Occurring Radioactive Materials from Uranium Mining Volume 1: Mining and Reclamation.” (<https://www.epa.gov/sites/production/files/2015-05/documents/402-r-08-005-v1.pdf>).

Figure 2.3. Uranium Mine and Exploratory Drilling in Northwest New Mexico Map  
Map created by Rose Elizabeth Rohrer using both the database generated by the NM Bureau of Geology and Mineral Resources and data compiled by Sofia Ximenez-Byrne

### Uranium Mines And Exploratory Drilling In Northwest New Mexico



The Dawes Act further divided Native land by claiming reservation land not specifically allocated to an owner as “surplus.” This land was again divided, set aside for the railroad, given federal or state management, and sold to private individuals and corporations. Due to the mixed jurisdictional nature of the space, two neighboring plots of land may have different laws which apply to them. This creates issues with development of a cohesive land-use plan. For example, the Navajo reservation has prohibited uranium extraction and transport within its boundaries. However due to the checkerboard nature of the region, plots of land directly adjacent to Navajo land could be potentially mined. Some of the jurisdictional issues were partially resolved in the 1980s when the Navajo nation in the state of New Mexico entered into a joint power agreement through which they are “able to enforce law within the other’s jurisdiction.”<sup>8</sup>

Abandoned uranium mines (AUMs) are a significant feature on the uranium remediation landscape. Abandoned uranium mines are defined as mines utilized for atomic energy defense related activities by the United States government with no record of a PRP. These mines may have a variety of features including partial remediation, existing permits with abandoned features, large scale or small scale exploration, waste piles, underground features, and the like. Not all of these mines have been fully surveyed so their characteristics are not known. However, the Department of Energy (DOE) was required to re-submit a report to Congress in July 2014, outlining the locations, risks, potential costs, and ranking for reclamation on these sites. 247 of these DOE AUM sites are located in New Mexico. Many of these lands are located on

<sup>8</sup> Indian Land Tenure Foundation. N.d. “Land Tenure Issues.” (<https://iltf.org/land-issues/issues/>).

Bureau of Land Management (BLM) parcels. However, some mines are on non-federal land or land of unknown ownership. This makes jurisdiction over the sites difficult. Additionally, some of the mines may have impacted groundwater, causing higher remediation costs. Cleanup standards also varied from state to state and site to site.

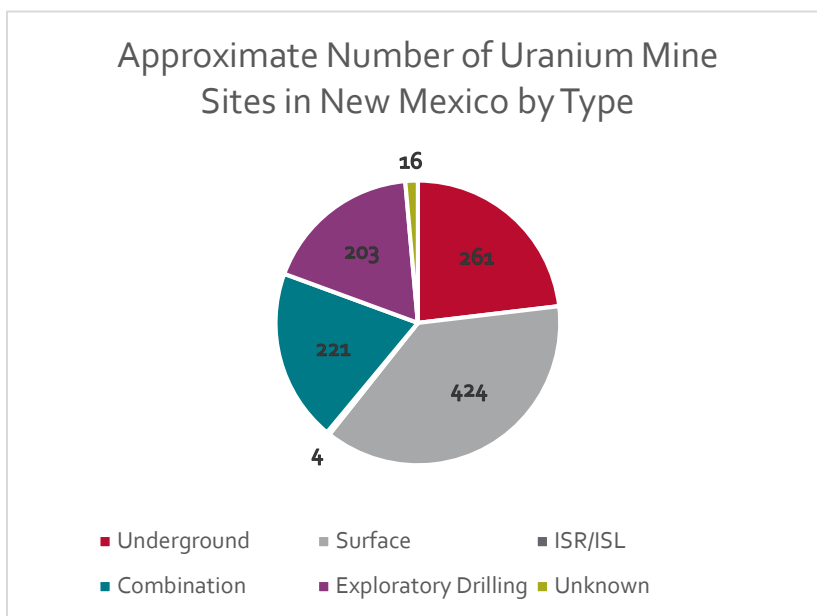
The federal government is in the process of conducting field visits to all of the mines in the AUM database. These visits are being conducted in order to verify the status the size and anything else that needs to be considered in the reclamation of these sites.<sup>9</sup>

### 2.2.2. Type

This section draws heavily on an EPA Technical Report discussing the methods involved in extracting uranium ore.<sup>10</sup> For greater detail on the types of uranium mines, please reference the document listed in the footnotes.

There are three primary methods of uranium mining used in the United States: open-pit, underground, and in-situ leach (ISL). Open-pit and underground mines are generally designated as “conventional” mining methods whereas ISL is considered “unconventional”. Each mine type requires different cleanup methods. Agencies assessing a uranium site for cleanup make such determinations. In our section on assessing the cost of cleanup, we further discuss what that might look like for different types of mines.

Figure 2.4. Approximate Number of Uranium Mine Sites in New Mexico by Type



Open-pit mining<sup>11</sup> generally occurs when desirable ore is found near the surface. It tends to be the least expensive of the three methods of extraction. To create an open-pit mine, a company excavates materials such as soil and other non-desired materials, some of which may be later reclaimed, physically removing them from the desired ore body. These materials may include protore, “conventionally mined uranium ore that is not rich enough to meet the market demand and price.” Once the ore body is exposed, it is assessed and the company has to determine if it will continue to utilize surface mining techniques to extract the ore or if it will need to develop underground mines, thus creating a combination mine site.

Underground mining techniques are utilized when the ore body is deeper below the surface. There are several types of underground mines, characterized by the size, shape, depth, and grade of the ore body, the stability of the ground, and economics. Some extractions require smaller access points such as adits, inclines, or small shafts. Deeper extractions, however, may utilize large, concrete-lined shafts and the development of stopes to access all of the ore body.

<sup>9</sup> Department of Energy. 2014. “Defense-Related Uranium Mines Location and Status Topic Report.” *US Department of Energy Legacy Management*.

<sup>10</sup> Environmental Protection Agency. 2006. “Technical Report on Technologically Enhanced Naturally Occurring Radioactive Materials from Uranium Mining Volume 1: Mining and Reclamation.” (<https://www.epa.gov/sites/production/files/2015-05/documents/402-r-08-005-v1.pdf>).

<sup>11</sup> Definitions of the technical terms used throughout the report can be found in the glossary in Appendix 4



Risks are highest in underground mines due to radon gas – ventilation is key. This means that these mines will have at least two openings, one for access and one for ventilation. These can be shafts (vertical) or adits (horizontal), or a combination. The extent of underground development is the biggest cost consideration in closure, especially if no remediation or reclamation has been done previously. The cost increases are due to the materials and labor needed to fill in the underground development on an increasing scale as well as the need to survey and assess the full extent of the mine.

In-Situ Leach (ISL) mines are unique in their use of groundwater resources to extract low-grade uranium. A solution utilizing the water and other chemicals is pumped into the area with uranium ore to “mobilize” it. Once the ore is mobilized into the solution, it is pumped back to the surface for processing. ISL mining techniques are generally used in conditions that make conventional forms of mining economically unviable. ISL mines require the most future monitoring and groundwater treatment and contracts for these types of mines require restoration plans for the water. However, the restoration process does not ensure post-use potability.

The mining itself is not the only concern for cleanup, as the refining and transportation processes have associated costs and concerns. Milling, or the processing of uranium ore into a usable product, creates large amounts of radioactive and toxic waste products. There are no mills currently in operation in New Mexico, though eight mills were in operation over the course of New Mexico’s uranium extraction history and will need remediation strategies as well.<sup>12</sup> However, the scope of this report focuses primarily on cleanup associated with the mines themselves, as the cost estimate documentation we had available was strictly for mine sites. More information about the issues with other processes can be found in the myriad technical resources we cite throughout the report.

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## 2.3. Current Status of Cleanup Work

Although the Navajo Abandoned Mine Lands Reclamation Department (NAML) has addressed hundreds of abandoned uranium mines on Navajo Nation lands and both State and Federal agencies have engaged in a variety of cleanup efforts, there is still a nearly endless amount of work still to be done. Funding is neither limitless, nor is it predictable, but with greater cooperation and involvement of the State, remediation work could become more streamlined throughout New Mexico. This section will discuss the funding and settlements impacting regional uranium mine cleanup efforts.

### 2.3.1. Available Funding and Settlements

The EPA has the power to enforce US environmental law, including cleanup enforcement. This may include working with companies that conduct their own cleanup efforts, creating legal orders compelling companies to perform cleanup actions, or litigating to have companies pay for cleanup by a third party or the EPA. Both the expenditures and the specific remediation actions taken are easiest to track when the EPA or a third party is responsible for site cleanup. Companies conducting their own cleanup actions, whether compelled by EPA litigation or not, are required to adhere to EPA cleanup standards, but do not offer the same degree of transparency about how they achieve those standards. For the purposes of this report, BBER uses documentation from the EPA and other government agencies on the cost of cleanup; corporate records do not have the same level of detail of hiring practices, wages, and operations.

For many uranium mine cleanup actions, the EPA may first need to find the PRPs as many of the mines were abandoned before they were cleaned up. In the remainder of this section, we will outline a few specific mine site actions and also examine current initiatives to bring in more cleanup funds.

The New Mexico Church Rock mine and mill sites serve as an example of complex liability and delays in cleanup. In 1959, the Santa Fe Pacific Railway entered into an agreement with the “Navajo Tribe of Indians” to prospect and mine for

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<sup>12</sup> [https://geoinfo.nmt.edu/staff/mclemore/projects/uranium/documents/50C\\_URANIUM\\_inprog\\_013ginger.pdf](https://geoinfo.nmt.edu/staff/mclemore/projects/uranium/documents/50C_URANIUM_inprog_013ginger.pdf)

uranium in specific areas of the Navajo Nation, including areas near Church Rock, New Mexico. These mines would change hands throughout the 1950s and 1960s, with the United Nuclear Corporation (UNC) and Kerr-McGee mining the Church Rock area extensively. In 1974-1975, UNC built a mill and tailings disposal area, forcing the relocation of Navajo families who had established camps and grazing areas on the land. Mill tailings were held in holding ponds until July 16, 1979, when the dam holding the tailings collapsed, causing largest release by volume of radioactive waste in US history. The UNC mines and mill were not closed until 1982. The Kerr-McGee mines did not close until 1983. Remediation is not yet complete on this site, despite the tireless advocacy work done by nearby and affected communities. The EPA completed an Engineering Evaluation/Cost Estimate for this site in 2012. The specific extraction and cleanup history of the Church Rock Mine and Mill Sites is illustrated in the timeline found on the next two pages of this report and detailed in Appendix 5.<sup>13</sup>

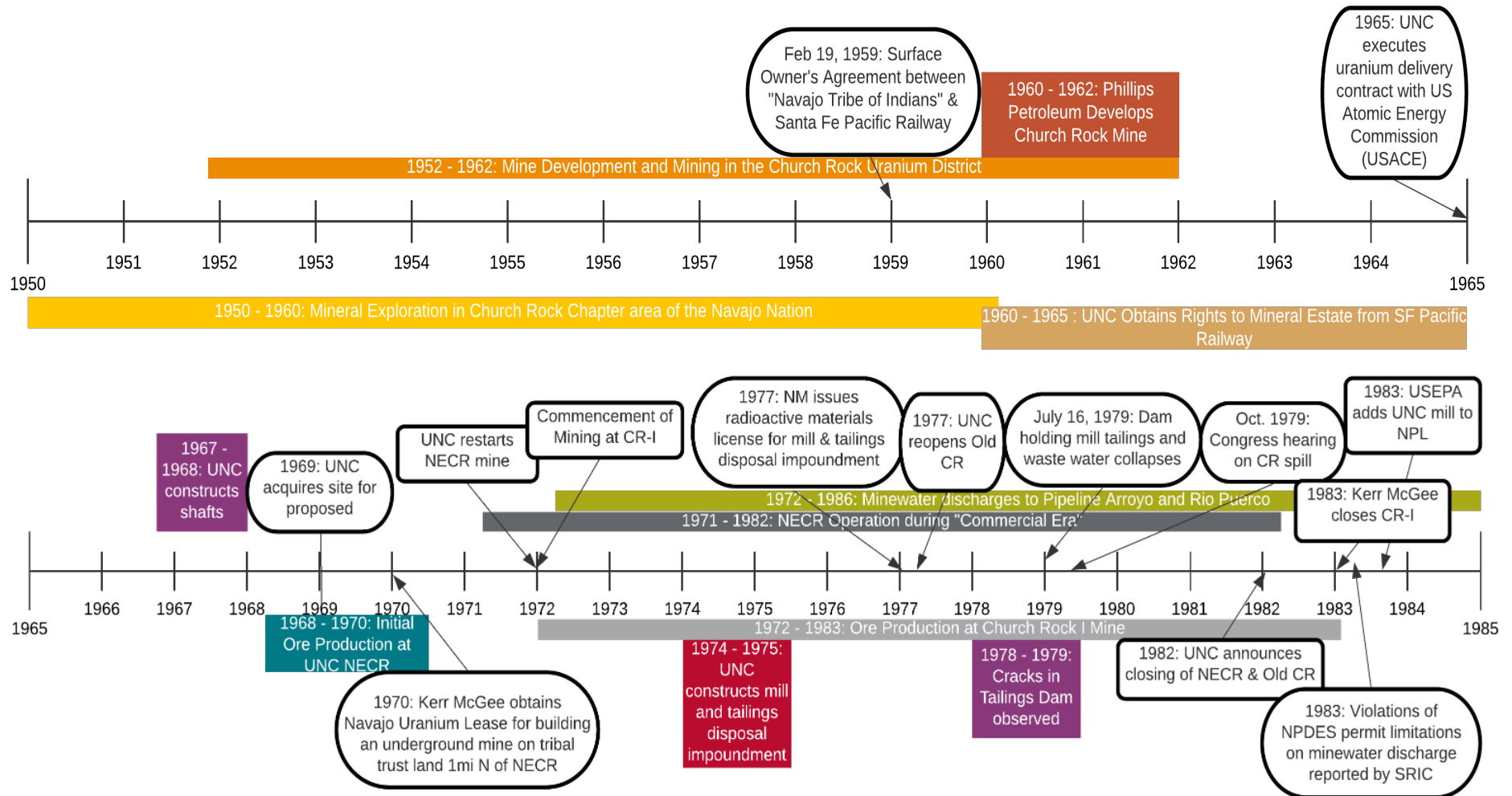
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<sup>13</sup> Data for this timeline was generated by the Southwest Research and Information Center; the timeline was designed by BBER's Sofia Ximenez-Byrne.

Figure 2.5. Northeast Church Rock Uranium Mine Timeline of Key Events

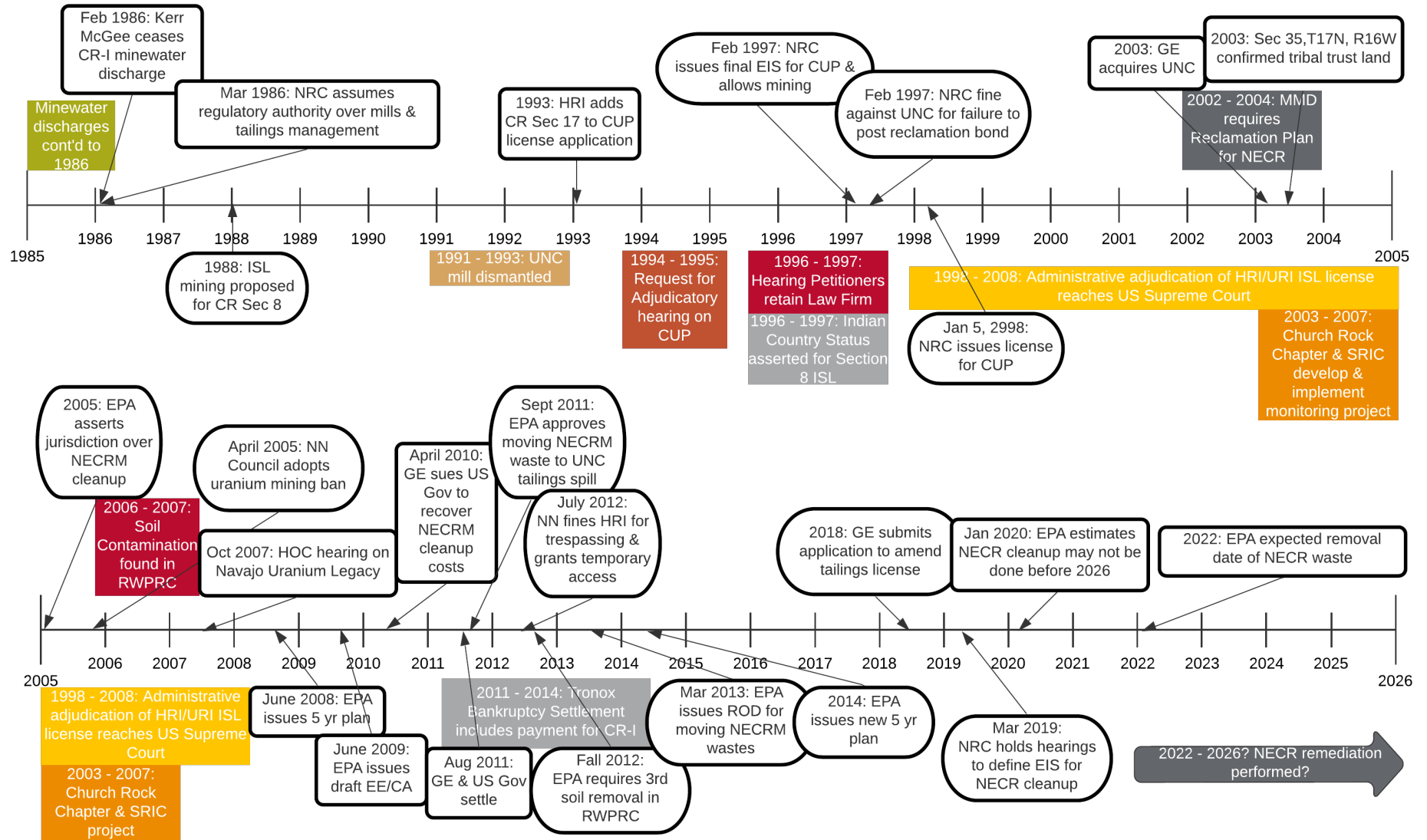
## Northeast Church Rock Mining Timeline

1950 - 1985



## Northeast Church Rock Mining Timeline

1986-2026



On the Laguna Pueblo sits the Jackpile-Paguete uranium mine site, once the biggest open pit uranium mine in the world. Uranium was extracted from this site between 1953 and 1982 by Anaconda Minerals Company. In 1986, the Laguna Pueblo and Anaconda's parent corporation, Atlantic Richfield Company (ARCO) entered into an agreement to remediate the mine site. Remediation activities took place from 1986-1995, but in 2007 follow-up testing demonstrated that the cleanup work was incomplete. The EPA determined that surface and groundwater were still being impacted by discharges from the remediated mine site. In 2013 that Jackpile-Paguete was listed on the EPA's National Priorities List (NPL), the "most serious sites identified for long-term cleanup."<sup>14,15</sup> This work needed to complete remediation is still undergoing investigation, 7 years later.

In 2013, the El Paso Natural Gas Company, LLC signed an Administrative Order on Consent (AOC) to take on remediation actions at 19 mines on the Navajo Nation in Arizona. Remediation of the sites began in 2015, but the company had to enter into a modification to the AOC in 2017, agreeing to complete additional cleanup work.<sup>16</sup> What makes this case particularly noteworthy is the Arizona Federal District Court's ruling in 2019 that only 65% of past and future costs of cleanup are to be paid by El Paso Natural Gas Company; the remaining 35% are to be paid by the Federal Government.<sup>17</sup> This case and the Tronox case represent significant precedents that may inform future uranium mine remediation decisions in New Mexico and throughout the US.

### 2.3.2. Remediation Completed and Underway

A recent case of EPA cleanup enforcement is the Tronox Settlement of 2015. This settlement was a larger case against the Anadarko Petroleum Corporation and its related subsidiaries found responsible for a variety of environmental damage across the United States. The settlement yielded approximately \$917 million to the EPA for cleanup of 54 uranium sites across and near Navajo Nation territory, \$92 million to the EPA for cleanup of Quivira mine site, and \$45 million to the Navajo Nation for work on the Shiprock Uranium Mill Site.<sup>18</sup> Although the cleanup associated with mill sites is outside this report's scope, the distribution is noteworthy, and many of the constraints and recommendations we discuss later in the report could also apply to mill sites.

The most recent EPA documentation shows \$44.6 million spent through FY2018 for approved projects related to the Tronox and Quivira sites.<sup>19</sup> This money was used primarily on contracts for infrastructure upgrades to access the sites; site assessments; educational outreach; and emergency and rapid response services, which provide "management, field personnel, and equipment resources to execute decontamination, demolition, and removal services."<sup>20</sup> This is a mere 4.2% of the total allocated for cleanup efforts and has focused on pre-cleanup work.

The share of the total funding for these sites that will be spent on preliminary work remains to be seen. Still, the report illustrates the broad scope of work to be done before addressing any contaminated land. Depending on the site, this work may consist of access improvement, technical assistance, and community outreach. Additionally, each site must be thoroughly evaluated, and a plan formulated to decide how the cleanup will be done. Tetra Tech<sup>21</sup> was awarded an \$85

<sup>14</sup> <https://www.epa.gov/superfund/about-superfund-cleanup-process#tab-2>

<sup>15</sup> <https://semspub.epa.gov/work/o6/300064.pdf>

<sup>16</sup> <https://www.epa.gov/navajo-nation-uranium-cleanup/el-paso-natural-gas-mines>

<sup>17</sup> <https://casetext.com/case/el-paso-natural-gas-co-v-united-states-g>

<sup>18</sup> Details of the Tronox Financial Settlement can be found at <https://www.epa.gov/navajo-nation-uranium-cleanup/tronox-abandoned-uranium-mines>.

<sup>19</sup> The complete financial report can be found on the EPA website at: <https://www.epa.gov/sites/production/files/2020-03/documents/tronox-naum-report-fy2011-2018-2020-03-05.pdf.pdf>.

<sup>20</sup> Ibid.

<sup>21</sup> Tetra Tech (<https://www.tetratech.com>) is a multinational firm that provides engineering and consulting services related to "water, environment, infrastructure, resource management, energy, and international development."

million capacity contract in 2017 to complete these assessments. The Removal Site Evaluation reports (RSEs), which document the nature of the contamination and assess the work to be done at each site, were published early in 2020.<sup>22</sup>

With this information, we can estimate that roughly 8-9% of the total costs of mine remediation efforts may go into assessment tasks alone. Because of the nature of the agreement and the involvement of the EPA in managing the funds, far more is known about Tronox than other cleanup efforts.

In addition to the Tronox Settlement, other noteworthy cases of funded cleanup enforcement include the following:<sup>23</sup>

- Cyprus Amex and Western Nuclear have been required through a 2017 settlement to clean up 94 uranium mine sites on the Navajo Nation, with the federal government providing half of the approximately \$600 million, requiring both US EPA and NN EPA oversight.<sup>24</sup> This includes the priority cleanup of the Ruby Mines in the Smith Lake Chapter, about 30 miles east of Gallup.
- Two agreements between the Navajo Nation and the US government to assess, evaluate, and clean up AUMs across the Navajo Nation. The first agreement established a trust of \$13 million to assess 16 priority mines in 2015; the second an initial funding of \$8.5 million for the assessment of 30 additional mines and the cleanup of the 16 mines from the first agreement. A trustee has been established to oversee the work and administer the contracts.
- Additionally, the EPA has enforcement agreements for the evaluation of 37 uranium mines across the Four Corners region. These sites must also have preliminary safety precautions installed, including, but not limited to, warning signs and appropriate fencing. Some of these agreements have funding associated with them, but not necessarily the full amount required to conduct a cleanup.
  - Within New Mexico, these agreements include the BNSF Railway Company's Haystack Mines near Prewitt, New Mexico, Chevron's Mariano Lake Mine southwest of Crownpoint, and Homestake's four mines near Mariano Lake and Smith Lake, United Nuclear Corporation's Northeast Church Rock Mine.

### 2.3.3. Other Cleanup Efforts in Discussion

Conversations with both the EPA Region 6 and EPA Region 9 staff indicate that the Tronox funding is not only unprecedented, but unlikely to be repeated at such a great scale. However, various entities continue to pursue cleanup funding and corporate responsibility for remediation. We will discuss a few of these cases below.

In July 2019, the EPA sent General Notice Letters to ten corporations under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), naming them as Potentially Responsible Parties (PRPs) that may be responsible for cleanup actions. These letters focus on the San Mateo Creek Basin Legacy Uranium Mines Superfund Site in Cibola and McKinley Counties. As the EPA took responsibility under Superfund authority for the assessment of these sites, the letters serve to notify the corporations of the potential cost for compensating the EPA for assessment costs and the potential cost for cleanup efforts. The letters suggest the corporations could conduct the cleanup work in-house with EPA supervision through the Superfund Alternative Approach; if the corporations do not agree to this action, the mines could be listed on the National Priorities List (NPL) and be subject to litigation for cleanup funds. The timeline for receipt of

<sup>22</sup> Access to the RSEs is found on this main EPA Tronox website: <https://www.epa.gov/navajo-nation-uranium-cleanup/tronox-abandoned-uranium-mines>.

<sup>23</sup> See ETD, Inc. 2018. "Abandoned Uranium Mine Funding Sources." <https://etd-inc.com/recent-news/abandoned-uranium-mine-funding-sources> for further documentation.

<sup>24</sup> <https://www.epa.gov/navajo-nation-uranium-cleanup/cyprus-amax-and-western-nuclear-mines>

a response was 14 days after the PRPs received the letter; however, due to confidentiality issues, we are unable to report the results of the conversations between the EPA and the individual corporations at this time.

In early 2020, Rio Grande Resources announced the closure of their 148-acre Mount Taylor uranium mine. This mine had not been active since the 1990s but held a permit to resume mining through New Mexico's Mining and Minerals Division (MMD). With this closure, the company enters into the cleanup phase, reclaiming the land and plugging or demolishing any underground structures and waste disposal ponds.<sup>25</sup> Although Rio Grande Resources is in charge of its own cleanup, there may be opportunity for local job development. This could also potentially apply to those PRPs named in the San Mateo Creek Basin letters.

## 2.4. Uranium Remediation

### 2.4.1. Defining "Cleanup"

Any cleanup of New Mexico's uranium mines falls under the jurisdiction of the New Mexico Mining Act (NMMA) and the New Mexico Water Quality Act.<sup>26,27</sup> These acts are administered by the New Mexico Energy, Minerals, and Natural Resources Department (EMNRD) and the New Mexico Environment Department (NMED). New Mexico agencies employ standards in guidance documents from various federal sources as well as locally established standards. There is no single standard for uranium mine reclamation; rather, each site is assessed, and a plan is put into place for remediation or reclamation. After a cleanup in New Mexico is deemed "complete" by the EPA, the State has the ability to assess the site according to State standards and law.

Regulations for cleanup vary depending on whether the mine site is new, recently active, idle, abandoned, and/or partially reclaimed as well as whether the contamination is in the soil, the air, or the water. Mine closeouts, as specified by NMMA, require reclamation of the "physical environment of the permit area to a condition that allows for the reestablishment of a self-sustaining ecosystem on the permit area following closure." However, should this reestablishment be technically or economically unfeasible or environmentally unsound, this requirement may be waived by the EMNRD Director, as long as cleanup meets other federal and state laws, regulations, and standards. The NMMA outlines the rights and responsibilities of utilizing and reclaiming mined lands in New Mexico and the MMD and NMED Joint Guidance for Cleanup and Reclamation covers the layers of regulatory framework for uranium mining operation cleanup in detail.

When a uranium mine site is found to have released or potentially released hazardous materials into the environment, CERCLA may apply and the location may be placed by the Environmental Protection Agency (EPA) on the National Priorities List (NPL). CERCLA requires that site be evaluated for potential damage to both environmental and human health and authorizes short-term, immediate actions and/or longer-term, remedial actions. This act gives the EPA the power to both identify companies responsible for environmental damage and to levy cooperation from those companies for cleanup compliance.

Remediation and restoration both refer to the cleanup of polluted sites but have different specifications. Remediation efforts work to reduce or stop pollution, focusing on the removal of pollutants and immediate reduction of contamination.<sup>28</sup> Restoration aims to rehabilitate the contaminated site to a healthy habitat. The majority uranium mine

<sup>25</sup> Davis, Theresa. 2020. "Owners to Close Mount Taylor Uranium Mine." *Albuquerque Journal*.

<https://www.abqjournal.com/1407671/owners-to-close-mount-taylor-uranium-mine-ex-navajo-pueblo-groups-hope-healing-can-start-with-cleanup-of-the-site.html>

<sup>26</sup> Full text of the NMMA can be found at <http://www.emnrd.state.nm.us/MMD/MARP/documents/MiningAct.PDF>

<sup>27</sup> Full text of the Water Quality Act can be found in NMSA 1978, §§ 74-6-1 to 74-6-17, <https://laws.nmresources.com/w/nmos/Chapter-74-NMSA-1978>

<sup>28</sup> The definition of reclamation from New Mexico's Energy, Minerals, and Natural Resources and Environment Departments (2016) reads as follows: "Employment of the measures during and after a mining operation designed to mitigate the disturbance of affected

sites within New Mexico have seen minimal remediation work and little-to-no restoration work, though assessments for several sites are currently underway.<sup>29</sup>

The documents that inform this report's economic impact analysis look at the first steps toward remediation. They represent a fraction of the work to be done if uranium mine sites in New Mexico are restored rather than remediated; however, cleanup is limited by what is feasible technically, economically, and politically.

#### 2.4.2. Potential Scope and Cost is Infinite

This background section serves as a brief overview of the history and future of uranium mine cleanup. The creation of this section, and the whole of this report, relied on many resources that delve more deeply into the legal, social, and environmental ramifications of remediation. It is important to note that the scope of remediation work will change dramatically as stakeholders continue to gather information and legal actions are taken to hold corporations responsible for cleanups. With approximately 1100 sites to cleanup in New Mexico alone, the cost is infinite and the timeline indeterminate. Remediation work will assuredly be taking place well into the future, with jobs and opportunities to follow, should New Mexico seize upon them.

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areas and permit areas and to the extent practicable, provide for the stabilization of a permit area following closure that will minimize future impact to the environment from the mining operation and protect air and water resources."

<sup>29</sup> Office of Response and Restoration (NOAA). 2020. "Remediation vs. Restoration: A Tale of Two Terms."

<https://response.restoration.noaa.gov/remediation-vs-restoration-tale-two-terms.html>



# Economic Impacts

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## 3.1. Objective and Scope

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The total economic impact of uranium mine cleanup is mainly determined by availability of funding. To date the US EPA and the Navajo Nation have recovered more than \$1 billion to fund the cleanup of abandoned mines on or neighboring Native lands in Arizona and New Mexico. Beyond this, it is not known how much more money might be recovered to fund further work, how much of these monies will be spent in New Mexico rather than Arizona, when work will be undertaken and completed, and which remediation or reclamation strategies may be employed.

The purpose of this section is to analyze the potential economic impact of investments in uranium mine cleanup in New Mexico. Rather than speculate on future settlements, the focus here is on more answerable questions. For any direct investment in cleanup, what are expected to be the additional or indirect impacts? Which industries will see growth of revenues? What kinds of jobs will be created and at what pay level? The results are presented on a per unit basis, for each \$1 million in direct expenditures. Accounts of future funding can be scaled accordingly.

Because it is not known which cleanup strategies will be used, we provide estimates for three distinct scenarios and two conventional mine types, each using different technologies with markedly different cost structures. These scenarios were developed with the help of technical experts and with reference to scores of technical documents.

## 3.2. Data and Methodology

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This economic impact analysis is based on estimates and costs of uranium mine cleanup of previously or currently funded projects. The principal source of data are federal and state cost-estimation documents, known as Engineering Evaluation/Cost Analysis (EE/CA). An EE/CA is a CERCLA mandated site evaluation, conducted when a uranium mine's preliminary assessment determines a non-emergency or a non-time-critical removal action is needed.<sup>30</sup>

We obtained copies of EE/CAs for sites across the Four Corners region and manually entered and coded the cost estimate data as a base for our analysis<sup>31</sup>. Additionally, we used documents detailing post-cleanup costs from New Mexico's Mining and Minerals Division, though these documents were less detailed than the EE/CAs.<sup>32</sup>

EE/CAs offer various cleanup scenarios, dependent on the type of mine, the amount of waste to be removed, and other site-specific features such as access and geology. We chose three general cleanup scenarios for our analysis: administrative controls only, onsite disposal, and offsite disposal.

We chose these three scenarios to illustrate the most basic possibilities for each site, to generalize about the possible impacts without getting caught up in the technical details that vary significantly from site-to-site. When conducting an impact analysis, we have to make certain assumptions to guide our work. These assumptions are found generally in Appendix F. Our sample size allowed us to analyze costs for varied mine types at several different sites, though geographically appropriate prices and cost estimates were still limited.

The first scenario, called "Administrative Controls," is often listed as the first option in an EE/CA and involves the minimum work required to secure a uranium mine site. This may include building fences, placing warning signs, installing bat gates,

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<sup>30</sup> Full details on the assignment of a site as "non-time critical" and a definition of "removal action" can be found on this website: <https://public.ornl.gov/sesa/environment/guidance/cercla/ntc-removals.pdf>

<sup>31</sup> Actual costs are often reported as lump sums in generic categories, and projected cost analyses contained multiple scenarios for cleanup for each site. Also, cost information for the preliminary work done to assess uranium mines for cleanup is not available, or available only as lump sums, unattached to specific work done.

<sup>32</sup> A list of the documents we used in our analysis is found in Appendix F.

or other small-scale, limited protection actions. Under this scenario, the abandoned mines' physical hazards, such as open shafts, can be addressed for a comparatively low cost – mitigating risks but leaving remediation unaddressed. These sites may still need preliminary work, such as the building of access roads, but are by far the lowest cost option.

The second scenario we examine is onsite disposal. Onsite disposal will vary significantly based on proximity to the water table, erosion, and other geological and geographic features. Waste may be buried onsite, in lined or unlined pits, which may include a cap – materials used as liners and caps vary. These factors contribute to the total cost of cleaning up a site, but generally do not impact how dollars are allocated job-wise or equipment-wise. Materials costs may change, but the rest is relatively consistent, as a function of the total cost. For this reason, we looked at all onsite burial options together in the analysis, to best understand how jobs and dollars might be generated from the essential activities required for this type of cleanup.<sup>33</sup> According to both the documentation we utilized for this report and the interviews we conducted to help inform our analysis, on-site disposal is the most consistently recommended action for uranium mine remediation.

The final scenario we analyzed is offsite disposal. This scenario is by far the most costly scenario and often the most desirable for communities affected by existing mines. Due to a lack of regional disposal sites, transportation costs make up most of the expenses associated with this type of clean up. The issue of finding an appropriate waste disposal site is compounded with the fact that new disposal sites for CERCLA-designated waste cannot be created unless the proposed site is already designated as a CERCLA site itself.

Economic impacts are measured in terms of employment, labor income, and output (revenues to businesses less changes to inventory).

Direct employment is the number of persons directly employed through funds allocated for uranium cleanup and living in New Mexico. Direct labor income is wages, salaries, benefits, and proprietors' income minus federal taxes paid by employees and proprietors engaged in cleanup. Direct output is the total value of production, including direct labor income and in-state expenditures.

Indirect economic impacts are the subsequent effects of business-to-business spending. These include impacts of in-state purchases by businesses engaged in uranium cleanup and remediation, again measured in terms of employment, labor income, and output. Induced economic impacts are subsequent effects of employee spending, including the spending of employees directly engaged in cleanup, employees of vendors and ultimately employees of businesses indirectly supported by earlier rounds of spending.<sup>34</sup> The total impacts are the sum of direct, indirect and induced impacts. The multiplier, a measure of indirect and induced impacts, reflect the extent to which monies are recycled within the state economy; higher values indicate that activities engage a greater share of in-state businesses.<sup>35</sup>

This economic impact analysis is accomplished in three main steps: First, the industry of interest is defined in terms of standard classification methods. In this case, the industrial sector definitions provided by the North American Industry Classification System (NAICS) are used. Second, the direct activities of the industry, as defined in the first step, are tabulated. Finally, impact analysis estimates the indirect and induced impacts on other sectors of the economy that result from the direct activities.

BBER uses the IMPLAN v3.1 proprietary databases and model to estimate the indirect and induced impacts of uranium cleanup. IMPLAN is widely used in regional economic modeling for estimating economic impacts and multipliers.<sup>36</sup> IMPLAN uses a variety of data sources to assess these impacts, including Bureau of Labor Statistics (BLS) Covered Employment and Wages; Census Bureau County Business Patterns (CBP); and Bureau of Economic Analysis Regional

<sup>33</sup> Again, for more details on our assumptions, please see the assumptions document in Appendix F.

<sup>34</sup> In this report, indirect and induced effects are summarized as indirect. Tables in Appendix A disaggregate indirect and induced effects.

<sup>35</sup> Mathematically: Multiplier =  $\frac{\text{Total Effect}}{\text{Direct Effect}}$

<sup>36</sup> <http://www.implan.com/>.

Economic Accounts (REA). Impacts are estimated for the entire state of New Mexico. Purchases expected to be made in the state are included in the estimation, while out-of-state purchases are excluded.

In this study, five possible scenarios are considered based upon the type of uranium mine (surface or underground) and the method of uranium disposal (onsite, offsite, and non-disposal). Note that for underground mines, non-disposal is not considered as there was insufficient data to calibrate that scenario. Table 1 shows the mine data used to run our analysis. Note that the "other" mine types were not used in the impact analysis, but are included in our discussion of the complexity of possible cleanup scenarios.

Figure 3.1. Cost Estimates and Invoices Used for the Impact Analysis by Mine Type

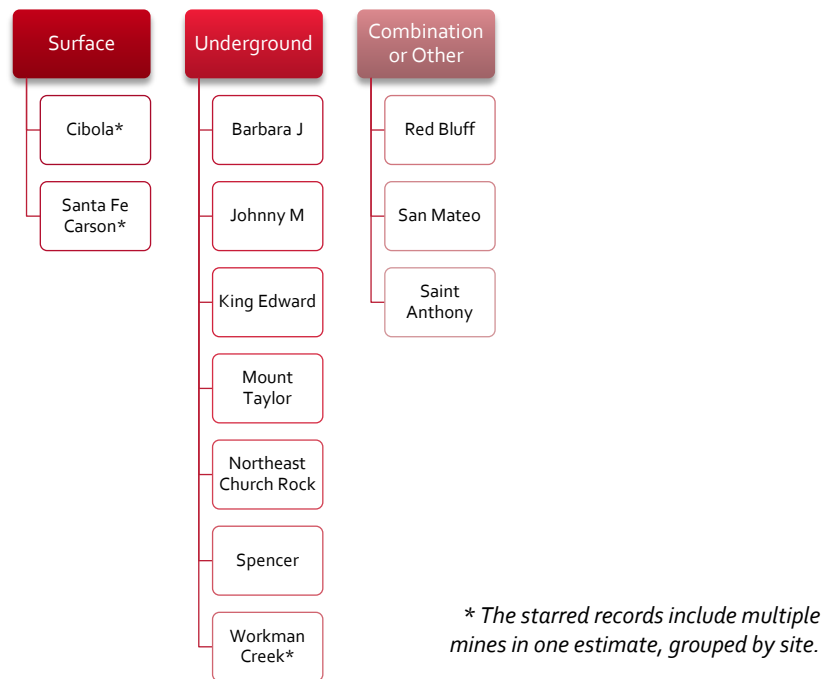


Table 3.1. Table of Possible Remediation Scenarios

		<u>Disposal Site</u>		
		<i>Non-Disposal</i>	<i>Onsite</i>	<i>Offsite</i>
<u>Mine Type</u>	<i>Surface</i>	(1)	(2)	(3)
	<i>Underground</i>	N/A	(4)	(5)

The following sections show the estimated direct, indirect<sup>37</sup>, and total effects (which is just the sum of the direct and indirect effects) for each of the five scenarios. Based on data gathered from the EE/CAs on likely expenditure patterns, it

<sup>37</sup> Recall that indirect effects include induced effects for the purposes of this report.

was possible to estimate direct labor requirements assuming \$1 million in direct expenditure for each scenario and to estimate indirect effects. This allows for a straightforward comparison of the in-state economic impacts of the five scenarios in terms of the jobs created, wages paid, and revenues generated.

In addition to the raw impact numbers described above, economic multipliers are also computed. Although there are large disparities in absolute terms between scenarios based on the data collected and compiled from the documentation, the economic multipliers can provide a clearer picture of how direct effects from employment, labor income, and output reverberate through the economy.

The charts in this section provide a summary account of economic impacts. Full impact results are detailed in tables and charts included in Appendix A.

### 3.2.1. Surface Non-Disposal

Assuming \$1 million in direct investment, the non-disposal scenario for a surface mine has a relatively small impact on the state. This is likely due to the purchase of wholesale goods such as fencing, gates, and other materials that are manufactured out of state. In addition, due to the limited labor requirements expected for non-disposal at surface mines, this scenario only contributes a total of 5.8 total jobs, with 3.3 direct jobs and 2.5 direct & induced jobs. However, this scenario uses the greatest share of professional workers, with 29% of the wages going to engineers and technical service workers.

Figure 3.2. Non-Disposal Impacts of Surface Mine Cleanup (per \$1 Million Direct Investment)

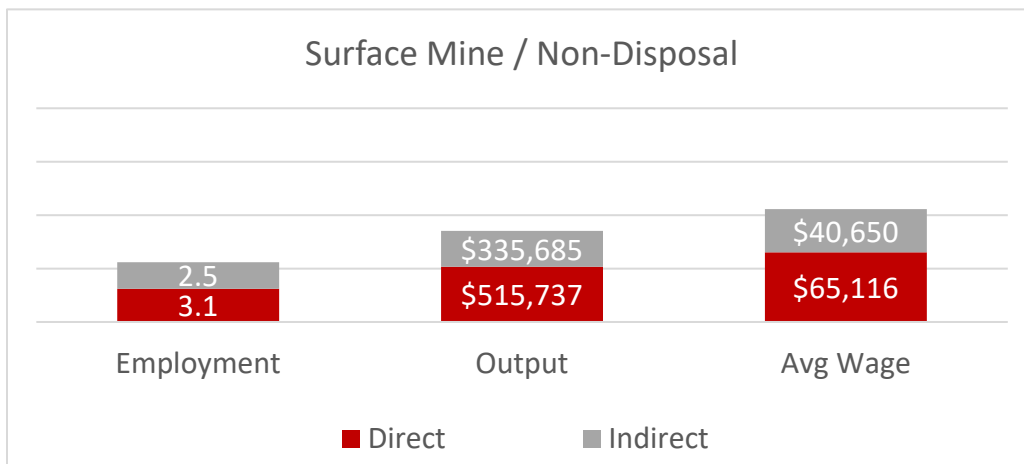


Table 3.2. Total Impact for Surface Mine Non-Disposal, by Industry (per \$1 Million Direct Investment)

Industry	Employment	Labor Income	Output
Commercial and industrial machinery and equipment rental and leasing	0.4	\$35,845	\$138,946
Wholesale trade	0.6	\$33,854	\$123,550
Architectural, engineering, and related services	0.5	\$36,071	\$76,921
Environmental and other technical consulting services	1.0	\$52,340	\$72,914
Truck transportation	0.3	\$15,784	\$43,741
Automotive equipment rental and leasing	0.1	\$7,030	\$31,036
Office administrative services	0.4	\$21,224	\$29,721
Real estate	0.1	\$1,978	\$28,303
Waste management and remediation services	0.1	\$7,634	\$22,459
Construction of new highways and streets	0.1	\$3,197	\$11,407
Other (Implied)	2.2	\$88,514	\$272,423
<b>Total</b>	<b>5.8</b>	<b>\$303,471</b>	<b>\$851,421</b>

### 3.2.2. Surface On-Site Disposal

On-site disposal for a surface mine is fairly capital-intensive compared with other scenarios, yielding \$206,394 in direct output for every direct job created, again assuming \$1 million in investment. This is because on-site disposal uses a large amount of commercial and industrial machinery and equipment rental and leasing (referred to as “yellow iron” within the industry).

17% of the labor income generated in this scenario goes to professional workers, including engineers and technical services and 7% goes to businesses directly engaged in waste remediation. This scenario also has the highest average wage (inclusive of direct and indirect workers) generated at \$55,998.

Figure 3.3. On-Site Disposal Impacts of Surface Mine Cleanup (per \$1 Million Direct Investment)

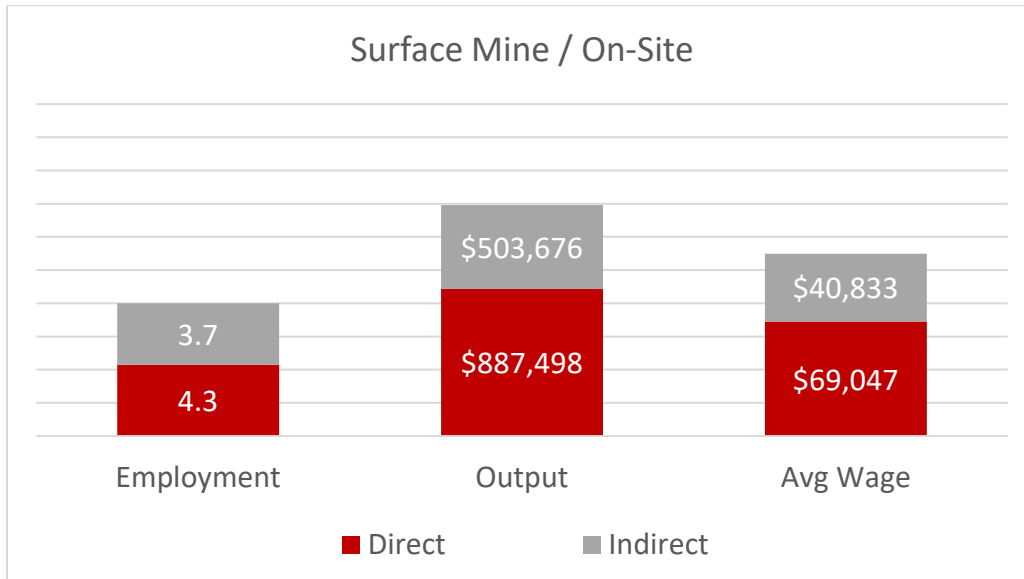


Table 3.3. Total Impact for Surface Mine On-Site Disposal, by Industry (per \$1 Million Direct Investment)

Industry	Employment	Labor Income	Output
Commercial and industrial machinery and equipment rental and leasing	1.3	\$119,494	\$463,187
Architectural, engineering, and related services	0.8	\$61,696	\$131,566
Construction of new highways and streets	0.5	\$25,055	\$89,385
Waste management and remediation services	0.3	\$25,712	\$75,641
Wholesale trade	0.3	\$17,912	\$65,368
Truck transportation	0.3	\$21,159	\$58,637
Environmental and other technical consulting services	0.6	\$32,789	\$45,678
Real estate	0.2	\$2,546	\$36,441
Office administrative services	0.3	\$15,336	\$21,475
Limited-service restaurants	0.2	\$3,079	\$12,530
Other (Implied)	3.2	\$123,206	\$391,266
<b>Total</b>	<b>8.0</b>	<b>\$447,984</b>	<b>\$1,391,174</b>

### 3.2.3. Surface Offsite Disposal

Despite significant losses to out of state vendors in the offsite disposal of a surface mine (22% of direct expenditures), this scenario has a high employment impact of 8.7 jobs for \$1 million invested. Importantly, however, fees paid to the offsite location are not included in the estimates; the estimates focus on the labor and materials required to complete the work.

Impacts in the offsite disposal for a surface mine are largely concentrated in truck and rail transportation; this holds true for all offsite disposal scenarios.

Figure 3.4. Offsite Disposal Impacts of Surface Mine Cleanup (per \$1 Million Direct Investment)

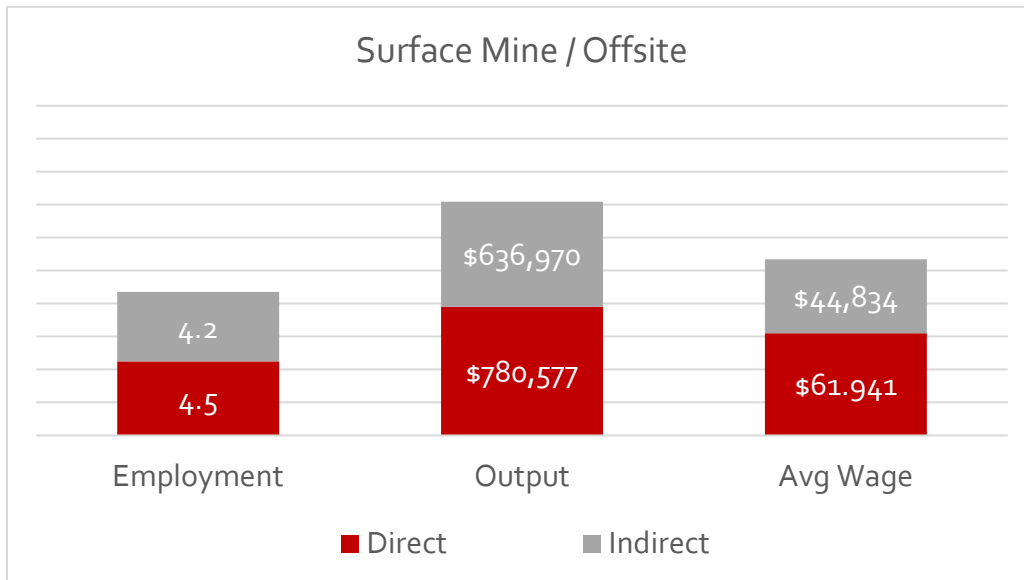


Table 3.4. Total Impact for Surface Mine Offsite Disposal, by Industry

Industry	Employment	Labor Income	Output
Truck transportation	3.6	\$224,265	\$621,493
Wholesale trade	0.4	\$21,653	\$79,023
Commercial and industrial machinery and equipment rental and leasing	0.2	\$17,318	\$67,128
Real estate	0.2	\$2,662	\$38,097
Couriers and messengers	0.3	\$10,160	\$30,575
Architectural, engineering, and related services	0.2	\$12,898	\$27,504
Postal service	0.2	\$15,376	\$18,810
Environmental and other technical consulting services	0.2	\$9,937	\$13,843
Extraction of natural gas and crude petroleum	0.1	\$4,796	\$12,387
Limited-service restaurants	0.2	\$2,874	\$11,696
Other (Implied)	3.1	\$145,100	\$496,992
<b>Total</b>	<b>8.7</b>	<b>\$467,039</b>	<b>\$1,417,548</b>

### 3.2.4. Underground On-Site Disposal

Data for non-disposal options of an underground uranium mine were inadequate for our estimates, so the first underground scenario we will describe is on-site disposal. In an on-site disposal scenario for an underground uranium mine, we expect to see significant investments in professional work, with 22% of employment in engineering, environmental, and other technical services. Waste remediation has the largest direct investment in a single industry with 10% of the total projected employment. However, this scenario includes significant spending on industrial equipment and machinery (19% of total impacts), which results in losses to out-of-state businesses and weighs against the total impacts of investment.



Figure 3.5. On-Site Disposal Impacts of Underground Mine Cleanup (per \$1 Million Direct Investment)

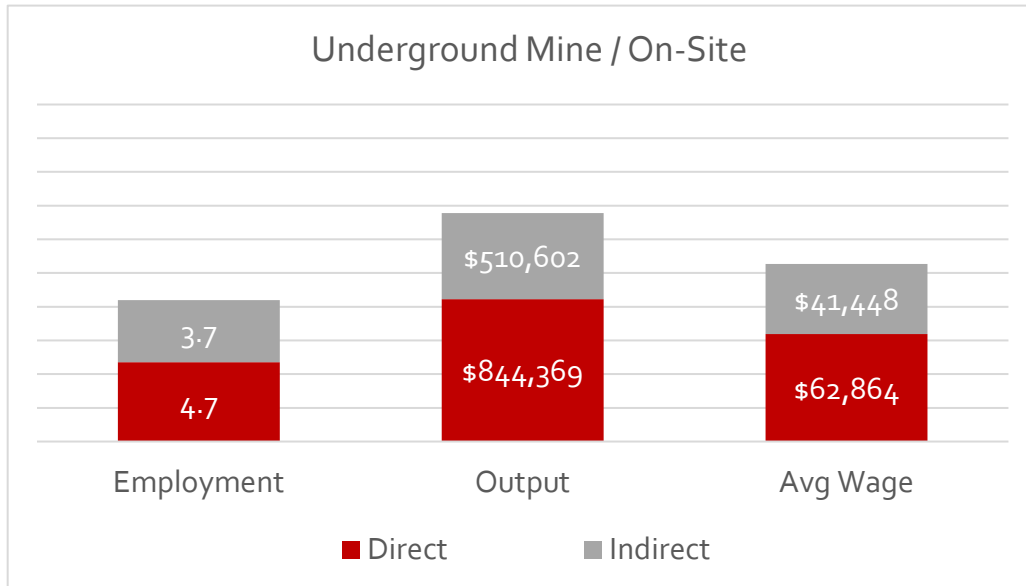


Table 3.5. Total Impact for Underground Mine On-Site Disposal, by Industry (per \$1 Million Direct Investment)

Industry	Employment	Labor Income	Output
Commercial and industrial machinery and equipment rental and leasing	1.0	\$84,214	\$326,435
Waste management and remediation services	0.6	\$45,846	\$134,872
Architectural, engineering, and related services	0.7	\$54,996	\$117,277
Construction of new highways and streets	0.5	\$21,665	\$77,291
Wholesale trade	0.3	\$18,913	\$69,023
Truck transportation	0.4	\$23,328	\$64,648
Environmental and other technical consulting services	0.9	\$46,069	\$64,179
Real estate	0.2	\$2,692	\$38,532
Office administrative services	0.4	\$18,482	\$25,880
Limited-service restaurants	0.2	\$3,093	\$12,587
Other (Implied)	3.3	\$134,219	\$424,248
<b>Total</b>	<b>8.5</b>	<b>\$453,517</b>	<b>\$1,354,972</b>

### 3.2.5. Underground Offsite Disposal

Offsite disposal of an underground uranium mine yields the highest impact on the State by far due to little out-of-state leakage (only 8% of direct investment). In this scenario, we see 53% of expenditures on truck and rail transportation alone, with a strong multiplier of 0.79 additional revenues for every \$1 of direct investment. However, offsite disposal estimates do not account for the cost and availability of offsite disposal options, which could potentially wash out a significant portion of investment. The issue of offsite disposal is discussed in more depth in the constraints and recommendations chapters of this report.

Figure 3.6. Offsite Disposal Impacts of Underground Mine Cleanup (per \$1 Million Direct Investment)

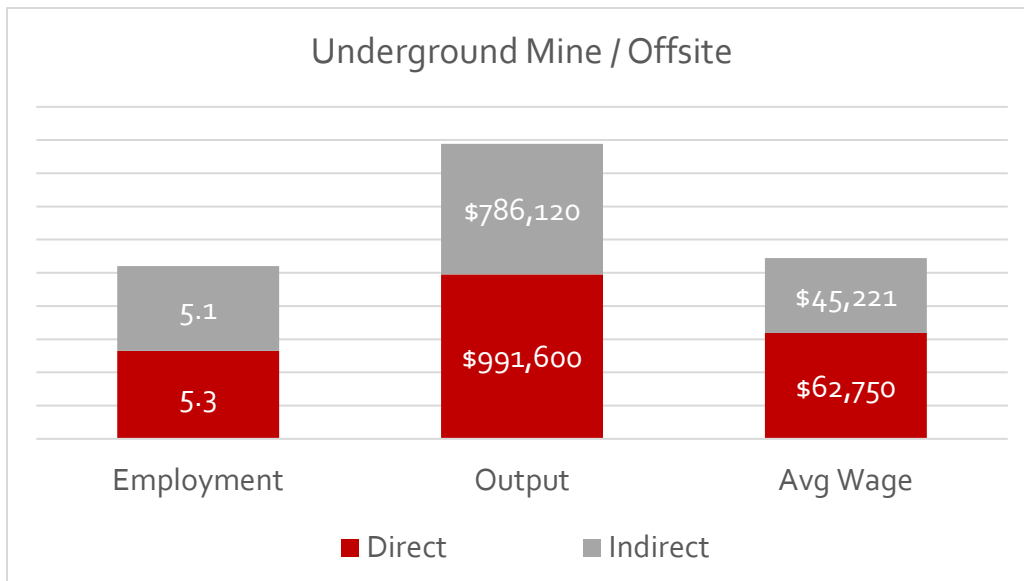


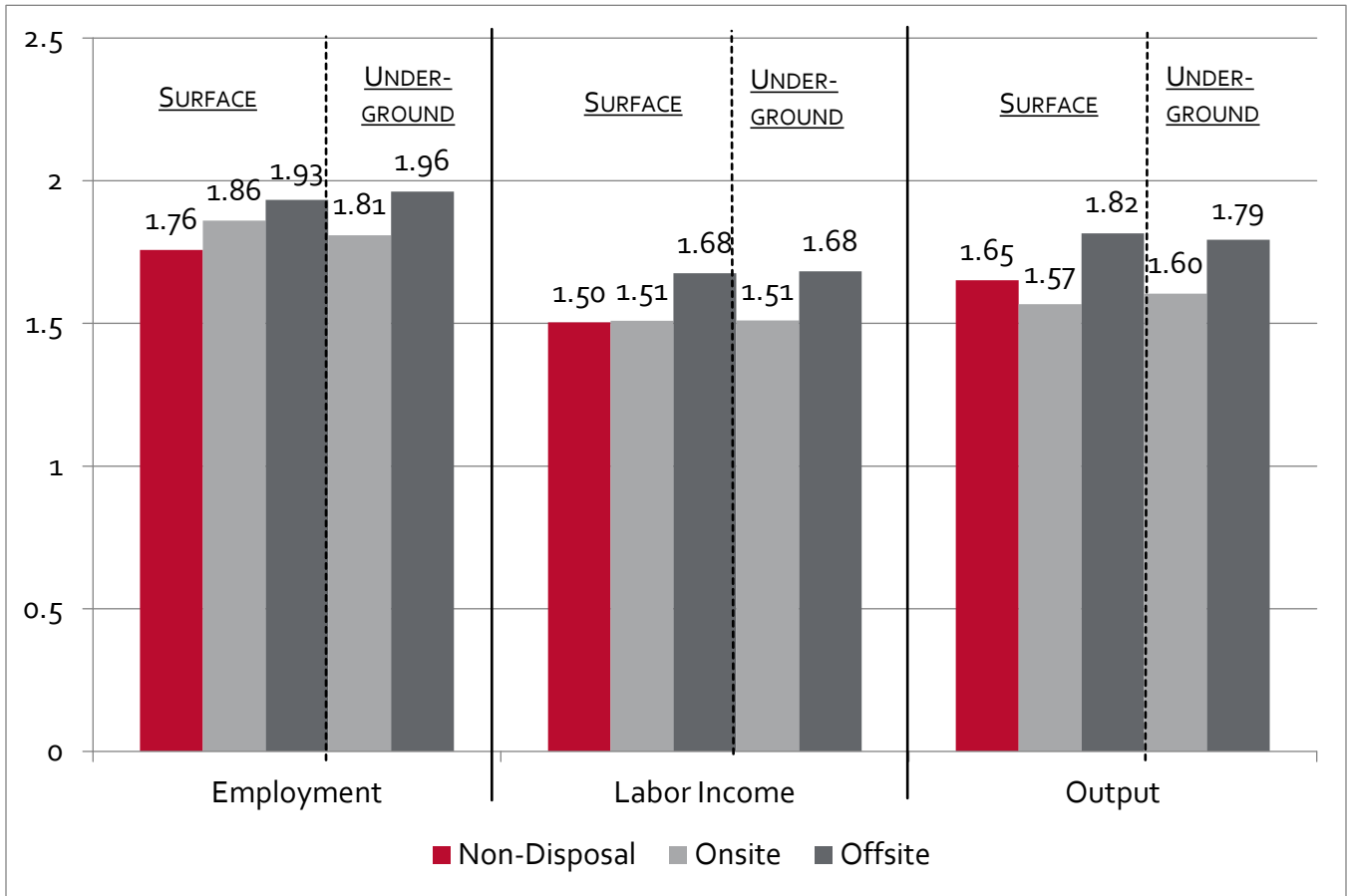
Table 3.6. Total Impact for Surface Mine Offsite Disposal, by Industry (per \$1 Million Direct Investment)

Industry	Employment	Labor Income	Output
Truck transportation	4.7	\$290,575	\$805,253
Rail transportation	0.2	\$25,508	\$141,538
Real estate	0.2	\$3,083	\$44,130
Wholesale trade	0.2	\$11,047	\$40,317
Couriers and messengers	0.4	\$12,838	\$38,632
Scenic and sightseeing transportation and support activities for transportation	0.2	\$14,969	\$34,222
Postal service	0.2	\$19,387	\$23,717
Extraction of natural gas and crude petroleum	0.1	\$6,609	\$17,068
Limited-service restaurants	0.2	\$3,415	\$13,895
Environmental and other technical consulting services	0.2	\$8,729	\$12,160
Other (Implied)	3.8	\$172,342	\$606,788
<b>Total</b>	<b>10.4</b>	<b>\$568,502</b>	<b>\$1,777,720</b>

### 3.2.6. Multipliers

Figure 3.7. shows economic impact multipliers by employment, labor income, and output for each of the five scenarios. At the most basic level, the multiplier can be interpreted as the impact of a one-unit change of a direct input (employment, labor income, or output).

Figure 3.7. Economic Impact Multipliers for Employment, Labor Income, and Output



For example, the first bar in Figure 3.7., which relates to employment impacts and corresponds to the non-disposal at a surface mine scenario, shows a multiplier of 1.76. This multiplier implies that for every direct job added in this scenario, a total of 1.76 jobs will be created. In other words, in addition to the 1.00 direct jobs added another 0.76 indirect jobs will be created. Therefore, if a reasonable estimate exists for the number of direct workers required to perform cleanup, it is possible to estimate the total number of jobs created by multiplying the number of direct jobs with the appropriate multiplier.

Note that because of the differences in the industrial make-ups for the direct jobs in each scenario, as well as variations in the associated average compensation in those industries and the average output per worker, multipliers will vary across scenarios, even for the same mine type. For example, the third bar, which relates to employment impacts at a surface mine but corresponds to offsite disposal, has a relatively higher multiplier of 1.93.

Multipliers are interpreted similarly for labor income and output; however, the multiplier is read in terms of an additional dollar or labor income or an additional dollar of output instead of in terms of an additional job. For example, the first labor

income bar, which corresponds to the non-disposal at a surface mine scenario, has a multiplier of 1.50. This multiplier implies that a total of \$1.50 of labor income will be created for each dollar of direct labor income. Similarly, the first bar output bar (again, referring to non-disposal at a surface mine) implies that a total of \$1.65 in output will be created for each dollar of direct output.

Overall, employment multipliers are generally the highest and labor income multipliers are generally the lowest. This is because although jobs are created through indirect effects, many of those jobs tend to be in relatively lower-paid industries. For example, if additional direct workers are added in truck transportation, which is well paid, those workers will spend income on, among other things, food at restaurants. To meet the demand of the new transportation workers, restaurants will hire additional workers, but the average wage for those new restaurant workers will likely be lower than the average wages for the new transportation workers.

Multipliers are generally highest for offsite disposal, reflecting greater indirect job-creation potential and the industries impacted and the relatively higher labor incomes and outputs in those industries. Other patterns across inputs are not as clear with employment and labor income multipliers for onsite disposal exceeding non-disposal (where applicable) at surface mines while the output multiplier for non-disposal exceeding onsite disposal at surface mines.

Full economic impact results are included in Appendix A for each of the five possible scenarios. In the next chapter, we discuss the readiness of New Mexico's workforce for the types of work described in the impact.

# Workforce Status & Requirements

In the previous section we illustrated the potential economic impact on New Mexico's industries should more money be invested into uranium mine remediation work. We argue that developing an industry explicitly designed to engage in environmental remediation would benefit the State.

In this chapter, we focus specifically on employment related to uranium mine remediation and the occupational skill sets already being developed in our local institutions. To that end, this chapter relies on data from the Federal Bureau of Labor Statistics (BLS) and New Mexico's Department of Workforce Solutions (DWS) rather than the industrial data provided in the previous chapter.

We begin by looking at historical employment in uranium extraction, followed by an examination of recent exploratory efforts and potential changes future extraction. We then discuss major occupational groups involved in uranium mine remediation and break down salary ranges and projected employment growth within those groups. Finally, we briefly overview training and educational programs related to uranium mine remediation, discussing what New Mexico is already engaged in and what is needed for further workforce development.

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## 4.1. Background

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At its height, New Mexico was the lead producer of uranium nationally and competitive globally.<sup>38</sup> 40% of the uranium produced in the United States between 1948 and 1982 came from New Mexico mines; nearly all of that was sourced from the Grants Mineral Belt. Additionally, New Mexico was home to eight uranium mill sites, which recovered U<sub>3</sub>O<sub>8</sub> for ore from New Mexico and the region.

By the mid-1970s, as the primary purchasers of uranium ore transitioned from the federal government to private energy companies and employment numbers peaked in New Mexico, the uranium industry directly employed over 6800 workers in the Grants Uranium Belt alone.<sup>39</sup> These numbers fell sharply by the 1980s, as the supply of uranium ore exceeded demand. Many mines entered standby status over this period, and exploration decreased dramatically. However, low-grade ore from the world's largest open pit uranium mine, Jackpile-Paguate, was extracted through 1982.

Since 1998, no uranium ore has been mined in New Mexico, though exploratory drilling has been done. Further, uranium has been recovered from inactive underground operations in the Ambrosia Lake area by Rio Algom Mining LLC.<sup>40</sup> Only in this past year has an idle permit for a mining operation at Mount Taylor been transitioned to inactive, thereby entering the cleanup phase. These shifts in the industry do not necessarily have to imply an end to regional job opportunities.

As mines move into remediation and reclamation, work will need to occur on a potentially massive scale. Many of the individuals previously employed by the mining industry already have labor skills that could transition to environmental remediation work but may need reorientation or training to complete that transition. Working in uranium mine cleanup requires specific training, but some of the base level skills developed across the mining industry could be transitioned to work in environmental remediation. Mining jobs fluctuate with the market for natural resources, but environmental remediation jobs have the potential to endure over time. We know that cleanups for even the fraction of assessed mines will require multiple years of intensive labor in addition to follow-up monitoring into the foreseeable future. Beyond what we already know, hundreds of mines in New Mexico remain unassessed for remediation actions. Work will depend on the intensity and speed of cleanup actions, but has the potential to last generations in New Mexico alone.

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<sup>38</sup> For a full account of the height of New Mexico production, see [https://geoinfo.nmt.edu/publications/periodicals/nmg/5/n3/nmg\\_v5\\_n3\\_p45.pdf](https://geoinfo.nmt.edu/publications/periodicals/nmg/5/n3/nmg_v5_n3_p45.pdf)

<sup>39</sup> <https://www.nrc.gov/docs/ML1010/ML101030860.pdf>; McLemore 1983.

<sup>40</sup> Szumigala, D.J. 2006. "State Summaries." *Mining and Engineering*

## 4.2. A Review of Major Occupational Groups Associated with Uranium Mine Cleanup

Uranium mine cleanup activities range from assessment and evaluation to heavy machinery operation to hazard monitoring and analysis. Thus, it is less important to focus on creating workforce training programs than concentrating on how programs might be retooled to include skills and certifications specifically needed to work in the uranium remediation industry. Rather than recreation, this repositioning of jobs was a common theme across our more than 75 in-depth interviews. We heard from industry professionals and educational programs alike that New Mexico possesses the skills to take on uranium mine remediation but lacks the infrastructure to support steady employment in the field and to match qualified workers with jobs.

To illustrate the workforce needs for uranium mine remediation, we will overview a few of the relevant occupational groups and the types of jobs associated with them, using the most current BLS and DWS data available. These data show where specific skills are employed within the state, providing an emphasis on the workforce itself rather than industrial profiles. For example, a construction laborer may have the appropriate training to engage in remediation work, but may be working in housing development. That individual's labor skills are better captured in the BLS and DWS data, showcasing the skills available in New Mexico, rather than persons already engaged in remediation activities.

### 4.2.1. Construction and Extraction

Jobs within the construction and extraction occupational group related to uranium mine remediation include operating heavy equipment, building roads and safety structures, and/or removal of waste materials. Many of these jobs require no formal educational credentialing at the entry level, though they generally require various certifications, formal training, and on-the-job skills development. Nationally, these occupations are projected to grow steadily on an average rate with other occupations over the next ten years.<sup>41</sup>

Location quotient measures reported by DWS show that New Mexico's construction and extraction occupational group is relatively large compared to other states.<sup>42</sup> Further, in the Farmington Metropolitan Statistical Area (MSA), 10.7% of total area employment was in the construction and extraction group in 2016. This indicates strong workforce numbers within the group, illustrating the idea that New Mexico already has skilled workers who may require only repositioning and/or additional training to engage in uranium mine remediation activities instead of recruitment into full workforce development programs. Further, the closure of the San Juan Generating Station will reduce area employment opportunities for workers in construction and extraction, increasing the need for job creation in this sector.<sup>43</sup>

The following table shows the jobs related to uranium mine remediation within the construction and extraction occupational group alongside their 2019 salary range in New Mexico and projected growth according to DWS data. We chose the jobs listed in each group using the data from the Engineering Evaluation/Cost Analysis (EE/CA) documentation discussed in the Economic Impact chapter of this report. The average salary range for construction and extraction workers is between \$52,820 and \$59,080. Additionally, all jobs within this group are projected to grow over 10 years by an average of 10.8%.

<sup>41</sup> <https://www.bls.gov/ooh/construction-and-extraction/home.htm>

<sup>42</sup> [https://www.dws.state.nm.us/Portals/0/DM/LMI/OccBulletin\\_May18\\_Construction.pdf](https://www.dws.state.nm.us/Portals/0/DM/LMI/OccBulletin_May18_Construction.pdf)

<sup>43</sup> O'Donnell, Kelly. 2019. <https://www.nmvoices.org/wp-content/uploads/2019/01/San-Juan-Tax-Study-report.pdf>

Table 4.1. New Mexico Construction and Extraction Occupational Group Salary and Growth Projection<sup>44</sup>

Construction & Extraction	Average Salary Range (2019)	Growth projection
	<b>\$52,820 - \$59,080</b>	<b>10.8%</b>
Paving, Surfacing & Tamping Equipment Operators	\$30,860 - \$45,300	12.3%
Earth Drillers, Explosive Ordinance Handling, Blasters	\$39,510 - \$63,960	11.9%
Construction Laborers	\$25,210 - \$37,090	11.3%
Hazardous Materials Removal Workers	\$35,120 - \$62,900	10.9%
First-Line Supervisors of Construction Trades & Extraction Workers	\$41,480 - \$77,330	10.8%
Helpers, Construction Trades, Other	\$22,970 - \$30,650	10.7%
Operating Engineers & Other Construction Equipment Operators	\$33,600 - \$50,880	10.0%
Fence Erectors	\$22,820 - \$34,350	9.8%
Underground Mining Machine Operators & Extraction Workers, All Other	\$39,570 - \$61,130	9.4%
Misc. Construction & Related Workers	\$27,800 - \$65,390	9.1%
Construction & Building Inspectors	\$43,240 - \$67,130	5.5%

<sup>44</sup> Data for all tables in this section were compiled using the most recent NM DWS (<https://www.dws.state.nm.us/>) data available at the time of writing.



## 4.2.2. Architecture and Engineering

Uranium mine remediation work requires a variety of engineers and technicians from the architecture and engineering occupational group. These jobs generally require a minimum of a four-year degree, though some entry-level technician positions require an associate's degree. The assessment, evaluation, planning, and long-term testing of uranium sites are critical tasks related to the architecture and engineering occupational group. The majority of associated jobs are projected to grow in New Mexico and nationally over the next ten years.

According to BLS data, New Mexico's architecture and engineering occupational group is large relative to other states.<sup>45</sup> Again, this illustrates that New Mexico has relatively high employment in these fields, indicating a strong foundation for growth. Further, wages for this occupational group are somewhat higher in New Mexico than in the United States on the whole and are competitive regionally.

The following table shows the jobs related to uranium mine remediation within the architecture and engineering occupational group alongside their 2019 salary range in New Mexico and projected growth according to DWS data. The average salary range for workers in architecture and engineering is \$54,260-120,920, and the growth projection is 7.2%. Additionally, all but one occupation (Industrial Engineering Technicians) within this group are projected to grow over 10 years.

<sup>45</sup> <https://www.bls.gov/oes/current/oes170000.htm>

Table 4.2. New Mexico Architecture and Engineering Occupational Group Salary and Growth Projection

Architecture & Engineering	Average Salary Range (2019)	Growth projection
Chemical Engineers	\$97,700 - \$134,360	14.0%
Environmental Engineering Technicians	\$37,140 - \$63,170	9.8%
Drafters, Other	\$35,250 - \$71,170	8.8%
Calibration Technologists & Technicians & Engineering Technologists & Technicians, Except Drafters, All Other	\$52,900 - \$105,150	8.1%
Health & Safety Engineers	\$72,720 - \$139,600	7.5%
Environmental Engineers	\$60,500 - \$104,180	7.1%
Surveyors	\$50,700 - \$94,100	6.4%
Surveying & Mapping Technicians	\$32,860 - \$56,740	4.7%
Industrial Engineers	\$69,310 - \$123,210	4.4%
Mining & Geological Engineers	\$80,550 - \$151,130	0.8%
Industrial Engineering Technicians	\$70,330 - \$86,020	-6.6%

### 4.2.3. Life, Physical, and Social Science

Although the occupational group of life, physical, and social science is very broad, it encompasses key occupations related to uranium mine remediation work. Jobs in these fields often require at least a four-year degree, but specialist and technician positions typically require an associate's degree. Essential work done in these occupations includes assessing, evaluating, and monitoring uranium sites along with implementing and enforcement of OSHA regulations.

Location quotient measures reported by the Bureau of Labor Statistics (BLS) show New Mexico's life, physical, and social science occupational group is relatively large compared to other states and has a higher than average mean annual wage.<sup>46</sup> Employment in this field is consistent across the country, though some consistency is due to the broadness of the occupational group itself. However, with high wages and high employment, the workforce has been well-developed in New Mexico; skills could be translated into uranium mine remediation work.

The following table shows the jobs related to uranium mine remediation within the life, physical, and social science occupational group alongside their 2019 salary range in New Mexico and projected growth according to DWS data. The average salary range for workers in life, physical, and social science is \$42,700-104,700, and the growth projection is 9.1%. All relevant occupations within this group are projected to grow over 10 years.

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<sup>46</sup> <https://www.bls.gov/oes/current/oes190000.htm>

Table 4.3. New Mexico Life, Physical, and Social Science Occupational Group Salary and Growth Projection

Life, Physical, & Social Science	Average Salary Range (2019)  \$42,700 - \$104,700	Growth projection  9.1%
Hydrologists	\$50,970 - \$105,390	11.9%
Occupational Health & Safety Technicians	\$39,290 - \$70,540	10.8%
Environmental Scientists & Specialists	\$51,900 - \$90,890	10.6%
Occupational Health & Safety Specialists	\$49,590 - \$86,590	10.6%
Environmental Science & Protection Technicians	\$32,410 - \$55,970	9.3%
Geological & Hydrologic Technicians	\$36,900 - \$73,220	9.2%
Geoscientists	\$53,080 - \$94,650	6.3%
Biological Scientists, Other	\$58,730 - \$86,430	4.9%
Conservation Scientists	\$45,350 - \$80,280	4.1%
Chemists	\$45,230 - \$105,600	2.0%
Forest & Conservation Technicians	\$28,820 - \$49,760	1.8%

#### 4.2.4. Transportation and Material Moving

Another occupational group essential to uranium mine remediation is transportation and material moving. Remediation activities will include the use and transportation of heavy equipment, earthwork, and sometimes the relocation of hazardous waste materials. These jobs include machine operators, material movers, heavy and tractor-trailer truck drivers, and rail and freight loading and transport positions. Many of these jobs do not require formal educational credentials, though they require particular training and on-the-job experience. Some of these jobs are expected to grow over the next ten-year period in New Mexico, but many at a slower rate than the other occupational groups we have reviewed. Nationally, this occupational group is expected to grow at a similar rate to other groups.<sup>47</sup>

BLS data show that the transportation and material moving occupational group is relatively small in New Mexico compared to other states, especially in the Northwest region of the state.<sup>48</sup> This may indicate a low demand for these types of occupations at this time, though significant industrial remediation activity would change that demand significantly. There may be a need to improve workforce development in this occupational group to support the demand for uranium mine remediation positions with a local workforce.

The following table shows the jobs related to uranium mine remediation within the transportation and material moving occupational group alongside their 2019 salary range in New Mexico and projected growth according to DWS data. The average salary range for workers in transportation and material moving is \$21,290-42,550, and the growth projection over the next ten years is 4.5%.

<sup>47</sup> <https://www.bls.gov/ooh/transportation-and-material-moving/home.htm>

<sup>48</sup> <https://www.bls.gov/oes/current/oes530000.htm>

Table 4.4. New Mexico Transportation and Material Moving Occupational Group Salary and Growth Projection

<p style="text-align: center;"><b>Transportation &amp; Material Moving</b></p>	<p>Average Salary Range (2019)</p> <p style="text-align: center;"><b>\$21,290 - \$42,550</b></p>	<p>Growth projection</p> <p style="text-align: center;"><b>4.5%</b></p>
Crane & Tower Operators	\$57,500 - \$73,050	13.9%
Hoist & Winch Operators	\$44,580 - \$59,540	13.7%
Refuse & Recyclable Material Collectors	\$24,750 - \$37,930	7.5%
Heavy & Tractor-Trailer Truck Drivers	\$32,080 - \$49,440	6.7%
Industrial Truck & Tractor Operators	\$25,150 - \$44,980	5.7%
First-Line Supervisors of Transportation & Material-Moving Machine & Vehicle Operators	\$34,520 - \$70,270	4.8%
Laborers & Freight, Stock & Material Movers, Hand	\$20,710 - \$33,500	3.2%
Conveyor Operators & Tenders	\$28,070 - \$40,940	1.0%
Transportation Inspectors	\$30,730 - \$70,360	-0.6%
Railroad Conductors & Yardmasters	\$51,920 - \$76,960	-1.1%
Locomotive Engineers	\$57,320 - \$82,330	-1.2%
Tank Car, Truck & Ship Loaders	\$32,160 - \$54,250	-1.6%

#### 4.2.5. Other (including mining, health, office administrative services, etc.)

The occupational groups detailed above are a cross-section of the needed skills to tackle uranium mine remediation activities. However, uranium mine cleanup work will also include work in office administrative services, business support services, and consulting services. In an interview with a larger corporation, the representative repeatedly referenced the need for technical writers and business administrators, illustrating how uranium mine remediation activities do not all occur at the mine site. These considerations are essential to note when developing a well-rounded workforce.

Further, although previously discussed in passing, it is important to reiterate that mining may not have a major role in uranium mine remediation directly; skills associated with that occupation are potentially translatable with minimal additional training. Individuals working on active mines will possess similar skills but will have completed the US Mine Safety and Health Administration (MSHA) trainings. Individuals seeking employment in uranium mine remediation will need to complete OSHA (Occupational Safety and Health Administration) trainings despite potentially engaging in similar work. In the next section, we overview the training programs and certifications available for uranium mine remediation work.

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### 4.3. Training Programs and Certifications

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#### 4.3.1. New Mexico's Training and Educational Programs

BBER's research into the workforce capacity for uranium mine remediation in New Mexico illustrates the diversity and comprehensiveness of the state's education programs. In general, there are two skill sets required for on-the-ground assessments and cleanups of uranium mines: technical, e.g., environmental engineering, generally requiring a bachelor's degree or higher, and physical cleanup skills, e.g., bulldozer operator, general construction skills, etc. Most New Mexico universities, colleges, and other vocational programs train individuals in the fields described above, though few focus on uranium remediation activities specifically. In the following paragraphs, we overview a few programs training workers in the skills needed to potentially address uranium mine remediation. It is not a comprehensive list, but rather a sample of what is available.

##### Diné College's Uranium Education Program

[https://www.dinecollege.edu/about\\_dc/dine-environmental-institute-dei/](https://www.dinecollege.edu/about_dc/dine-environmental-institute-dei/)

[https://www.dinecollege.edu/about\\_dc/uranium-education-program/](https://www.dinecollege.edu/about_dc/uranium-education-program/)

The Uranium Education Program (UEP) is housed in the Diné Environmental Institute at Diné College. This program works with Navajo students and community members to research and rectify environmental health issues arising from the legacy of uranium mining on the Navajo lands. The program is designed to empower the community to design mitigation actions, establish research plans, and evaluate the effectiveness and cultural competency of educational efforts in their own communities.

The research in the UEP ranges in scope from specific health impacts of uranium exposure to investigations of the pathways of exposure, such as locally sourced food and water. This is critical training as it includes economic, social, environmental, and health research opportunities for faculty and students. Students graduating from this program are trained specifically in technical and professional activities related to uranium mine remediation.

Navajo Technical University's (NTU) Environmental Science & Natural Resources Department

<http://www.navajotech.edu/academics/bachelor-of-science/environmental-science-natural-resources>

Navajo Technical University (NTU) is a tribal university on the Navajo Nation, with community-based academic and vocational education programs. The university was named as a collaborative partner in the recent EPA awarded Tetra Tech contract to conduct assessments on the Tronox uranium mines. NTU's Environmental Science and Natural Resources Department has the training and capacity to conduct such work and is training students directly in remediation studies.

NTU offers associate's through master's degrees in relevant disciplines such as environmental engineering, environmental sciences, and radiation health physics. Students conduct field and laboratory research, particularly in the environmental science master's program. Additionally, NTU is a participant in the Community College Consortium for Health and Safety Training (CCCHST)<sup>49</sup> and is therefore able to offer required OSHA trainings for students directly entering into uranium mine remediation work.

New Mexico Tech's (NMT) Earth and Environmental Science Department

<https://www.nmt.edu/academics/ees/>

<https://www.nmt.edu/academics/mining/index.php>

<https://geoinfo.nmt.edu/resources/uranium/research/home.cfm>

The Earth and Environmental Science Department at New Mexico Tech (NMT) has both undergraduate and graduate level programs with research in geology, geochemistry, geobiology, geophysics, and hydrology. It is home to various research facilities and conducts both laboratory and fieldwork with its students.

The Mineral Engineering Program at NMT also has undergraduate and graduate level programs and many of their graduates work in mining exploration.<sup>50</sup> However, the skills acquired in the Mineral Engineering program are highly translatable to remediation work and some students conduct research on state-held abandoned mine lands. At this time, the Mining Safety Health Administration trainings are built into the curriculum; these are the trainings necessary for active mine sites. The analogous trainings required for inactive mine sites are discussed in the next section.

Although these departments do not specifically focus on uranium-related research, the degrees they confer include training the requisite skills to enter into remediation work. Further, NMT is home to the New Mexico Bureau of Geology & Mineral Resources, which serves as the geological survey for the State and engages in a wide variety of uranium-specific research.

New Mexico Water Resources Research Institute (WRRI) at New Mexico State University (NMSU)

<https://cduaws.nmwri.nmsu.edu>

<https://nmwri.nmsu.edu>

Focusing on New Mexico's water supplies, the Water Resources Research Institute (WRRI) at New Mexico State University (NMSU) houses students and faculty researching complex water quality and supply issues. This institute was established by the New Mexico legislature in 1963 and funds research by faculty and students at

<sup>49</sup> <https://nationalpete.org/ccchst/>; In our interviews with NTU, they supported the idea of a state-led OSHA training as opposed to a piecemeal, institution-by-institution subscription to said trainings as offering the trainings is not always efficient or straightforward.

<sup>50</sup> Interview with NMT's Mineral Engineering Department 01/31/2020.



multiple universities throughout the state. Additionally, the institute hosts the annual New Mexico Water Conference at various locations statewide.

WRRI's work is not limited to a specific degree path or research orientation; students who participate in the work come from a variety of skilled backgrounds. Some of the research partners with the Bureau of Reclamation (BOR) and seeks to innovate and examine technological solutions for treating otherwise unusable water. The collaboration with the BOR has funded 20 water research projects since it was established in 2011.

Hands-on experience provided at WRRI prepares students for potential entry into uranium mine remediation work related to water issues, though its current work is not uranium-specific. However, the research done at the institute could lend itself to larger-scale innovation and collaboration as it is already an inter-university program.<sup>51</sup>

UNM METALS Superfund Research Program Center

<https://hsc.unm.edu/pharmacy/research/areas/metals/>

The UNM Metal Exposure and Toxicity Assessment on Tribal Lands in the Southwest (UNM METALS) Superfund Research Program Center focuses its efforts on researching uranium and mixed metals exposure and toxicity amongst tribal communities. The first program of its kind in the United States, UNM METALS works directly with communities affected by uranium exposure and brings together professionals from the health and sciences to innovate and explore solutions with community members. METALS works with and trains technical professionals in public health, pharmaceutical sciences, engineering, health communication, and other related fields. They partner with local organizations as well as community members to solve problems and inform policy.

Some organizations such as the Greater Gallup Economic Development Corporation (GGEDC)<sup>52</sup> have worked with local employers to develop industrial workforce programs. This collaboration with local businesses should be further explored, especially given the scale of cleanup we describe in this report. The GGEDC's programming built in the necessary OSHA training described in the next section, which made their program uranium remediation ready. However, specialized training and specific risks posed by activities involved in uranium mine remediation are not usually captured in general educational programs.

New Mexico's institutions provide essential skills training, but there could be improvement in the specificity of the training, the communication among institutions with similar educational programs, and the availability and timing of specialized trainings designed to place workers on the ground. In the next section, we briefly discuss the OSHA training requirements needed to enter into the field of uranium mine remediation.

### 4.3.2. OSHA Trainings

One of the significant barriers to entering into uranium mine reclamation, even with a relevant degree or with relevant experience, is the need for specialized Occupational Safety and Health Administration (OSHA) trainings that deal with hazardous waste and radiation. The most general of these trainings is the Hazardous Waste Operations and Emergency Response (HAZWOPER) training, which addresses a variety of topics related to health and safety relevant to hazardous waste operations. Various levels of this training are required for all on-site personnel, and the training must be renewed annually.

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<sup>51</sup> WRRI also maintains a directory of water experts throughout the state and a searchable library database for research related to water issues. These are key informational repositories that could be better utilized by the State when creating a clearinghouse for all potential remediation resources.

<sup>52</sup> <https://www.gallupedc.com/>

Generally, technically qualified workers for on-the-ground assessments and cleanups will easily maintain their certification because they can perform these technical jobs on multiple hazardous material sites and thereby maintain consistent employment. Typical technical skills are transportable and can move from site to site, which may mean working on sites in different states. That sort of mobility is usually not as feasible for general contract labor. Maintaining OSHA trainings for employees becomes more problematic for general construction labor, as they may or may not be initially certified, and their employment opportunities will not always be related to hazardous waste. These workers may have no occasion to utilize the certification prior to its expiration and will need to renew with no work necessarily at hand, due to uncertain timelines for uranium remediation. The sort of mobility seen in technical careers is usually not as feasible for general contract labor.

Additionally, certain jobs may call for training specific to remediating types of mines, e.g., confined spaces training. These specific trainings are required on a task-by-task basis and are not needed for all employees at a given firm. However, our interviews with major remediation corporations indicated that subcontract proposals for cleanup activities from businesses that included a wider variety of relevant OSHA training for their staff had a slight advantage over proposals that did not. Workforce development with a focus on specialized trainings could be more responsive to specific remediation needs with better coordination at the state level.

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## 4.4. Conclusions

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In this chapter, we examined the workforce skills available in New Mexico to address uranium mine remediation. We briefly outlined the history of work in uranium mining and discussed how that may translate into the field of environmental remediation. Overviewing some of the career paths and the institutions that train our workforce, we illustrated that New Mexico has the skills to tackle remediation issues, but needs both a repositioning and slight retraining of workers and consistency in available employment.

In the next section, we will discuss constraints on uranium mine remediation in New Mexico, addressing industrial concerns, workforce concerns, and additional issues that arose in our research.

# Constraints

This chapter of the report discusses the constraints on uranium mine cleanup efforts, outlining the limits that may seem insurmountable, but have many actionable and straightforward remedies. A comprehensive state plan could develop lasting capacity but requires significant input from all relevant stakeholders.

To this end, we break down the constraints into four main categories, which correspond to the recommendations we offer in the next chapter of this report:

- Planning and administrative issues
- Challenges to businesses
- Challenges to workforce development
- Factors limiting the scope of cleanup efforts

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## 5.1. Planning and Administration

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Efforts by the State of New Mexico to remediate contamination related to uranium mines have been stymied by a lack of consistent, transparent, and well-referenced information; complex jurisdictional and ownership status of the mines; and the absence of a strategic plan that includes a clear timeline. Because of these challenges, the State is too often reactive to unanticipated initiatives advanced by other stakeholders.

As discussed in previous chapters of this report, not all uranium mine sites fall under US EPA jurisdiction. Remediation actions on various sites throughout the southwest have been enacted by state governments,<sup>53</sup> tribal governments,<sup>54</sup> the US Forest Service,<sup>55</sup> the Bureau of Land Management,<sup>56</sup> and the US EPA. Tracking the remediation work that has been done by each of these entities and linking it to sites and costs is laborious. Further, though some communication may be happening between agencies, it is not clear that each player knows what the others have done. There is a significant need for an information exchange and clearinghouse to ensure the work is being done in a comprehensive and cost-effective manner and interagency cooperation.

### 5.1.1. Informational Barriers

New Mexico lacks a single transparent, well-referenced repository of information. Rather, numerous federal, state, and tribal agencies, educational institutions, and community organizations have maintained information independently, with little sharing between them. The chart below identifies only a subset of organizations that generate or provide access to information critical to an effective program to cleanup uranium sites in New Mexico.

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<sup>53</sup> <https://deq.utah.gov/waste-management-and-radiation-control/uranium-mills-and-disposal-facilities>

<sup>54</sup> <https://www.aml.navajo-nsn.gov>

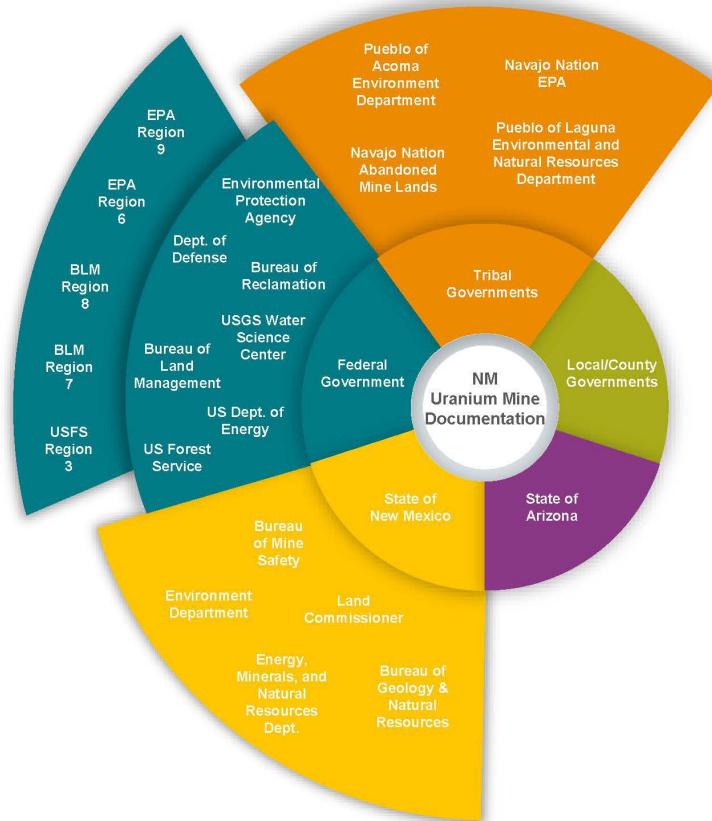
<sup>55</sup> <https://www.fs.usda.gov/science-technology/geology/aml>

<sup>56</sup> <https://www.blm.gov/programs/public-safety-and-fire/abandoned-mine-lands>

This scattering of information is problematic because it is:

- 1) costly – any effort to address any aspect of the problem begins with an expensive, time-consuming processing of collecting and organizing data and information, often repeating the work of someone who has come before;
- 2) partial or contradictory; access to only a subset of information reinforces the tendency of individual organizations to approach the work from a narrow, siloed perspective, often failing to account for concerns of other stakeholders;
- 3) not up-to-date: the regulatory environment is complex and almost constantly changing.

*Figure 5.1. Sources of Government Information Used for the Research Presented in this Report by Agency*



A significant amount of time for this study went into the compilation and verification of documents explicitly related to uranium mine cleanup efforts. The reference section in this report illustrates the beginning of the work needed to be done to better organize and consolidate documentation pertaining not only to the cleanup efforts on these mines but also the histories, academic studies, technical reports, and other resources that pertain to uranium mining in New Mexico.

### 5.1.2. Lack of Process for Identifying Liability and Specifying Action

Cleanup project timelines present significant constraints; however, the State can take administrative actions to mitigate industry and workforce development challenges. Interagency coordination is essential for identifying unremediated mine site liability and specifying future cleanup plans. Cooperation and transparency in these processes could shorten the timelines and facilitate the deployment of a trained workforce to tackle remediation tasks.

As described in earlier chapters of this report, holding corporations and government entities responsible for cleanup stems from the difficulty of tracking down the potentially responsible parties (PRPs) of abandoned mine sites. Many of these sites have repeatedly changed ownership over time, resulting in difficulty determining the responsible party/parties for remediation. Under CERCLA and subsequent executive orders from Presidents Reagan and Clinton, the US EPA is responsible for tracking down potentially responsible parties.<sup>57</sup> However, the EPA's PRP Search Team was only formed in

<sup>57</sup> <https://www.epa.gov/sites/production/files/2015-10/documents/prpbasictrainingmanual2015.pdf>

2011 and exclusively focuses on CERCLA designated sites, excluding many uranium sites. Working with this search team to design a methodology for New Mexico's non-CERCLA designated sites would improve our ability to hold corporations financially responsible for cleanup.

Further, as the US Department of Energy was the primary purchaser of uranium from 1947-1973, uranium producers point to the government's liability for cleanup as well.<sup>58</sup> This often leads to split revenue streams for cleanup and more complications in asserting state control over funds. Litigation can slow remediation efforts, creating an uncertain timeline for actual cleanup to begin. Even with funding available, the process of addressing uranium mine sites can take decades. These delays make job creation and retention difficult, and the continued living conditions of those near the mine sites unacceptable. The slowdown of cleanup efforts is an economic, environmental, and social concern that can be partially remedied by a more robust State-led process for identifying liability and specifying action.

Finally, remediation efforts can be hindered by the inability to find solutions for cleaning up various sites. Different stakeholders will have differing views on the extent and outcomes of a cleanup project. Although this point fits into the discussion on innovation, it is also important to note here, as the transparency of how cleanup decisions are made often feels out of local communities' hands, despite public hearings and comment sessions. BBER repeatedly heard that the outreach efforts, especially from the EPA, often felt hollow rather than stemming from meaningful engagement with the community to find solutions for contaminated lands.

### 5.1.3. Land Ownership and Intergovernmental Relations

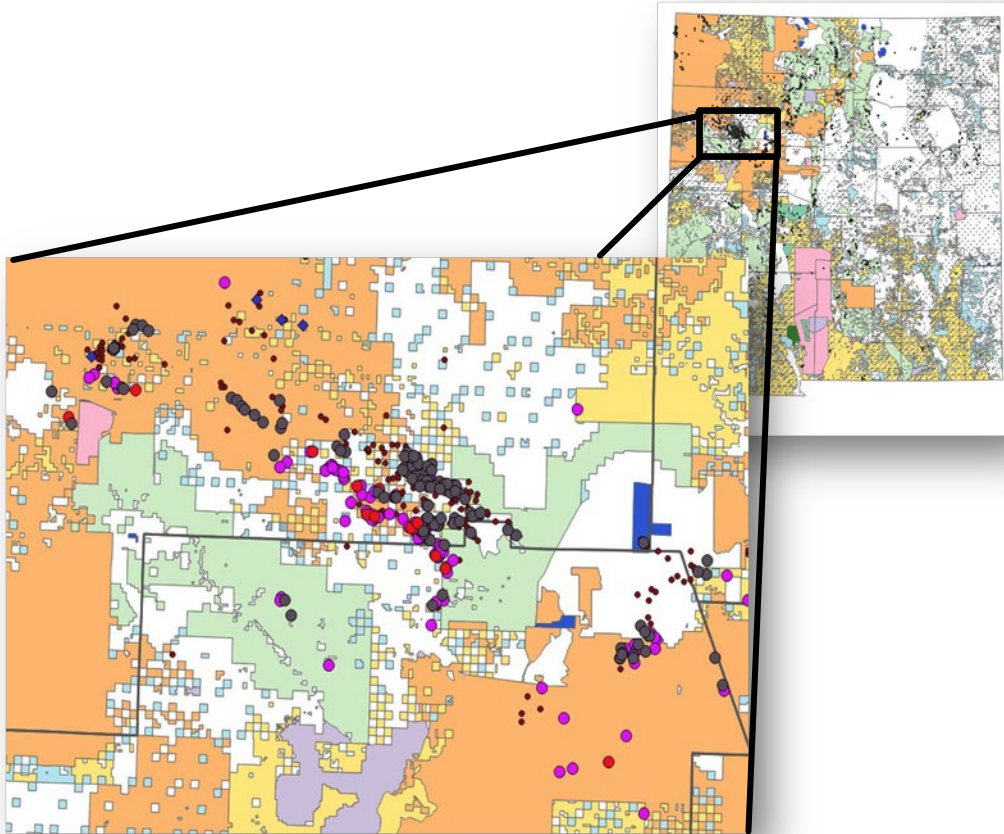
A significant constraint holding back uranium mine cleanup involves both land ownership and intergovernmental relations. As discussed in the background section, many of these mines are located on the "checkerboard," land divided up into parcels that may be controlled by the Federal government, governments of the Native Nations, the State government, and private property holders. This impacts not only the ability to clean up the mines, as different jurisdictions may have additional requirements but the ability to access the mines and transport equipment and potentially waste from one jurisdiction across another.

The following map encompasses one small portion of the Grants Uranium Belt, focused on the border between McKinley and Cibola Counties. There are seven different land management agencies in this projection, each with its own regulations, and five types of uranium sites, each with its own technical challenges. Additionally, some of the uranium sites may overlap or cross jurisdictional boundaries, creating ownership, responsibility, and regulation problems. This sample cutout illustrates the complexity of addressing uranium mine remediation from a jurisdictional, technical, and geographic perspective and reinforces the need for interagency cooperation.<sup>59</sup>

<sup>58</sup> The role of the US Department of Energy in uranium production is discussed in the background section of this report.

<sup>59</sup> The full map and legend are found in the Background Chapter of this report.

Figure 5.2. A Small Section of New Mexico's Uranium Mines and Drilling Sites Overlaid on Jurisdictional Boundaries



For example, without prior consent from the Navajo Nation, it is against the law to transport radioactive materials across Navajo Nation lands. This restriction came as a result of the Radioactive and Related Substances, Equipment, Vehicles, Persons, and Materials Transportation Act of 2012. Although this legislation builds on the Diné Natural Resources Protection Act of 2005, which prohibits the mining and processing of uranium on Navajo Nation sites, it may also affect agencies' ability to remove radioactive waste from sites undergoing remediation.<sup>60</sup> Recognizing that the land division patterns play a major role in not only the solutions for remediation but the process of cleanup efforts themselves is a first step in seeing the importance of interagency and intergovernmental cooperation. No single entity or government can tackle this problem alone.

<sup>60</sup> [http://www.navajonationcouncil.org/pressReleases/2015/Aug/NABI\\_adopts\\_plan\\_of\\_operation\\_for\\_Dine\\_Uranium\\_Remediation\\_Advisory\\_Commission.pdf](http://www.navajonationcouncil.org/pressReleases/2015/Aug/NABI_adopts_plan_of_operation_for_Dine_Uranium_Remediation_Advisory_Commission.pdf)

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## 5.2. Business Challenges

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The obstacles described in this section present difficult barriers for smaller companies wishing to join the bidding. The following factors determine a company's ability to bid and perform such work: organizational capacity, networks, and collateral/cash for bonding.

### 5.2.1. Organizational Capacity

Bidding on, winning, managing, and maintaining an EPA contract requires a high level of administrative and legal capacity, such as filing the necessary documentation in a timely and correct manner. The reporting requirements for these contracts present formidable barriers for small companies that have never had a Federal Government project. Small, local firms often lack the general back-office skills for meeting all of the reporting requirements.

#### 5.2.1.1. Formal Barriers

Formal institutional barriers that create obstacles for firms to participate in uranium mine cleanup efforts often involve navigating contracts on multiple levels. This section describes some of the specific formal barriers raised by the smaller firms we interviewed for this study.

At the Federal level, the EPA requires potential bidders on such projects to be registered as a Federal Government Contractor through the System for Award Management (SAM)<sup>61</sup>. There are several requirements to determine eligibility as a contractor for federal contracts to be registered in SAM. Beyond complying with these requirements, companies seeking to bid on uranium mine remediation projects – in whole or in part – must demonstrate the capacity and experience in hazardous waste cleanup. More specifically, they must retain employees with the requisite training and certifications to address and handle materials related to these mine sites, such as the OSHA HAZWOPER training and certification, which we discuss in greater detail in the workforce challenges section.

Once accepted as a potential Federal Contractor, companies need to monitor federal contract announcement sites such as FedConnect,<sup>62</sup> which requires registering to be allowed to use the site to find federal contract opportunities. Active monitoring of EPA sites to find announcements regarding potential uranium mine cleanup opportunities may give companies an advantage.<sup>63</sup>

Beyond completing and complying with the requisite bid registration requirements, a company awarded a contract funded by the EPA must complete required assurances and certifications. While they may vary to some extent by Federal agency, many are necessary regardless of the Federal funding source. These documents may be 20 or more pages in length and, in some cases, require certification of the company's legal counsel and board to ensure they are authorized to engage in these kinds of projects. Again, the additional hurdles after being awarded a contract may prove to be more burdensome for small companies than the potential rewards from the project.

Further, since many of the uranium mine sites are situated within the Navajo Nation, registering as a potential vendor<sup>64</sup> with the Navajo Nation is critical. Successful bidders for work on the Navajo Nation are also encouraged to engage and work with a Certified Navajo Business. For those eligible to be considered a Certified Navajo Business, registration must be done through the Navajo Business Regulatory Department at the Division of Economic Development. For companies deemed to be interested bidders for Navajo uranium mine cleanup projects, the Navajo Nation has a list of interested

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<sup>61</sup> <https://www.sam.gov/SAM/>

<sup>62</sup> <https://www.fedconnect.net/FedConnect/Default.htm>

<sup>63</sup> [https://www.epa.gov/newsreleases/search/field\\_press\\_office/region09?filter=abandoned%2ouranium%2ocontract](https://www.epa.gov/newsreleases/search/field_press_office/region09?filter=abandoned%2ouranium%2ocontract)

<sup>64</sup> <https://www.surveymonkey.com/r/AUMInterestedParties2>

bidders,<sup>65</sup> which provides information regarding potential partners for companies trying to enter into uranium mine cleanup on the Navajo Nation lands.

Finally, there are two Federal EPA Regions responsible for uranium mine cleanup in New Mexico. In general, US EPA Region 9 is responsible for overseeing and coordinating uranium mine cleanup on Navajo Nation Lands. However, there are other sites in New Mexico, not on Navajo Lands, mostly in the Grants Mining District area.<sup>66</sup> This area falls under the auspices of US EPA Region 6 for coordination and administration. This District also falls under the State of New Mexico Environment Department's jurisdiction and the New Mexico Energy, Minerals, and Natural Resources Department. As with bidding on the EPA and Navajo Nation contracts, bidding on State contracts generally requires bidding firms to be registered with the state as bona fide contractors capable of performing the work. There are in-state preferences for New Mexico resident businesses; thus, companies residing in New Mexico can and should become registered by the New Mexico Tax and Revenue Department.<sup>67</sup>

It is clear that any company wishing to compete for uranium mine cleanup work in New Mexico faces many institutional hurdles. Each one typically entails completing multiple applications and, in some cases, obtaining other identifying information before it is possible to qualify for the work. For small companies, the challenges may be insurmountable. Further, in areas such as the Grants Mining District, it is possible that a cleanup project may be in multiple regulatory jurisdictions and therefore requires coordination with numerous separate agencies.

The formal institutional barriers are formidable, but there is potential for the State to implement activities and policies that could help mitigate these challenges, which we discuss in the recommendations section.

### **5.2.1.2. Informal Barriers**

In addition to the formal barriers, informal barriers create challenges for New Mexico companies seeking to participate in uranium mine cleanup activities. These barriers are generally related to how subcontracts are awarded and followed through on.

While the EPA clarifies during the bidding process that Native firms are prioritized for subcontracts on the Navajo Nation, many of these companies indicated little follow up beyond the first year to ensure that Navajo or Native-owned firms are meaningfully engaged in the cleanup work. Once the large firm has demonstrated to the EPA that the minority/local community/firm has been committed in the first year, it was reported to BBER that monitoring and enforcement seem to disappear. As one respondent noted, "once the contract is awarded and an EPA Environmental Protection Specialist takes on the local management of the contract, [there is] little concern for subcontractors as long as the assessment/cleanup is completed according to EPA specs. The Environmental Protection Specialist's role is to make sure the work is completed to EPA technical standards, not contractual standards regarding local involvement." This issue of monitoring subcontracts came up in more than one interview and is something worth further exploration by the relevant agencies.

Another informal barrier – although to some extent a formal barrier that agency regulations or mandates may require – is the "requirement" to accept the lowest cost bid. Two New Mexico contractors, who are recognized bidders on the qualified bidders list, voiced this sentiment, arguing that the policy needed to be reconsidered as it allowed larger companies to outcompete the smaller businesses.

Finally, BBER heard from several contractors who have worked or attempted to work with the Navajo Nation on cleanup projects. It was frequently stated that the Navajo Nation Government is a challenging entity to work with bureaucratically. Whether this is a lived reality or an ingrained prejudice, ideas of bureaucratic difficulty create issues for both the Tribal

<sup>65</sup> [Navajo AUM \(AMRCS\) Interested Vendors List \(XLS\)](#)

<sup>66</sup> <https://www.epa.gov/grants-mining-district>

<sup>67</sup> <http://www.tax.newmexico.gov/Businesses/in-state-veteran-preference-certification.aspx>



Government and for businesses attempting to secure remediation contracts. This is illustrated by the following statement made by a representative of a Navajo-owned consulting firm. “The problem with the Navajo Nation is there are so many vested interests and cross-purposes associated with cleanup that even when there is an agreement, which is hard to get, there will be changes in mid-stream when new administrations/players come into the mix.” This becomes a challenge to overcome on multiple levels, with the State needing to do the work to build better trust relationships with the Navajo Nation Government and other Tribal Governments on cleanup efforts, facilitating a collaborative effort to support local businesses in securing remediation contracts.

### 5.2.2. Networking

Due to cultural and institutional factors, smaller companies with limited experience often find it difficult to establish and maintain critically important relationships with larger national/multinational firms that typically oversee uranium mine cleanup projects.

For example, one New Mexico company owner offered, “The EPA does have higher qualification requirements for small contractors, so for small companies to participate, they have to be tied to a large, qualified bidder unless they can meet the US EPA requirements as a small business...Team up with knowledgeable players in the field to get experience and exposure.”

Even for well-established New Mexico contractors and consultants, building and participating in a network that provides access to major national and international uranium mine remediation firms is a prerequisite to be considered in potential bidding opportunities. This becomes a significant barrier when most small firms' primary focus is pursuing and capturing the next project on which it can bid. The universal perception is that there are not enough opportunities to try to find and interact with large uranium mine cleanup firms or become known to regulatory bodies and demonstrate that the firm has the requisite skills and experience to engage in this kind of specialized work. Uncertain timelines for cleanup activities further exacerbate this issue. Additionally, personal networking is not always a skill that small contractors may even recognize as necessary.

In general, to successfully compete for a uranium mine EPA assessment and cleanup, firms must have experience doing this kind of work and demonstrate compliance and skills as required. This presents a particularly difficult barrier to competition as the only way to gain experience is through performing the work. The only path around this dilemma is for the in-state companies to develop working relationships with the large out of state firms usually granted the EPA contracts. The out of state firms are likely to subcontract a certain percentage of the work, which presents an opportunity, albeit small, for experience. This, however, requires effective networking to become part of a recognized group of in-state companies that are regularly used in projects.

Networking is an ongoing process and requires time and effort to be successful. Although the US Small Business Administration (SBA) offers counseling and technical support to businesses, the District Office is located in Albuquerque.<sup>68</sup> Additionally, in partnership with SBA, the New Mexico Small Business Development Center Network offers services to small New Mexico businesses – both startups and existing businesses.<sup>69</sup> These services could be expanded to better encompass New Mexico businesses' specialized needs attempting to win federal subcontracts. In Appendix 6, we discuss further networking options and opportunities as a resource for businesses, but ideally, these resources could be better tailored by the State to fit the complexity of the uranium mine remediation industry.

### 5.2.3. Insurance and Surety Bonding

<sup>68</sup> <https://www.sba.gov/offices/district/nm/albuquerque>

<sup>69</sup> <http://www.nmsbdc.org/about-us.aspx>

Uranium mine assessments and cleanups are often multi-million-dollar contracts and typically require surety bonds and liability insurance to guarantee the successful completion of work. Smaller firms often lack the financial assets and collateral needed to secure bonding and insurance. Even smaller firms that can access the bonding are required to pay premium costs that may price them out of the competition.

Short of having some pooled bonding authority for small New Mexico companies, the primary route around this challenge again lies with networking and subcontracting with a large out-of-state firm that can provide the bonding coverage for all its subcontractors.

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## 5.3. Workforce Challenges

This section discusses the challenges to building a strong, diverse, New Mexico-based workforce that can do the specialized work required for uranium mine remediation. BBER found that the challenges for workers were not about the educational programs we have in place; New Mexico is doing a strong job educating workers across skill sets. Instead, we found that obtaining and maintaining specialized certifications, matching workers with jobs, and ensuring our educational institutions are coordinating their efforts are the key constraints on workforce development.

### 5.3.1. Specialized Certifications and Trainings

Uranium mine remediation requires both technical and physical skill sets. Additionally, because of the hazardous and radioactive substances present, onsite personnel must possess up-to-date OSHA certifications. In our extensive interviews with training programs, universities, and other workforce training organizations, we found that the burden of obtaining and maintaining the OSHA certifications falls primarily on the employee unless employed by a larger, well-established company. Only in limited instances do educational institutions offer OSHA trainings to their students.

Companies competing for contracts must have employees with the required credentials before beginning the bidding process to be successful. Worker training and certification often must be renewed annually. Yet, remediation work may not be consistent enough for many local businesses to justify the hiring and maintaining specialized employees.<sup>70</sup> Lack of regular employment in uranium mine cleanup directly relates to other constraints we have discussed, all of which impact the state's ability to mobilize an appropriately trained workforce when the need arises.

### 5.3.2. Worker Retention and Placement

Compounding training and certification issues, professional and technical employees are often challenging to attract and retain. Often, wages in rural New Mexico are not competitive, especially when compared to nearby metropolitan areas like Denver or Phoenix. Similarly, these urban areas offer more amenities for young professionals, as well as job opportunities for those with partners in the workforce.

Multiple firms BBER interviewed stated things such as, "One of the challenges [our firm] faces is that when it seeks to hire qualified young people who are excited about the work [our firm] does, the location of the firm becomes a barrier, particularly for younger people." One contractor noted, "If you hire a "newbie," train them and put them on jobs for a couple of years, you will likely lose them to higher paying jobs in cities and places where they would rather live than out in some remote area a long way from something that resembles the kind of life they wish to live. Further, they may start single, then get married, then have a family, and life priorities change. When that happens, they leave." Qualified workers will often take higher-paying jobs in larger metropolitan areas, only coming to sites for specific, short-term projects rather than permanently living and working in the region or the state.

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<sup>70</sup> An important point to note is that many individuals in the region have been trained in the extraction industry and that this workforce could be potentially mobilized into remediation work with the appropriate OSHA trainings and job matching.

However, some stakeholders argue that if New Mexico could provide consistent remediation employment, underemployed individuals within the region will already be familiar with the area and want to remain residents.

Finally, the lack of a platform for statewide communication and networking makes it difficult for businesses to find workers and for workers to find jobs that appropriately match qualifications with employment. At this time, it isn't easy to find accurate information about job requirements and necessary skills for entering into uranium mine remediation work at any level of employment. This impedes the ability for meaningful job matching and our educational institutions' ability to respond to marketplace needs. To address workforce placement concerns, there needs to be greater effort to ensure needs are anticipated and met without duplication and that resources are effectively distributed and deployed.

### 5.3.3. Job Site Constraints

Another constraint on workforce development is that uranium mine sites are often in remote areas, not proximate to any towns or significant residential areas. Those with the required skills may likely have to drive an hour or two each way from their residence to get to a job site, which takes a heavy toll and may be unsustainable for the employees. In some cases, contractors indicate they take on the costs of transporting workers to sites daily, but not all contractors are able to do this, forcing the employee to not only have access to transportation at all times but the funds available to fuel and maintain vehicles that can travel long distances.

Additionally, roads into the area may be challenging to navigate and may be inaccessible except to high-clearance four-wheel-drive vehicles. As one contractor noted in a conversation: "We hire someone who is enthusiastic about the job, has the requisite skills or is easily trainable, and within a day or two on the job, they just don't show up. This is a real problem because of the remoteness, we may not be able to get a cellular connection, or they may live where there is no cellular connection. So, suddenly, we don't have that skillset on the jobsite to do what we are contractually obligated to do." Again, this is not necessarily something the State can tackle in policy change but noting the lack of cellular coverage and difficult terrain near many of these mines is an important constraint that needs attention.

### 5.3.4. Coordination among Universities

BBER's investigation suggests that higher education institutions in New Mexico currently provide most of the coursework that professionals need to undertake uranium mine cleanup. However, there is little consistency in applied training and professional placement due to limited collaboration and coordination among institutions.

Professional work in environmental engineering fields requires academic training, but students must tie this training to on-the-ground experience to be successful. Some universities, often due to the initiative of individual professors, are able to link coursework to hands-on research at uranium mine sites, but these opportunities are hit-or-miss. Coordination at the university level would allow for academic programs to share resources and encourage greater collaboration among students working on similar problems, rather than constraining the applications to individual institutions. Sharing resources, both physical and academic, could help New Mexico build a workforce ready to take on the complex issues involving abandoned uranium mines.

Similarly, there is a lack of adequate matching of students and young professionals with in-state employers, not unlike trades workers' challenges, as discussed above. Although jobs are posted in various locations online, most of the professors we spoke with described networks as being critical for job placement. In one interview, a professor mentioned that their graduating students were seeking jobs out of state, as the work was more regular, and the professor had ties to other universities and firms. However, in the course of the same interview, BBER mentioned that a state agency had job postings for relevant positions open for a month, something we had learned in an interview approximately one week earlier. The professor was unaware of these positions and mentioned that the state agency's network was better tied into a different university. Lack of communication should not be the reason New Mexico graduates are taking out-of-state jobs.

## 5.4 Broader Constraints

### 5.4.1 Dated and Expensive Remediation Solutions

The site cleanup solutions are often dated and/or very expensive because the waste from uranium mines is hazardous and radioactive, requiring specialized methods for disposal. All actions need EPA approval. In general, the EPA allows for three primary actions: non-disposal, on-site disposal, and offsite disposal. Non-disposal is an effort to improve community safety by limiting access, but it does not involve waste remediation. On-site disposal means the waste will stay in place, but the damage to the communities and the environment is reduced by developing physical barriers such as waste liners, caps, or other strategies to prevent further contamination. Offsite disposal removes the waste from the affected site, but the hauling of hazardous and radioactive waste through communities is dangerous and expensive, and facilities for permanent storage currently do not exist in New Mexico.

None of these options offers a satisfactory long-term solution, either from a technical perspective or in the eyes of affected communities. There has been little advancement in developing new solutions, which poses the ultimate barrier to an effective uranium cleanup.

Should new solutions be proposed, whether it be new technology or a more locally-based repository and processing center for waste, the economics of the solution will be a critical factor. Offsite disposal is currently cost-prohibitive as uranium mine waste – particularly waste from CERCLA designated sites – has severe restrictions on where it can be stored. This further limits the options for cost-effective disposal to on-site solutions, which is not acceptable to many affected communities. More work needs to be done investigating local and/or innovative solutions for uranium mine waste disposal.

### 5.4.2 Lack of Local Context in Remediation Decisions

#### 5.4.2.1. *Technical and Geographic Expertise*

Affected communities have long been working on their own technological and engineering solutions to environmental problems. Yet, the EPA and other institutions' initiatives involving environmental remediation too often fail to acknowledge, let alone incorporate this knowledge.

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*"We told them where they wanted to place the bridge was not going to work because of how water acted in the arroyo. They ignored us and built a beautiful new bridge, and within one year, that bridge was no longer safe because the rate of the water flowing through the arroyo during the seasonal rains destroyed the bridge foundations and connections to the roadway leading to the bridge."*

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Local knowledge can provide solutions based on historical, physical, and climactic factors that may not be obvious to those doing the work. Engineering solutions may fail when they miss vital details related to local knowledge. One example of such a situation was given at a public meeting by a member of a local Native American community in which a new bridge had been built to accommodate the heavy trucks carrying waste materials from the uranium mine site to a disposal site. The community member stated, "We told them where they wanted to place the bridge was not going to work because of how water acted in the arroyo. They ignored us and built a beautiful new bridge, and within one year, that bridge was no longer safe because the rate of the water flowing through the arroyo during the seasonal rains destroyed the bridge foundations and connections to the roadway leading to the bridge." Ignoring Traditional Ecological Knowledge does not

generate solutions appropriate for New Mexico communities. This is one way in which failing to listen to local knowledge creates problems and disrespects the people most impacted near the sites.

Another example illustrates the importance of utilizing local knowledge throughout the entire remediation process. During a public meeting, BBER attended one community expert, demonstrated that the current EPA standards for food consumption bear little to no resemblance to the dietary practices of Navajo Nation community members. In particular, those living closest to uranium mine sites may be grazing sheep in the area, growing and harvesting edible plants, and foraging for other foodstuffs. In his demonstration, he showed how the current standards for cleanup grossly underestimate the amount of uranium isotope uptake in the Navajo diet, as they fail to account for localized dietary practices. This is another way in which failing to listen to local knowledge can impact even the metrics used to determine standards of exposure and cleanup.

New Mexico communities' technical and geographic expertise should not be overlooked when considering solutions to remediation issues. Rather, solutions informed by best practices and driven by New Mexico-based expertise have the potential to pave the way for more complete and appropriate remediation actions given local context.

#### ***5.4.2.2. Cultural and Spiritual Relationships to the Land***

Sensitivity, acknowledgment, and understanding are required when addressing issues on many sites, as there are often cultural and spiritual connections to the land and its various aspects and inhabitants. Cultural and spiritual issues may present unique challenges, most notably when the government established standards don't allow for accommodations agreed upon by stakeholders.

It is not unreasonable to expect companies, employees, and government agencies involved in cleanup to recognize the reality of a community's concerns and to make serious attempts to engage community members. At a minimum, these entities should engage with members and attempt to establish trusting working relationships with the impacted communities. As one Native-owned firm stated, "Cultural sensitivities are extremely important in working on Native lands. Some sort of 'sensitivity' training probably is appropriate for anyone who is not Native that wants to work in this arena." It is essential that this remediation work be done respectfully and with local knowledge treated as an equal resource.

Even in non-tribal lands, it is not uncommon for residents in these generally remote areas to have longstanding ties to the land and a wealth of local knowledge. Any entity that undertakes cleanup in New Mexico should address concerns and area-specific issues in ways that make community members feel their interests were considered, if not accommodated. Local knowledge and expertise illustrate the challenges to developing the remediation industry's use of nationally determined standards.

# Recommendations for State Action

New Mexico has approximately 1100 uranium mines and mine sites, many of which have had no remediation actions taken. These features pose environmental problems, but remediation offers economic opportunities. This report has documented the potential economic benefits of remediation of mines, based on estimates and invoices of uranium mine cleanup activities regionally (Section 3). We then discussed developing the skills and talent to tackle remediation activities in New Mexico and documented the qualifications needed to work specifically with radioactive and hazardous waste. We drew on our interviews with businesses that operate nationally, regionally, and locally to illustrate the nature of the environmental remediation industry and how to best match workers with opportunities (Section 4). Drawing on interviews with State and federal officials, representatives of Native government agencies, community members, industry professionals, legal groups, advocates and non-profit organizations, and educators and institutions involved in all levels of workforce training and research, we discussed challenges that the state faces in cleaning up the uranium sites. In particular, we considered the challenges New Mexico businesses and workers faced in sharing in the opportunities that cleanup efforts represent.

In all, the findings of this report are based on more than 75 in-depth interviews, cost-estimate and invoice data from government agencies conducting uranium mine cleanups, geographic, geologic, and historical information about the nature and scope of uranium mining in New Mexico.

The following are recommendations to New Mexico State agencies to systematically address the challenges laid out in the previous section. Addressing these challenges will require the involvement of *all* stakeholders: federal, State and local governments, Native nations, private landowners, private sector firms, educational institutions, and community organizations; however, the recommendations here are designed for State action, as the State of New Mexico sponsored this research project. Recommendations are presented not necessarily in order of priority but as a logically structured program to promote the cleanup of uranium sites.

The twelve recommendations are in four categories, each directly tied to the constraints described in the previous chapter:

- Overall Planning
- Challenges faced by state businesses
- Challenges faced by the state's workforce,
- Development of future opportunities

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## 6.1. Overall Planning

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### 6.1.1. Create a Central Repository for Information

The state needs to create a clearinghouse for all documentation related to uranium mining, employment, remediation, ownership, and land status. BBER pulled information from documents housed in federal, state, native government, academic, nonprofit, and business sources. Each of these institutions holds different pieces of a larger puzzle. However, without a better view of the larger picture, it is not easy to see what needs to be done collaboratively and comprehensively to address the more significant problem of working toward uranium mine remediation.

The New Mexico State Library could be a resource for housing this information; however, someone would need to continually catalog and update information as identifying and cleaning up these sites is an evolving event. The EPA is continually doing site evaluations and working on remediation litigation to address these long-contaminated sites. BBER would be happy to share the documentation we have cataloged during this research process; however, more needs to be done.

### 6.1.2. Identify and Engage Key Stakeholders

Unremediated uranium sites are found on state lands, private lands, federal lands, and Native lands across New Mexico. All of these different stakeholders have addressed remediation in some ways, but not all have been brought to the table to discuss how to work together.

Bringing the stakeholders together is essential to addressing remediation as environmental pollution does not respect political boundaries. Many uranium sites may be between two jurisdictions or may involve the waste from two different corporations; collaboration is required to facilitate cleanup efforts. Further, remediation in one jurisdiction will likely impact others at minimum due to transportation and an influx of workers and activity. To best ensure all impacted groups are being considered, a critical step is identifying who will be affected by remediation work.

Identifying key stakeholders is not a simple task. As more information about the mines is uncovered, more stakeholders may need to be brought to the table. Thus, this action needs to be ongoing and flexible, and the unified plan discussed in the next recommendation needs to adapt accordingly.

### 6.1.3. Develop a Unified Plan with Stakeholders

The state's first priority should be communication and collaboration among the various entities and stakeholders in this work. The Navajo Nation has its own remediation plans and has acted to address many of its abandoned uranium mines. The affected Pueblos have addressed and continue to address some of their remediation concerns. State and federal agencies are also working to attend to contamination concerns. Each of these stakeholders has taken steps to generate funding for remediation through lawsuits and other types of accountability endeavors. All of this could be done more efficiently with enhanced communication and collaboration, drawing upon cultural and historical values that underpin stakeholders' relationships to the land and how remediation can be best addressed moving forward. Some steps toward generating a unified plan are explicitly addressed in subsequent recommendations; however, much needs to be done to ensure that all affected voices have a seat at the table during its development.

Although more attention is now being given to the many issues related to uranium mines in New Mexico, there is still no single State plan to address these issues. Community organizations have repeatedly called for a Legislative effort to address the problems, akin to agencies and actions created within the Navajo Nation and at the federal level. Given the scale and complexity of the issue – overlapping Federal, Native, State, and local jurisdictions; the geographical patchwork of the mines, millings, transportation routes, and the flow of groundwater – establishment of a venue for relevant stakeholders to forge a unified strategy is a necessary first step to coordinated State action.

When the State develops a unified plan with all relevant stakeholders, it should include funding and strategies to acquire future funding. This plan then needs to be widely publicized and continually managed to maximize the opportunities we describe in the following sections.

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## 6.2. Challenges Faced by State Businesses

### 6.2.1. Establish a Specialized Small Business Assistance Center

Identifying opportunities and successful application for subcontracts are barriers for local companies hoping to work in environmental remediation. Small businesses lack the necessary administrative scale and specialization to compete with larger, often out-of-state businesses. To support local businesses, the State of New Mexico should establish a small business assistance center specializing in the unique challenges of environmental remediation and particularly uranium

mine remediation. The center should be located in the northwestern quadrant of the state, close to impacted communities.

The business assistance center should be staffed by personnel trained in business licensing, environmental regulation, and subcontracting paperwork, especially under federal agencies. The center would maintain an up-to-date listing of contracting opportunities in environmental remediation and assist in navigating the paperwork and certification processes both before and in managing federal contracts. Our interviews illustrated the need for both upfront support in securing a contract and continued assistance in managing the documentation needed to maintain the contract. These services could be free of charge until a business successfully secures a subcontract; after that time, a business could pay fees for project management documentation to help the center become self-supporting over time. The center may also host workshops conducted by federal agencies and contractors.

This type of work could be done within the Economic Development Department, the Energy, Minerals, and Natural Resources Department, or the Environment Department, but should be consistent and available to New Mexico businesses seeking to apply for environmental remediation subcontracts. Wherever the position is stationed, the person or persons must be trained in the specific types of work and certifications required for uranium mine remediation efforts.

### 6.2.2. Create Shared Workspace for Businesses

As discussed in the report's constraints section, networking and coordination become critical skills for small businesses to develop. To facilitate relationships between smaller New Mexico businesses and larger businesses looking to subcontract remediation work and between the smaller businesses themselves, the state should consider creating co-work spaces in northwestern New Mexico for businesses to utilize when doing environmental remediation work. These spaces could be used not only to host networking events in which businesses may set up tables and discuss their specializations, but also a place for companies to better meet one another and do business. This work could be done in conjunction with the establishment of a small business assistance center or separately.

Workspaces would be set up in key locations throughout the state with inadequate access to internet services, phone services, and meeting space. This could look like a "one-stop-shop" for local and national businesses to rent cubicles, meeting rooms, and access information about remediation work. These spaces would need dedicated phone, internet, and workspace access in addition to a staff member who manages the space.

These spaces could also serve as a repository for contact information, both for businesses able to do remediation work in New Mexico and individuals with certifications and skill sets appropriate for the industry. They would provide centralized locations for notification of upcoming RFPs and potential subcontracting opportunities.

It may be beneficial for the state to investigate commercial properties in a few target areas in northwestern New Mexico to see what the availability of adequate space may look like. Should sufficient space be unavailable, commercial services deliver rentable, portable workspaces for various terms and costs.

### 6.2.3. Create a Facility to Provide Support or Guarantee for Bonding

Some of the biggest barriers for small companies involved and bidding on uranium mine cleanup are bonding and capital requirements.

There are several types of Surety Bonds for contractors: Bid Bonds, Performance Bonds, Payment Bonds, License Bonds and Supply Bonds are a few. In general, surety bonds assure a project owner that they can rely on contractor performance, ability to make payments to certain other parties (sub-contractors, e.g.), good faith bid submissions, and so on. The issuer



of sureties, usually an insurance company subsidiary, investigates a contractor's abilities and, in the event of a valid claim, will make reimbursement for non-performance according to the terms of the surety.

New Mexico could support meeting those requirements by establishing a funding mechanism to be the bond agent for small companies. The SBA has a model that could be adopted by the state. While the SBA Surety Bond program for small companies has some limitations, such as no environmental work, multi-year contracts, and excessive warranty and liquidated damages provisions, the basic concepts warrant consideration by the state to establish a program specifically for small businesses seeking to enter the uranium mine cleanup domain.

Three SBA programs could be considered for emulation regarding uranium mine cleanup:

- Prior Approval Program
- Preferred Surety Bond Program
- Quick Bond Program

The Prior Approval and Preferred Surety Bond Programs offer an 80% guarantee on contracts up to \$6.5 million and up to \$10 million on federal projects (with a federal contracting officer's certification). The Quick Bond Program is designed for smaller contracts, up to \$400,000, and offers an 80-90% guarantee rate, depending on the size of the contract. A benefit of the SBA bond guaranty program is the minimum working capital requirement. The SBA will go to 20 times working capital of the total (bonded and unbonded) costs to complete work on hand. This is aggressive; the standard industry caps at 10 times. Additionally, the SBA will also count unused credit lines toward working capital.

This sort of program coupled with support services for small companies to help with all the ancillary but crucial mechanisms to be effective in bidding on uranium mine remediation projects, e.g., accounting services, contract review services, marketing support services, etc. could go a long way toward helping small local firms enter the market and could potentially attract large cleanup firms to consider partnering with smaller New Mexico businesses that are seeking entry in this arena.

One potential mechanism is for the state to create a fund – created by state law and funded initially under state law but then established with state funding and administrative support for assisting smaller New Mexico companies entering the uranium mine cleanup arena. The state has established such an entity for assisting companies and workers regarding Workers Compensation issues – NM Mutual – which helps companies, workers, and agents.

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## 6.3. Challenges Faced by the State's Workforce

### 6.3.1. Advance Consistent Safety Certification Training Programs

We recommend that the State consider coordinating remediation-related Occupational Safety and Health Administration (OSHA) training programs so that New Mexico workers and students entering uranium mine remediation work would be more easily able to access this coursework that is necessary to work in this field. At the time of this writing, few OSHA programs related to uranium mine cleanup are being held across the state. In our conversations with different educational institutions, we found that it was cost-prohibitive for those institutions to shoulder the burden of the OSHA trainings along with the subsequent testing. Additionally, training students by institution results in small, expensive classes with a lack of adequate records as to which professionals hold the training credentials state-wide, thereby further distancing those professionals from opportunities that may arise outside of the institutional network.

To streamline the training process, we recommend the State look to agencies well-positioned to provide the OSHA courses, such as the Bureau of Mine Safety, which already provides Mine Safety and Health Administration (MSHA)

trainings across New Mexico. In conversations with the Bureau of Mine Safety, they felt that providing OSHA trainings was analogous to providing MSHA trainings and would not require massive repositioning of their agency. In this way, an OSHA training model that looks like the MSHA training would not require creating a new institution, but instead a reorientation and expansion of existing resources. Additionally, the State is better positioned than individual institutions to offer OSHA trainings at critical junctures as the timeline for remediation activities is unclear. State-led actions cannot fully overcome the timeline constraint, but the State can be more directly involved with federal and corporate cleanup initiatives, thereby structuring training opportunities to benefit the most workers simultaneously.

Finally, some of the institutions in New Mexico currently offering limited OSHA trainings argued that a state-led initiative would benefit their programs immensely, and they could better focus on workforce development. BBER suggests that the State consider how to potentially fund these programs through existing channels to minimize costs and maximize benefits to students and workers across New Mexico.

### 6.3.2. Facilitate Collaboration among Higher Education Institutions

Although many of our higher education institutions are training engineers, health physicists, geologists, and other professionals that are essential for addressing uranium mine cleanup efforts, there is little evidence that these programs are coordinating with one another, nor is there evidence they are coordinating with state agencies on a large scale. This can be remedied, in part, with intervention by state initiatives to incentivize or encourage collaboration among relevant institutions and departments. This could be as simple as holding annual conferences on the topic of uranium mine remediation and developing sessions designed to bring New Mexico's professionals together in a common setting to discuss research and development of ideas.

Collaboration would help ensure the research being done at the educational institutions across the state is being shared and that institutional overlap is minimized. Additionally, research and innovation need to be shared with state agencies working on cleanup efforts and other educational institutions. With state-led collaborative sessions or conferences, students and professors would be able to discuss their research with state professionals. Then, our educational institutions could begin to partner on educational strategies, promote one another's work, build skills and innovation into the professional degrees most needed for uranium mine remediation, and share new ideas with the State. We discuss specific ideas related to this proposed collaboration in sections 6.4.2. and 6.4.3., with our recommendations on facilitating innovation and continuing research into topics related to uranium mine remediation.

### 6.3.3. Create Opportunities for Worker Placement Locally

Whether talking about skilled professionals or those with an advanced degree, more networking opportunities need to be made to connect those workers with employment opportunities. Most of the businesses we interviewed, from small, local businesses to major corporations, talked about the need for matching workers to opportunities. Worker placement should also be prioritized in the state agencies concerned with cleanup efforts. There is no current skills/certifications directory to help companies find workers, as we discussed in 6.2.3., nor are there job fairs that focus specifically on environmental remediation. Many of the professors we spoke with at different educational institutions described a lack of communication about opportunities unless that specific professor had ties directly to state agencies or corporations. As a result, many trained students left the state in search of appropriate work elsewhere.

One example of a growing worker placement initiative is STEM Boomerang<sup>71</sup>. We spoke with representatives of this organization, which does not, at this time, focus on engineering or environmental remediation. However, their work should be seen as a model for an effective worker placement program. STEM Boomerang's mission is to "establish connections between Science, Technology, Engineering, and Math (STEM) professionals and the companies and colleges

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<sup>71</sup> <https://stemboomerang.org/>

that want to hire them.” They are funded through community partnerships with organizations across New Mexico. In addition to hosting job fair events, they also maintain a database of employment opportunities for job seekers and a database of resumes for employers to search. The state could build on this model when considering how to match local professionals with local businesses and reduce the “brain drain” we see as students leave New Mexico for other opportunities.

## 6.4. Development of Future Opportunities

### 6.4.1. Prioritize Environmental Remediation as a Target Industry

This report has focused on the remediation of uranium mines; however, there is a consensus that environmental remediation, in general, is an emerging growth industry for the 21st century. New Mexico’s prioritization of this industry can be leveraged to create success in other remediation opportunities.

From a New Mexico economic development perspective, given the significant levels of expertise in this state concerning nuclear materials, mining, engineering, health, and legal and legislative matters, developing a model for how to bring all these resources together to address the various issues surrounding uranium mine cleanup could represent not only immediate benefit to residents and businesses in New Mexico but could also parlay this model into a significant new business sector. As we continue to see fluctuations in the extractive energy economy’s stability, it is essential to diversify our economic development priorities. In those regions, such as northwestern New Mexico, most dependent on energy resource development, planning for environmental remediation work repositions our already experienced workforce to be ready for economic shifts.

Beyond New Mexico, a sector focused specifically on environmental remediation with specialized expertise in radioactive cleanup could export its industry nationally and internationally. Uranium mine sites exist all around the world. Further, there are still active uranium mines that someday will close out either because the demand and economics don’t justify the continuation of the mines or because the deposits are sufficiently depleted as to render them uneconomic to continue when there are other sites with greater reserves. With the inclusion of environmental remediation as a priority industry, New Mexico could develop a skills list for businesses and individuals trained to do uranium mine cleanup work and help grow our educational programs alongside our companies. This focus could also make New Mexico a place for international education, attracting students from other countries to learn from our professionals at our state institutions.

### 6.4.2. Generate Pathways for Greater Innovation

In the current setting, there have been insufficient resources to investigate the evidence to alter the current approaches to uranium mine cleanup both from the private and the public sectors. Utilizing the resources in New Mexico for innovation would benefit not only the state but potentially the remediation industry on the whole. The state’s jurisdiction over some of the lands with uranium mines and waste could provide the opportunity for specific research and projects in collaboration with our higher education institutions and local innovators.

One model discussed in our interviews with stakeholders was a collaborative session in which experts from various institutions were brought together by Harvard in 1998 to tackle complex problems in the health field.<sup>72</sup> When a project was completed, these experts went back to their “home” institutions. Out of this revolving collection of experts, many new patents were obtained for new products, services, and medicines.

In principle, there is no reason why New Mexico could not become the national/global market leader in addressing the remediation and cleanup of nuclear waste materials. We have countless experts in our state who could be called upon to innovate new solutions to address this massive problem. Educational institutions such as Diné College, Navajo Technical

<sup>72</sup> <https://cimit.org/about>

University, New Mexico State University, New Mexico Tech, and the University of New Mexico have all been examining various aspects of uranium mine remediation. The state could facilitate information exchanges and brainstorming sessions with these experts, alongside experts from Los Alamos National Laboratories and Sandia Labs. These sessions would have the potential to improve the economic and social well-being of impacted communities and yield new products and services that are marketable well beyond New Mexico.

#### 6.4.3. Continue Research on the Effects of Unremediated Uranium Mines

Finally, there seems to be some level of agreement that collaborative research needs to be done to identify and address additional pathways wherein uranium waste products are harmful to local citizenry beyond the known routes of groundwater contamination and living on or proximate to former mining and milling sites that often contain high levels of radioactive materials. Experts from different fields seem to agree that airborne exposure, for example, needs to be investigated in such a manner that USEPA can recognize there is sufficient and unequivocal evidence to support defined remedies and/or the need to marshal such research to find such remedies. It is evident within uranium mine cleanup sites that residual materials are fundamentally “hot” and represent potential vectors for wind-borne toxic materials in the form of dust.

Another area of research currently being investigated within the state is the validity of the metrics used to determine exposure. For example, some research examines culturally appropriate metrics for measuring impacts – many exposed communities generally don’t eat much beef, but they do eat mutton. Yet, the current EPA metrics with regard to meat consumption are based on the grazing patterns of cattle, which are unlikely to be the same grazing patterns as for sheep. These metrics determine the level of cleanup required and/or accepted and may well be grossly inappropriate in areas primarily inhabited by Native populations, where many mines are situated. Incorporating localized research and expertise on Traditional Ecological Knowledge will be critical to gaining full insight into the magnitude of the impacts of unremediated uranium mines in New Mexico.

The State could help facilitate bringing together the myriad technical specialties that have a keen interest in addressing exposure problems and finding ways around the existing hurdles to more rapid development and technology. There is a clear need to assess the negative consequences such as disease, diminished life expectancy, disturbed or destroyed community life, and ties that have been mentioned in public meetings, research reports, various media campaigns, and testimony before Congress. Once these are more fully understood, the real economic and social costs can be more readily calculated. Thus, the deeper benefits to remediation and cleanup efforts could be sufficiently demonstrated and resources more appropriately allocated.

# Appendix A. Economic Impact

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*Full economic impact results are shown below for each of the five possible scenarios. Each table displays direct, indirect, induced, and total impacts as well as economic multipliers for employment, labor income, and output. Note that "value added" is also included for completeness. Value added incorporates labor income as well as taxes on production and other property income. Below each impact table is an additional table listing the most impacted employment industries (in descending order by the number of jobs) as well as associated labor income, value added, and output.*

*The results are organized first by mine type (surface and underground) and then by disposal method (non-disposal, onsite, offsite).*

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Surface Mine – Non-Disposal	A-2
Surface Mine - Onsite	A-3
Surface Mine - Offsite	A-4
Underground Mine - Onsite	A-5
Underground Mine - Offsite	A-6

## Surface Mine

### Non-Disposal (Surface Mine)

Impact Type	Employment	Labor Income	Labor Income/Job	Output	Output/Job
Direct Effect	3.3	\$201,846	\$61,165.45	\$515,737	\$156,283.94
Indirect Effect	1.1	\$49,066	\$44,605.45	\$154,203	\$140,184.55
Induced Effect	1.4	\$52,559	\$37,542.14	\$181,482	\$129,630.00
<b>Total Effect</b>	<b>5.8</b>	<b>\$303,471</b>	<b>\$52,322.59</b>	<b>\$851,421</b>	<b>\$146,796.72</b>
Multiplier	1.8	1.5	N/A	1.7	N/A

Sector	Description	Employment	Labor Income	Labor Income/Job	Output	Output/Job
455	Environmental and other technical consulting services	1	\$52,340	\$52,340	\$72,914	\$72,914
395	Wholesale trade	0.6	\$33,854	\$56,423	\$123,550	\$205,917
449	Architectural, engineering, and related services	0.5	\$36,071	\$72,142	\$76,921	\$153,842
445	Commercial and industrial machinery and equipment rental and leasing	0.4	\$35,845	\$89,613	\$138,946	\$347,365
462	Office administrative services	0.4	\$21,224	\$53,060	\$29,721	\$74,303
411	Truck transportation	0.3	\$15,784	\$52,613	\$43,741	\$145,803
56	Construction of new highways and streets	0.1	\$3,197	\$31,970	\$11,407	\$114,070
405	Retail - General merchandise stores	0.1	\$1,471	\$14,710	\$3,767	\$37,670
440	Real estate	0.1	\$1,978	\$19,780	\$28,303	\$283,030
442	Automotive equipment rental and leasing	0.1	\$7,030	\$70,300	\$31,036	\$310,360
464	Employment services	0.1	\$4,037	\$40,370	\$7,181	\$71,810
465	Business support services	0.1	\$2,759	\$27,590	\$4,386	\$43,860
468	Services to buildings	0.1	\$908	\$9,080	\$1,790	\$17,900
471	Waste management and remediation services	0.1	\$7,634	\$76,340	\$22,459	\$224,590
482	Hospitals	0.1	\$4,773	\$47,730	\$9,480	\$94,800
x	Other (Implied)	1.7	\$74,560	\$43,859	\$245,814	\$144,596
<b>Total</b>		<b>5.8</b>	<b>\$303,471</b>	<b>\$52,323</b>	<b>\$851,421</b>	<b>\$146,797</b>

**Onsite Disposal (Surface Mine)**

Impact Type	Employment	Labor Income	Labor Income/Job	Output	Output/Job
Direct Effect	4.3	\$296,903	\$69,047	\$887,498	\$206,395
Indirect Effect	1.6	\$73,534	\$45,959	\$235,906	\$147,441
Induced Effect	2.1	\$77,547	\$36,927	\$267,770	\$127,510
<b>Total Effect</b>	<b>8</b>	<b>\$447,984</b>	<b>\$55,998</b>	<b>\$1,391,174</b>	<b>\$173,897</b>
Multiplier	1.9	1.5	N/A	1.6	N/A

Sector	Description	Employment	Labor Income	Labor Income/Job	Output	Output/Job
445	Commercial and industrial machinery and equipment rental and leasing	1.3	\$119,494	\$91,918	\$463,187	\$356,298
449	Architectural, engineering, and related services	0.8	\$61,696	\$77,120	\$131,566	\$164,458
455	Environmental and other technical consulting services	0.6	\$32,789	\$54,648	\$45,678	\$76,130
56	Construction of new highways and streets	0.5	\$25,055	\$50,110	\$89,385	\$178,770
395	Wholesale trade	0.3	\$17,912	\$59,707	\$65,368	\$217,893
411	Truck transportation	0.3	\$21,159	\$70,530	\$58,637	\$195,457
462	Office administrative services	0.3	\$15,336	\$51,120	\$21,475	\$71,583
471	Waste management and remediation services	0.3	\$25,712	\$85,707	\$75,641	\$252,137
440	Real estate	0.2	\$2,546	\$12,730	\$36,441	\$182,205
501	Full-service restaurants	0.2	\$4,586	\$22,930	\$9,766	\$48,830
502	Limited-service restaurants	0.2	\$3,079	\$15,395	\$12,530	\$62,650
400	Retail - Food and beverage stores	0.1	\$1,889	\$18,890	\$4,214	\$42,140
405	Retail - General merchandise stores	0.1	\$2,171	\$21,710	\$5,561	\$55,610
415	Couriers and messengers	0.1	\$1,866	\$18,660	\$5,617	\$56,170
433	Monetary authorities and depository credit intermediation	0.1	\$3,115	\$31,150	\$9,667	\$96,670
x	Other (Implied)	2.6	\$109,572	\$42,143	\$356,435	\$137,090
<b>Total</b>		<b>8</b>	<b>\$447,984</b>	<b>\$55,998</b>	<b>\$1,391,174</b>	<b>\$173,897</b>

**Offsite Disposal (Surface Mine)**

<b>Impact Type</b>	<b>Employment</b>	<b>Labor Income</b>	<b>Labor Income/Job</b>	<b>Output</b>	<b>Output/Job</b>
Direct Effect	4.5	\$278,736	\$61,941	\$780,577	\$173,462
Indirect Effect	2.1	\$107,422	\$51,153	\$357,693	\$170,330
Induced Effect	2.1	\$80,881	\$38,515	\$279,277	\$132,989
<b>Total Effect</b>	<b>8.7</b>	<b>\$467,039</b>	<b>\$53,683</b>	<b>\$1,417,548</b>	<b>\$162,937</b>
Multiplier	1.9	1.7	N/A	1.8	N/A

<b>Sector</b>	<b>Description</b>	<b>Employment</b>	<b>Labor Income</b>	<b>Labor Income/Job</b>	<b>Output</b>	<b>Output/Job</b>
411	Truck transportation	3.6	\$224,265	\$62,296	\$621,493	\$172,637
395	Wholesale trade	0.4	\$21,653	\$54,133	\$79,023	\$197,558
415	Couriers and messengers	0.3	\$10,160	\$33,867	\$30,575	\$101,917
440	Real estate	0.2	\$2,662	\$13,310	\$38,097	\$190,485
445	Commercial and industrial machinery and equipment rental and leasing	0.2	\$17,318	\$86,590	\$67,128	\$335,640
449	Architectural, engineering, and related services	0.2	\$12,898	\$64,490	\$27,504	\$137,520
455	Environmental and other technical consulting services	0.2	\$9,937	\$49,685	\$13,843	\$69,215
501	Full-service restaurants	0.2	\$3,617	\$18,085	\$7,703	\$38,515
502	Limited-service restaurants	0.2	\$2,874	\$14,370	\$11,696	\$58,480
518	Postal service	0.2	\$15,376	\$76,880	\$18,810	\$94,050
20	Extraction of natural gas and crude petroleum	0.1	\$4,796	\$47,960	\$12,387	\$123,870
56	Construction of new highways and streets	0.1	\$2,966	\$29,660	\$10,582	\$105,820
396	Retail - Motor vehicle and parts dealers	0.1	\$3,552	\$35,520	\$7,269	\$72,690
400	Retail - Food and beverage stores	0.1	\$2,028	\$20,280	\$4,523	\$45,230
405	Retail - General merchandise stores	0.1	\$2,446	\$24,460	\$6,264	\$62,640
x	Other (Implied)	2.5	\$130,480	\$52,192	\$460,644	\$184,258
<b>Total</b>		<b>8.7</b>	<b>\$467,039</b>	<b>\$53,683</b>	<b>\$1,417,548</b>	<b>\$162,937</b>



## Underground Mine

### Onsite Disposal (Underground Mine)

Impact Type	Employment	Labor Income	Labor Income/Job	Output	Output/Job
Direct Effect	4.7	\$300,160	\$63,864	\$844,369	\$179,653
Indirect Effect	1.6	\$74,823	\$46,764	\$239,427	\$149,642
Induced Effect	2.1	\$78,535	\$37,398	\$271,175	\$129,131
<b>Total Effect</b>	<b>8.5</b>	<b>\$453,517</b>	<b>\$53,355</b>	<b>\$1,354,972</b>	<b>\$159,408</b>
Multiplier	1.8	1.5	N/A	1.6	N/A

Sector	Description	Employment	Labor Income	Labor Income/Job	Output	Output/Job
445	Commercial and industrial machinery and equipment rental and leasing	1	\$84,214	\$84,214	\$326,435	\$326,435
455	Environmental and other technical consulting services	0.9	\$46,069	\$51,188	\$64,179	\$71,310
449	Architectural, engineering, and related services	0.7	\$54,996	\$78,566	\$117,277	\$167,539
471	Waste management and remediation services	0.6	\$45,846	\$76,410	\$134,872	\$224,787
56	Construction of new highways and streets	0.5	\$21,665	\$43,330	\$77,291	\$154,582
411	Truck transportation	0.4	\$23,328	\$58,320	\$64,648	\$161,620
462	Office administrative services	0.4	\$18,482	\$46,205	\$25,880	\$64,700
395	Wholesale trade	0.3	\$18,913	\$63,043	\$69,023	\$230,077
19	Support activities for agriculture and forestry	0.2	\$4,609	\$23,045	\$10,436	\$52,180
440	Real estate	0.2	\$2,692	\$13,460	\$38,532	\$192,660
501	Full-service restaurants	0.2	\$4,577	\$22,885	\$9,747	\$48,735
502	Limited-service restaurants	0.2	\$3,093	\$15,465	\$12,587	\$62,935
400	Retail - Food and beverage stores	0.1	\$1,915	\$19,150	\$4,272	\$42,720
405	Retail - General merchandise stores	0.1	\$2,205	\$22,050	\$5,646	\$56,460
415	Couriers and messengers	0.1	\$1,941	\$19,410	\$5,840	\$58,400
x	Other (Implied)	2.6	\$118,958	\$45,753	\$388,303	\$149,347
<b>Total</b>		<b>8.5</b>	<b>\$453,517</b>	<b>\$53,355</b>	<b>\$1,354,972</b>	<b>\$159,408</b>

**Offsite Disposal (Underground Mine)**

<b>Impact Type</b>	<b>Employment</b>	<b>Labor Income</b>	<b>Labor Income/Job</b>	<b>Output</b>	<b>Output/Job</b>
Direct Effect	5.3	\$337,874	\$63,750	\$991,600	\$187,094
Indirect Effect	2.5	\$132,165	\$52,866	\$446,138	\$178,455
Induced Effect	2.6	\$98,462	\$37,870	\$339,982	\$130,762
<b>Total Effect</b>	<b>10.4</b>	<b>\$568,502</b>	<b>\$54,664</b>	<b>\$1,777,720</b>	<b>\$170,935</b>
Multiplier	2.0	1.7	N/A	1.8	N/A

<b>Sector</b>	<b>Description</b>	<b>Employment</b>	<b>Labor Income</b>	<b>Labor Income/Job</b>	<b>Output</b>	<b>Output/Job</b>
411	Truck transportation	4.7	\$290,575	\$61,824	\$805,253	\$171,330
415	Couriers and messengers	0.4	\$12,838	\$32,095	\$38,632	\$96,580
395	Wholesale trade	0.2	\$11,047	\$55,235	\$40,317	\$201,585
409	Rail transportation	0.2	\$25,508	\$127,540	\$141,538	\$707,690
414	Scenic and sightseeing transportation and support activities for transportation	0.2	\$14,969	\$74,845	\$34,222	\$171,110
440	Real estate	0.2	\$3,083	\$15,415	\$44,130	\$220,650
455	Environmental and other technical consulting services	0.2	\$8,729	\$43,645	\$12,160	\$60,800
501	Full-service restaurants	0.2	\$4,196	\$20,980	\$8,936	\$44,680
502	Limited-service restaurants	0.2	\$3,415	\$17,075	\$13,895	\$69,475
518	Postal service	0.2	\$19,387	\$96,935	\$23,717	\$118,585
20	Extraction of natural gas and crude petroleum	0.1	\$6,609	\$66,090	\$17,068	\$170,680
62	Maintenance and repair construction of nonresidential structures	0.1	\$2,585	\$25,850	\$8,302	\$83,020
396	Retail - Motor vehicle and parts dealers	0.1	\$4,440	\$44,400	\$9,088	\$90,880
400	Retail - Food and beverage stores	0.1	\$2,474	\$24,740	\$5,519	\$55,190
405	Retail - General merchandise stores	0.1	\$2,994	\$29,940	\$7,667	\$76,670
x	Other (Implied)	3.2	\$155,639	\$48,637	\$567,271	\$177,272
<b>Total</b>		<b>10.4</b>	<b>\$568,502</b>	<b>\$54,664</b>	<b>\$1,777,720</b>	<b>\$170,935</b>

# Appendix B. References

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*The following section is a list of the sources used (whether referenced or not) in the process of researching the data for this report.*

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# Appendix C. Contacts

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*The following section is a list of the contacts and/or sources of information used (whether referenced or not) in the process of researching the data for this report.*

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Government Organizations _____	C-2
Community Organizations _____	C-3
Educational Institutions _____	C-3
Economic Development Organizations _____	C-3
Labor Unions _____	C-4
Business & Industry _____	C-4

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## Contacts

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*-Government Organizations-*

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- Laguna Pueblo Environmental and Natural Resources Department
- Montana Department of Environmental Quality
- Navajo Nation Abandoned Mine Lands
- Navajo Nation Chapter Presidents and Chapter Delegates (various)
- Navajo Nation Environmental Protection Agency
- Nevada Bureau of Mining
- New Mexico Bureau of Geology and Natural Resources
- New Mexico Bureau of Mine Safety
- New Mexico Energy, Minerals, and Natural Resources Department: Mining and Minerals Division
- New Mexico Environment Department
- New Mexico Land Commissioner
- New Mexico Office of the Natural Resource Trustee
- New Mexico State Mine Inspector's Office
- New Mexico Water Science Center
- Pueblo of Acoma Environment Department
- US Bureau of Land Management New Mexico
- US Department of Energy: Office of Legacy Management
- US Department of Labor: Mine Safety and Health Administration
- US Department of the Interior: Office of Surface Mining Reclamation and Enforcement
- US Environmental Protection Agency Regions 6, 8, and 9
- US Forest Service New Mexico, Arizona, Utah
- Utah Division of Oil, Gas, and Mining: Abandoned Mine Reclamation Program



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*-Community Organizations-*

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- Conservation Voters New Mexico
- Diné Uranium Mine Remediation Advisory Commission
- Eastern Navajo Diné Against Uranium Mining
- Multicultural Alliance for a Safer Environment
- New Mexico Environmental Law Center
- Post-71 Uranium Workers Committee
- Red Water Pond Road Community Association
- Southwest Research and Information Center
- STEM Boomerang

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*-Educational Institutions-*

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- Central New Mexico Community College
- Diné College
- Navajo Technical University
- New Mexico EPSCoR
- New Mexico State University
- New Mexico Institute of Mining and Technology
- Northern Arizona University Institute for Tribal Environmental Professionals
- San Juan College
- University of New Mexico Engineering
  - University of New Mexico METALS Superfund Research Program Center

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*-Economic Development Organizations-*

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- Center for Indian Country Development – Minneapolis Federal Reserve Board

- Greater Gallup Economic Development Corporation
- Native Community Development Financial Institutions Network
- Northwest New Mexico Council of Governments

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*-Labor Unions-*

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- Laborers' International Union of North America
- New Mexico Building and Construction Trades Council
- United Mine Workers of America

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*-Business and Industry-*

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- 814 Solutions
- Arrow Indian Contractors
- Bitco Corporation
- Clawson Excavating
- Diné Construction
- Diné Tah Doo Cultural Resources Management, LLC
- Disa, LLC
- Duran Bokich Enterprise, LLC
- Dwyer Engineering
- Ecology and Environment, Inc.
- Ellis Erosion Control Systems
- Energy Fuels (formerly Strathmore Resources US)
- Engineering/Remediation Resources Group
- Enviro-Systems of Utah, LLC
- Enviroworks, LLC
- ETD Incorporated
- Helio Resources, Ltd.
- iiná bá
- Intera Geoscience and Engineering Solutions

- Laramide Resources Ltd.
- Navajo Engineering and Construction Authority
- Navarro Research and Engineering
- Oxbow Environmental Engineering
- Rio Algom/BHP
- Rio Grande Resources
- Runyan Construction
- SC&A
- Tetra Tech
- General Electric - United Nuclear Corporation
- Weston Solutions
- Western Water & Land
- Westwater Resources (formerly Uranium Resources)
- Woodard & Curran (formerly TREC, Inc.)

## Appendix D. EPA Cleanup Terms

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*This glossary defines the various specific legal terms used in official documentation of work related to uranium mine cleanup. In the report, we use "remediation" less specifically than is described in this document, but were consistent with our usage of the other terms.*

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A-Ec

D-2

En-R

D-3

Re-Z

D-4

## TERMS & ACRONYMS

## DEFINITIONS

Administrative Settlement Agreement and Order on Consent (AOC)	A legal agreement signed by EPA and an individual, business, or other entity through which the violator agrees to pay for correction of violations, take the required corrective or cleanup actions, or refrain from an activity. It describes the actions to be taken, may be subject to a comment period, applies to civil actions, and can be enforced in court.
Applicable or Relevant and Appropriate Requirement(s) ARAR(s)	Applicable requirements are those clean-up standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, response action, location, or other circumstance at a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site. "Relevant and appropriate" requirements are those clean-up standards which, while not "applicable" at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. ARARs can be action-specific, location-specific, or chemical-specific.
Clean-up and Remediation	Cleanup: Actions taken to deal with a release or threat of release of a hazardous substance that could affect humans and/or the environment.  Remediation: Cleanup or other methods used to remove or contain a toxic spill or hazardous materials from a Superfund site.
Closed	Portals, vents, adits, and other openings have been blocked or backfilled to prevent future entry by humans (some have bat gates which do not fully close the opening but use bars to keep humans out and allow bats and small animals to enter).
Consent decree / Consent Order (CD)	A legal document, approved by a judge, that formalizes an agreement reached between EPA and potentially responsible parties (PRPs) through which PRPs will conduct all or part of a cleanup action at a Superfund site; cease or correct actions or processes that are polluting the environment; or otherwise comply with EPA initiated regulatory enforcement actions to resolve the contamination at the Superfund site involved. The consent decree describes the actions PRPs will take and may be subject to a public comment period.
Ecological Restoration	The process of repairing damage caused by humans to the diversity and dynamics of indigenous ecosystems.

**TERMS & ACRONYMS**

**DEFINITIONS**

<p>Engineering Evaluation / Cost Analysis (EA/CA)</p>	<p>[Federal] An EE/CA is an analysis of removal alternatives for a site, similar to a feasibility study. Upon completion, the EE/CA must be made available for a 30-day public comment period. Upon a timely request, the comment period will be extended by a minimum of 15 days.</p>
<p>Environmental Remediation</p>	<p>Environmental Remediation supports the immediate and long-term activities associated with the correcting and offsetting of environmental deficiencies or imbalances, including restoration activities. [EPA BRM]</p>
<p>In-process</p>	<p>An agency is conducting ongoing activities that should lead to reclamation or remediation such as negotiations with potentially responsible parties, a screening report, engineering evaluation/cost analysis, or a remedial investigation/feasibility study.</p>
<p>Judicial Consent Decree (CD)</p>	<p>A consent decree (CD) is a legal agreement entered into by the United States (through EPA and the Department of Justice) and PRPs. CDs are lodged with a court. Consent decrees are the only settlement type that EPA can use for the final cleanup phase (remedial action) at a Superfund site. EPA also uses CDs to recover cleanup costs in cost recovery and cash-out settlements and on rare occasions to perform removal work or remedial investigations/feasibility studies. A consent decree is final when it is approved and entered by a U.S. district court.</p>
<p>Land Remediation</p>	<p>The return of land to the original uncontaminated state. [Adapted from USDA National Agricultural Library Thesaurus]</p>
<p>Not Reclaimed</p>	<p>No work has been performed to reclaim, remediate, or mitigate physical and environmental hazards. No information is available for these sites, and the status is typically unknown.</p>
<p>Partially Reclaimed</p>	<p>Typically, some physical hazards have been addressed. The reclamation/remediation is phased, and not all phases are complete.</p>
<p>Permitted</p>	<p>Operator has a reclamation bond with a regulatory agency. And/or privately owned, and owner is responsible for reclamation/remediation. Although a claim may have been filed on BLM land, this does not mean the individual is responsible for a mine located within the claim.</p>
<p>Reclamation</p>	<p>Process of restoring surface environment to acceptable pre-existing conditions. Includes surface contouring, equipment removal, well plugging, re-vegetation, etc.[DOE Energy Information Administration Glossary]</p>

**TERMS & ACRONYMS**

**DEFINITIONS**

<p>Reclamation Area</p>	<p>Surface area of a coal mine which has been returned to required contour and on which revegetation (specifically, seeding or planting) work has commenced. [40 CFR 434.11 (CFR 2013)]</p>
<p>Reclamation Plan</p>	<p>Plan detailing activities and milestones to accomplish reclamation of impoundments or piles containing uranium byproduct material or tailings. Activities and milestones to be addressed include, but are not limited to, dewatering and contouring of conventional impoundments and heap leach piles, and removal and disposal of non-conventional impoundments. A reclamation plan prepared and approved in accordance with 10 CFR part 40, Appendix A is considered a reclamation plan in this subpart. [40 CFR 61.251 (CFR 2017)]</p>
<p>Reclamation Site</p>	<p>Generally, a waste site which has the potential of being restored to productive uses.</p>
<p>Remediation</p>	<p>Cleanup or other methods used to remove or contain a toxic spill or hazardous materials from a Superfund site.</p>
<p>Remediation Optimization</p>	<p>Efforts at any phase of the removal or remedial response to identify and implement specific actions that improve the effectiveness and cost-efficiency of that phase. Such actions may also improve the remedy's protectiveness and long-term implementation which may facilitate progress towards site completion. To identify these opportunities, regions may use a systematic site review by a team of independent technical experts, apply techniques or principles from Green Remediation or Triad, or apply other approaches to identify opportunities for greater efficiency and effectiveness. Optimization support was known by the remedial phases or for the type of support provided. These terms and acronyms have been phased out.</p>
<p>Remediation Services</p>	<p>This industry comprises establishments primarily engaged in one or more of the following: (1) remediation and cleanup of contaminated buildings, mine sites, soil, or ground water; (2) integrated mine reclamation activities, including demolition, soil remediation, waste water treatment, hazardous material removal, contouring land, and revegetation; and (3) asbestos, lead paint, and other toxic material abatement. [NAICS]</p>
<p>Restoration</p>	<p>Return of an ecosystem to a close approximation of its presumed condition prior to disturbance.</p>

# Appendix E.

## Northeast Church Rock Mining Timeline

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*The Northeast Church Rock Mine (NECR) is a former uranium mine located approximately 17 miles northeast of Gallup, NM at the northern end of State Highway 566 in the Pinedale Chapter of the Navajo Nation. EPA is working with the Navajo Nation Environmental Protection Agency (NNEPA) to oversee cleanup work being done by the United Nuclear Corporation (UNC), a company owned by General Electric (GE).*

*The graphic timeline of key moments in the operation, closure, and cleanup of the mine illustrates the complexity and significant delays plaguing the community. Below the visual timeline is additional information surrounding each point in the timeline.*

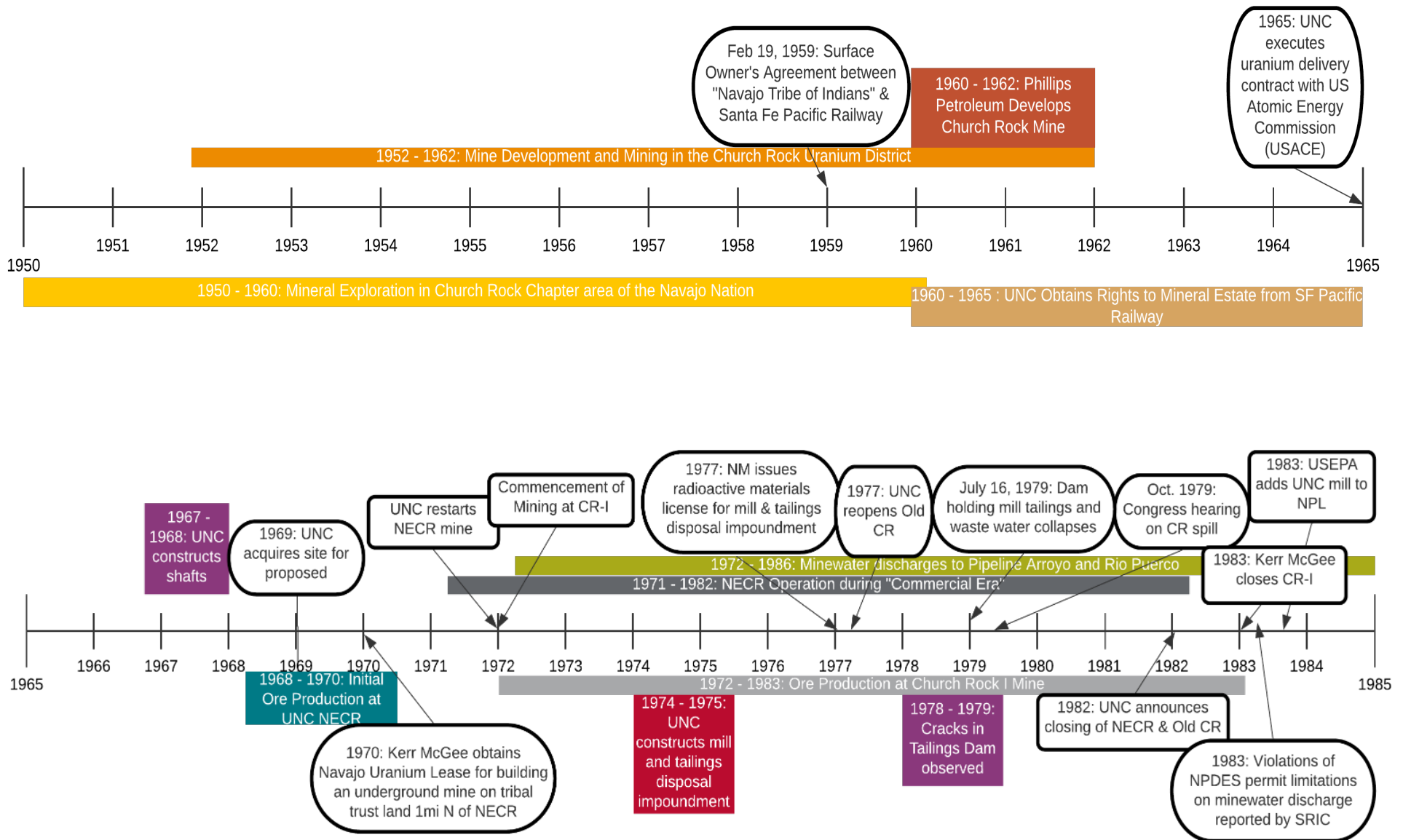
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Visual Timeline – 1950-1985	E-2
Visual Timeline – 1986-2026	E-3
Timeline Details – 1950-July, 1979	E-4
Timeline Details – October, 1979-April, 2005	E-5
Timeline Details – 2006-2020	E-6



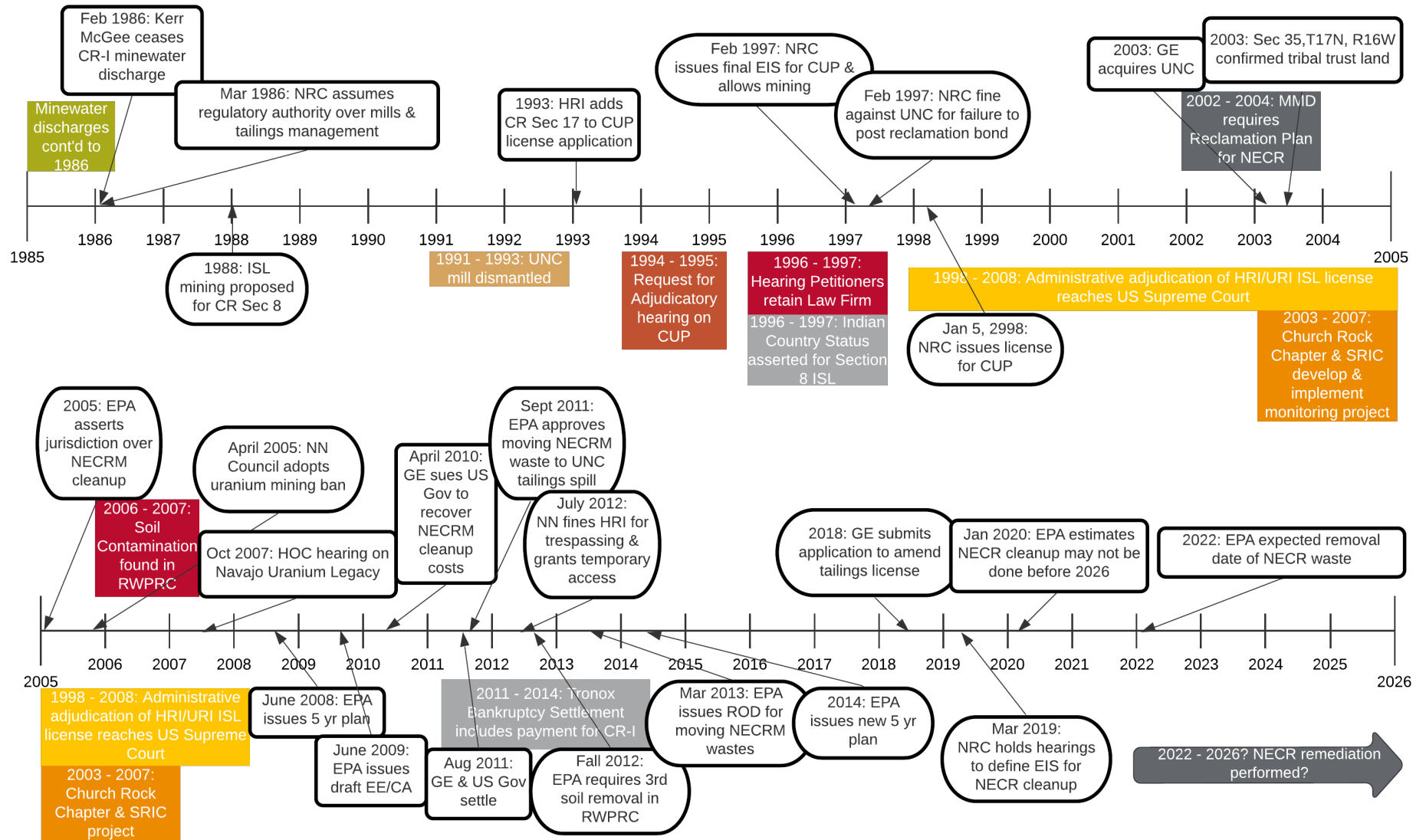
# Northeast Church Rock Mining Timeline

1950 - 1985



# Northeast Church Rock Mining Timeline

1986-2026



**1950 – 1960: Mineral exploration in Church Rock Chapter of the Navajo Nation.** Prospecting and exploration occurred on tribal trust and allotments, federal, state, and private lands.

**1952 – 1962: Mine development in the Church Rock uranium district.** At least 13 small mines were developed. About 150,000 tons of ore were extracted at these sites.

**Feb 19, 1959: Surface Owner's Agreement between "Navajo Tribe of Indians" and Santa Fe Pacific Railway.** Authorized SFPR to prospect and mine for uranium on lands specified in the agreement, totaling 19,000 acres spread across ~200 square miles. Included were lands owned by the US Government and held "in trust" for the Navajo Tribe, bordered by the 1880 Navajo Reservation boundary. At least 5 mines were developed – the two largest were the Northeast Church Rock Mine and the Old Church Rock Mine.

**1960 – 1965: United Nuclear Corp. (UNC) obtains rights to mineral estate from Santa Fe Pacific Railway.** UNC acquires Sec 35 and begins exploratory drilling in 1962.

**1960 – 1962: Phillips Petroleum develops Church Rock Mine.** Later known as the Old Church Rock Mine produced ore from Sec 17.

**1965: UNC executes uranium-delivery contract with US Atomic Energy Commission.** USACE contract covers production from not yet built mine in Sec 35 and is for \$3.8 million in U<sub>3</sub>O<sub>8</sub>.

**1967 – 1968: UNC begins shaft construction at Sec 35.** Site of mine development called North East Church Rock Mine (NECR). Shaft depths reach 1800 ft below land surface.

**1968 – 1970: Initial ore production at UNC NECR.** Start of operations believed to be in early 1968. Additional shaft and stope development in 1969. Ore production estimated at 2 million lbs of U<sub>3</sub>O<sub>8</sub> during this period.

**1969: UNC acquires site for proposed uranium mill from State of NM Land Office.** Purchased Sec 2 from the NM State Land Office to construct a uranium mill and mill tailings pile.

**1971 – 1982: "Commercial Era" of operation at NECR.** Produced an estimate 20 million pounds of U<sub>3</sub>O<sub>8</sub>. Sold to utilities for power generation.

**1970: Kerr-McGee Corp. obtains Navajo Uranium Lease for underground mine.** Site on tribal trust land included Church Rock I (CR-I) and Church Rock IE (CR-IE) mines.

**1972: UNC restarts NECR.** Completed improvements and resumed ore production which lasted into 1982.

**1972: Mining begins at CR-I and CR-IE.** And Red Water Pond Road constructed for ore hauling.

**1972 – 1983: CR-I ore production.** Records estimate between 2 – 20 million lbs of U<sub>3</sub>O<sub>8</sub>.

**1972 – 1986: Mine water discharges to Pipeline Arroyo and Puerco River (North Fork).** An estimated 200 gal per min of mine water was discharged from NECR, CR-I, and Old CR mines. Water quality irregularly monitored. Only had to meet Clean Water Act standards after 1980.

**1974 – 1975: UNC builds mill and tailings disposal impoundment.** Sec 2 cleared for development, forcing relocation of Navajo families who had established camps and grazing areas on the land.

**1977: NM issues radioactive materials license for mill and tailings disposal impoundment.**

**1977: UNC reopens Old CR.** Original shaft deepened, mine water discharged into holding ponds.

**1978 – 1979: UNC workers find cracks in tailings dam.** Cracks photographed and reported to the NMEIA and State Engineer Office.

**July 16, 1979: Dam holding back mill tailings and wastewater collapses.** 94 million gals and 1100 tons of mill tailings are released into the Pipeline Arroyo and North Fork of the Puerco River – the largest release, by volume, of radioactive waste in US history. Livestock were swept away in the surge, and people and animals in the water suffered acid burns. NMEID suspends mill license, orders investigation into cause of dam break and UNC to remove contaminated materials from Puerco River.

**Oct 1979: Congress holds hearing on Church Rock Spill.** House Committee on Interior and Insular Affairs, Subcommittee on Energy and Environment, holds oversight hearing to assess the causes and responses to the dam break.

**1982: UNC announces closure of NECR and Old CR mines.** Collapse of uranium market forces UNC to close its mines and shutter the CR mill. 700 – 800 workers are laid off.

**1983: KMC closes CR-I and CR-IE.** 200 – 300 workers laid off.

**1983: USEPA adds UNC mill tailings facility to CERCLA National Priorities List.**

**1983: Violations of NPDES permit limitations on mine water discharge reported by SRIC.** Staff of the Southwest Research and Information Center (SRIC) report dozens of violations of limits imposed on the quantity and quality of mine water discharges permitted under the CWA's National Pollutant Discharge Elimination System (NPDES).

**Feb 1986: KMC ceases CR-I mine water discharge.**

**Mar 1986: NRC assumes regulatory authority over uranium mills and tailings management.** UNC's radioactive materials license is transferred from NMEID to NRC.

**1988: In situ leach (ISL) mining proposed for Church Rock Sec 8.** Hydro Resources, Inc. (HRI/URI) files radioactive materials license application with NRC to conduct ISL mining on private land in Sec 8.

**1991 – 1993: UNC mill dismantled.** Large pieces of equipment buried in pits at the tailings site.

**1993: HRI/URI adds CR Sec 17 to its "Crownpoint Uranium Solution Mining Project." (CUP)**

**1994 – 1995: Navajo citizens' group and allies request adjudicatory hearing on proposed CUP.** Eastern Navajo Dine Against Uranium Mining (ENDAUM), SRIC, allege that a draft EIS is inadequate to judge the impacts of the proposed operation.

**1996 – 1997: USEPA, Navajo Nation assert "Indian Country" status or Sec 8 ISL project.**

**1996 – 1997: Hearing petitioners retain law firm.** NM Environmental Law Center (NMELC) and Washington, DC attorney Diane Curran to represent them before NRC.

**Feb 1997: NRC issues final EIS for CUP.** Final EIS with Safety Evaluation Report documents NRC's decision to allow ISL mining.

**Feb 1997: NRC levies fine against UNC for failing to post reclamation bond.**

**Jan 5, 1998: NRC issues license for CUP.**

**1998 – 2008: Administrative adjudication of HRI/URI license reaches US Supreme Court.** ENDAUM and SRIC lose appeal in 10<sup>th</sup> Circuit Appeals Court; US Supreme Court denies certiorari, ending litigation.

**2002 – 2004: NM Mining and Minerals Division (MMD) asserts authority to require reclamation plan for NECR.** UNC submits water monitoring data and close-out plan.

**2003: GE acquires UNC.** Becomes owner of NECR and licensee for the mill and mill tailings disposal impoundment.

**2003: Sec 35 confirmed as tribal trust land, owned by US Government.** NN EPA staff receives confirmation that Sec 35, site of NECR, was conveyed into trust status in 1929 and has remained under US Government ownership.

**2003 – 2007: CR Chapter and SRIC develop and implement monitoring project.** SRIC obtains grant to assess radiological and heavy metals impacts from previous mining (CRUMP).

**Apr 2005: Navajo Nation Council adopts ban on uranium mining and processing.**

**2005: USEPA asserts jurisdiction over reclamation of NECR.** At the request of the NN, the USEPA asserts jurisdiction under CERCLA to require GE/UNC to assess and cleanup lands impacted by releases of hazardous substances.

**Aug 2006: Red Water Pond Road Community (RWPRC) Association founded.** (Citizens advocacy group).

**2006 – 2007: Extensive soil contamination found in RWPRC.** First interim removal action authorized, 5 families temporarily relocated to Gallup hotels for 3 months.

**Oct 2007: House Oversight Committee holds hearing on Navajo Uranium Legacy.** Two residents testify before the committee, describing their personal experiences with the impacts of uranium mining in their community. The Committee also hears testimony from Navajo Nation officials and representatives of five federal agencies. The Committee requires the agencies to prepare and execute a Five-Year Plan to address the Navajo Uranium Legacy.

**June 2008: EPA and federal agencies issue Five-Year Plan.**

**2009 – 2010: Second EPA Removal order address additional soil contamination around residence in RWPRC.** 12 families temporarily relocated for 8 months.

**Jun 2009: EPA issues draft EE/CA for NECR and holds public hearings.** EPA chooses \$44 million alternative of moving NECR waste to UNC tailings facility; reject community comments to move waste to licensed disposal facility due to cost.

**Jul 2009: Community observes 30<sup>th</sup> anniversary of tailings spill.**

**Apr 2010: GE sues US Government to recover remediation costs of NECR mine.** GE asserts that the US Government should share cost as it approved mining on Sec 35 and granted the uranium-delivery contract with the AEC.

**2011 – 2014: Tronox bankruptcy settlement includes payment for CR-I.**

**Aug 2011: GE and US Government announce settlement of cost-recovery lawsuit.** The Government agrees to reimburse GE about \$2.5 million in response costs incurred to date in the context of the EPA's CERCLA decision, and 33% of the final cost of removal and decontamination.

**Sep 2011: EPA approves plan to move NECR waste to UNC tailings site.**

**Jul 2012: Navajo Nation fines HRI/URI for trespassing on tribal trust land and enters into a "temporary access" agreement.** They can access the site only with permission from the NN, submit to NN jurisdiction, and conduct reclamation at Sec 17 before any extraction.

**Fall 2012: EPA requires third soil removal action in RWCR.** All families were temporarily relocated to hotels in Gallup for five months.

**Mar 2013: EPA issues Record of Decision approving moving NECR wastes to tailings pile.**

**2014: EPA issues second Five-Year Plan.**

**2018: GE submits application to amend tailings license.** The application addresses technical issues related to moving the NECR wastes to the UNC tailings site, including whether the existing dam can contain the mine waste.

**Mar 2019: NRC holds "scoping" hearings to define EIS for NECR cleanup.** Two hearings to take comments on issues in and Environmental Impact Statement related to moving the NECR wastes.

**Jul 2019: RWPRC sponsors commemoration of 40<sup>th</sup> anniversary of tailings spill.** More than 150 people attend.

**Jan 2020: EPA estimates the NECR remediation may not be done before 2026.** A fact sheet stated that the NRC is expected to approve the moving of NECR wastes sometime in 2022. After, removal will take at least another four years.

# Appendix F.

## Cost Guidance Assumptions

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*The following assumptions guided our impact analysis. They were verified by experts versed in the technical aspects of uranium mine remediation.*

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Characteristics and Challenges	F-2
Methods & References Used in Cost Estimation	F-8
Key Facts & Assumptions	F-13

## Section I: Characteristics and Challenges

The project presented several challenges:

### Information

- Data was inconsistent and difficult to locate, despite contacts at agencies and companies who have done this work.
- Many documents don't exist online, or possibly at all, because of the age and number of mining records.
- Information about methods in mining and ore production is impossible to find for many defense-related operations
- The most comprehensive and easily accessible collection of information is McLemore's database
- The distribution of authority and responsibility creates a loss of information due to lack of interagency communication. Agency authority has also changed over time, as have regulations governing the access to information and requirements of each agency to get public feedback.
- There are hundreds to thousands of sites – including some anomalies – this presents a huge task for any agency responsible for locating, monitoring, or investigating sites.
- Because information was unclear or nonexistent, it's difficult to come up with an exact number of mines that have been cleaned up, or how many are left.

### Site Characteristics

- Geological similarities aside, geographical and hydrological differences can cause major fluctuations in cost.
- Sites that were left prior to the new regulations could be partially cleaned up or not at all, and this changes costs.
- Additional actions performed on these sites can significantly increase the levels and area of contamination.
  - Processed ore storage from a nearby mill
  - Ore left with the usual protore/waste
  - Exploratory drilling
  - Changes in mining methods over time
  - Erosion and other extreme weather events
- Different mining methods change the amount of work needed for clean up

Organization of the information included in the investigative or cost documents was necessary to understand the variables. First, we outlined terms that we would use in our own documentation:

- Site: refers to a geographic area delineated by operational, ownership, or lease history.
- Project: refers to the entirety of the work to be done to a specific area – this can be one mine or multiple, depending on how they are related and costs are estimated. For some larger projects this

is important as there are multiple mines spread out geographically, and therefore the work is divided differently.

- Project Type refers to the mining methods used, which changes the nature of the work.
- Option refers to what is often called an alternative in the EE/CAs. An option is the type of remediation work that will be done. There are usually three – an administrative control alternative, onsite disposal, and offsite disposal. These are important to separate because they change cost significantly.
- Job refers to a type of work being done, which can include labor, materials, and equipment. This could be “road improvement.”
- Action refers to the specific action being done within a job – “scrape road”
- Input is the thing being used to complete the action – this can be labor, equipment, materials, or travel.
- Type refers to the type of input – to scrape the road we need equipment, and the type would be a scraper.

By splitting into these categories we could seek out similarities in what was needed for every type of work. Additionally, we defined what are universal costs – things that are always included (but not a fixed price). Then to be more specific, we broke down the work needed for each type of mine. Most of the mines in New Mexico are surface mines, followed by underground, then combination (surface & underground), and rarely, in-situ leach operations.

### *Universal Costs/Needs*

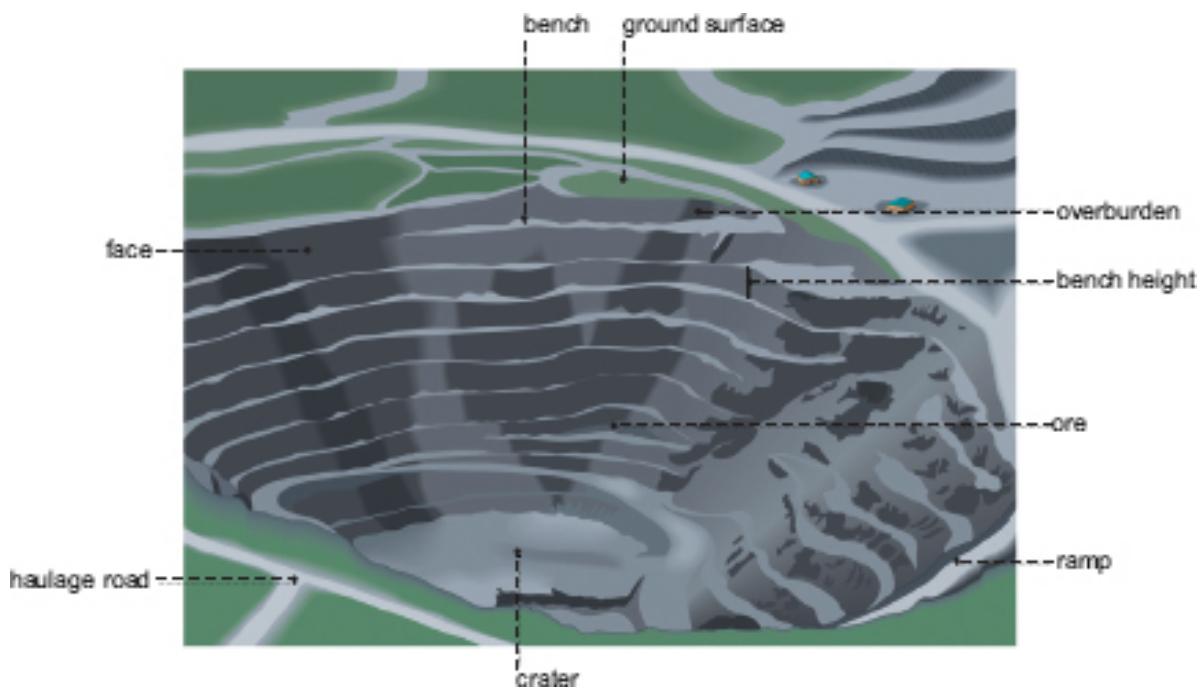
1. RSE/POLREP (Site Investigation)
  - a. Each site requires an initial site investigation, usually determined by regulatory agency. This is not always present in cost documentation; the company performing work will do the investigation as part of the EE/CA preparation.
2. Mobilization/Demobilization
  - a. 10% of total capital costs
  - b. Cost usually associated with the transport of heavy equipment
3. Access Improvement
  - a. Establishment or improvement of roads for easy access.
4. Resource Surveys
  - a. Cultural and/or archaeological surveys are necessary before work begins
5. Fencing
6. Project Management
  - a. Project managers, lead engineers, site supervisors, etc.
7. Administrative and Planning Costs



- a. Administrative/Office employee work, report preparation, lab analysis
- 8. Future Costs
  - a. Annual site inspections, monitoring, fence or other feature maintenance

**Specific Costs: Surface Mines**

Most surface mines are open pit mines, characterized by their large footprint and amount of waste. The open pit mines use conventional techniques and equipment during mining. The style is used for ore bodies closer to the surface and higher grade. The features include the pit itself, overburden and other waste, storage areas for ore, and water/erosion control measures. There may also be additional monitoring equipment used during mining.



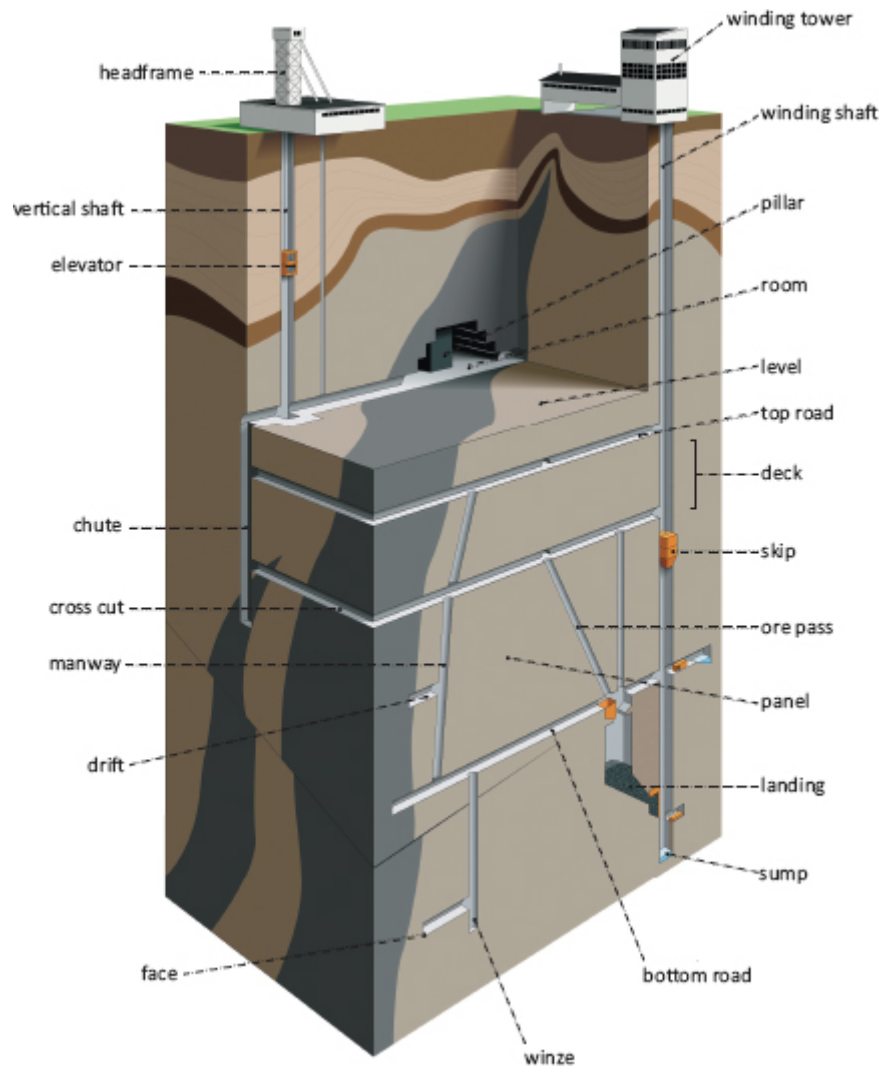
Source: QA International, "The Visual Dictionary"

- 1. Onsite Disposal Option
  - a. Waste consolidation & transport to repository
  - b. Repository excavation/establishment
  - c. Borrow area excavation
  - d. Removal area cover/cap
  - e. Repository cover/cap
  - f. Surface water diversion features
  - g. Confirmation sampling and reporting

- h. Site restoration (revegetation, fixing disturbances caused by work)
- 2. Offsite Disposal Option
  - a. Waste consolidation and loading
  - b. Removal area cover/cap
  - c. Confirmation sampling and reporting
  - d. Transport and disposal
  - e. Site restoration

### *Specific Costs: Underground Mines*

Underground mines are used where orebodies are not close enough for open cut/pit mining. Risks are highest in underground mines due to radon gas – ventilation is key. This means that these mines will have at least two openings, one for access and one for ventilation. These can be shafts (vertical) or adits (horizontal), or a combination. The extent of underground development is the biggest cost consideration in closure, especially if no remediation or reclamation has been done previously.



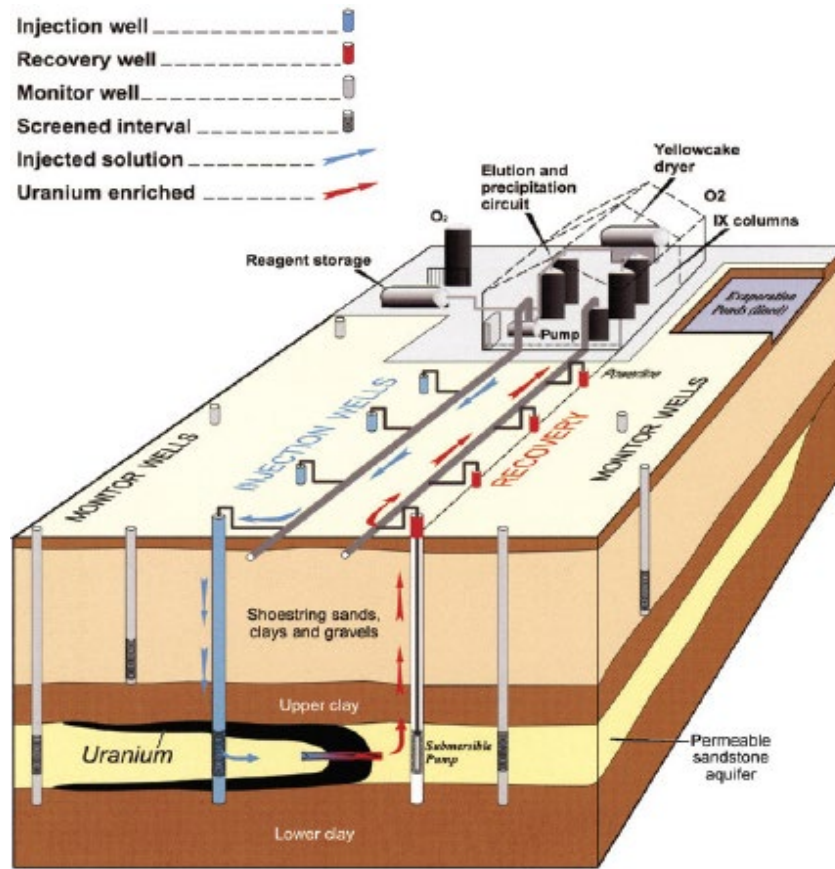
*Underground Mine with vertical shaft. Source: QA International "The Visual Dictionary"*

1. Onsite Disposal Option
  - a. Main shaft/adit closure
  - b. Excavate spoils and/or waste
  - c. Establish borrow
  - d. Establish repository
  - e. Fill shafts/adits with borrow
  - f. Dispose of wastes in repository
  - g. Polyurethane foam

- h. Contour, cover/cap
- i. Erosion control
- j. Site restoration
- 2. Offsite Disposal Option
  - a. Main shaft/adit Closures
  - b. Excavate spoils and/or waste and load
  - c. Establish borrow
  - d. Fill shafts/adits with borrow
  - e. Polyurethane foam
  - f. Erosion control
  - g. Transportation & Disposal
  - h. Site restoration

### *Specific Costs: In-Situ Leach Operations*

In-Situ Leach (ISL)/In-Situ Recovery (ISR) mines are unique in their use of ground water resources to extract low-grade uranium. In New Mexico, there are few of these types of mines. Those that exist are small in scale and usually pilot mines or a few "stope leaching" operations. ISL/ISR mines require the most future monitoring and groundwater treatment.



NOTE: Not to scale - diagrammatic only

*In-Situ Leach Operation. Source: Heathgate Resources Pty*

1. Decommissioning ISL/ISR Facilities
  - a. Dismantle and decontaminate recovery plant
  - b. Transport and dispose of materials and equipment at designated site
  - c. Remove contaminated ground and restore
  - d. Clean groundwater in leached zone
  - e. Remove well-field equipment
  - f. Shred and dispose of piping
  - g. Plug holes, fill, resurface
  - h. Remove pond residues and dispose at designated site
  - i. Fill, contour, and resurface ponds
  - j. Extended monitoring of groundwater.

## Section II: Methods and References Used in Cost Estimation

### Standardized Reclamation Cost Estimator (2006, Updated 2017)

The Standardized Reclamation Cost Estimator (SRCE) model was developed for the state of Nevada by SRK consulting. The project was a joint effort between the Nevada Division of Environmental Protection Bureau of Mining Regulation and Reclamation (NDEP), the Bureau of Land Management (BLM), the Nevada Mining Association (NvMA).

- The SRCE model is an interactive estimator that has the potential to benefit regulatory agencies and bidders working on uranium mine reclamation in New Mexico.
- While the model was used most for coal mine reclamation, its reliance on volumetric data, Caterpillar (CAT) productivity calculations, and CAD and GIS data has proven the model's accuracy for various situations.
- For more complex situations, or itemized cost data, the SRCE model may be manipulated to reflect costs specific to uranium mines and New Mexico.
- For bidding companies or engineers producing bids and cost estimates in general, the SRCE calculator can provide a standardized approach, resulting in an accurately detailed final document. In general, this would help reduce major changes to costs while the work is being performed.
- This model helped us develop our own methods to create a universal format for the different types of cost data.

The screenshot shows an Excel spreadsheet titled 'Copy of SRCE 2.0 Beta011 estimator cost data 1.xlsx'. The 'MISCELLANEOUS COST TABLE' is highlighted in yellow. It contains a 'JOB DESCRIPTION' table with columns for Basis 1-11. Below this are two main sections: 'REVEGETATION' and 'BUILDING and WALL DEMOLITION'. The 'REVEGETATION' section lists items like 'Seeding - Broadcast Manual', 'Seeding - Broadcast Mechanical', 'Seeding - Orb', 'Seeding - Hydroseeding', 'Shrub Planting - bare root 6-10 in (150-250mm)', 'Tree Planting - bare root 11-16 in (270-400mm)', and 'Cactus Planting'. The 'BUILDING and WALL DEMOLITION' section lists items like 'Building Demolition', 'Lg. steel', 'Lg. concrete', 'Lg. masonry', 'Sm. steel', 'Sm. concrete', 'Sm. masonry', 'Sm. wood', and 'Wall Demolition' with sub-items for different block thicknesses (100mm, 150mm, 200mm, 300mm, 150mm). The table has columns for 'Units', 'Labor', 'Equip', and 'Materials' for each basis.

Figure 1. Detail View of SRCE model, blank. Beta 2.0 from NDEP bond site. <https://nvbond.org/>

## “Joint Guidance for the Cleanup and Reclamation of Existing Uranium Mining Operations in New Mexico” - Energy, Minerals & Natural Resources Department (EMNRD) Mining & Minerals Division (MMD) & New Mexico Environment Department (NMED) (2016)

The joint guidance document offers information about clean-up requirements by regulatory agency, recommended methodology, and implementation guidance.

- Regulatory authorities and requirements change depending on site location and status. Methodology and implementation, however, are generally the same across sites.
- An outlined, acceptable reclamation methodology provides important guidance for bidders, as well as informs the public about the basic processes that go into reclamation. This type of methodology can be used to help calculate costs as well as timelines.
- We used the outlined reclamation guidance to better understand the process, and outline specific actions and their personnel, material, and equipment needs.

## “Financial Assurance Calculation Handbook” - US Department of the Interior, Office of Surface Mining Reclamation and Enforcement (1987)

The handbook was made to provide methodology for MMD employees to calculate reclamation bonds. Although it's older, the methodology itself is still relevant.

- The handbook uses standardized methodology for estimating costs of earthwork and revegetation for site-specific operations. Earthmoving activities represent the greatest costs in most mining reclamation projects.
- The handbook uses four sources of data for determining costs:
  - o The mining reclamation/closeout plans provided by the applicant
  - o The Caterpillar Performance Handbook
  - o The Dataquest Cost Reference Guide for Construction Equipment
  - o RS Means Building Construction Cost Data
- With new legislation, some mines do have closeout plans. However, this is not the case for the majority of the abandoned uranium mines in New Mexico.
- Two data sources remain relevant in estimating reclamation costs today: The Caterpillar Performance Handbook, and the RS Means Construction Cost Data. These two sources are used by bidders for reclamation projects and regulatory agencies alike and are constantly updated.
- Volumetric data to calculate the costs of earthmoving in reclamation can be taken from existing closeout plans or can be calculated during aerial or ground surveying. This data is the most important in determining the overall costs
- These methods use standard engineering cost estimating procedures and include worksheets that can be used to highlight the unique characteristics of different mine sites.

When speaking with project engineers, consulting companies, or agency employees about how to calculate a universal cost, they overwhelmingly agreed this was not possible. Though approaches to estimating costs are very similar, the work itself differs greatly. There are many factors that influence cost, and many characteristics that make each project unique. This presented a challenge, especially as uranium mine cleanup projects seem extremely technical and unpredictable. However, documents like this one provided an important framework for understanding the complexity of this type of work.

The smallest details can make major differences in the type of work done, and it's an engineer's job to know about these details. For us, on the other hand, the large details of these projects – and these projects in New Mexico – were the most important. Most abandoned uranium mines don't have EE/CAs, and not all have site investigations that provide feature or status information – examples of unique scenarios are few compared to a vast number of unreclaimed mines. To approach estimation from a large-scale, area-specific perspective, it is important to understand the mine-specific processes for estimation. Thanks to this document we could identify the “universal” factors influencing cost and apply this to our large-scale model.

### The CAT (Caterpillar) Performance Handbook

The CAT handbook is used by agencies and companies alike to estimate costs related to equipment usage.

- Productivity is estimated in the handbook, based on ideal conditions. Productivity is then used to calculate the hours needed to complete the work required.
- Productivity estimates are used to determine periods of equipment usage and rental, as well as operator hours.
- The handbook is updated often so there are differences based on when an EE/CA was done, however, every document we encountered referenced the handbook as the tool used for estimating.
- The handbook is comprehensive and includes every type of heavy equipment used in uranium mine cleanup.
- We used the handbook as guidance to identify the similarities in equipment needs and hours with different sites to create general assumptions about the equipment needed and associated hours.

### RS Means Construction Cost Data

RS Means is a North American based construction cost data base created and monitored by cost engineers. It is an industry standard to use estimating software and/or cost books for construction related cost estimation. We used the data, provided by Gordian in a free trial, to check the accuracy of our data and the data of our other sources for cost.

### Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM) from Uranium Mining - - Volume I: Mining & Reclamation Background

TENORM Volume I examines uranium extraction methods over time. In addition, it examines volume and characteristics of uranium mine waste over time. We used this data to calculate ore to waste ratios that were used to check our other final numbers. These ratios will be key in estimating a universal, large-scale remediation estimate. With ratios like these, we're able to predict the potential for work that remediation of New Mexico's mines will create. With further research and testing, the ore to waste ratios, as well as our own earthwork ratios, can be used to produce a generalized cost per ton of waste, depending on mine type.



1. Reclamation and remediation costs at uranium mines could include costs associated with:
  - a. Overburden and waste rock piles
  - b. Heap-leach piles
  - c. Ore storage and loading areas
  - d. Underground mines
  - e. Open-pit mines
  - f. Buildings and infrastructure
  - g. ISL/ISR infrastructure
  - h. Contaminated soils and groundwater
  
2. Costs of environmental management following closure of a mine consist of reclamation and monitoring costs. Reclamation may include:
  - a. Partial or complete backfilling of pits
  - b. Stabilization of waste rock
  - c. Appropriate contouring of disturbed land surfaces
  - d. And revegetation
  - e. Monitoring is generally a future cost most mines
  
3. Costs of reclamation vary significantly due to differences in ore conditions, mining methods, climate, remediation scope, and objectives. In instances where a facility has been reclaimed due to releases of hazardous substances under CERCLA, costs can be much larger.
  
4. The DOE conducted a summary of cleanup costs for 75 production facilities, including mining and milling sites. The costs of reclaiming and remediating the 21 mines that were part of this summary vary widely, by more than two orders of magnitude in terms of cost per ton of ore produced.
  - a. The differences can be attributed to acreage of disturbance, but mostly due to the different methods of accounting for cleanup costs.
  - b. Some mines performed reclamation during mining, charging the costs against operations. While others had to be separately charged under reclamation costs.
  - c. The average cost of cleanup for these 21 mines were:
    - i. \$3.01/metric ton (MT) of ore mined
    - ii. \$2,545/kg of uranium produced
    - iii. \$29,969/hectare of land disturbed
  - d. Excluding the most uniquely expensive mine, the Day-Loma mine, the averages drop to:

- i. \$2.77/MT of ore
  - ii. \$2.34/kg of uranium produced
  - iii. \$27,900/hectare of land disturbed.
5. Standard weight per volume figures used in mine waste calculations are 1.68 tons/y<sup>3</sup>
- a. Large, open pit mines have ratios of waste rock to ore between 8 : 1 to 20 : 1
  - b. Underground mines range from 1 : 1 to 20 : 1
  - c. See table below for figures

**Total and Average Production and Costs of Reclamation of All Uranium Mines**  
*This table includes mines as well as mill sites.*

Number of sites included	21
Metric tons of ore processed	96,900,000
Metric tons of uranium produced	114,803
Average cost of closure, \$/MT ore	\$3.01
— excluding Day-Loma	\$2.77
Lowest cost of closure, \$/MT ore	\$0.24
Highest cost of closure, \$/MT ore	\$33.33
Average cost of closure, \$/kg U	\$2.54
—excluding Day-Loma	\$2.34
Lowest cost of closure, \$/lb U <sub>3</sub> O <sub>8</sub>	\$0.18
Highest cost of closure, \$/lb U <sub>3</sub> O <sub>8</sub>	\$23.74
Average cost of closure, \$/ha disturbance	\$29,969
—excluding Day-Loma	\$27,900
Lowest cost of closure, \$/ha disturbance	\$2,337
Highest cost of closure, \$/ha disturbance	\$269,531
<b>Average Closure Cost per Site</b>	<b>\$13,900,000</b>

*Source: U.S. DOE/EIA 2000b.*

## Utah Abandoned Mine Reclamation Program’s “Boilerplate” Construction Contract Specifications

The state of Utah and the U.S. Bureau of Land Management teamed up to address abandoned mines in the state. As part of this the SRCE model was created by an outside firm, and the state of Utah created a construction bid “boilerplate” template. The document contains relevant regulations, types of work, necessary certifications, and is a detailed model for others to follow. It differs from New Mexico’s own bid templates because it contains more regulatory information, as well as explains various different scenarios that can change the nature of the work. We used this information to check our own data.

## Defense-Related Uranium Mines - Cost and Feasibility Topic Report & Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA

These two documents outline the processes necessary to estimate the costs and feasibility of mine remediation, as well as the regulations guiding them. We used both documents to check our assumptions and data. An example of cost guidance from the cost and feasibility report is included in Appendix C.

## Site Investigation Reports, Engineer Evaluation/Cost Analysis, and other Site-Specific Documents and Databases

Our main source of cost data were the cost documents for 12 sites we evaluated. These documents primarily consist of formal EE/CAs, however, there are invoices, bids, and informal cost comparisons used for some sites. The site data we examined included:

1. Barbara J Mine Sites – Engineer’s Cost Estimate
2. Cibola Uranium Mines – EE/CA
3. Johnny M Mine – EE/CA
4. King Edward Mines – EE/CA
5. Mt Taylor – Closure Cost Estimate
6. NE Church Rock Mine – EE/CA
7. Red Bluff Mine – EE/CA
8. San Mateo Mine – EE/CA
9. Santa Fe Carson Mines – EE/CA
10. Spencer Mine – Application for Payment
11. St Anthony Mine – Closure Cost Estimate
12. Workman Creek Mines – Invoice

In addition to these documents, which contain cost tables and waste volumetric data (most), we relied on databases with information about the features at different sites, ore production tables, site investigative reports, scholarly articles published about mines, and contacts at various companies and agencies.

## Section III: Key Facts and Assumptions

### General Facts & Assumptions

1. Assumption: Elevation variance is not significant enough to include in estimates
  - a. According to geographic data, the Uranium ore deposits in Colorado, Utah, Arizona, and New Mexico are located on the Colorado Plateau.

- i. Elevation ranges from 500 ft at the bottom of Grand Canyon to 13,000 ft at the tallest peaks. Average elevation is 5,000 ft.
  - ii. Average elevation of mines has been identified as 5,200 ft for the Colorado Plateau
2. Assumption: Host rock is the same/similar enough to not majorly effect remedial work (see figure A-10).
  - a. Geology of the Colorado Plateau is characterized by superimposed layers of sedimentary rock, a result of the erosion of the large mountain ranges surrounding it. Lower layers can be metamorphic, and there are some igneous formations, but most uranium is found within the upper sedimentary layers. Mesozoic Era, primarily Cretaceous and Jurassic eras.
3. Mines in the same areas tend to be of the same type
  - a. Mining booms and busts occurred at the same time, and many mine claims were established during the first boom. During this time period deposits were found by surface detection and subsequent exploratory drilling.
  - b. Historically, costs of deep underground mining were prohibitive. Many of the oldest mines are large open pit mines. Some were later further developed underground or with in-situ leach facilities as technology changed.
  - c. Mine age determines the development – many were first developed as open pits and in sedimentary rocks, the most historically productive areas were in New Mexico.
4. Assumption: The geographical province has relatively shared and predictable precipitation.
  - a. Documents recommending mine development, or addressing remedial needs, all cite that the Colorado Plateau receives low precipitation, around 9"-16" annually. High elevation mountains have more precipitation, but generally, this holds true due to the bordering mountains creating a rain shadow.
5. Assumption: Ground water contamination is not a significant factor.
  - a. The Colorado Plateau is a semi-arid region with low precipitation, and is characterized by seasonal surface water features.
  - b. The Colorado Plateau aquifers have some extractable water, however, the quantity and quality is extremely variable.
  - c. Permeable rock aquifers cover 27.5% of the U.S. Colorado River Basin states and 51.5% within the basin boundary. (Foos)
  - d. Rural areas depended on seasonal surface water and some underground sources. These sources were presumed to be small because populations were small.

### New Mexico Specific Facts & Assumptions

6. New Mexico deposits are primarily in the Grants Uranium District, which is comprised of the two most productive areas: Laguna and Ambrosia Lake. This area is bordered by the San Juan Basin, the Rio Grande trough, the Acoma sag, and Zuni uplift.

- a. Between these border landmarks, elevation is fairly consistent accounting for normal faults and minor folds. Generally, the elevation is between 6,000 and 7,000 feet
  - b. Deposits are listed as existing within 1,000 – 4,000 feet from the surface, most around 1,500 – we will assume an average of 2,000 ft depth based on available data.
7. The Morrison Formation and Todilto Limestone have yielded almost all of the ore.
  - a. Sandstone & Limestone are the primary host rocks in New Mexico.
  - b. Limestone host rock is rare, but in the Grants district it accounted for a significant percentage of mines.
  - c. "Uranium ore deposits in the Grants uranium district are mainly in fluvial sandstones in the Westwater Canyon, Brushy Basin, and Jackpile Sandstone Members of the Upper Jurassic Morrison Formation."(Hilpert)
8. The Grants Uranium District accounts for the largest number of mines in the state of New Mexico
  - a. The district was also the most productive during the first boom – most deposits were relatively close to the surface and were mined by open pit mining.
  - b. Open pits in the district were further developed in underground, though this is only a small amount. These have a large footprint and produce a significant amount of waste.
  - c. Underground, usually room and pillar type mines, are the second most common. These have a smaller surface area footprint and generally produce less waste.
  - d. In-situ leach operations are rare because it's a fairly new technology and most mine development stopped before it could be used. The numbers for New Mexico are insignificant.
9. Like the rest of the Colorado Plateau, New Mexico has consistent and predictable annual precipitation.
  - a. 9 – 16" of annual precipitation, many areas around 11", with mountain ranges between 14 – 16".
10. For rural areas, where mining was concentrated, populations relied on a combination of seasonal surface water and deep groundwater.
  - a. Mines tend to reach below the water table (especially underground). The presence of drinking water quality aquifers is unpredictable, and many sources are naturally contaminated by metals and uranium.
  - b. Areas of drinking water contamination have largely been identified and remedied due to their effects on people in the area. Some unknown mines and conditions could be a source of contamination.
    - i. Any water contamination is subject to additional regulations and guidelines for remediation. The costs associated with this type of contamination are much different than with mines not involving drinking water.