Environmental Report
High-Pressure Slurry Ablation
Performance-Based, Multi-Site License Application
Casper, Wyoming

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prepared for:

Disa Technologies, Inc.

1653 English Avenue
Casper, WY 82601

prepared by:

Environmental Restoration Group, Inc.

8809 Washington St. NE
Suite 150
Albuquerque, NM 87113

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Prepared by: Stephen J. Cohen Digitally signed by Stephen J. Cohen Date: 2022.07.13 14:52:23 -06'00'

Stephen J. Cohen, PG, CHP, CHMM, Project Manager

Approved by:

Greyson Buckingham, CEO & President

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SECTION 1.0 INTRODUCTION

Disa Technologies, Inc. (Disa), is applying for a performance-based, multi-site Radioactive Materials License to use its High-Pressure Slurry Ablation (HPSA) to remediate waste rock piles and contaminated soils at abandoned uranium mine sites and other contaminated sites. The purpose of this mine site remediation is to provide a safer radiological signature allowing for recreational and other appropriate land uses at otherwise unusable properties. This Environmental Report (ER) presents information, consistent with NUREG-1748 (NRC, 2003), that supports the licensing of the HPSA technology for remediation.

As described in this ER, Disa seeks to apply its HPSA technology to remediate waste rock piles and contaminated soils associated with abandoned uranium mines and other contaminated sites that contain radioactive constituents and other constituents of concern (e.g., vanadium, RCRA metals). The HPSA process generates two products: The clean coarse fraction is an inert sand that may be reused for mine reclamation. The isolated mineral fraction contains isolated constituents of concern including uranium and/or thorium, that will be either disposed of as low-level radioactive waste or used as alternate feed at a licensed uranium recovery facility.

1.1 Purpose and Need

Currently over 15,000 abandoned uranium mines exist across the western United States (US). The uranium mining industry began in the 1940s primarily to produce uranium for weapons and later for nuclear fuel. Although approximately 4,000 mines exist with documented production, a database compiled by EPA, with information provided by other Federal, state, and tribal agencies, includes 15,000 uranium mines in 14 western states. Most of those locations are found in Colorado, Utah, New Mexico, Arizona, and Wyoming, with approximately 75% of those on Federal and tribal lands (abandonedmines.gov). Figure 1-1 presents a uranium mine location map from the US Environmental Protection Agency (EPA) Uranium Location Database (EPA, 2006).

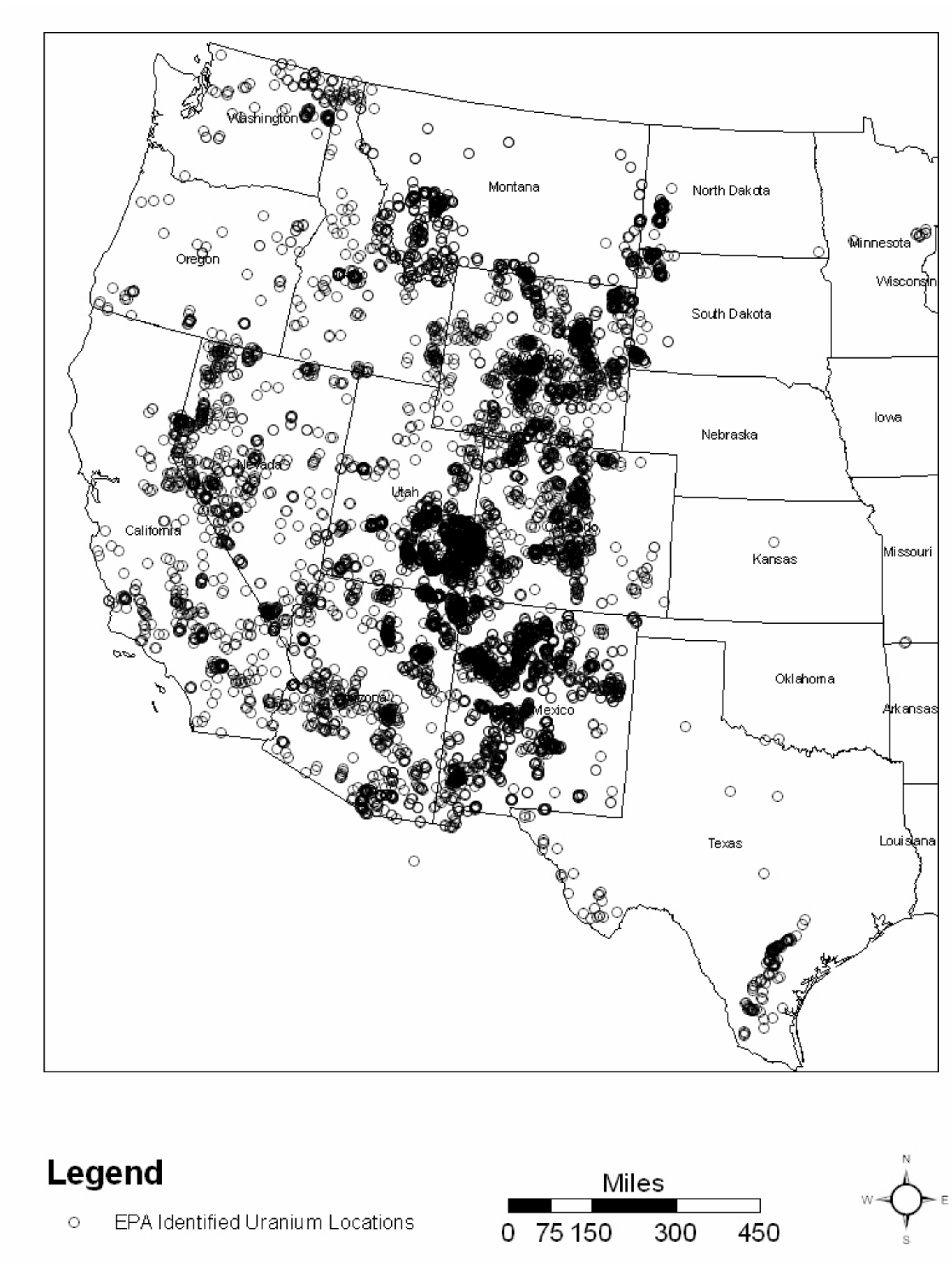
The majority of these sites were conventional (open pit and underground) mines. Uranium mining by both underground and surface methods produces large amounts of bulk waste material, including bore hole drill cuttings, excavated topsoil, barren overburden rock, and uranium-contaminated waste rock. Furthermore, transfer stations at some distance from remote mines may contain uranium-contaminated soil and rock without any visible facilities to mark their location. In many instances before the 1970s, miners left behind mines that were not reclaimed and exposed wastes elevated in radioactivity from uranium and its radioactive decay progeny, potentially exposing people, and the environment to its hazards (EPA, 2006).

1.1.1 Proposed Action

Disa has designed HPSA units that can be mobilized to abandoned uranium mine sites and other contaminated sites, along with the necessary supporting equipment, to be used for treating waste rock and contaminated soils at. Upon completion of remediation, Disa will leave behind only an inert clean coarse fraction. No permanent facilities will be left onsite, no waste storage will be required, no contaminated water will be discharged, and the radiological and non-radiological characteristics of the remediated site will be protective at human health and environment. The isolated mineral fraction, containing uranium and/or thorium and other constituents of concern such as vanadium and RCRA metals will be removed from the site and disposed of as a low-level radioactive waste at licensed facilities or use as alternate feed at a licensed uranium recovery facility. Below is a description of the HPSA process and technology.

HPSA is a patented technology owned by Disa. The HPSA process is applied to waste rock that has been crushed and slurried. Dust suppression methods, such as water spraying or dust enclosures, will be utilized as part of the crushing process. The slurry is pumped through injection nozzles that are contained within a steel enclosure, known as the collision cell. Use of high-pressure nozzles creates a high energy impact zone that separates the mineral-rich patina from the host sand. This process is generally used on roll front uranium deposits or similar deposits where the mineral-rich material is precipitated onto host rock.

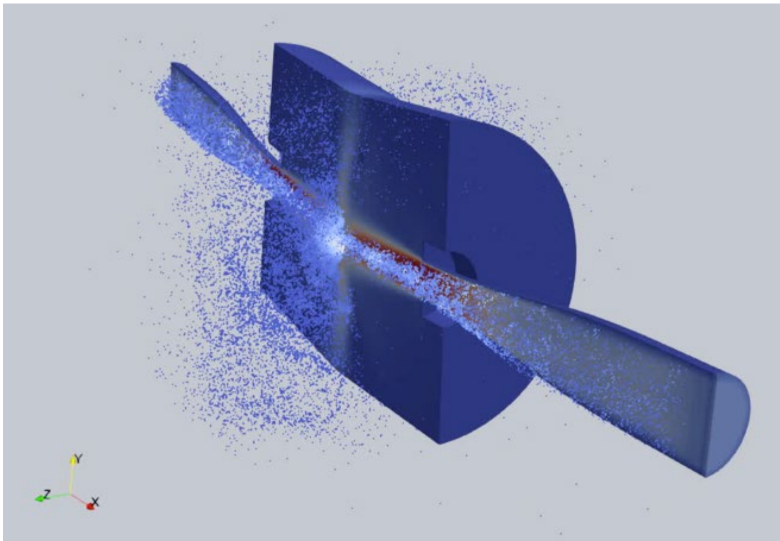
Figure 1-1: Abandoned Uranium Mine Location Map



Source: EPA, 2006

The principal HPSA action is the focused high energy collision of particles inside the high energy impact zone within the HPSA collision chamber. This collision causes the particles to dissociate and/or liberate into smaller particles increasing surface areas and improving the separation rate. A computational model of the collision zone is shown in Figure 1-2.

Figure 1-2: Collision Zone Model



Source: cmpip, 2022

The HPSA process is uniquely effective in remediating composite materials that can be fractured along discreet subfraction boundaries. This high energy collision zone depicted in Figure 1-2 allows a thin, soft, mineral-rich patina coating of a material such as those found on sand grains in roll front, sandstone hosted uranium deposits to be easily ablated as a result of the low and mid-shear stresses inside the collision chamber. Low and mid-shear stresses cause distortion, deformation, and rebounding, allowing for sand grain particles to remain intact while the thin patina coating of uranium is fractured and isolated as mineral-rich fines.

The HPSA system includes three main components. Component one is the feed loading and slurry transfer system. Component two is the pump nozzle assembly, including the collision chamber and the pumps that discharge through the nozzles. Component three is the solids separation and dewatering process. Figure 1-3 shows and example of an HPSA unit.

Figure 1-3: Large Scale HPSA Unit

Source: cmpip, 2022

To implement this technology, Disa will deploy multiple HPSA units at one time to remediate multiple abandoned uranium mine sites. Disa's main headquarters is currently in Casper, Wyoming; however, satellite offices may be established depending on the business need. Disa will utilize standard health physics care at each site, by performing pre-operational surveys, health physics monitoring during operations, and post-operational surveys to ensure that Disa's operations did not contaminate the workspace portion of any mine site project.

1.1.2 Benefits of the Proposed Action

The purpose of the proposed action, environmental remediation of contaminated abandoned mine sites, is its primary benefit. Radiologically contaminated waste rock piles have been allowed to sit in an uncontrolled manner for decades as the result of a lack of economically viable treatment options. Disa's HPSA technology and process can be used to remediate these waste rock piles and other contaminated materials. Successful remediation will transform unusable and unsafe land to land safely available for beneficial uses without creating the need for disposal cells or economically prohibitive materials transport. Remediation using HSPA will also prevent further degradation of land due to the potential migration of contamination from the waste rock piles to subsurface soils.

1.2 Applicable Regulatory Requirements, Permits, and Required Consultations

Disa's HPSA will be regulated under 10 CFR Part 40 requirements for the possession and transfer of source material and 10 CFR 20 radiation protection standards. The Proposed Action that is the subject of this ER involves the isolation at contaminated sites of source material into a smaller mineral fraction due to the HPSA process and the possession of such licensable source material until the time it is delivered to a low-level radioactive waste facility or a licensed uranium recovery facility as alternate feed. This ER does not assess receipt and processing of uranium residuals at either NRC/Agreement State-licensed uranium recovery facilities or disposal of such residuals at licensed disposal facilities. Disa also understands that Agreement State licenses may be required if HPSA establishes long-term operations in an Agreement State.

Licensing is required because Disa's remediation activities will result in an isolated mineral fraction that includes a concentration of source material above the exemption limit presented in 10 CFR 40.13, which is 0.05 percent by weight or 500 mg/kg uranium and/or thorium. This expectation is based on bench and laboratory testing of Disa's small-scale HPSA equipment and small samples of waste rock. In addition to the clean coarse fraction and the isolated mineral fraction, Disa will be managing water for each project. The total amount of water utilized for each project varies based on the size of the HPSA unit deployed. Each unit that is deployed will be engineered to use as little water as possible. Water loss occurs during the dewatering stage as moisture in the isolated mineral fraction and the clean coarse fraction (~20%). Therefore, water is added on a continuous basis. Because dewatering will involve filter presses and centrifuges, no free liquids will remain in the clean coarse fraction. HPSA water will be filtered/treated to meet the effluent or sewer discharge standards in 10 CFR 20, Appendix B. Disa will discharge this water to the ground or a sewer system. No water will be discharged directly to surface water bodies.

Disa anticipates utilizing HPSA to address contamination on Federal Indian Reservations and Federal public lands. Laws and regulations associated with conducting activities on public lands and/or reservations will be followed. Although Disa anticipates using HPSA on contaminated lands that have been previously disturbed, consultation with any potentially affected federally recognized tribe will be conducted and, where appropriate, arrangements will be made with tribal cultural resource experts to survey sites to avoid disturbing tribal cultural and historic resources prior to initiating remediation activities.

In addition, Disa recognizes that within this Environmental Report it cannot identify all potential ecological and cultural resources on every site on which it will utilize HPSA. Therefore, Disa agrees to consult with ecological and cultural resource experts before mobilizing to a site to determine if the potential for endangered species or cultural and historic resources may be present. This commitment is memorialized in two proposed license conditions found in Section 8.0 of Disa's application document.

Other permits, such as sediment and erosion control permits, may be required on a case-by-case basis. Disa will consult local and county regulators to determine the need for such permits. Disa will use transporters that are licensed to ship source material. Disa itself will not transport source material.

1.3 Bounding Conditions

Considering that this environmental report addresses a performance-based, multi-site license application bounding conditions will be general to represent the types of sites and conditions in which HPSA will be operated. These bounding conditions are as follows:

1. HPSA will be used on mine sites that have been inactive for five years or more.
2. HPSA will be used on private, state, and Federal public lands, and Federal Indian Reservations.
3. HPSA will not be used at licensed uranium mills.

SECTION 2.0 ALTERNATIVES

2.1 No-Action Alternative

The no-action alternative is to leave the 15,000 abandoned uranium mines without an economically viable remediation option and therefore to continue to remain untreated. This will result in continued degradation of the land, continued loss of use, and potential contamination of subsurface soils. Consequently, communities adjacent to and near these abandoned mines will continue to endure the impacts of the radiological contamination occurring from these sites without any real prospect of cleanup.

2.2 Excavation and Disposal

Excavation and disposal will consist of the following activities:

- Perform background surveys to calculate remediation criteria.
- Perform characterization surveys to determine the extent to required excavation and the necessary excavation volume.
- Excavate contaminated materials.
- Load the contaminated materials onto trucks and transport the materials to a disposal facility.
- Perform post-remediation surveys to ensure the sites meet remediation criteria.
- Regrade and restore the mine sites for safety and environmental benefit.

Because of the large number of sites and high volumes of material, commercial disposal facilities will not likely be capable of accepting all the material that would be excavated from these sites. Therefore, one or multiple disposal facilities will need to be constructed to accept this material for permanent storage. This option also presents a number of additional challenges:

- No estimate of the contaminated soil volume exists and estimating this volume for all the mine sites is a monumental undertaking.
- The number of truckloads required to move all this material to disposal facilities poses significant risks relating to traffic accidents and radiological exposures to people.
- In addition to removing material for disposal, large quantities of soil will likely be needed to regrade and reclaim these mine sites. Soil will be trucked to each site further increasing the risks due to traffic accidents.
- Costs for seed, fertilizer, and the availability of water will be significant issues.
- The funds to perform all these mine site remediation projects has not been historically available and is not likely to be available in the future.

2.3 Waste Regrading

This alternative involves leaving the waste rock onsite, regrading it for safety and environmental considerations, placing topsoil above it, and seeding it. This alternative shares many issues with the Excavation and Disposal alternative including:

- No estimate of the contaminated soil volume exists, or the quantity of topsoil required and estimating this volume for all the mine sites is a monumental undertaking.
- Large quantities of soil will likely be needed to regrade and reclaim the mine sites. Soil will be trucked to each site resulting in risks due to traffic accidents.

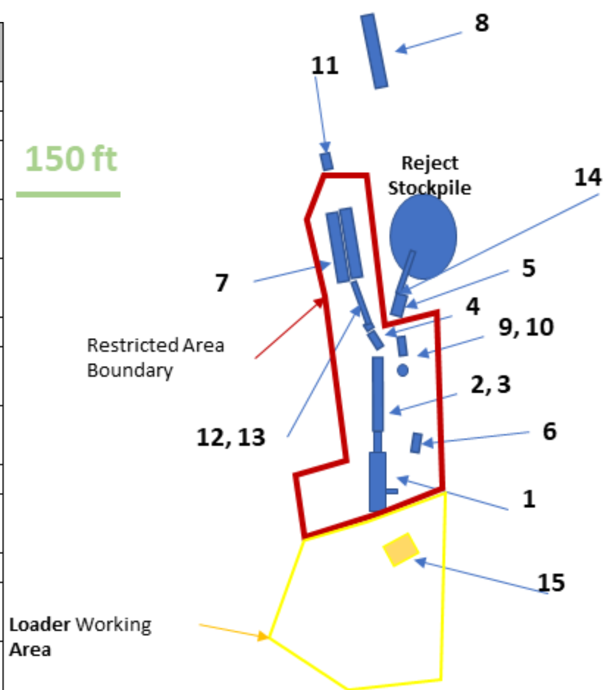
- Costs for seed, fertilizer, and the availability of water will be significant issues.
- Funds for large mine site reclamation projects have not been available and are unlikely to attract the necessary public or private investment.

2.4 Details of the Proposed Action

Section 1.1 describes the HPSA process; this section describes the mechanics of the operations. Disa's operations include the transportation and assembly of its HPSA units at various sites to be used for reclamation/remediation. A typical layout is found in Figure 2-1.

Figure 2-1: Typical Layout

Feature Number	Equipment Description	Approximate Size [L x W x H]
1	Crusher and 0.25" Screen	56'6" x 19'1" x 15'5"
2	HPSA Processing Unit	30' x 9' x 11'
3	HPSA Unit Containment Berm	50' x 10' x 1'6"
4	Product Centrifuge/Filter Press	16' x 9' x 10'
5	Clean Coarse Centrifuge/Filter Press	16' x 9' x 10'
6	Analytical Trailer	24' x 8'6" x 8'6"
7	Loaded Transportation Truck	(24' x 8' x 5.6') x 2
8	Unloaded Transportation Truck	24' x 8' x 5.6'
9	Process Water Tank	24' x 12' x 13'
10	Process Water Treatment Unit	11' x 8' x 8'
11	Office Trailer/Lavatory	30' x 9' x 10'
12	Product Centrifuge/Filter Press Hopper	8'x 5' x 4'
13	Product Centrifuge/Filter Press Auger Conveyor	20' x 6' x 8"
14	Clean Coarse Centrifuge/Filter Press Stacker	35' x 2' x 16"
15	Front-end Loader	15' x 9' x 11'4"



As shown in Figure 2-1, Disa will establish a restricted area to include all aspects of the operation that will handle and manage source materials. Equipment and operations that are not used to handle or manage source material will be excluded from the restricted area including: the clean coarse fraction stockpile, clean coarse fraction centrifuge (5), empty transportation trucks (8), office trailer/lavatory (11), and clean coarse fraction centrifuge stacker (14). Although Figure 4-1 represents a typical layout, other equipment may be brought onto a particular site or substituted, as needed. No equipment will require the use of chemicals; HPSA is completely mechanical. If additional equipment will be used to handle and/or manage source material, it will be located in the restricted area. Regarding other equipment required by the application, the locations are as follows:

- Safety Equipment will be stored in the Analytical Trailer (Feature No. 6).

- Safety equipment and features related to spill response and containment include a containment berm (Feature No. 3) and shovels and drums for removing and storing potentially contaminated soils.

- Radioactive material warning signs will be placed at each access/egress point and on each side of the restricted area.
- Notice to Employees and emergency telephone numbers will be maintained in the Office Trailer (Feature No. 11).

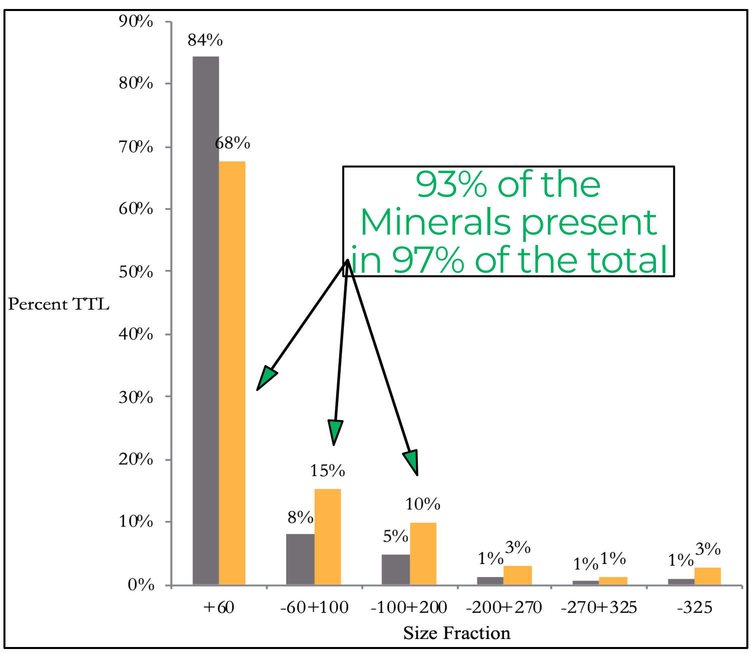
Once the HPSA system is set up on a site, waste rock will be crushed to size it for the HPSA (maximum 0.25" diameter). Water or dust enclosures will be used in the crushing process for dust suppression and to slurry the crushed waste rock. Once slurried, the mixture is transferred to the hopper on the HPSA to feed the collision chamber. After collision, the resulting stream is mechanically separated to isolate the clean coarse fraction (> No. 270 sieve) and isolated mineral fraction (< No. 270 sieve).

The isolated mineral fraction will be containerized in a lined dumpster, or other suitable container, and covered to protect it from the elements, except during loading operations. The clean coarse fraction will be placed in a pile and will remain onsite for use in mine reclamation. Once the operation is completed, the isolated mineral fraction will be transported offsite as alternate feed at a licensed uranium mill or low-level radioactive waste disposal facility depending on client preference. All transportation and disposal/alternate feed documentation will be maintained by Disa at its Casper, Wyoming, headquarters.

2.4.1 Expected Results

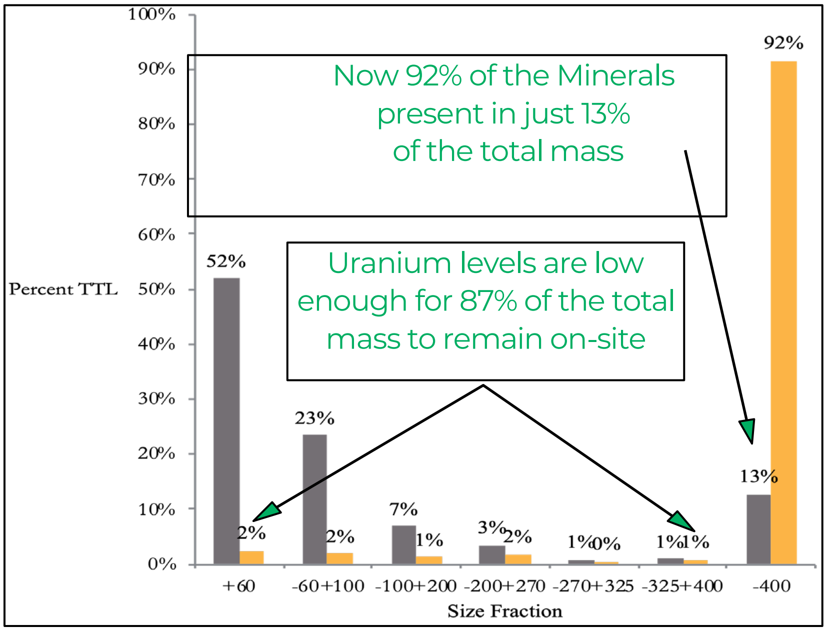
Bench scale testing waste rock using HPSA has been validated on numerous sites throughout the Western U.S. including validation from Idaho National Laboratory. Results are presented in Figures 2-2 and 2-3 that show pre-ablation data and post-ablation data, respectively.

Figure 2-2: Pre-Ablation Mass and Mineral Distribution



Source: Disa, 2022

Figure 2-3: Post-Ablation Mass and Mineral Distribution



Source: Disa, 2022

Generally, Disa expects that the HPSA technology will collect approximately 90% of the source material in the isolated mineral fraction (< No. 270 sieve), while 80% to 90% of the mass remains with the clean coarse fraction. This type of waste minimization is a critical aspect of uranium mine reclamation because the use of HPSA drastically reduces the amount of material that must be transported offsite and produces an inert material for reuse onsite. Furthermore, because source material is retained in the isolated mineral fraction, processing this material at a uranium mill will be more efficient and produce significantly less waste.

2.4.2 Controlled Areas During Remediation

As discussed above, Disa will establish restricted areas at each worksite. Generally, the restricted area will encompass, the following operations: crushing and grinding, ablation, fines storage, and staging areas. Disa will establish a restricted area by erecting a temporary boundary consisting of posts or drums that will support a rope or another type of physical barrier. Attached to the rope with standard yellow and magenta radioactive materials warning signs stating, "Caution – Radioactive Materials."

Only authorized users will be allowed to enter the restricted area. Personnel entering the restricted area will be required to don all necessary personal protection equipment (PPE) pursuant to the operational radiation protection plan and site-specific health and safety plans. All personnel entering the restricted area will be required to scan out when leaving the area to minimize potential cross-contamination. Eating, drinking, and smoking are prohibited within the restricted area. However, drinking from a container that can be sealed will be allowed, to avoid the effects of heat stress and dehydration.

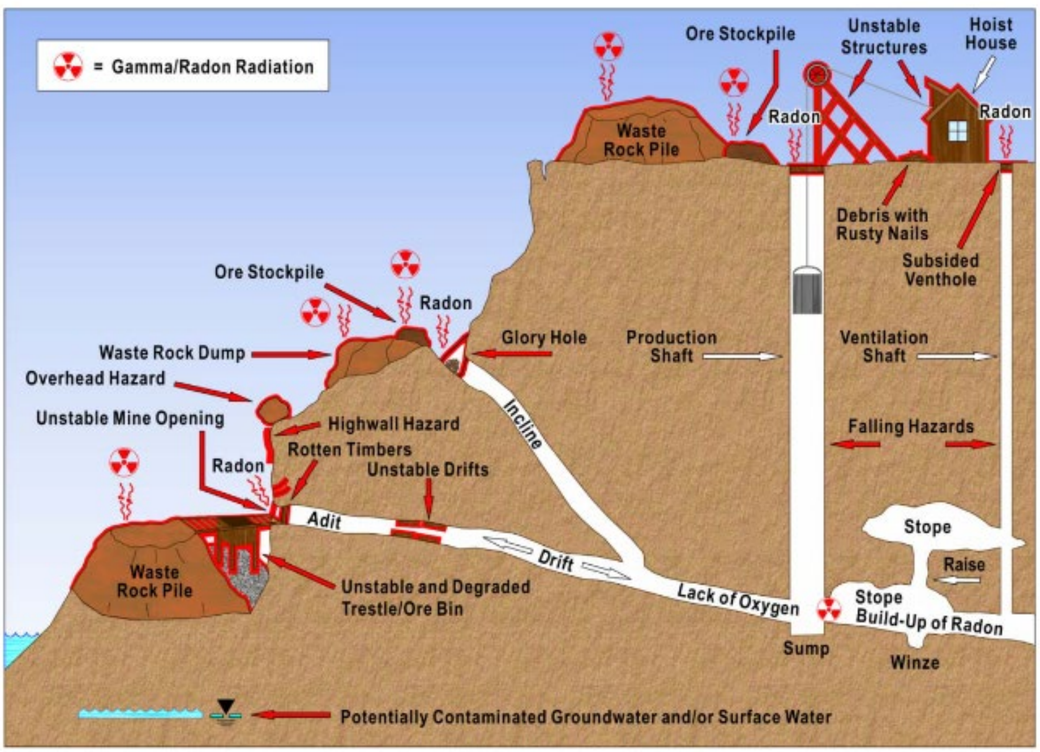
SECTION 3.0 DESCRIPTION OF AFFECTED ENVIRONMENT

Disa is seeking a performance-based, multi-site license for the use of HPSA in waste rock and contaminated site remediation. As such, multiple crews, equipped with HPSA units and supporting equipment, will be located at multiple sites throughout the western USA. Therefore, a presentation of the affected environment for one site is not applicable because the affected environment will vary across half of the USA. Disa will provide affected environment information that is generalized for the western USA in the Rocky Mountain region. Areas in the Great Plains and east (except Texas) will not be included in this assessment.

3.1 Generic Site Description

As stated in Section 1.1, approximately 15,000 mine locations with uranium occur in 14 western states, including: Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, North Dakota, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming. Most of those locations are found in Arizona, Colorado, New Mexico Utah, and Wyoming, with approximately 75% of those on Federal and tribal lands. Figure 3-1 is a schematic of a typical underground uranium mine. Figure 3-2 is an aerial image of the open pit mine at Riley Pass, South Dakota.

Figure 3-1: Schematic of a Typical Underground Mine



Source: DOE, 2013

Figure 3-2: Aerial Image of Riley Pass Open Pit Mine

Source: bing.com, 2022

A review of Figures 3-1 and 3-2 indicates that abandoned uranium mines occur in a variety of types and forms. However, all of these abandoned mine sites have one issue in common; waste rock piles are created to accumulate the cover materials and low-grade materials to get to the economically viable material. In addition to waste rock piles, abandoned uranium mines may have abandoned or open adits and shafts that access underground workings, pits with steep slopes, and other features that make these areas physically hazardous.

3.2 Land Use

Table 3-1 presents the major land uses for the 14 western states containing abandoned uranium mines. Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, North Dakota, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming.

Table 3-1: Percent Land Use by State

State	Cropland	Grassland	Forest-Use	Special-Use	Urban Areas	Miscellaneous
Arizona	1%	56%	17%	15%	2%	2%
California	15%	43%	27%	40%	9%	26%

State	Cropland	Grassland	Forest-Use	Special-Use	Urban Areas	Miscellaneous
Colorado	11%	34%	16%	8%	1%	0%
Idaho	9%	28%	25%	10%	0%	8%
Montana	17%	48%	18%	7%	0%	3%
Nevada	0%	31%	3%	7%	0%	0%
New Mexico	3%	77%	19%	10%	1%	1%
North Dakota	61%	30%	1%	4%	0%	3%
Oregon	11%	56%	57%	10%	2%	9%
South Dakota	40%	51%	4%	4%	0%	1%
Texas	40%	144%	20%	9%	8%	9%
Utah	2%	53%	16%	10%	1%	3%
Washington	14%	14%	34%	14%	3%	1%
Wyoming	4%	87%	13%	12%	0%	1%

Source: USDA, 2017

In Table 3-1, Miscellaneous land uses include marshes, open swamps, bare rock areas, deserts, rural residential areas, and other uses not inventoried. Special-Use land uses are rural transportation, rural parks and wildlife, defense and industrial, and farmsteads and farm roads.

3.3 Transportation

Transportation at abandoned uranium mine sites is generally accessed by dirt roads. Abandoned uranium mines are generally not near major highways or roads, and access to these areas is difficult. Some of the mine sites may be accessed for unauthorized recreation but are generally not trespassed by vehicles.

Mobilizing HPSA to a mine site involves the use of semi-tractors and trailers to all the necessary equipment to and from a site. A typical mobilization and transportation requirement is presented in Table 3-2.

Table 3-2: List of Transportation Vehicles (Worst Case Scenario)

Vehicle Type	Purpose
Mobilization/Demobilization	
Semi-Tractor/Trailer	HPSA Unit
Semi-Tractor/Trailer	Coarse Fraction Centrifuge
Semi-Tractor/Trailer	Fine Fraction Centrifuge
Semi-Tractor/Trailer	Loader
Semi-Tractor/Trailer	Conveyor
Semi-Tractor/Trailer	Grizzly Skid
Semi-Tractor/Trailer	Water Tanks
Semi-Tractor/Trailer	Generator
Semi-Tractor/Trailer	Screening/Crushing System
Passenger Truck	Mobile Lab
Water Truck	Initial Water Fill
Passenger Truck	Employees and Miscellaneous Supplies
Operations	
Water Truck	Make-up water during operations

Vehicle Type	Purpose
Fuel Truck	Refueling during operations
Semi-Tractor/Trailer	Transportation of Isolated mineral fraction
Passenger Truck	Employees Daily Commute
Semi-Tractor/Trailer	Second Loader for Regrading

HPSA equipment will originate from Disa's Headquarters in Casper, Wyoming, or potentially from another future satellite Disa office directly. The farthest reasonable distance that Disa personnel will need to travel is 1,400 miles. Most of the sites at which Disa would operate the HPSA equipment are within approximately 800 miles of Disa's Casper, Wyoming, Headquarters.

Transportation to each site would be both singular and steady occurrences. HPSA equipment would be delivered to each site pursuant to Table 3-2 under "Mobilization/Demobilization". HPSA equipment would be picked up at the end of the project pursuant to Table 3-2 under "Mobilization/Demobilization." The isolated mineral fraction would be transported during the project and/or at the end of the project. Steady truck traffic would be limited to the vehicles presented above under "Operations".

Disa will not operate its own trucks for transporting the isolated mineral fraction as alternate fee or for disposal, but rather will arrange for transportation of the isolated mineral fraction by a contracted commercial carrier. Disa, and the contracted carrier, will comply with the requirements of the applicable NRC's regulations for transportation of radioactive material, as well as 49 CFR Parts 171-173 (DOT). Disa will comply with the applicable regulations related to marking, manifesting, and transporting the isolated mineral fraction. Destinations for the isolated mineral fraction will either be a licensed uranium mill or a licensed low-level radioactive waste disposal facility. Disa will ensure that all disposals comply with the requirements of the various low-level waste compacts.

3.4 Geology

HPSA's operations will occur at abandoned uranium mines, which contain varying geology depending on the geographic location of the specific mine. In all cases, HPSA's operations do not involve excavation of any kind except on waste rock piles found on the surface and in soils that are contaminated. Disa's HPSA equipment is designed to prevent releases of constituents to surface soils. In all cases, pre- and post-remediation surveys will be performed to ensure that contamination releases to the environment have not occurred. Because Disa's operations are strictly surface operations, subsurface geologic structures have no influence over Disa's operations.

Because of the large number of potential sites eligible for HPSA, a description of the geology for each site is not reasonable and not necessary. However, the following physiographic provinces contain abandoned uranium mines were HPSA could be utilized (NPS, 2022). This list is as follows:

- Great Plains
- Rocky Mountain System
- Colorado Plateau
- Basin and Range
- Columbia Plateau
- Cascade-Sierra

- Pacific Border

3.5 Soils

Identifying the soils for each potential site is not possible due to the large number of abandoned uranium mines. Table 3-3 presents basic soil types by physiographic province (NSF, undated).

Table 3-3: Soil Types by Physiographic Province

Physiographic Province	Soil Description
Basin and Range	Aridisols dominate the Basin and Range. One of the identifying characteristics of these soils is their inherent dryness. There is very little plant life in much of the region, so an organic soil horizon takes either a long time to form or does not form at all. More calcium carbonate-rich soils, called Calcids (a suborder of Aridisols), are common in the southern portions, while more silica-rich Argids (a suborder of Aridisols) are common in the northern areas. Traces of Mollisols and Entisols can be found around the edges of the region, and small amounts of Gelisols can be found in eastern Nevada.
Columbia Plateau	The Columbia Plateau is mostly is composed primarily of Mollisols. These soils tend to be dry in the summer and are later remoistened by the fall and winter rains. They typically rest on top of gently sloped surfaces. This region experiences slower erosion than the more steeply sloped and continuously changing mountainous regions nearby, which allows the soils ample time to develop a rich and dark topsoil horizon
Rocky Mountain System	Inceptisols are common due to the steep slopes and wet conditions found in elevated areas. The rapid erosion and frequent washing away of soils means that soils in many areas are poorly developed. Although the bulk of Inceptisols occur on the East Coast, there are parts of the Western US, like the Rockies, that are both humid and forested enough for them to form. The Northern Rockies are unique to the rest of the Rockies in that they also harbor Andisols, a relict of the region's volcanic past that are more dominant in the Cascade-Sierra region.
Cascade-Sierra	Andisols compose most of the Washington area of the Cascades, while Inceptisols dominate the Oregon Cascades. Uniquely identified by the presence of volcanic glass and minerals derived from igneous rocks, many of these soils formed under dense coniferous forests. As in the Rocky Mountains, erosion is frequent in this terrain, making prolonged and deeper soil development difficult. The Sierras act as a transition zone between the arid climate in the east and the coastal climate to the west, and Alfisols tend to form in this type of zone. Although these soils form throughout the nation, and over a greater area east of the Mississippi River, the unique suborder of Xeralfs make up the majority of the Alfisols in the region. These soils can be forested, or even used as crop and grazing lands.

Physiographic Province	Soil Description
Pacific-Border	All of the dominant soil types previously discussed can be found in this region due to the variance in climate, vegetation, and geology that exists from north to south. Andisols are found mostly along the Washington coast, Inceptisols cover the coasts of Oregon and northern California, and Mollisols are scattered around the rest of California's coast.
Colorado Plateau	Aridisols are the most common soils on the Colorado Plateau, which are also common in the Basin and Range Province. Soils are formed from the weathering of limestones and carbonate parent material deposited in ancient seas. Aridisols contain high concentrations of gypsum, carbonates, and salt, which sometimes solidify into caliche—a hard, light-colored layer cemented together by lime.
Great Plains	Alfisols in the Great Plains are mostly limited to drier and slightly higher-elevation plateaus of northern Texas, such as the Llano Estacado, where they are interspersed with Mollisols. Aridisols occur in the lower-elevation portions of this area, especially around the border with southeastern New Mexico. Entisols are very limited in extent, occurring mostly along the Canadian and Pecos rivers. Inceptisols are likewise limited and are found only in the northernmost parts of Texas in the Great Plains region. Vertisols are limited to a small area in western Texas.

Source: NSF, Undated(a-c)

Soil types described above are defined as follows:

- Alfisols: Highly fertile and productive agricultural soils in which clays often accumulate below the surface. Found in humid and subhumid climates.
- Andisols: Often formed in volcanic materials, these highly productive soils possess very high water- and nutrient-holding capabilities. Commonly found in cool areas with moderate to high levels of precipitation.
- Aridisols: Soils formed in very dry (arid) climates. The lack of moisture restricts weathering and leaching, resulting in both the accumulation of salts and limited subsurface development. Commonly found in deserts.
- Entisols: Soils of relatively recent origin with little or no horizon development. Commonly found in areas where erosion or deposition rates outpace rates of soil development, such as floodplains, mountains, and badland areas.
- Gelisols: Weakly weathered soils formed in areas that contain permafrost within the soil profile.
- Inceptisols: Soils that exhibit only moderate weathering and development. Often found on steep (relatively young) topography and overlying erosion-resistant bedrock.
- Mollisols: Agricultural soils made highly productive due to a very fertile, organic-rich surface layer.
- Vertisols: Clayey soils with high shrink/swell capacity. During dry periods, these soils shrink and develop wide cracks; during wet periods, they swell with moisture.

It is important to note that the locations of contaminated material will not likely be native soils but waste rock placed on the ground or otherwise impacted soils with contamination.

3.6 Water Resources

3.6.1 Groundwater

No groundwater is used during this process and groundwater will not be impacted by Disa's operations. As shown in Table 3-4, the clean coarse fraction that is to be left on the mine sites, will not be toxic according to the Toxic Characteristic Leaching Procedure (TCLP). Consequently, no toxic constituents will leach into groundwater.

Table 3-4: Toxicity Data – Clean Coarse Fraction and Waste Rock

Parameter	Units	Waste Rock	Clean Coarse Fraction	RCRA Standard
Arsenic	mg/L	0.3	**ND**	5
Barium	mg/L	2.7	**1.2**	100
Cadmium	mg/L	0.08	**ND**	1
Chromium	mg/L	ND	**ND**	5
Lead	mg/L	ND	**ND**	5
Mercury	mg/L	ND	**ND**	0.2
Selenium	mg/L	ND	**ND**	1
Silver	mg/L	ND	**ND**	5

3.6.2 Surface Water

Disa's operations will generally be conducted in the Western United States. As such, Disa's operations will occur on both sides of the Continental Divide. Major watersheds where remediation operations will occur are: Pacific Northwest, California, Great Basin, Lower Colorado, Upper Colorado, Rio Grande, Texas Gulf, Arkansas Red White, and Missouri basins (National Geographic, 2022).

Disa's operations will not result in the discharge of process water directly to surface water. However, water will be needed for HPSA operations, and that water will be provided to the site by Disa. HPSA operations involve recycling water continuously and adding makeup water from water tanks transported to the site. Because up to 20% of water is lost in the form of moisture in the clean coarse fraction and the isolated mineral fraction, makeup water must be added continuously. This amount could be at least 2,000 gallons per day.

Water will be filtered or otherwise treated and analyzed to determine if concentrations of radiological constituents meet 10 CFR 20, Appendix B effluent limits or Appendix B sewerage discharge limits. Furthermore, Disa will determine if non-radiological constituents meet surface discharge limits of the individual states or EPA where operations are being conducted. Based on these determinations, water will either be discharged to the ground, a sanitary sewer, or to a licensed disposal facility.

Disa will manage surface water runoff at the site during operations. First, no operations will occur during storm events. Second, trailers containing the isolated mineral fraction will be covered to protect the product and prevent migration of constituents to the soil below the trailers. Third, the clean coarse fraction is inert and does not require protection from precipitation. However, care will be taken to prevent erosion and unauthorized direct discharge of the clean coarse fraction to surface water bodies. For example, the HPSA unit contains a tray to capture potential spilled liquids, and, if necessary, diversion booms may be used to divert water around the restricted area. Other standard and best practices will be used to prevent erosion, as needed.

3.7 Ecological Resources

3.7.1 Generic Ecological Description

Ecological issues at abandoned mine sites are highly site-specific. As a general matter, abandoned uranium mines are impacted areas that do not support common or endangered wildlife or plant communities. Waste rock piles and other impacted lands will not likely provide sufficient habitat to support plant and animal communities.

3.7.2 Identification of Endangered Species

Appendix A contains lists of endangered flora and fauna by each of the western states. Because of the impacted nature of abandoned uranium mine sites, Disa has no reasonable expectation that endangered flora and fauna will be found at these sites.

3.8 Meteorology, Climatology, Air Quality

The following description of the climate in the main area of concern for this environmental report is from climatestotravel.com (https://www.climatestotravel.com/climate/united-states#plateaus). Information presented below is representative of the high plateau area covering eastern Washington, California, and Oregon, along with western Montana, and parts of Nevada, Arizona, New Mexico, Texas, Kansas, Nebraska, and South Dakota, and the entire states of Colorado, Wyoming, Utah, and Idaho (see Figure 3-3).

Figure 3-3: Area of Climate Information

Source: climatestotravel.com, 2022

3.8.1 General Description

East of the Pacific Coast, two mountain ranges, both parallel to the coast, the Cascade Range in the north and the Sierra Nevada in the south, isolate the interior of the continent from maritime influences. East of these mountain chains are the Rocky Mountains, which cross the central-western United States from north to south. In addition to the highest peaks and ranges, wide areas of plateaus and valleys exist at high altitudes, where the climatic characteristics are quite similar:

- cold winters/hot summers
- significant difference in temperature between night and day; low precipitation
- clear air
- summer thunderstorms
- sudden increases in temperature due to the Chinook (warm wind coming down from the mountains which is able to melt the snow in a short time)
- intense cold waves in winter, with snowfalls and strong northern winds.

Proceeding from north to south, the climate becomes progressively warmer, while there are also some local differences (as regards to precipitation as well) depending on altitude and slope exposure. In general, the southern highlands are the driest; however, rain shadows exist in areas in the north. Examples of parts of the plateau are presented below.

3.8.2 Spokane, Washington

Climate of Washington and Oregon are represented by the City of Spokane. In the states of Washington and Oregon are mild and rainy along the coast, and the bulk of precipitation coming from the ocean is released on the Cascade Range. To the east of this mountain range, is the arid plateau, where the climate is continental, with wide temperature ranges between day and night. Total precipitation is scarce, though it is more abundant in winter, with possible heavy snowfalls. Strong waves of frost may occur in winter and also some heat waves in summer. Table 3-5 presents average temperatures.

Table 3-5: Spokane, Washington, Average Temperatures (1991 – 2020)

Month	Min (°C)	Max (°C)	Mean (°C)	Min (°F)	Max (°F)	Mean (°F)
January	-3	3	-0.1	26	38	31.8
February	-3	6	1.4	27	42	34.6
March	0	11	5.3	32	51	41.5
April	3	15	8.9	37	60	48.1
May	7	21	13.8	44	70	56.9
June	10	24	17.3	50	76	63.1
July	13	31	22	56	87	71.5
August	12	30	21.3	54	86	70.3
September	8	24	16.3	47	76	61.4
October	3	16	9.5	38	60	49.1
November	-1	7	3.3	31	45	37.9
December	-4	3	-0.4	26	37	31.3
Year	3.9	16	9.9	39	60.8	50

Source: climatestotravel.com, 2022

Precipitation in Spokane amounts to 440 mm (17.5 in) per year, with a minimum in summer. On average, 1 meter and 15 centimeters (45 inches) of snow fall per year, and the snow season runs from November to early April (of course, it takes several centimeters of melted snow to have one cm of rain, and the same applies to inches). Table 3-6 presents monthly averages.

Table 3-6: Spokane, Washington, Average Precipitation

Month	Millimeters	Inches	Days
January	50	2	15
February	35	1.4	12
March	45	1.8	13
April	40	1.6	11
May	45	1.8	10
June	40	1.6	9
July	15	0.6	3
August	15	0.6	3
September	15	0.6	5
October	35	1.4	10
November	50	2	14
December	55	2.2	14
Year	440	17.3	119

Source: climatestotravel.com, 2022

3.8.3 Denver, Colorado

Denver is located at 1,610 meters (5,280 feet) and has similar characteristics to Spokane but exhibits a slightly milder climate. The monthly average temperature ranges from -0.5 °C (31 °F) in December to 24 °C (75 °F) in July. In the summer, nights are typically mild to cool and days are hot.

Table 3-7: Denver, Colorado, Average Temperatures (1991 – 2020)

Month	Min (°C)	Max (°C)	Mean (°C)	Min (°F)	Max (°F)	Mean (°F)
January	-7	7	-0.2	19	45	31.6
February	-7	8	0.4	20	46	32.7
March	-2	13	5.4	28	56	41.6
April	1	16	8.8	34	62	47.8
May	6	22	14.1	44	71	57.4
June	12	29	20.2	53	83	68.3
July	16	32	24	60	90	75.1
August	15	31	22.7	58	87	72.9
September	10	26	18.2	50	80	64.8
October	3	18	10.6	37	65	51.2
November	-3	12	4.2	26	53	39.5
December	-8	7	-0.4	18	44	31.2
Year	2.9	18.5	10.7	37.3	65.2	51

Source: climatestotravel.com, 2022

Precipitation in Denver averages 370 mm (14.5 in) per year, with a maximum in summer, primarily because of monsoonal flows. Snow falls from October to May and may accumulate to approximately 1 meter and 25 cm (49 in) per year. Table 3-8 presents monthly precipitation averages.

Table 3-8: Spokane, Washington, Average Precipitation

Month	Millimeters	Inches	Days
January	10	0.4	4
February	10	0.4	6
March	20	0.8	6
April	45	1.8	9
May	55	2.2	10
June	50	2	8
July	55	2.2	8
August	40	1.6	8
September	35	1.4	6
October	25	1	5
November	15	0.6	5
December	9	0.4	4
Year	370	14.6	80

Source: climatestotravel.com, 2022

3.8.4 Other Areas

Table 3-9 presents the average winter temperature, summer temperature, and annual precipitation for various other locations in the high plateau areas.

Table 3-9: Various Locations – Temperature and Precipitation

Location	Average Winter Temperature (°F)	Average Summer Temperature (°F)	Average Precipitation (in)
Eureka, MT	23	68	14.5
Alturas, CA	30	68	11.5
Boise, ID	32	77	11.5
Reno, NV	34.5	77	7.3
Salt Lake City, UT	31.5	81	15.5
Cheyenne, WY	28	70	16

Source: climatestotravel.com, 2022

3.9 Noise

Mine sites and other contaminated sites are isolated from the public; therefore, the public will not be impacted by noise from mobilization/demobilization. Disa will require hearing protection during operations to protect employees from potential noise injuries. While noise levels are expected to be below 85 dBA, hearing protection will be standard personal protective equipment (PPE) during operations.

3.10 Historic and Cultural Resources

Due to the number of sites, and fact that all sites on which HPSA will be used are mining impacted or contaminated sites, assessing historic or cultural resources is not possible. Also, because of the impacted nature of these sites, historic and cultural resources will likely be absent or otherwise impacted. However, Disa will likely be utilized on Native American Reservations, and some sites have the potential to contain historic or cultural resources. Disa will either consult with experts or with Federal agencies regarding tribal historic and cultural resources.

3.11 Socioeconomic Impacts

Generally, abandoned uranium mine sites or contaminated sites are located at significant distances from communities or may be near small and/or impoverished communities. Table 3-10 presents socioeconomic data for typical communities located near abandoned uranium mines, as an example of the socioeconomic conditions that may occur near these mines. These communities were selected for Table 3-10 based on a loose proximity to large concentrations of abandoned uranium mines in each state represented in this table.

Disa's HPSA operations have the ability to provide jobs for communities located near large concentrations of abandoned uranium mines. Furthermore, if Disa's license is approved, Disa's HPSA operations will successfully convert large areas of unusable land into lands for beneficial use. This, in-turn, could have a positive impact on the local economy, job creation, and tax revenues.

3.12 Public and Occupational Health

Currently, abandoned uranium mines are sources of potential physical hazards and hazards from radiological doses to Disa's employees and members of the public. Disa's HPSA operations will be secure

Table 3-10: Socioeconomic Information – Various Communities

Community	Total Pop.	Median Income ($)	Bachelor's degree or higher (%)	Employ-ment Rate (%)	Total Housing Units	Total Households	Poverty (%)	Without Health Care (%)	American Indian and Alaska Native (%)	Asian (%)	Black (%)	Hispanic or Latino (%)	Other Race (%)	Two or More Races (%)
Glade Park - Gateway CCD, CO	2,267	75,115	44.5	41.3	1,164	1,210	2.3	5.8	1	0.4	0.4	5	1.3	7.3
Monticello, UT	1,824	65,928	26.9	50.9	692	797	9.3	10.3	5.7	0.2	0.2	15	5.3	7.9
Casper, WY	59,038	59,412	26.5	66.9	27,166	24,850	10.5	12.6	1.4	0.9	1.1	9.5	2.8	7.6
Gallup, NM	21,899	45,754	20.9	49.1	8,306	7,499	33.7	15.7	51	3	1	27.8	16.7	10.5
Wickenburg, AZ	7,474	52,898	30.2	47.2	4,499	3,450	13.7	15.8	1.3	0.6	0.7	13	5.2	7.7
Yerington CCD, NV	8,231	37,067	12.8	36.2	3,883	3,563	18.4	10	6	0.7	0.8	24.0	13.2	9.4
Dubois, ID	511	34,120	17	47	248	255	1	31.8	0.2	0.2	1.2	44.8	27.4	0.4

Source: US Census Bureau, 2022

to avoid injury or unnecessary radiological dose to members of the public. Furthermore, Disa's occupational health and safety plan, and radiation protection plan will minimize the potential for occupational injury or radiological dose. As part of its application, Disa performed dose assessments to assess public and occupational doses from its operations; this dose assessment is contained in Appendix B. Section 4.12 discusses radiological doses to the workers and members of the public.

Results from bench scale testing of the waste rock and the clean coarse fraction indicate that significant reductions in the radionuclide signature of a remediated site. Table 3-11 presents radiological analyses for both waste rock and the clean coarse fraction.

Table 3-11: Radionuclide Analyses

Parameter	Units	Waste Rock	Clean Coarse Fraction	Total Reduction	Percent Reduction
Lead -210	pCi/g	149	37.1	111.9	**75.10%**
Radium-226	pCi/g	125	70.4	54.6	**43.68%**
Radium-228	pCi/g	1.9	1	0.9	**47.37%**
Thorium-230	pCi/g	153	74.7	78.3	**51.18%**
Thorium 232	pCi/g	ND	ND	NA	NA
Vanadium	mg/kg	1,362	409	953	**70%**
Uranium	mg/kg	912	129	782	**86%**

Samples for this analysis were analyzed by Pace Analytics, Sheridan, Wyoming. Analytical methods used for these samples are as follows:

- Lead -210 – Method OTW01
- Radium-226 – Ga-Tech Method
- Radium-228 - Ga-Tech Method
- Thorium-230 – Method ACW10
- Thorium 232 – Method ACW10
- Uranium – EPA Method 200.8

A review of Table 3-11 indicates that reductions in radiological signature range from 44 to 75%.

3.13 Radiation Protection and ALARA Program

Appendix C presents Disa's radiation protection program and ALARA commitments.

SECTION 4.0 ASSESSMENT OF IMPACTS

Disa assessed the potential environmental impacts from each of the alternatives discussed above including: (1) no-action, (2) excavation and disposal, (3) waste rock regrading, and (4) Proposed Project - HPSA. Based on this assessment, Disa has determined that implementing the Proposed Project – HPSA does not create any significant potential impacts to public health and safety or the environment. In fact, the use of HPSA minimizes potential adverse impacts to public health and safety.

4.1 Land Use Impacts

4.1.1 No-Action

Land use impacts of the No-Action alternative are substantial. Waste rock remains at the mine site and continues to pose a radiological and hazardous materials contamination risk at each site. No beneficial use of the land can occur.

4.1.2 Excavation and Disposal

Excavating waste rock from each mine and then regrading and reclaiming the mine sites restores a beneficial land use to each mine site. Land use would be restored to the typical uses described in Section 3.2.

4.1.3 Waste Rock Regrading

Waste rock regarding followed by reclamation restores the beneficial land use to each mine site. However, the types of land uses would be limited to recreation due to the presence of the waste rock. Excavation or erosion of the surface can once again expose members of the public and the environment to radiological and hazardous constituents.

4.1.4 HPSA

HPSA followed by regrading restores the typical land use as described in Section 3.2, to each mine site. No limits on land use would be necessary, because radiological and inorganic constituents would be removed and would not present a future hazard.

4.2 Transportation

4.2.1 No-Action

The No-Action alternative would not present any transportation impacts.

4.2.2 Excavation and Disposal

Excavation would involve 20-ton trucks moving material offsite. For a site of 8,500 tons of waste rock, 425 trucks would be required to remove the waste. Then, at least 50 truckloads of topsoil would be required to reclaim the mine site. This would be repeated for 15,000 mine sites. Because many of the sites are isolated, these trucks would be traversing substandard roads. Below are accident statistics regarding disposing of the excavated waste rock; these statistics do not include truck loads required for delivering topsoil. Statistics also only include delivery of the waste to a disposal facility and not the mileage for the trucks to be arrive at the site for picking up the loads.

4.2.2.1 Accident and Fatality Statistics

According to the US Department of Transportation, Federal Motor Carrier Safety Administration (FMCSA), in 2019, 4,479 fatal crashes of large trucks occurred out of the 13,085,643 large trucks that are registered (FMCSA, 2021). Regarding fatalities normalized for vehicle miles traveled (VMT), 1.8 fatalities occurred per 100 million miles traveled in large trucks in 2019. Regarding injuries normalized for VMT, 40 injuries occurred per every 100 million miles traveled in 2019.

4.2.2.2 Potential Accidents due to Alternative

Based on the number of trucks and an assumed 500 miles required for disposal, a total of 3,187,500,000 miles will be driven to dispose of contaminated materials at 15,000 mine sites. Based on the 2019 FMCSA data, approximately 57 fatalities can be expected at a rate of 1.8 fatalities per 100 million miles. Also based on the 2019 FMCSA, 1,275 injury crashes will occur involving large trucks.

4.2.3 Waste Rock Regrading

Approximately 3 semi-tractor/trailers would be required to bring excavators to a site for the grading work. Then approximately 50, 20-ton trucks would be required to supply topsoil for a site along with water trucks. Because many of the sites are isolated, these trucks would be traversing substandard roads. Assuming 200 miles is required for delivering the excavators and delivering topsoil a total of 10,600 miles will be driven, per mine site. The probability of fatalities or injuries occurring from crashes at this low level of mileage is statistically zero.

4.2.4 Proposed Project-HPSA

Nine semi-tractor/trailers, 2 personnel trucks, and a water truck would be required for mobilization / demobilization. Two semi-tractor/trailers, 1 personnel truck, 1 water truck, and 1 fuel truck would be required for operations. This includes 2 semi-tractor/trailer loads of isolated mineral fraction transported for disposal or alternate feed. Because many of the sites are isolated, these trucks would be traversing substandard roads. Similar to the Waste Rock Regrading alternative, probability of fatalities or injuries occurring from crashes at the low level of mileage is statistically zero for the Proposed Project - HPSA. Trucks are assumed to be traveling 500 miles to each site.

The transportation of source material in the isolated mineral fraction along public roads has been evaluated extensively in the context of ISL and conventional uranium recovery operations. The operation of HPSA requires that the isolated mineral fraction be disposed at a low-level radioactive waste disposal facility or utilized as alternate feed at a licensed uranium recovery facility. Transportation will occur pursuant to USDOT regulations in 49 CFR Parts 171-173, as well as NRC's regulations in 10 CFR Parts 40. Semi-tractors with covered roll-off containers will be used to transport the isolated mineral fraction to the appropriate facility. No free liquids will be present in the roll-off containers; therefore, accidents will not release liquids to the environment. The isolated mineral fraction will contain sufficient moisture that will avoid air transport of any spilled material.

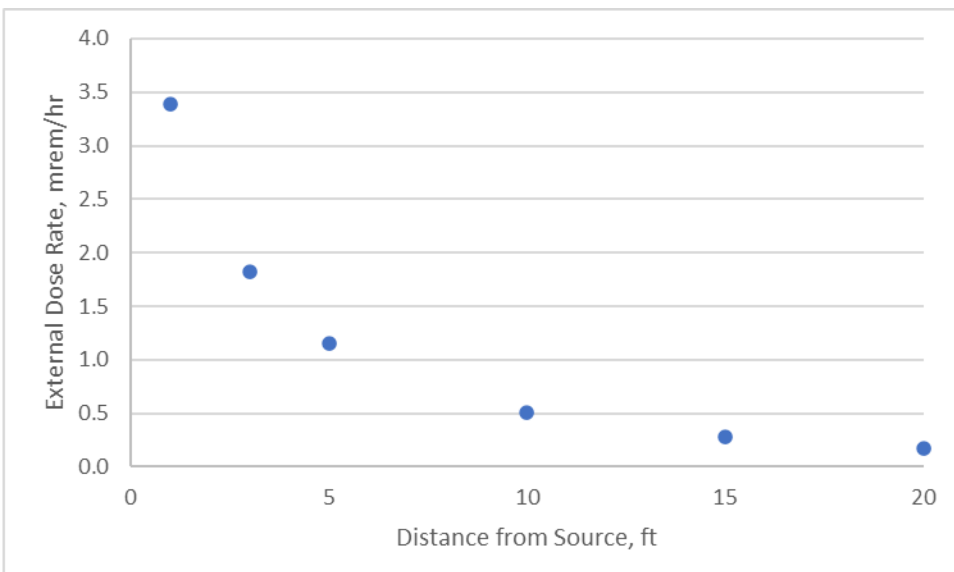
If trailers containing the mineral-rich fraction spill during transportation, it may be picked up with shovels or small excavators and placed into another container or drums. Materials will not flow due to the lack of free liquids in the isolated mineral fraction. The following sections present an assessment of doses to emergency workers responding to a potential spill. The following sections explore doses due to spills and spill response.

4.2.4.1 Direct Radiation Dose from Spill Cleanup

The volume of material being transported was modeled using MicroShield 9.07. Direct radiation dose is highly dependent on geometry, time, distance, shielding, material concentrations, and amount of material. Conservative assumptions were made to estimate the effective dose rates and various distances from the entire volume of material.

A cleanup likely would involve small excavators and shovels, a more dispersed source, and controls to reduce the amount of time individuals would be near the spill material. Therefore, doses from an actual emergency response would result in lower direct radiation doses than those calculated herein. The maximum dose rate for an individual standing a foot from the volume of material is 3.39 mrem/hr; this area would not be considered a radiation area. Cleanup using heavy equipment could reduce doses to workers by a factor of 2 from these unshielded results and keep individuals at a distance greater than a foot. Assuming the average distance a worker is from the entire volume of material is 5 feet, and the worker is exposed and unshielded for 10 hours, this would result in a total external dose of 11.6 mrem.

Figure 4-1: Direct Radiation Dose vs. Distance from Spill



4.2.4.2 Inhalation Dose

MILDOS 4.1 was used to simulate air concentrations from a dry pile of material. The pile of material modeled was slightly larger than the surface area of the two largest dimensions of the trailer carrying the material (300 m2 total area). While respirators and dusk masks can reduce risks from particulate inhalation as well, this model assumes no respiratory protection is used. Additionally, the material is likely to be moist or wet which would greatly reduce any risk of suspension of spill material. Cleans up should also include dust suppression techniques and materials kept moist (not dry) during cleanup. Radon exhalation from the material could be a concern if the spill occurs indoors in an enclosed space. However, it is not likely a transportation accident would occur in an enclosed space. Radon rapidly dissipates in outdoor environments. For the modeling, a radon flux rate of 200 pCi/m2/second was assumed. This high radon flux value can sometimes be seen from tailings wastes.

The modeling results indicate that a receptor at 15 feet from the spill would receive approximately 21.2 mrem/yr from inhalation dose (including radon). The occupancy time is assumed to be 10 hours (0.11% of the year). This would give a total inhalation dose of 0.02 mrem.

4.2.4.3 Ingestion Dose

Ingestion dose from a spill cleanup can effectively be removed as a dose pathway by proper use of PPE (gloves, coveralls, etc.), contamination control procedures (e.g., personnel contamination surveys), and good industrial hygiene such as washing hands and face prior to eating, tobacco use, leaving the site, etc. Accidental ingestion is expected to be smaller than an inhalation dose and therefore negligible.

4.3 Impacts to Geology and Soils

This section describes the impacts to geology and soils. It should be noted that abandoned uranium mine sites currently contain impacted soils. Therefore, this section will address impacts from the perspective of continued negative or positive impacts on soils

4.3.1 No-Action

The No-Action alternative will result in ongoing radiological and non-radiological contamination of soils. Contaminants may either mix in with native soils or could contaminate soils through leaching. Generally geologic resources are not impacted by the No-Action alternative unless contaminants migrate to depths that would impact geologic units below the soils.

4.3.2 Excavation and Disposal

Impacts from the excavation of contaminated waste rock will disturb underlying soils as remediation crews attempt to remove all waste rock from a mine site. However, contamination will be removed, and clean soil will be transported to the site for reclamation. Over time, the soil impacts will be indistinguishable from native areas near the abandoned mine sites. Geologic units will not be impacted by this alternative.

4.3.3 Waste Rock Regrading

Waste rock regrading will permanently impact soils. Although the site will be regraded and covered with clean fill for safety, the waste will remain in place. This alternative leaves a small potential for radiological and non-radiological constituents to contaminate deep soils in-tact. If contamination migrates deeply (highly unlikely), then geological units below the soil may be impacted.

4.3.4 Proposed Action - HPSA

The Proposed Action will temporarily impact soils due to excavation of waste rock and regrading of the clean coarse fraction. However, once the clean coarse fraction is graded and either covered with topsoil and/or seeded, the site will return to a more natural state that is indistinguishable from native areas near the mine site. It should be noted that regrading the clean coarse fraction is not a requirement of this alternative. Furthermore, regrading the clean coarse fraction is likely an activity to be performed by the owner of the materials. No geologic units will be impacted from this alternative.

4.4 Water Resources Impacts

4.4.1 No-Action

The No-Action alternative could result in minimal shallow groundwater impacts from contaminants potentially leaching from the waste rock piles. The degree of leaching is highly site-specific based on the minerology of the waste rock and the climate of the particular site. Considering, most of the sites are in areas that receive 7 to 16 inches of rain; therefore, the potential for shallow groundwater contamination exists at every mine site.

Surface water impacts may occur from the No-Action alternative depending upon the proximity between the mine sites and surface water. Surface water transport of radiological constituents does not occur typically over long distances and surface water bodies are not typically located near these sites. However, topography and close proximity water bodies to abandoned uranium mine sites may result in contamination issues.

4.4.2 Excavation and Disposal

No impacts to groundwater are expected using the excavation and disposal alternative. Excavation removes the contaminant sources from the site, and the material will be replaced with clean fill and/or topsoil. Significant quantities of water will be required for dust control and also irrigation for revegetation efforts. This represents an irretrievable loss of a surface water resource.

4.4.3 Waste Rock Regrading

Impacts to groundwater are not expected from this alternative, regardless of the fact that the material remains onsite. Since the waste rock will be covered with clean fill and/or topsoil and seeded, precipitation would likely runoff without contacting the waste rock, especially if reclaimed area is positively graded. Surface water resources would not be likely impacted because regrading and reclaiming the waste rock would stabilize the site, except is significant erosion occurs. However, significant quantities of water will be required for dust control and also irrigation for revegetation efforts. This represents an irretrievable loss of a surface water resource.

4.4.4 Proposed Action – HPSA

Implementation of the Proposed Action - HPSA would not result in impacts to groundwater or surface water. The clean coarse fraction is proven, through chemical and radiological analyses, that it is an inert material that will not leach radiological and non-radiological constituents into groundwater and will not harm surface water or groundwater. Because of the need for makeup water in HPSA operations, surface water will be used for and will be considered an irretrievable loss of surface water.

4.5 Ecological Resource Impacts

4.5.1 No-Action Alternative

Ecological impacts of the No-Action alternative are substantial. The No-Action alternative maintains lands in an impacted state that does not foster habitat for common and endangered species.

4.5.2 Excavation and Disposal

Excavation and disposal will result in positive impacts for ecological resources. Contaminated materials will be removed and disposed offsite, and new fill and soil will be imported to reclaim the mine sites. As the reclaimed site matures, the land will likely become habitat for flora and fauna.

4.5.3 Waste Rock Regrading

Waste rock regrading will have a partially positive/negative impact on ecological resources. The surface of the reclaimed mine sites may become habitat for common and endangered species. However, below the shallow topsoil, the contaminated materials will remain onsite, which reduces the usefulness of this alternative for benefiting ecological resources.

4.5.4 Proposed Action – HPSA

The Proposed Action will have a positive impact on ecological resources. HPSA produces a clean coarse fraction that is not a radiological or toxicity hazard. Therefore, these materials may be used in the regrading and reclaiming of mine sites without impacts to ecological resources.

4.6 Air Quality Impacts

Air quality impacts will generally involve emissions from trucks. Impacts of emissions from trucks will be based on the following emissions standards (see Table 4-1).

Table 4-1: Heavy Truck Diesel Emissions

Non-Methane Hydrocarbon (NMHC) (g/bhp-hr)	NMHC + Nitrogen Oxides (NOx) (g/bhp-hr)	NOx (g/bhp-hr)	Particulates (g/bhp-hr)	Carbon Monoxide (CO) (g/bhp-hr)
0.14	2.4	0.2	0.01	15.5

Source: EPA, 2016

At 55 miles per hour, the horsepower (HP) required to move a tractor trailer (80,000 lbs) is 176 HP (Caterpillar, 2006). This does not include the effects of grade, climate, vehicle speed, and other factors. For the sake of this report, Disa will consider HP and brake HP (BHP) to be the same. Based on the HP and the emissions standards presented above, emissions quantities have been calculated for each alternative where applicable.

4.6.1 No-Action Alternative

No air quality impacts from the No-Action alternative.

4.6.2 Excavation and Disposal

As stated above, 475 trucks would be required to remove the waste rock and travel 500 miles for disposal or use as alternate feed at a licensed uranium recovery facility. At 55 mph, each truck would require 9 hours to drive 500 miles. The emissions from this alternative are presented in Table 4-2.

Table 4-2: Excavation and Disposal Truck Emissions

Non-Methane Hydrocarbon (NMHC) (kg)	NMHC + Nitrogen Oxides (NOx) (kg)	NOx (kg)	Particulates (kg)	Carbon Monoxide (CO) (kg)
105.34	1,805.76	150.48	7.52	11,662.20

4.6.3 Waste Rock Regrading

As stated above, 50 trucks would be required to import topsoil and fill to each mine site. Trucks would travel 200 miles for delivering the materials. At 55 mph, each truck would require 4 hours to drive 200 miles. The emissions from this alternative are presented in Table 4-3.

Table 4-3: Waste Rock Regrading Truck Emissions

Non-Methane Hydrocarbon (NMHC) (kg)	NMHC + Nitrogen Oxides (NOx) (kg)	NOx (kg)	Particulates (kg)	Carbon Monoxide (CO) (kg)
4.93	84.48	7.04	0.35	545.60

4.6.4 Proposed Action

As stated above, 16 trucks would be required to import topsoil and fill to each mine site. Trucks would travel 200 miles for delivering the materials. At 55 mph, each truck would require 9 hours to drive 500 miles. The emissions from this alternative are presented in Table 4-4.

Table 4-4: Propose Action Truck Emissions

Non-Methane Hydrocarbon (NMHC) (kg)	NMHC + Nitrogen Oxides (NOx) (kg)	NOx (kg)	Particulates (kg)	Carbon Monoxide (CO) (kg)
3.55	60.83	5.07	0.25	392.83

4.7 Noise Impacts

4.7.1 No-Action Alternative

Because the No-Action alternative does not involve any remedial actions, no noise impacts will occur due to this option.

4.7.2 All Other Alternatives

Noise due to trucks and earth moving equipment will likely exceed, at least in part, occupational noise exposures in excess of the OSHA standard of 85 dBA. Therefore, hearing protection will be standard PPE for all employees and visitors during operations. However, noise impacts will be negligible for members of the public, because all the sites will be in areas that are isolated from communities.

4.8 Historic and Cultural Resources Impacts

Abandoned uranium mines are impacted sites. As such, any cultural and historic resources currently at a mine are likely impacted, or absent. Disa notes that some of its work will likely occur on tribal lands. Therefore, consultations with tribal experts and Federal agencies would be considered to avoid disturbing Native American historic or cultural resources. Furthermore, as stated in Section 1.2, Disa will consult with ecological and cultural and historic resource experts before mobilizing to a site to conduct HPSA operations.

4.8.1 No-Action Alternative

The No-Action alternative will not harm cultural or historic resources further.

4.8.2 Excavation and Disposal

Excavation and disposal is not expected to disturb historic and cultural resources, as the excavation will occur on materials that have been disposed of on the ground. However, over excavation could disturb resources that are unknown and are buried below the waste rock.

4.8.3 Waste Rock Regrading

Waste rock regrading is not expected to disturb historic and cultural resources as surface materials will be graded, and topsoil will be added for final reclamation. Over excavation is not expected to occur.

4.8.4 Proposed Action – HPSA

The Proposed Action-HPSA is not expected to disturb historic and cultural resources as no deep excavation would occur. Only waste disposed on the surface will be subjected to HPSA and a clean coarse fraction will be placed on the surface near the waste rock.

4.9 Visual/Scenic Impacts

4.9.1 No-Action Alternative

The No-Action alternative results in significant visual and scenic impacts. Because the waste rock piles are left onsite, abandoned uranium mines will have the appearance of an old mine site with waste piles, resulting in an unnatural and low-useability landscape.

4.9.2 Excavation/Disposal, Waste Rock Regrading, Proposed Action – HPSA

All three of the remaining alternatives will result in positive visual/scenic impacts by reclaiming the mine sites and restoring them to a more natural and useable landscape. Reclaimed mine sites blend in the mining landscape into the natural landscape and allow for habitats to reform.

4.10 Socioeconomic Impacts

4.10.1 No-Action

Potential socioeconomic impacts from the No-Action alternative will result in continued contamination of the surface soils and potentially subsurface soils. The loss of land use will continue to impact small or larger communities by lack of revenue due to tourism that could burgeon from the renewed use of the land. The lack of revenue would also eliminate any addition tax receipts for local communities.

4.10.2 Excavation and Disposal

Due to the large numbers of trucks, small communities may experience large increases in commercial activity to service the truck drivers. This commercial activity would be related to fuel, food, hardware, and hotel use. These impacts will be temporary since project completion would eliminate the increased commercial activity. However, communities located near clusters of abandoned uranium mines may experience long commercial activity and the need for temporary housing. Longer periods of commercial activity would increase tax receipts for communities and counties.

4.10.3 Waste Rock Regrading

Because the number of trucks required to implement this alternative are significantly less than excavation and disposal, the short-term increases in commercial activity would be less than excavation and disposal. Commercial activity would likely include fuel, food, hardware, and hotel use. Similar to excavation and disposal, communities located near clusters of abandoned uranium mines may experience longer commercial activity and the need for temporary housing. Longer periods of commercial activity would increase tax receipts for communities and counties.

4.10.4 Proposed Action-HPSA

Short-term commercial activity may be larger than waste rock regrading. Although the truck traffic would be less, HPSA would likely last longer, resulting in more commercial activity for fuel, food, hardware, and hotel use. Similar to excavation and disposal and waste rock regrading, communities located near clusters of abandoned uranium mines may experience longer commercial activity and the need for temporary housing. Furthermore, satellite Disa locations may be opened to service clusters of abandoned uranium mines to decrease travel times and project lead times. Consequently, mine clusters and satellite operations will substantially increase commercial activity and tax receipts for communities and counties.

4.11 Environmental Justice Considerations

4.11.1 No-Action Alternative

For the No-Action alternative, contaminated waste rock remains at the abandoned uranium mine sites. Therefore, any contamination and radiological dose issues will remain. Communities will receive no benefit from remediation of these sites including restoration of land use and potential tax revenues.

4.11.2 All Other Alternatives

Disa has no choice regarding the locations of the abandoned uranium mines. As presented in Section 3.11, minority communities will be located at various proximities to Disa project sites. Excavation and disposal, waste rock regrading, and the Proposed Action will all restore mine sites to a safer condition. However, the Proposed Action provides the least disruptive and the best long-term commercial viability alternative, which will improve the economic conditions of minority communities.

4.12 Public and Occupational Health Impacts

4.12.1 No-Action Alternative

Public and Occupational Health Impacts are considered based on physical safety and radiological doses. No occupational health impacts exist for the No-Action alternative, since no work will be performed onsite. Radiological doses as determined by a dose assessment (Appendix B), indicate that radiological doses would be 10.3 mrem/yr, which is below the unrestricted release limit of 25 mrem/yr (10 CFR 20.1402).

4.12.2 Excavation and Disposal

Excavation and disposal would pose occupational health impacts due to heavy equipment use onsite and operating heavy trucks. Heavy earth moving equipment use typically poses risks of injury due to direct contact between equipment and personnel, direct collisions between pieces of equipment, and direct contact between personnel and loads. Section 4.2 discusses risks from transportation. Radiological doses would be similar to doses that exist onsite; based on the dose assessment in Appendix B, radiological doses would be 10.3 mrem/year. Public health issues would be a minimal radiological dose due to natural background.

4.12.3 Waste Rock Regrading

Waste rock regrading would pose occupational health impacts due to heavy equipment use onsite and operating heavy trucks. The degree of these impacts would be less than those for excavation and disposal, and the types of occupational impacts are the same as excavation and disposal. Section 4.2 discusses risks from transportation. Occupational radiological doses would be similar to doses that exist onsite; based on the dose assessment in Appendix B, radiological doses would be 10.3 mrem/year. Public health issues would be a minimal radiological dose due to natural background.

4.12.4 Proposed – HPSA

The Proposed Action would pose significantly less occupational health impacts than excavation and disposal and waste rock regrading from heavy equipment use onsite and operating heavy trucks. Only one piece of excavating equipment would be needed at the site, and the number of trucks required for the HPSA operation is significantly less than excavation and disposal and waste rock regrading. Radiological doses would be similar to doses that exist onsite. Based on the dose assessment in Appendix B, radiological doses would be 10.3 mrem/year. Conservative modeling of the clean coarse fraction indicates that public doses would be 8.8 mrem/yr, which is well below doses due to the waste rock and the unrestricted release dose limit. Public health issues would be a minimal radiological dose, as stated above from the clean coarse fraction, if these materials were not regraded.

4.13 Waste Management Impacts

Potential waste management impacts for each of the alternatives discussed above are as follows:

4.13.1 No-Action Alternative

The No-Action alternative will not require any waste management.

4.13.2 Excavation and Disposal

Assuming the average site contains 8,500 tons (a very conservative estimate) of waste rock or contaminated materials, extrapolating that mass over 15,000 sites results in a total mass of 127,500,000 tons. Assuming a density of 1.275 tons per cubic yard, the total volume of this material is 100,000,000 cubic yards of material. This is the equivalent to a 688-acre landfill at depth of 30 yards. This volume of material would likely overwhelm disposal facilities and uranium recovery facilities in the Western United States; therefore, new facilities would be required.

4.13.3 Waste Rock Regrading

Waste rock regrading would leave contaminated material to remain onsite. Therefore, offsite waste management would not be required. However, on-site waste treatment may not be a permanent solution as erosion could expose the contamination over time resulting in hazardous conditions requiring additional future remediation efforts.

4.13.4 Proposed Project – HPSA

Waste management impacts occur depending primarily on the requirement for managing the isolated mineral fraction removed from the mine site. If the isolated mineral fraction is used as alternate feed at a licensed facility, then no radioactive wastes are generated. If the isolated mineral fraction containing the radioactive contamination removed from the site is transported to a low-level waste disposal facility, then this material will occupy space in a disposal cell. However, when compared to excavation and disposal of mine site contaminated material, the volume of the isolated mineral fraction will be significantly less, approximately less than 15%, and is not expected to overwhelm any disposal facilities. Compared to the calculation above of disposal of contaminated material without HPSA treatment from all 15,000 contaminated sites, the volume of the mineral fraction would equal a 68-acre landfill at a depth of 30 yards. Only water that has been treated will be discharged or, as a worst-case scenario, sent to a licensed facility for treatment

SECTION 5.0 MITIGATION MEASURES

5.1 No-Action Alternative

No mitigation measures would be required for the No-Action Alternative.

5.2 Excavation and Disposal

No significant or permanent impacts occur with excavation and disposal that require mitigation. Excavation and disposal will result in an irretrievable loss of surface water due to irrigation during revegetation. Standard erosion and sediment controls will be required to prevent sediment releases off the mine site.

5.3 Waste Rock Regrading

Waste rock will be permanently graded and placed onsite which is a permanent soil impact. Mitigation will consist of placing topsoil and seed on top of the graded waste. Waste rock regrading will also result in an irretrievable loss of surface water due to irrigation during revegetation. Standard erosion and sediment controls may be required to prevent sediment releases off the mine site.

5.4 Proposed Action – HPSA

The Proposed Action will not result in any significant or permanent impacts; however, the Proposed Action – HPSA will result in an irretrievable loss of surface water due to the need of makeup water during HPSA operations. A radiation protection program has been developed to protect workers from occupational radiation exposures. In some cases, standard erosion and sediment controls may be required to prevent sediment releases offsite. Hearing protection for workers will be standard PPE at any Disa worksite.

SECTION 6.0 COST BENEFIT ANALYSIS

Disa prepared this cost benefit analysis by comparing environmental benefits and impacts and relative costs of the alternative. This analysis is relative using the following numerical scale:

- 1 – Does not accomplish the benefit
- 2 – Somewhat accomplishes the benefit
- 3 – Accomplishes the benefit

Specific benefits and other criteria are those listed in Section 6.7 of NUREG-1748 and from the National Contingency Plan at 40 CFR 300, Subpart E . Table 6-1 presents the results of this analysis.

Cost calculations assumed the following:

1. The amount of waste rock to be addressed is 8,500 tons.
2. The capacity of the trucks is 20 tons.
3. Distances that trucks must travel are specified in Section 4.2
4. Transport cost is $130/truck load
5. Disposal for excavation and disposal will occur at a low-level radioactive waste landfill at $100/cubic foot, which will represent the cost if new disposal cells must be constructed.
6. Costs for excavation, rental equipment, and other labor not included.

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Table 6-1: Cost Benefit Analysis Results

Benefit/Cost	No-Action	No-Action Comments	Excavation and Disposal	Excavation and Disposal Comments	Waste Rock Regrading	Waste Rock Regrading Comments	Proposed Action - HPSA	Proposed Action – HPSA Comments
Cost (one site)	$0.00		$18,613,250	Costs are for trucking only. Regional disposal facilities would be required because volume would overwhelm current low-level rad waste facilities. Assumes $100/cu.ft. for disposal	>1% of Excavation and Disposal	Low cost due to no offsite disposal required	4% of Excavation and Disposal	Low cost due to small number of trucks and very small volume for offsite disposal
Cost Rating	3		1		3		3	
Tax revenues received by local, State, and Federal governments;	1	No increase in tax revenues	3	Temporary increase in tax revenues, longer-term increases where sites are clustered	2	Smaller temporary and longer-term tax increase	3	Temporary increase in tax revenues, longer-term increases where sites are clustered due to satellite Disa Offices
Increased public health and safety;	1		2	Remediated sites improve public health and safety, but large amount of truck traffic increases accident risk	2	Remediated sites improve public health and safety, contaminated materials remain onsite	3	Remediated sites improve public health and safety
Enhancement of recreational values;	1		3		2	Contaminated materials remain onsite,	3	

Benefit/Cost	No-Action	No-Action Comments	Excavation and Disposal	Excavation and Disposal Comments	Waste Rock Regrading	Waste Rock Regrading Comments	Proposed Action - HPSA	Proposed Action – HPSA Comments
						decreases recreational value enhancements		
Incremental increases in regional productivity;	1	Land remains unusable	3	Beneficial use of land will improve the local economy	3	Beneficial use of land will improve the local economy	3	Beneficial use of land will improve the local economy
Effectiveness	1		3		2	Decreased effectiveness due to contaminated materials remaining onsite	3	
Implementability across the entire program	3		1	Not feasible to remediate all sites by this method due to cost, would need new regional disposal cells, because disposal capacity would be insufficient	3	Operations are simple, no transportation of waste or disposal facilities are required	2	Operations are more complex than other options, transportation of isolated mineral fraction for alternate feed or disposal is required
Community acceptance	1		2	Community-specific. Some may prefer this alternative while others would be against large truck traffic required to implement	1	Waste would remain onsite, which many communities would find objectionable.	3	EPA and certain Native American tribes would be accepting of this alternative. Non-governmental organizations have

Benefit/Cost	No-Action	No-Action Comments	Excavation and Disposal	Excavation and Disposal Comments	Waste Rock Regrading	Waste Rock Regrading Comments	Proposed Action - HPSA	Proposed Action – HPSA Comments
								issued letters of support for this technology.
State acceptance	2	States are allowing waste piles to remain	3	States would accept removal of waste	3	States currently accept various forms of grading and stabilization as reclamation method	3	States would accept complete remediation of waste rock and contaminated soils
Waste minimization	1		1		1		3	Waste is minimized through isolation of constituents of concern; meets RCRA goals/requirements
Total	15		22		22		29	

A review of Table 6-1 indicates that the Proposed Action – HPSA is the most cost-effective means of remediating sites with the most benefits. The Proposed Action – HPSA receives the highest rank for most of the criteria listed in Table 6-1 because it is the most beneficial to the environment, recreational land uses, and communities. Unlike all the other alternatives, the Proposed Action – HPSA actually contributes to waste minimization instead of disposing of the entire waste pile onsite or at a disposal facility.

SECTION 7.0 SUMMARY OF ENVIRONMENTAL CONSEQUENCES

Based on information provided in this report, Disa provides the following summary of environmental consequences (Table 7-1)

Table 7-1: Environmental Consequences

Consequence Type	Applicability to Proposed Action
Unavoidable adverse environmental impacts;	None
Irreversible and irretrievable commitments of resources used in project construction, operation, and decommissioning	An irretrievable loss of surface water occurs because HPSA operations requires makeup water. Approximately 20% of the water is lost due to moisture that remains in the isolated mineral fraction and the clean coarse fraction.
Short-term impacts	• Slight increase in commercial traffic • Slight soil disturbance as waste rock is treated • Small quantities of air emissions from trucks • Occupational noise levels, no impacts to communities • Increase in commercial activity for food, fuel, hardware, and hotels • Occupational health during construction and radiological exposures
Long-term impacts	• Higher levels of potential commercial activity where clusters of abandoned uranium mines occur near communities • Contaminated sites that have remained on the surface for decades are finally remediated
Short-term uses of the environment and the maintenance and enhancement of long-term productivity.	None

SECTION 8.0 REFERENCES

1. Bing.com, 2022. Image of Riley Pass Mine, South Dakota. bing.com/maps. Accessed June 2022.

2. Caterpillar, 2022. Understanding Tractor-Trailer Performance. Caterpillar. 2006.

3. Climatestotravel.com, 2022. Climates to Travel, World Climate Guide. https://www.climatestotravel.com/climate/united-states#mountains. Accessed June 2022.

4. cmpip, 2022. High-Pressure Slurry Ablation (HPSA): An Emerging Liberation Technology. Canadian Mill Processing Innovation. https://cmpip.ca/post/high-pressure-slurry-ablation. Accessed June 2022.

5. Disa, 2022a. Results of Bench Scale Testing of October Reclamation Pile Waste Rock. Disa Technologies, Inc. 2022.

6. DOE, 2013. Legacy Management Work Progresses on Defense-Related Uranium Mines Report to Congress. https://www.energy.gov/lm/articles/legacy-management-work-progresses-defense-related-uranium-mines-report-congress. October 23, 2016.

7. EPA, 2006. Uranium Location Database Compilation. Office of Radiation & Indoor Air, Radiation Protection Division (6608J). EPA 402-R-5-009. August 2006.

8. FMCSA, 2021. Large Truck and Bus Crash Facts, 2019. Federal Motor Carrier Safety Administration, Analysis Division. FMCSA-RRA-20-055. October 2021.

9. NPS, 2022. Physiographic Provinces. https://www.nps.gov/subjects/geology/physiographic-provinces.htm. Accessed June 2022.

10. National Geographic, 2022. Watersheds of the United States. National Geographic Society. https://www.nationalgeographic.org/activity/mapping-us-watersheds. Accessed June 2022.

11. NRC, 2003. NUREG-1748, Environmental Review Guidance for Licensing Actions Associated with NMSS Programs. U.S. Nuclear Regulatory Commission. August 2003.

12. NSF, undated(a). The Teacher-Friendly Guide to the Earth Science of the Western US, Basin and Range, Columbia Plateau, Northern Rocky Mountains, Cascade-Sierra, Pacific Border. http://geology.teacherfriendlyguide.org/index.php/soils-w. Accessed June 2022.

13. NSF, undated(b). The Teacher-Friendly Guide to the Earth Science of the South Central US, Great Plains. http://geology.teacherfriendlyguide.org/index.php/soils-sc/soils-region4-sc. Accessed June 2022.

14. NSF, undated(c). The Teacher-Friendly Guide to the Earth Science of the Southwestern US, Colorado Plateau. http://geology.teacherfriendlyguide.org/index.php/big-ideas/80-southwestern/soils-sw/621-soils-region1-sw. Accessed June 2022.

15. US Census Bureau, 2022. http://data.census.gov/cedsci. Accessed June 2022.

16. USDA, 2017. Summary Table 1, Major Uses of Land, by Region, State, and United States, 2012. https://www.ers.usda.gov/data-products/major-land-uses/major-land-uses/#Summary%20tables. Last Updated 2017.

APPENDIX A – ENDANGERED SPECIES LIST

Endangered Fauna Species By State

Endangered	Ambersnail, Kanab Entire (Oxyloma haydeni kanabensis)	Arizona
Endangered	Bat, lesser long-nosed Entire (Leptonycteris curasoae yerbabuenae)	Arizona
Endangered	Bobwhite, masked (quail) Entire (Colinus virginianus ridgwayi)	Arizona
Endangered	Chub, bonytail Entire (Gila elegans)	Arizona
Endangered	Chub, Gila Entire (Gila intermedia)	Arizona
Endangered	Chub, humpback Entire (Gila cypha)	Arizona
Endangered	Chub, Virgin River Entire (Gila seminuda (=robusta))	Arizona
Endangered	Chub, Yaqui Entire (Gila purpurea)	Arizona
Endangered	Condor, California Entire, except where listed as an experimental population (Gymnogyps californianus)	Arizona
Endangered	Ferret, black-footed entire population, except where EXPN (Mustela nigripes)	Arizona
Endangered	Flycatcher, southwestern willow Entire (Empidonax traillii extimus)	Arizona
Endangered	Jaguar Wherever found (Panthera onca)	Arizona
Endangered	Minnow, loach Entire (Tiaroga cobitis)	Arizona
Endangered	Mouse, New Mexico meadow jumping (Zapus hudsonius luteus)	Arizona
Endangered	Ocelot wherever found (Leopardus (=Felis) pardalis)	Arizona
Endangered	Pikeminnow (=squawfish), Colorado Entire, except EXPN (Ptychocheilus lucius)	Arizona
Endangered	Pronghorn, Sonoran Entire (Antilocapra americana sonoriensis)	Arizona
Endangered	Pupfish, desert Entire (Cyprinodon macularius)	Arizona
Endangered	Rail, Yuma clapper Entire (Rallus longirostris yumanensis)	Arizona
Endangered	Salamander, Sonora tiger Entire (Ambystoma tigrinum stebbinsi)	Arizona
Endangered	Spikedace Entire (Meda fulgida)	Arizona
Endangered	Springsnail, Three Forks Entire (Pyrgulopsis trivialis)	Arizona
Endangered	Squirrel, Mount Graham red Entire (Tamiasciurus hudsonicus grahamensis)	Arizona
Endangered	Sucker, razorback Entire (Xyrauchen texanus)	Arizona
Endangered	Sucker, Zuni bluehead (Catostomus discobolus yarrowi)	Arizona

Endangered	Tern, California least (Sterna antillarum browni)	Arizona
Endangered	Topminnow, Gila (incl. Yaqui) Entire (Poeciliopsis occidentalis)	Arizona
Endangered	Vole, Hualapai Mexican Entire (Microtus mexicanus hualpaiensis)	Arizona
Endangered	Wolf, Mexican Entire, except where an experimental population (Canis lupus baileyi)	Arizona
Endangered	Woundfin Entire, except EXPN (Plagopterus argentissimus)	Arizona
Threatened	Catfish, Yaqui Entire (Ictalurus pricei)	Arizona
Threatened	Chub, Sonora Entire (Gila ditaenia)	Arizona
Threatened	Cuckoo, yellow-billed Western U.S. DPS (Coccyzus americanus)	Arizona
Threatened	Frog, Chiricahua leopard Entire (Rana chiricahuensis)	Arizona
Threatened	gartersnake, narrow-headed (Thamnophis rufipunctatus)	Arizona
Threatened	gartersnake, northern Mexican (Thamnophis eques megalops)	Arizona
Threatened	Owl, Mexican spotted Entire (Strix occidentalis lucida)	Arizona
Threatened	Rattlesnake, New Mexican ridge-nosed Entire (Crotalus willardi obscurus)	Arizona
Threatened	Shiner, beautiful Entire (Cyprinella formosa)	Arizona
Threatened	Spinedace, Little Colorado Entire (Lepidomeda vittata)	Arizona
Threatened	springsnail, San Bernardino Entire (Pyrgulopsis bernardina)	Arizona
Threatened	Tortoise, desert Entire, except in Sonoran Desert (Gopherus agassizii)	Arizona
Threatened	Trout, Apache Entire (Oncorhynchus apache)	Arizona
Threatened	Trout, Gila Entire (Oncorhynchus gilae)	Arizona
Endangered	Abalone, White North America (West Coast from Point Conception, CA, U.S.A., to Punta Abreojos, Baja California, Mexico) (Haliotis sorenseni)	California
Endangered	Albatross, short-tailed Entire (Phoebastria (=Diomedea) albatrus)	California
Endangered	Beetle, Casey's June Entire (Dinacoma caseyi)	California
Endangered	Beetle, Mount Hermon June Entire (Polyphylla barbata)	California
Endangered	Butterfly, Behren's silverspot Entire (Speyeria zerene behrensii)	California
Endangered	Butterfly, callippe silverspot Entire (Speyeria callippe callippe)	California
Endangered	Butterfly, El Segundo blue Entire (Euphilotes battoides allyni)	California
Endangered	Butterfly, Lange's metalmark Entire (Apodemia mormo langei)	California

Endangered	Butterfly, lotis blue Entire (Lycaeides argyrognomon lotis)	California
Endangered	Butterfly, mission blue Entire (Icaricia icarioides missionensis)	California
Endangered	Butterfly, Myrtle's silverspot Entire (Speyeria zerene myrtleae)	California
Endangered	Butterfly, Palos Verdes blue Entire (Glaucopsyche lygdamus palosverdesensis)	California
Endangered	Butterfly, Quino checkerspot Entire (Euphydryas editha quino (=E. e. wrighti))	California
Endangered	Butterfly, San Bruno elfin Entire (Callophrys mossii bayensis)	California
Endangered	Butterfly, Smith's blue Entire (Euphilotes enoptes smithi)	California
Endangered	Chub, bonytail Entire (Gila elegans)	California
Endangered	Chub, Owens Tui Entire (Gila bicolor ssp. snyderi)	California
Endangered	Condor, California Entire, except where listed as an experimental population (Gymnogyps californianus)	California
Endangered	Crayfish, Shasta Entire (Pacifastacus fortis)	California
Endangered	Fairy shrimp, Conservancy Entire (Branchinecta conservatio)	California
Endangered	Fairy shrimp, longhorn Entire (Branchinecta longiantenna)	California
Endangered	Fairy shrimp, Riverside Entire (Streptocephalus woottoni)	California
Endangered	Fairy shrimp, San Diego (Branchinecta sandiegonensis)	California
Endangered	Flycatcher, southwestern willow Entire (Empidonax traillii extimus)	California
Endangered	Fly, Delhi Sands flower-loving Entire (Rhaphiomidas terminatus abdominalis)	California
Endangered	Fox, San Joaquin kit wherever found (Vulpes macrotis mutica)	California
Endangered	Fox, San Miguel Island wherever found (Urocyon littoralis littoralis)	California
Endangered	Fox, Santa Catalina Island Wherever found (Urocyon littoralis catalinae)	California
Endangered	Fox, Santa Cruz Island wherever found (Urocyon littoralis santacruzae)	California
Endangered	Fox, Santa Rosa Island wherever found (Urocyon littoralis santarosae)	California
Endangered	Frog, mountain yellow-legged Northern California DPS (Rana muscosa)	California
Endangered	Frog, mountain yellow-legged Southern California DPS (Rana muscosa)	California
Endangered	Frog, Sierra Nevada Yellow-legged (Rana sierrae)	California
Endangered	Goby, tidewater Entire (Eucyclogobius newberryi)	California
Endangered	Grasshopper, Zayante band-winged (Trimerotropis infantilis)	California

Endangered	Kangaroo rat, Fresno Entire (Dipodomys nitratoides exilis)	California
Endangered	Kangaroo rat, giant Entire (Dipodomys ingens)	California
Endangered	Kangaroo rat, Morro Bay Entire (Dipodomys heermanni morroensis)	California
Endangered	Kangaroo rat, San Bernardino Merriam's Entire (Dipodomys merriami parvus)	California
Endangered	Kangaroo rat, Stephens' Entire (Dipodomys stephensi (incl. D. cascus))	California
Endangered	Kangaroo rat, Tipton Entire (Dipodomys nitratoides nitratoides)	California
Endangered	Lizard, blunt-nosed leopard Entire (Gambelia silus)	California
Endangered	Mountain beaver, Point Arena Entire (Aplodontia rufa nigra)	California
Endangered	Mouse, Pacific pocket Entire (Perognathus longimembris pacificus)	California
Endangered	Mouse, salt marsh harvest wherever found (Reithrodontomys raviventris)	California
Endangered	Pikeminnow (=squawfish), Colorado Entire, except EXPN (Ptychocheilus lucius)	California
Endangered	Pupfish, desert Entire (Cyprinodon macularius)	California
Endangered	Pupfish, Owens Entire (Cyprinodon radiosus)	California
Endangered	Rabbit, riparian brush Entire (Sylvilagus bachmani riparius)	California
Endangered	Rail, California clapper Entire (Rallus longirostris obsoletus)	California
Endangered	Rail, light-footed clapper Entire (Rallus longirostris levipes)	California
Endangered	Rail, Yuma clapper Entire (Rallus longirostris yumanensis)	California
Endangered	Salamander, California tiger U.S.A. (CA - Santa Barbara County) (Ambystoma californiense)	California
Endangered	Salamander, California tiger U.S.A. (CA - Sonoma County) (Ambystoma californiense)	California
Endangered	Salamander, desert slender Entire (Batrachoseps aridus)	California
Endangered	Salamander, Santa Cruz long-toed Entire (Ambystoma macrodactylum croceum)	California
Endangered	Salmon, coho Central California Coast ESU (Oncorhynchus (=Salmo) kisutch)	California
Endangered	Sea turtle, leatherback Entire (Dermochelys coriacea)	California
Endangered	Sheep, Peninsular bighorn Peninsular CA pop. (Ovis canadensis nelsoni)	California
Endangered	Sheep, Sierra Nevada bighorn Sierra Nevada (Ovis canadensis sierrae)	California

Endangered	Shrew, Buena Vista Lake ornate Entire (Sorex ornatus relictus)	California
Endangered	Shrike, San Clemente loggerhead Entire (Lanius ludovicianus mearnsi)	California
Endangered	Shrimp, California freshwater Entire (Syncaris pacifica)	California
Endangered	Skipper, Carson wandering Entire (Pseudocopaeodes eunus obscurus)	California
Endangered	Skipper, Laguna Mountains Entire (Pyrgus ruralis lagunae)	California
Endangered	Snail, Morro shoulderband (=Banded dune) (Helminthoglypta walkeriana)	California
Endangered	Snake, San Francisco garter Entire (Thamnophis sirtalis tetrataenia)	California
Endangered	Steelhead Southern California DPS (Oncorhynchus (=Salmo) mykiss)	California
Endangered	Stickleback, unarmored threespine Entire (Gasterosteus aculeatus williamsoni)	California
Endangered	Sucker, Lost River Entire (Deltistes luxatus)	California
Endangered	Sucker, razorback Entire (Xyrauchen texanus)	California
Endangered	Sucker, shortnose Entire (Chasmistes brevirostris)	California
Endangered	Tadpole shrimp, vernal pool Entire (Lepidurus packardi)	California
Endangered	Tern, California least (Sterna antillarum browni)	California
Endangered	Tiger beetle, Ohlone (Cicindela ohlone)	California
Endangered	Toad, arroyo (=arroyo southwestern) Entire (Anaxyrus californicus)	California
Endangered	Tui chub, Mohave Entire (Gila bicolor ssp. mohavensis)	California
Endangered	Vireo, least Bell's Entire (Vireo bellii pusillus)	California
Endangered	Vole, Amargosa Entire (Microtus californicus scirpensis)	California
Endangered	Whale, blue Entire (Balaenoptera musculus)	California
Endangered	Whale, finback Entire (Balaenoptera physalus)	California
Endangered	Whale, humpback Entire (Megaptera novaeangliae)	California
Endangered	Whale, Sei Entire (Balaenoptera borealis)	California
Endangered	Whale, sperm Entire (Physeter catodon (=macrocephalus))	California
Endangered	Wolf, gray (Canis lupus)	California
Endangered	Woodrat, riparian	California
Threatened	Beetle, delta green ground Entire (Elaphrus viridis)	California
Threatened	Beetle, valley elderberry longhorn Entire (Desmocerus californicus dimorphus)	California

Threatened	Butterfly, bay checkerspot Entire (Euphydryas editha bayensis)	California
Threatened	Butterfly, Oregon silverspot Entire (Speyeria zerene hippolyta)	California
Threatened	Cuckoo, yellow-billed Western U.S. DPS (Coccyzus americanus)	California
Threatened	Fairy shrimp, vernal pool Entire (Branchinecta lynchi)	California
Threatened	Frog, California red-legged Entire (Rana draytonii)	California
Threatened	Frog, Oregon spotted (Rana pretiosa)	California
Threatened	Gnatcatcher, coastal California Entire (Polioptila californica californica)	California
Threatened	Lizard, Coachella Valley fringe-toed Entire (Uma inornata)	California
Threatened	Lynx, Canada Contiguous U.S. DPS (Lynx canadensis)	California
Threatened	Moth, Kern primrose sphinx Entire (Euproserpinus euterpe)	California
Threatened	Murrelet, marbled CA, OR, WA (Brachyramphus marmoratus)	California
Threatened	Otter, southern sea (Enhydra lutris nereis)	California
Threatened	Owl, northern spotted Entire (Strix occidentalis caurina)	California
Threatened	Plover, western snowy Pacific coastal pop. (Charadrius alexandrinus nivosus)	California
Threatened	Salamander, California tiger U.S.A. (Central CA DPS) (Ambystoma californiense)	California
Threatened	Salmon, Chinook California Coastal ESU (Oncorhynchus (=Salmo) tshawytscha)	California
Threatened	Salmon, coho Southern Oregon - Northern California Coast ESU (Oncorhynchus (=Salmo) kisutch)	California
Threatened	Seal, Guadalupe fur Entire (Arctocephalus townsendi)	California
Threatened	Sea turtle, olive ridley Except where endangered (Lepidochelys olivacea)	California
Threatened	Smelt, delta Entire (Hypomesus transpacificus)	California
Threatened	Snake, giant garter Entire (Thamnophis gigas)	California
Threatened	Sparrow, San Clemente sage Entire (Amphispiza belli clementeae)	California
Threatened	Steelhead Central California Coast DPS (Oncorhynchus (=Salmo) mykiss)	California
Threatened	Steelhead Northern California DPS (Oncorhynchus (=Salmo) mykiss)	California
Threatened	sturgeon, green Southern DPS (Acipenser medirostris)	California
Threatened	Sucker, Santa Ana 3 CA river basins (Catostomus santaanae)	California
Threatened	Sucker, Warner Entire (Catostomus warnerensis)	California

Threatened	toad, Yosemite (Anaxyrus canorus)	California
Threatened	Tortoise, desert Entire, except in Sonoran Desert (Gopherus agassizii)	California
Threatened	Towhee, Inyo California (Pipilo crissalis eremophilus)	California
Threatened	Trout, Lahontan cutthroat Entire (Oncorhynchus clarkii henshawi)	California
Threatened	Trout, Little Kern golden Entire (Oncorhynchus aguabonita whitei)	California
Threatened	Trout, Paiute cutthroat Entire (Oncorhynchus clarkii seleniris)	California
Threatened	Whipsnake (=striped racer), Alameda Entire (Masticophis lateralis euryxanthus)	California
Endangered	Butterfly, Uncompahgre fritillary Entire (Boloria acrocnema)	Colorado
Endangered	Chub, bonytail Entire (Gila elegans)	Colorado
Endangered	Chub, humpback Entire (Gila cypha)	Colorado
Endangered	Flycatcher, southwestern willow Entire (Empidonax traillii extimus)	Colorado
Endangered	Mouse, New Mexico meadow jumping (Zapus hudsonius luteus)	Colorado
Endangered	Pikeminnow (=squawfish), Colorado Entire, except EXPN (Ptychocheilus lucius)	Colorado
Endangered	Sucker, razorback Entire (Xyrauchen texanus)	Colorado
Endangered	Tern, least interior pop. (Sterna antillarum)	Colorado
Threatened	Cuckoo, yellow-billed Western U.S. DPS (Coccyzus americanus)	Colorado
Threatened	Lynx, Canada Contiguous U.S. DPS (Lynx canadensis)	Colorado
Threatened	Mouse, Preble's meadow jumping wherever found (Zapus hudsonius preblei)	Colorado
Threatened	Owl, Mexican spotted Entire (Strix occidentalis lucida)	Colorado
Threatened	Plover, piping except Great Lakes watershed (Charadrius melodus)	Colorado
Threatened	Prairie-chicken, lesser (Tympanuchus pallidicinctus)	Colorado
Threatened	sage-grouse, Gunnison entire (Centrocercus minimus)	Colorado
Threatened	Skipper, Pawnee montane Entire (Hesperia leonardus montana)	Colorado
Threatened	trout, Greenback Cutthroat Entire (Oncorhynchus clarki stomias)	Colorado
Endangered	Caribou, woodland Selkirk Mountain population (Rangifer tarandus caribou)	Idaho
Endangered	Limpet, Banbury Springs Entire (Lanx sp.)	Idaho

Endangered	Snail, Snake River physa Entire (Physa natricina)	Idaho
Endangered	Springsnail, Bruneau Hot Entire (Pyrgulopsis bruneauensis)	Idaho
Endangered	Sturgeon, white U.S.A. (ID, MT), Canada (B.C.), Kootenai R. system (Acipenser transmontanus)	Idaho
Threatened	Bear, grizzly lower 48 States, except where listed as an experimental population (Ursus arctos horribilis)	Idaho
Threatened	Cuckoo, yellow-billed Western U.S. DPS (Coccyzus americanus)	Idaho
Threatened	Lynx, Canada Contiguous U.S. DPS (Lynx canadensis)	Idaho
Threatened	Snail, Bliss Rapids Entire (Taylorconcha serpenticola)	Idaho
Threatened	Squirrel, Northern Idaho Ground Entire (Urocitellus brunneus)	Idaho
Threatened	Trout, bull U.S.A., conterminous, lower 48 states (Salvelinus confluentus)	Idaho
Endangered	Crane, whooping except where EXPN (Grus americana)	Montana
Endangered	Ferret, black-footed entire population, except where EXPN (Mustela nigripes)	Montana
Endangered	Sturgeon, pallid Entire (Scaphirhynchus albus)	Montana
Endangered	Sturgeon, white U.S.A. (ID, MT), Canada (B.C.), Kootenai R. system (Acipenser transmontanus)	Montana
Endangered	Tern, least interior pop. (Sterna antillarum)	Montana
Threatened	Bat, Northern long-eared (Myotis septentrionalis)	Montana
Threatened	Bear, grizzly lower 48 States, except where listed as an experimental population (Ursus arctos horribilis)	Montana
Threatened	Cuckoo, yellow-billed Western U.S. DPS (Coccyzus americanus)	Montana
Threatened	Knot, red (Calidris canutus rufa)	Montana
Threatened	Lynx, Canada Contiguous U.S. DPS (Lynx canadensis)	Montana
Threatened	Plover, piping except Great Lakes watershed (Charadrius melodus)	Montana
Threatened	Trout, bull U.S.A., conterminous, lower 48 states (Salvelinus confluentus)	Montana
Endangered	Beetle, American burying Entire (Nicrophorus americanus)	Nebraska
Endangered	Crane, whooping except where EXPN (Grus americana)	Nebraska
Endangered	Mussel, scaleshell (Leptodea leptodon)	Nebraska
Endangered	Shiner, Topeka Entire (Notropis topeka (=tristis))	Nebraska
Endangered	Sturgeon, pallid Entire (Scaphirhynchus albus)	Nebraska
Endangered	Tern, least interior pop. (Sterna antillarum)	Nebraska

Endangered	Tiger beetle, Salt Creek Entire (Cicindela nevadica lincolniana)	Nebraska
Threatened	Bat, Northern long-eared (Myotis septentrionalis)	Nebraska
Threatened	Knot, red (Calidris canutus rufa)	Nebraska
Threatened	Plover, piping except Great Lakes watershed (Charadrius melodus)	Nebraska
Endangered	Butterfly, Mount Charleston blue (Icaricia (Plebejus) shasta charlestonensis)	Nevada
Endangered	Chub, bonytail Entire (Gila elegans)	Nevada
Endangered	Chub, Pahranagat roundtail Entire (Gila robusta jordani)	Nevada
Endangered	Chub, Virgin River Entire (Gila seminuda (=robusta))	Nevada
Endangered	Cui-ui Entire (Chasmistes cujus)	Nevada
Endangered	Dace, Ash Meadows speckled Entire (Rhinichthys osculus nevadensis)	Nevada
Endangered	Dace, Clover Valley speckled Entire (Rhinichthys osculus oligoporus)	Nevada
Endangered	Dace, Independence Valley speckled Entire (Rhinichthys osculus lethoporus)	Nevada
Endangered	Dace, Moapa Entire (Moapa coriacea)	Nevada
Endangered	Flycatcher, southwestern willow Entire (Empidonax traillii extimus)	Nevada
Endangered	Poolfish, Pahrump Entire (Empetrichthys latos)	Nevada
Endangered	Pupfish, Ash Meadows Amargosa Entire (Cyprinodon nevadensis mionectes)	Nevada
Endangered	Pupfish, Devils Hole Entire (Cyprinodon diabolis)	Nevada
Endangered	Pupfish, Warm Springs Entire (Cyprinodon nevadensis pectoralis)	Nevada
Endangered	Skipper, Carson wandering Entire (Pseudocopaeodes eunus obscurus)	Nevada
Endangered	Spinedace, White River Entire (Lepidomeda albivallis)	Nevada
Endangered	Springfish, Hiko White River Entire (Crenichthys baileyi grandis)	Nevada
Endangered	Springfish, White River Entire (Crenichthys baileyi baileyi)	Nevada
Endangered	Sucker, razorback Entire (Xyrauchen texanus)	Nevada
Endangered	Woundfin Entire, except EXPN (Plagopterus argentissimus)	Nevada
Threatened	Cuckoo, yellow-billed Western U.S. DPS (Coccyzus americanus)	Nevada
Threatened	Dace, desert Entire (Eremichthys acros)	Nevada
Threatened	Naucorid, Ash Meadows Entire (Ambrysus amargosus)	Nevada

Threatened	Spinedace, Big Spring Entire (Lepidomeda mollispinis pratensis)	Nevada
Threatened	Springfish, Railroad Valley Entire (Crenichthys nevadae)	Nevada
Threatened	Sucker, Warner Entire (Catostomus warnerensis)	Nevada
Threatened	Trout, bull U.S.A., conterminous, lower 48 states (Salvelinus confluentus)	Nevada
Threatened	Trout, Lahontan cutthroat Entire (Oncorhynchus clarkii henshawi)	Nevada
Endangered	Amphipod, Noel's (Gammarus desperatus)	New Mexico
Endangered	Bat, lesser long-nosed Entire (Leptonycteris curasoae yerbabuenae)	New Mexico
Endangered	Bat, Mexican long-nosed Entire (Leptonycteris nivalis)	New Mexico
Endangered	Chub, Gila Entire (Gila intermedia)	New Mexico
Endangered	Ferret, black-footed entire population, except where EXPN (Mustela nigripes)	New Mexico
Endangered	Flycatcher, southwestern willow Entire (Empidonax traillii extimus)	New Mexico
Endangered	Gambusia, Pecos Entire (Gambusia nobilis)	New Mexico
Endangered	Isopod, Socorro Entire (Thermosphaeroma thermophilus)	New Mexico
Endangered	Jaguar Wherever found (Panthera onca)	New Mexico
Endangered	Minnow, loach Entire (Tiaroga cobitis)	New Mexico
Endangered	Minnow, Rio Grande Silvery Entire, except where listed as an experimental population (Hybognathus amarus)	New Mexico
Endangered	Mouse, New Mexico meadow jumping (Zapus hudsonius luteus)	New Mexico
Endangered	Pikeminnow (=squawfish), Colorado Entire, except EXPN (Ptychocheilus lucius)	New Mexico
Endangered	Salamander, Jemez Mountains (Plethodon neomexicanus)	New Mexico
Endangered	Snail, Pecos assiminea (Assiminea pecos)	New Mexico
Endangered	Spikedace Entire (Meda fulgida)	New Mexico
Endangered	Springsnail, Alamosa Entire (Tryonia alamosae)	New Mexico
Endangered	Springsnail, Chupadera (Pyrgulopsis chupaderae)	New Mexico
Endangered	Springsnail, Koster's (Juturnia kosteri)	New Mexico
Endangered	Springsnail, Roswell (Pyrgulopsis roswellensis)	New Mexico
Endangered	Springsnail, Socorro Entire (Pyrgulopsis neomexicana)	New Mexico
Endangered	Sucker, razorback Entire (Xyrauchen texanus)	New Mexico
Endangered	Sucker, Zuni bluehead (Catostomus discobolus yarrowi)	New Mexico
Endangered	Tern, least interior pop. (Sterna antillarum)	New Mexico

Endangered	Topminnow, Gila (incl. Yaqui) Entire (Poeciliopsis occidentalis)	New Mexico
Endangered	Wolf, Mexican Entire, except where an experimental population (Canis lupus baileyi)	New Mexico
Threatened	Chub, Chihuahua Entire (Gila nigrescens)	New Mexico
Threatened	Cuckoo, yellow-billed Western U.S. DPS (Coccyzus americanus)	New Mexico
Threatened	Frog, Chiricahua leopard Entire (Rana chiricahuensis)	New Mexico
Threatened	gartersnake, narrow-headed (Thamnophis rufipunctatus)	New Mexico
Threatened	gartersnake, northern Mexican (Thamnophis eques megalops)	New Mexico
Threatened	Lynx, Canada Contiguous U.S. DPS (Lynx canadensis)	New Mexico
Threatened	Owl, Mexican spotted Entire (Strix occidentalis lucida)	New Mexico
Threatened	Plover, piping except Great Lakes watershed (Charadrius melodus)	New Mexico
Threatened	Prairie-chicken, lesser (Tympanuchus pallidicinctus)	New Mexico
Threatened	Rattlesnake, New Mexican ridge-nosed Entire (Crotalus willardi obscurus)	New Mexico
Threatened	Shiner, Arkansas River Arkansas R. Basin (Notropis girardi)	New Mexico
Threatened	Shiner, beautiful Entire (Cyprinella formosa)	New Mexico
Threatened	Shiner, Pecos bluntnose Entire (Notropis simus pecosensis)	New Mexico
Threatened	Trout, Gila Entire (Oncorhynchus gilae)	New Mexico
Endangered	Crane, whooping except where EXPN (Grus americana)	North Dakota
Endangered	skipperling, Poweshiek Entire (Oarisma poweshiek)	North Dakota
Endangered	Sturgeon, pallid Entire (Scaphirhynchus albus)	North Dakota
Endangered	Tern, least interior pop. (Sterna antillarum)	North Dakota
Threatened	Bat, Northern long-eared (Myotis septentrionalis)	North Dakota
Threatened	Knot, red (Calidris canutus rufa)	North Dakota
Threatened	Plover, piping except Great Lakes watershed (Charadrius melodus)	North Dakota
Threatened	Skipper, Dakota (Hesperia dacotae)	North Dakota
Endangered	Albatross, short-tailed Entire (Phoebastria (=Diomedea) albatrus)	Oregon
Endangered	Butterfly, Fender's blue (Icaricia icarioides fenderi)	Oregon
Endangered	Checkerspot, Taylor's (=whulge) (Euphydryas editha taylori)	Oregon
Endangered	Chub, Borax Lake Entire (Gila boraxobius)	Oregon
Endangered	Deer, Columbian white-tailed Columbia River DPS (Odocoileus virginianus leucurus)	Oregon

Endangered	Salmon, sockeye Snake River ESU (Oncorhynchus (=Salmo) nerka)	Oregon
Endangered	Sea turtle, leatherback Entire (Dermochelys coriacea)	Oregon
Endangered	Sea turtle, loggerhead North Pacific Ocean DPS (Caretta caretta)	Oregon
Endangered	Sucker, Lost River Entire (Deltistes luxatus)	Oregon
Endangered	Sucker, shortnose Entire (Chasmistes brevirostris)	Oregon
Endangered	Wolf, gray (Canis lupus)	Oregon
Threatened	Butterfly, Oregon silverspot Entire (Speyeria zerene hippolyta)	Oregon
Threatened	Chub, Hutton tui Entire (Gila bicolor ssp.)	Oregon
Threatened	Cuckoo, yellow-billed Western U.S. DPS (Coccyzus americanus)	Oregon
Threatened	Dace, Foskett speckled Entire (Rhinichthys osculus ssp.)	Oregon
Threatened	Fairy shrimp, vernal pool Entire (Branchinecta lynchi)	Oregon
Threatened	Frog, Oregon spotted (Rana pretiosa)	Oregon
Threatened	Horned lark, streaked (Eremophila alpestris strigata)	Oregon
Threatened	Lynx, Canada Contiguous U.S. DPS (Lynx canadensis)	Oregon
Threatened	Murrelet, marbled CA, OR, WA (Brachyramphus marmoratus)	Oregon
Threatened	Owl, northern spotted Entire (Strix occidentalis caurina)	Oregon
Threatened	Plover, western snowy Pacific coastal pop. (Charadrius alexandrinus nivosus)	Oregon
Threatened	Salmon, Chinook Lower Columbia River ESU (Oncorhynchus (=Salmo) tshawytscha)	Oregon
Threatened	Salmon, Chinook Snake River fall-run ESU (Oncorhynchus (=Salmo) tshawytscha)	Oregon
Threatened	Salmon, Chinook Snake River spring/summer-run ESU (Oncorhynchus (=Salmo) tshawytscha)	Oregon
Threatened	Salmon, Chinook Upper Willamette River ESU (Oncorhynchus (=Salmo) tshawytscha)	Oregon
Threatened	Salmon, chum Columbia River ESU (Oncorhynchus keta)	Oregon
Threatened	Salmon, coho Oregon Coast ESU (Oncorhynchus (=Salmo) kisutch)	Oregon
Threatened	Sea turtle, olive ridley Except where endangered (Lepidochelys olivacea)	Oregon
Threatened	Steelhead Lower Columbia River DPS (Oncorhynchus (=Salmo) mykiss)	Oregon
Threatened	Steelhead Middle Columbia River DPS (Oncorhynchus (=Salmo) mykiss)	Oregon

Threatened	Steelhead Snake River Basin DPS (Oncorhynchus (=Salmo) mykiss)	Oregon
Threatened	Steelhead Upper Willamette River DPS (Oncorhynchus (=Salmo) mykiss)	Oregon
Threatened	Sucker, Warner Entire (Catostomus warnerensis)	Oregon
Threatened	Trout, bull U.S.A., conterminous, lower 48 states (Salvelinus confluentus)	Oregon
Threatened	Trout, Lahontan cutthroat Entire (Oncorhynchus clarkii henshawi)	Oregon
Endangered	Beetle, American burying Entire (Nicrophorus americanus)	South Dakota
Endangered	Crane, whooping except where EXPN (Grus americana)	South Dakota
Endangered	Ferret, black-footed entire population, except where EXPN (Mustela nigripes)	South Dakota
Endangered	Higgins eye (pearlymussel) Entire (Lampsilis higginsii)	South Dakota
Endangered	Mussel, scaleshell (Leptodea leptodon)	South Dakota
Endangered	Shiner, Topeka Entire (Notropis topeka (=tristis))	South Dakota
Endangered	skipperling, Poweshiek Entire (Oarisma poweshiek)	South Dakota
Endangered	Sturgeon, pallid Entire (Scaphirhynchus albus)	South Dakota
Endangered	Tern, least interior pop. (Sterna antillarum)	South Dakota
Threatened	Bat, Northern long-eared (Myotis septentrionalis)	South Dakota
Threatened	Knot, red (Calidris canutus rufa)	South Dakota
Threatened	Plover, piping except Great Lakes watershed (Charadrius melodus)	South Dakota
Threatened	Skipper, Dakota (Hesperia dacotae)	South Dakota
Endangered	Amphipod, diminutive (Gammarus hyalleloides)	Texas
Endangered	Amphipod, Peck's cave (Stygobromus (=Stygonectes) pecki)	Texas
Endangered	Amphipod, Pecos (Gammarus pecos)	Texas
Endangered	Bat, Mexican long-nosed Entire (Leptonycteris nivalis)	Texas
Endangered	Beetle, American burying Entire (Nicrophorus americanus)	Texas
Endangered	Beetle, Coffin Cave mold Entire (Batrisodes texanus)	Texas
Endangered	Beetle, Comal Springs dryopid (Stygoparnus comalensis)	Texas
Endangered	Beetle, Comal Springs riffle (Heterelmis comalensis)	Texas
Endangered	Beetle, Helotes mold (Batrisodes venyivi)	Texas
Endangered	Beetle, Kretschmarr Cave mold Entire (Texamaurops reddelli)	Texas
Endangered	Beetle, [no common name] (Rhadine exilis)	Texas
Endangered	Beetle, [no common name] (Rhadine infernalis)	Texas
Endangered	Beetle, Tooth Cave ground Entire (Rhadine persephone)	Texas

Endangered	Crane, whooping except where EXPN (Grus americana)	Texas
Endangered	Curlew, Eskimo Entire (Numenius borealis)	Texas
Endangered	Darter, fountain Entire (Etheostoma fonticola)	Texas
Endangered	falcon, northern aplomado Entire, except where listed as an experimental population (Falco femoralis septentrionalis)	Texas
Endangered	Flycatcher, southwestern willow Entire (Empidonax traillii extimus)	Texas
Endangered	Gambusia, Big Bend Entire (Gambusia gaigei)	Texas
Endangered	Gambusia, Clear Creek Entire (Gambusia heterochir)	Texas
Endangered	Gambusia, Pecos Entire (Gambusia nobilis)	Texas
Endangered	Harvestman, Bee Creek Cave Entire (Texella reddelli)	Texas
Endangered	Harvestman, Bone Cave Entire (Texella reyesi)	Texas
Endangered	Harvestman, Cokendolpher Cave (Texella cokendolpheri)	Texas
Endangered	Jaguarundi, Gulf Coast Wherever found (Herpailurus (=Felis) yagouaroundi cacomitli)	Texas
Endangered	Manatee, West Indian Entire (Trichechus manatus)	Texas
Endangered	Meshweaver, Braken Bat Cave (Cicurina venii)	Texas
Endangered	Meshweaver, Government Canyon Bat Cave (Cicurina vespera)	Texas
Endangered	Meshweaver, Madla's Cave (Cicurina madla)	Texas
Endangered	Meshweaver, Robber Baron Cave (Cicurina baronia)	Texas
Endangered	Ocelot wherever found (Leopardus (=Felis) pardalis)	Texas
Endangered	Prairie-chicken, Attwater's greater Entire (Tympanuchus cupido attwateri)	Texas
Endangered	Pseudoscorpion, Tooth Cave Entire (Tartarocreagris texana)	Texas
Endangered	Pupfish, Comanche Springs Entire (Cyprinodon elegans)	Texas
Endangered	Pupfish, Leon Springs Entire (Cyprinodon bovinus)	Texas
Endangered	Salamander, Austin blind (Eurycea waterlooensis)	Texas
Endangered	Salamander, Barton Springs Entire (Eurycea sosorum)	Texas
Endangered	Salamander, Texas blind Entire (Typhlomolge rathbuni)	Texas
Endangered	Sea turtle, hawksbill Entire (Eretmochelys imbricata)	Texas
Endangered	Sea turtle, Kemp's ridley Entire (Lepidochelys kempii)	Texas
Endangered	Sea turtle, leatherback Entire (Dermochelys coriacea)	Texas
Endangered	Shiner, sharpnose (Notropis oxyrhynchus)	Texas
Endangered	Shiner, smalleye (Notropis buccula)	Texas
Endangered	Snail, Pecos assiminea (Assiminea pecos)	Texas

Endangered	Spider, Government Canyon Bat Cave (Neoleptoneta microps)	Texas
Endangered	Spider, Tooth Cave Entire (Neoleptoneta myopica)	Texas
Endangered	Springsnail, Phantom (Pyrgulopsis texana)	Texas
Endangered	Tern, least interior pop. (Sterna antillarum)	Texas
Endangered	Toad, Houston Entire (Bufo houstonensis)	Texas
Endangered	Tryonia, Diamond (Pseudotryonia adamantina)	Texas
Endangered	Tryonia, Gonzales (Tryonia circumstriata (=stocktonensis))	Texas
Endangered	Tryonia, Phantom (Tryonia cheatumi)	Texas
Endangered	Vireo, black-capped Entire (Vireo atricapilla)	Texas
Endangered	Warbler (=wood), golden-cheeked Entire (Dendroica chrysoparia)	Texas
Endangered	Woodpecker, red-cockaded Entire (Picoides borealis)	Texas
Threatened	Cuckoo, yellow-billed Western U.S. DPS (Coccyzus americanus)	Texas
Threatened	Knot, red (Calidris canutus rufa)	Texas
Threatened	Minnow, Devils River Entire (Dionda diaboli)	Texas
Threatened	Owl, Mexican spotted Entire (Strix occidentalis lucida)	Texas
Threatened	Plover, piping except Great Lakes watershed (Charadrius melodus)	Texas
Threatened	Prairie-chicken, lesser (Tympanuchus pallidicinctus)	Texas
Threatened	Salamander, Georgetown (Eurycea naufragia)	Texas
Threatened	Salamander, Jollyville Plateau (Eurycea tonkawae)	Texas
Threatened	Salamander, Salado (Eurycea chisholmensis)	Texas
Threatened	Salamander, San Marcos Entire (Eurycea nana)	Texas
Threatened	Sea turtle, loggerhead Northwest Atlantic Ocean DPS (Caretta caretta)	Texas
Threatened	Shiner, Arkansas River Arkansas R. Basin (Notropis girardi)	Texas
Endangered	Ambersnail, Kanab Entire (Oxyloma haydeni kanabensis)	Utah
Endangered	Chub, bonytail Entire (Gila elegans)	Utah
Endangered	Chub, humpback Entire (Gila cypha)	Utah
Endangered	Chub, Virgin River Entire (Gila seminuda (=robusta))	Utah
Endangered	Flycatcher, southwestern willow Entire (Empidonax traillii extimus)	Utah
Endangered	Pikeminnow (=squawfish), Colorado Entire, except EXPN (Ptychocheilus lucius)	Utah
Endangered	Sucker, June Entire (Chasmistes liorus)	Utah

Endangered	Sucker, razorback Entire (Xyrauchen texanus)	Utah
Endangered	Woundfin Entire, except EXPN (Plagopterus argentissimus)	Utah
Threatened	Cuckoo, yellow-billed Western U.S. DPS (Coccyzus americanus)	Utah
Threatened	Lynx, Canada Contiguous U.S. DPS (Lynx canadensis)	Utah
Threatened	Owl, Mexican spotted Entire (Strix occidentalis lucida)	Utah
Threatened	Prairie dog, Utah Entire (Cynomys parvidens)	Utah
Threatened	sage-grouse, Gunnison entire (Centrocercus minimus)	Utah
Threatened	Tortoise, desert Entire, except in Sonoran Desert (Gopherus agassizii)	Utah
Threatened	trout, Greenback Cutthroat Entire (Oncorhynchus clarki stomias)	Utah
Threatened	Trout, Lahontan cutthroat Entire (Oncorhynchus clarkii henshawi)	Utah
Endangered	Albatross, short-tailed Entire (Phoebastria (=Diomedea) albatrus)	Washington
Endangered	Caribou, woodland Selkirk Mountain population (Rangifer tarandus caribou)	Washington
Endangered	Checkerspot, Taylor's (=whulge) (Euphydryas editha taylori)	Washington
Endangered	Deer, Columbian white-tailed Columbia River DPS (Odocoileus virginianus leucurus)	Washington
Endangered	Rabbit, Columbia Basin Pygmy Columbia Basin DPS (Brachylagus idahoensis)	Washington
Endangered	Salmon, Chinook Upper Columbia spring-run ESU (Oncorhynchus (=Salmo) tshawytscha)	Washington
Endangered	Salmon, sockeye Snake River ESU (Oncorhynchus (=Salmo) nerka)	Washington
Endangered	Sea turtle, leatherback Entire (Dermochelys coriacea)	Washington
Endangered	Whale, humpback Entire (Megaptera novaeangliae)	Washington
Endangered	Whale, killer Southern Resident DPS (Orcinus orca)	Washington
Endangered	Wolf, gray (Canis Lupus)	Washington
Threatened	Bear, grizzly lower 48 States, except where listed as an experimental population (Ursus arctos horribilis)	Washington
Threatened	Butterfly, Oregon silverspot Entire (Speyeria zerene hippolyta)	Washington
Threatened	Cuckoo, yellow-billed Western U.S. DPS (Coccyzus americanus)	Washington
Threatened	Frog, Oregon spotted (Rana pretiosa)	Washington
Threatened	Horned lark, streaked (Eremophila alpestris strigata)	Washington

Threatened	Lynx, Canada Contiguous U.S. DPS (Lynx canadensis)	Washington
Threatened	Murrelet, marbled CA, OR, WA (Brachyramphus marmoratus)	Washington
Threatened	Owl, northern spotted Entire (Strix occidentalis caurina)	Washington
Threatened	Plover, western snowy Pacific coastal pop. (Charadrius alexandrinus nivosus)	Washington
Threatened	Pocket gopher, Olympia (Thomomys mazama pugetensis)	Washington
Threatened	Pocket gopher, Roy Prairie (Thomomys mazama glacialis)	Washington
Threatened	Pocket gopher, Tenino (Thomomys mazama tumuli)	Washington
Threatened	Pocket gopher, Yelm (Thomomys mazama yelmensis)	Washington
Threatened	Salmon, Chinook Lower Columbia River ESU (Oncorhynchus (=Salmo) tshawytscha)	Washington
Threatened	Salmon, Chinook Puget Sound ESU (Oncorhynchus (=Salmo) tshawytscha)	Washington
Threatened	Salmon, Chinook Snake River fall-run ESU (Oncorhynchus (=Salmo) tshawytscha)	Washington
Threatened	Salmon, Chinook Snake River spring/summer-run ESU (Oncorhynchus (=Salmo) tshawytscha)	Washington
Threatened	Salmon, chum Columbia River ESU (Oncorhynchus keta)	Washington
Threatened	Salmon, chum Hood Canal summer-run ESU (Oncorhynchus keta)	Washington
Threatened	Salmon, sockeye Ozette Lake ESU (Oncorhynchus (=Salmo) nerka)	Washington
Threatened	Steelhead Lower Columbia River DPS (Oncorhynchus (=Salmo) mykiss)	Washington
Threatened	Steelhead Puget Sound DPS (Oncorhynchus (=Salmo) mykiss)	Washington
Threatened	Steelhead Snake River Basin DPS (Oncorhynchus (=Salmo) mykiss)	Washington
Threatened	Steelhead Upper Columbia River DPS (Oncorhynchus (=Salmo) mykiss)	Washington
Threatened	Steelhead Upper Willamette River DPS (Oncorhynchus (=Salmo) mykiss)	Washington
Threatened	Trout, bull U.S.A., conterminous, lower 48 states (Salvelinus confluentus)	Washington
Endangered	Dace, Kendall Warm Springs Entire (Rhinichthys osculus thermalis)	Wyoming
Endangered	Ferret, black-footed entire population, except where EXPN (Mustela nigripes)	Wyoming
Endangered	Toad, Wyoming Entire (Bufo hemiophrys baxteri)	Wyoming
Threatened	Bat, Northern long-eared (Myotis septentrionalis)	Wyoming

Threatened	Bear, grizzly lower 48 States, except where listed as an experimental population (Ursus arctos horribilis)	Wyoming
Threatened	Cuckoo, yellow-billed Western U.S. DPS (Coccyzus americanus)	Wyoming
Threatened	Lynx, Canada Contiguous U.S. DPS (Lynx canadensis)	Wyoming
Threatened	Mouse, Preble's meadow jumping wherever found (Zapus hudsonius preblei)	Wyoming

Endangered Flora by State

Endangered	Blue-star, Kearney's (Amsonia kearneyana)	Arizona
Endangered	Cactus, Acuna (Echinomastus erectocentrus var. acunensis)	Arizona
Endangered	Cactus, Arizona hedgehog (Echinocereus triglochidiatus var. arizonicus)	Arizona
Endangered	Cactus, Brady pincushion (Pediocactus bradyi)	Arizona
Endangered	Cactus, Fickeisen plains (Pediocactus peeblesianus fickeiseniae)	Arizona
Endangered	Cactus, Nichol's Turk's head (Echinocactus horizonthalonius var. nicholii)	Arizona
Endangered	Cactus, Peebles Navajo (Pediocactus peeblesianus var. peeblesianus)	Arizona
Endangered	Cactus, Pima pineapple (Coryphantha scheeri var. robustispina)	Arizona
Endangered	Cliffrose, Arizona (Purshia (=Cowania) subintegra)	Arizona
Endangered	Ladies'-tresses, Canelo Hills (Spiranthes delitescens)	Arizona
Endangered	mallow, Gierisch (Sphaeralcea gierischii)	Arizona
Endangered	Milk-vetch, Holmgren (Astragalus holmgreniorum)	Arizona
Endangered	Milk-vetch, Sentry (Astragalus cremnophylax var. cremnophylax)	Arizona
Endangered	Water-umbel, Huachuca (Lilaeopsis schaffneriana var. recurva)	Arizona
Threatened	Cactus, Cochise pincushion (Coryphantha robbinsiorum)	Arizona
Threatened	Cactus, Siler pincushion (Pediocactus (=Echinocactus,=Utahia) sileri)	Arizona
Threatened	Cycladenia, Jones (Cycladenia humilis var. jonesii)	Arizona
Threatened	Fleabane, Zuni (Erigeron rhizomatus)	Arizona
Threatened	Milkweed, Welsh's (Asclepias welshii)	Arizona
Threatened	Ragwort, San Francisco Peaks (Packera franciscana)	Arizona
Threatened	Sedge, Navajo (Carex specuicola)	Arizona
Endangered	Allocarya, Calistoga (Plagiobothrys strictus)	California
Endangered	Alopecurus, Sonoma (Alopecurus aequalis var. sonomensis)	California

Endangered	Ambrosia, San Diego (Ambrosia pumila)	California
Endangered	Barberry, island (Berberis pinnata ssp. insularis)	California
Endangered	Barberry, Nevin's (Berberis nevinii)	California
Endangered	Bedstraw, El Dorado (Galium californicum ssp. sierrae)	California
Endangered	Bedstraw, island (Galium buxifolium)	California
Endangered	Bird's beak, palmate-bracted (Cordylanthus palmatus)	California
Endangered	Bird's-beak, Pennell's (Cordylanthus tenuis ssp. capillaris)	California
Endangered	Bird's-beak, salt marsh (Cordylanthus maritimus ssp. maritimus)	California
Endangered	Bird's-beak, soft (Cordylanthus mollis ssp. mollis)	California
Endangered	Bladderpod, San Bernardino Mountains (Lesquerella kingii ssp. bernardina)	California
Endangered	Bluegrass, Napa (Poa napensis)	California
Endangered	Bluegrass, San Bernardino (Poa atropurpurea)	California
Endangered	Buckwheat, cushenbury (Eriogonum ovalifolium var. vineum)	California
Endangered	Buckwheat, Ione (incl. Irish Hill) (Eriogonum apricum (incl. var. prostratum))	California
Endangered	Bush-mallow, San Clemente Island (Malacothamnus clementinus)	California
Endangered	Bush-mallow, Santa Cruz Island (Malacothamnus fasciculatus var. nesioticus)	California
Endangered	Button-celery, San Diego (Eryngium aristulatum var. parishii)	California
Endangered	Cactus, Bakersfield (Opuntia treleasei)	California
Endangered	Ceanothus, coyote (Ceanothus ferrisae)	California
Endangered	Ceanothus, Pine Hill (Ceanothus roderickii)	California
Endangered	Checker-mallow, Keck's (Sidalcea keckii)	California
Endangered	Checker-mallow, Kenwood Marsh (Sidalcea oregana ssp. valida)	California
Endangered	Checker-mallow, pedate (Sidalcea pedata)	California
Endangered	Clarkia, Pismo (Clarkia speciosa ssp. immaculata)	California
Endangered	Clarkia, Presidio (Clarkia franciscana)	California
Endangered	Clarkia, Vine Hill (Clarkia imbricata)	California
Endangered	Clover, Monterey (Trifolium trichocalyx)	California
Endangered	Clover, showy Indian (Trifolium amoenum)	California
Endangered	Crownscale, San Jacinto Valley (Atriplex coronata var. notatior)	California
Endangered	Dudleya, Santa Clara Valley (Dudleya setchellii)	California

Endangered	Evening-primrose, Antioch Dunes (Oenothera deltoides ssp. howellii)	California
Endangered	Evening-primrose, Eureka Valley (Oenothera avita ssp. eurekensis)	California
Endangered	Fiddleneck, large-flowered (Amsinckia grandiflora)	California
Endangered	Flannelbush, Mexican (Fremontodendron mexicanum)	California
Endangered	Flannelbush, Pine Hill (Fremontodendron californicum ssp. decumbens)	California
Endangered	Fringepod, Santa Cruz Island (Thysanocarpus conchuliferus)	California
Endangered	Fritillary, Gentner's (Fritillaria gentneri)	California
Endangered	Gilia, Hoffmann's slender-flowered (Gilia tenuiflora ssp. hoffmannii)	California
Endangered	Gilia, Monterey (Gilia tenuiflora ssp. arenaria)	California
Endangered	Goldfields, Burke's (Lasthenia burkei)	California
Endangered	Goldfields, Contra Costa (Lasthenia conjugens)	California
Endangered	Grass, Eureka Dune (Swallenia alexandrae)	California
Endangered	Grass, Solano (Tuctoria mucronata)	California
Endangered	Jewelflower, California (Caulanthus californicus)	California
Endangered	Jewelflower, Metcalf Canyon (Streptanthus albidus ssp. albidus)	California
Endangered	Jewelflower, Tiburon (Streptanthus niger)	California
Endangered	Larkspur, Baker's (Delphinium bakeri)	California
Endangered	Larkspur, San Clemente Island (Delphinium variegatum ssp. kinkiense)	California
Endangered	Larkspur, yellow (Delphinium luteum)	California
Endangered	Layia, beach (Layia carnosa)	California
Endangered	Lessingia, San Francisco (Lessingia germanorum (=L.g. var. germanorum))	California
Endangered	Lily, Pitkin Marsh (Lilium pardalinum ssp. pitkinense)	California
Endangered	Lily, Western (Lilium occidentale)	California
Endangered	Liveforever, Santa Barbara Island (Dudleya traskiae)	California
Endangered	Lupine, clover (Lupinus tidestromii)	California
Endangered	Lupine, Nipomo Mesa (Lupinus nipomensis)	California
Endangered	Malacothrix, island (Malacothrix squalida)	California
Endangered	Malacothrix, Santa Cruz Island (Malacothrix indecora)	California
Endangered	Mallow, Kern (Eremalche kernensis)	California
Endangered	Manzanita, Del Mar (Arctostaphylos glandulosa ssp. crassifolia)	California

Endangered	Manzanita, Franciscan (Arctostaphylos franciscana)	California
Endangered	Manzanita, Presidio (Arctostaphylos hookeri var. ravenii)	California
Endangered	Manzanita, Santa Rosa Island (Arctostaphylos confertiflora)	California
Endangered	Meadowfoam, Butte County (Limnanthes floccosa ssp. californica)	California
Endangered	Meadowfoam, Sebastopol (Limnanthes vinculans)	California
Endangered	Mesa-mint, Otay (Pogogyne nudiuscula)	California
Endangered	Mesa-mint, San Diego (Pogogyne abramsii)	California
Endangered	Milk-vetch, Applegate's (Astragalus applegatei)	California
Endangered	Milk-vetch, Braunton's (Astragalus brauntonii)	California
Endangered	Milk-vetch, Clara Hunt's (Astragalus clarianus)	California
Endangered	Milk-vetch, Coachella Valley (Astragalus lentiginosus var. coachellae)	California
Endangered	Milk-vetch, coastal dunes (Astragalus tener var. titi)	California
Endangered	Milk-vetch, Cushenbury (Astragalus albens)	California
Endangered	Milk-vetch, Lane Mountain (Astragalus jaegerianus)	California
Endangered	Milk-vetch, triple-ribbed (Astragalus tricarinatus)	California
Endangered	Milk-vetch, Ventura Marsh (Astragalus pycnostachyus var. lanosissimus)	California
Endangered	Monardella, willowy (Monardella viminea)	California
Endangered	Monkeyflower, Vandenberg (Diplacus vandenbergensis)	California
Endangered	Morning-glory, Stebbins' (Calystegia stebbinsii)	California
Endangered	Mountain balm, Indian Knob (Eriodictyon altissimum)	California
Endangered	Mountain-mahogany, Catalina Island (Cercocarpus traskiae)	California
Endangered	Mustard, slender-petaled (Thelypodium stenopetalum)	California
Endangered	Navarretia, few-flowered (Navarretia leucocephala ssp. pauciflora (=N. pauciflora))	California
Endangered	Navarretia, many-flowered (Navarretia leucocephala ssp. plieantha)	California
Endangered	Niterwort, Amargosa (Nitrophila mohavensis)	California
Endangered	Onion, Munz's (Allium munzii)	California
Endangered	Orcutt grass, California (Orcuttia californica)	California
Endangered	Orcutt grass, hairy (Orcuttia pilosa)	California
Endangered	Orcutt grass, Sacramento (Orcuttia viscida)	California
Endangered	Oxytheca, cushenbury (Oxytheca parishii var. goodmaniana)	California
Endangered	Paintbrush, soft-leaved (Castilleja mollis)	California
Endangered	Paintbrush, Tiburon (Castilleja affinis ssp. neglecta)	California

Endangered	Penny-cress, Kneeland Prairie (Thlaspi californicum)	California
Endangered	Pentachaeta, Lyon's (Pentachaeta lyonii)	California
Endangered	Pentachaeta, white-rayed (Pentachaeta bellidiflora)	California
Endangered	Phacelia, island (Phacelia insularis ssp. insularis)	California
Endangered	Phlox, Yreka (Phlox hirsuta)	California
Endangered	Piperia, Yadon's (Piperia yadonii)	California
Endangered	Polygonum, Scotts Valley (Polygonum hickmanii)	California
Endangered	Potentilla, Hickman's (Potentilla hickmanii)	California
Endangered	Rock-cress, Hoffmann's (Arabis hoffmannii)	California
Endangered	Rock-cress, McDonald's (Arabis macdonaldiana)	California
Endangered	Rockcress, Santa Cruz Island (Sibara filifolia)	California
Endangered	Sandwort, Marsh (Arenaria paludicola)	California
Endangered	Seablite, California (Suaeda californica)	California
Endangered	Sedge, white (Carex albida)	California
Endangered	Spineflower, Ben Lomond (Chorizanthe pungens var. hartwegiana)	California
Endangered	Spineflower, Howell's (Chorizanthe howellii)	California
Endangered	Spineflower, Orcutt's (Chorizanthe orcuttiana)	California
Endangered	spineflower, Robust (Chorizanthe robusta var. robusta)	California
Endangered	spineflower, Scotts Valley (Chorizanthe robusta var. hartwegii)	California
Endangered	Spineflower, slender-horned (Dodecahema leptoceras)	California
Endangered	Spineflower, Sonoma (Chorizanthe valida)	California
Endangered	Stonecrop, Lake County (Parvisedum leiocarpum)	California
Endangered	Sunburst, Hartweg's golden (Pseudobahia bahiifolia)	California
Endangered	Sunflower, San Mateo woolly (Eriophyllum latilobum)	California
Endangered	Sunshine, Sonoma (Blennosperma bakeri)	California
Endangered	Taraxacum, California (Taraxacum californicum)	California
Endangered	Tarplant, Gaviota (Deinandra increscens ssp. villosa)	California
Endangered	Thistle, Chorro Creek bog (Cirsium fontinale var. obispoense)	California
Endangered	Thistle, fountain (Cirsium fontinale var. fontinale)	California
Endangered	Thistle, La Graciosa (Cirsium loncholepis)	California
Endangered	Thistle, Loch Lomond coyote (Eryngium constancei)	California
Endangered	Thistle, Suisun (Cirsium hydrophilum var. hydrophilum)	California
Endangered	Thornmint, San Mateo (Acanthomintha obovata ssp. duttonii)	California
Endangered	Tuctoria, Greene's (Tuctoria greenei)	California
Endangered	Wallflower, Ben Lomond (Erysimum teretifolium)	California

Endangered	Wallflower, Contra Costa (Erysimum capitatum var. angustatum)	California
Endangered	Wallflower, Menzies' (Erysimum menziesii)	California
Endangered	Watercress, Gambel's (Rorippa gambellii)	California
Endangered	Woodland-star, San Clemente Island (Lithophragma maximum)	California
Endangered	Woolly-star, Santa Ana River (Eriastrum densifolium ssp. sanctorum)	California
Endangered	Wooly-threads, San Joaquin (Monolopia (=Lembertia) congdonii)	California
Endangered	Yerba santa, Lompoc (Eriodictyon capitatum)	California
Threatened	Amole, purple (Chlorogalum purpureum)	California
Threatened	Baccharis, Encinitas (Baccharis vanessae)	California
Threatened	Bluecurls, Hidden Lake (Trichostema austromontanum ssp. compactum)	California
Threatened	Brodiaea, Chinese Camp (Brodiaea pallida)	California
Threatened	Brodiaea, thread-leaved (Brodiaea filifolia)	California
Threatened	Butterweed, Layne's (Senecio layneae)	California
Threatened	Ceanothus, Vail Lake (Ceanothus ophiochilus)	California
Threatened	Clarkia, Springville (Clarkia springvillensis)	California
Threatened	Crownbeard, big-leaved (Verbesina dissita)	California
Threatened	Cypress, Gowen (Cupressus goveniana ssp. goveniana)	California
Threatened	Cypress, Santa Cruz (Cupressus abramsiana)	California
Threatened	Daisy, Parish's (Erigeron parishii)	California
Threatened	Dudleya, Conejo (Dudleya abramsii ssp. parva)	California
Threatened	Dudleya, marcescent (Dudleya cymosa ssp. marcescens)	California
Threatened	Dudleya, Santa Cruz Island (Dudleya nesiotica)	California
Threatened	Dudleya, Santa Monica Mountains (Dudleya cymosa ssp. ovatifolia)	California
Threatened	Dudleya, Verity's (Dudleya verityi)	California
Threatened	Dwarf-flax, Marin (Hesperolinon congestum)	California
Threatened	Evening-primrose, San Benito (Camissonia benitensis)	California
Threatened	Grass, Colusa (Neostapfia colusana)	California
Threatened	Howellia, water (Howellia aquatilis)	California
Threatened	Indian paintbrush, San Clemente Island (Castilleja grisea)	California
Threatened	Ivesia, Webber (Ivesia webberi)	California
Threatened	Liveforever, Laguna Beach (Dudleya stolonifera)	California

Threatened	Lotus, San Clemente Island (Acmispon dendroideus var. traskiae (=Lotus d. ssp. traskiae))	California
Threatened	Manzanita, Ione (Arctostaphylos myrtifolia)	California
Threatened	Manzanita, Morro (Arctostaphylos morroensis)	California
Threatened	Manzanita, pallid (Arctostaphylos pallida)	California
Threatened	Mariposa lily, Tiburon (Calochortus tiburonensis)	California
Threatened	Milk-vetch, Fish Slough (Astragalus lentiginosus var. piscinensis)	California
Threatened	Milk-vetch, Peirson's (Astragalus magdalenae var. peirsonii)	California
Threatened	Navarretia, spreading (Navarretia fossalis)	California
Threatened	Orcutt grass, San Joaquin (Orcuttia inaequalis)	California
Threatened	Orcutt grass, slender (Orcuttia tenuis)	California
Threatened	Owl's-clover, fleshy (Castilleja campestris ssp. succulenta)	California
Threatened	Paintbrush, ash-grey (Castilleja cinerea)	California
Threatened	Pussypaws, Mariposa (Calyptridium pulchellum)	California
Threatened	Rush-rose, island (Helianthemum greenei)	California
Threatened	Sandwort, Bear Valley (Arenaria ursina)	California
Threatened	Spineflower, Monterey (Chorizanthe pungens var. pungens)	California
Threatened	Spurge, Hoover's (Chamaesyce hooveri)	California
Threatened	Sunburst, San Joaquin adobe (Pseudobahia peirsonii)	California
Threatened	Tarplant, Otay (Deinandra (=Hemizonia) conjugens)	California
Threatened	Tarplant, Santa Cruz (Holocarpha macradenia)	California
Threatened	Thornmint, San Diego (Acanthomintha ilicifolia)	California
Threatened	Vervain, Red Hills (Verbena californica)	California
Threatened	Wild-buckwheat, southern mountain (Eriogonum kennedyi var. austromontanum)	California
Endangered	Beardtongue, Penland (Penstemon penlandii)	Colorado
Endangered	Cactus, Knowlton's (Pediocactus knowltonii)	Colorado
Endangered	Milk-vetch, Mancos (Astragalus humillimus)	Colorado
Endangered	milkvetch, Osterhout (Astragalus osterhoutii)	Colorado
Endangered	Phacelia, North Park (Phacelia formosula)	Colorado
Endangered	Skyrocket, Pagosa (Ipomopsis polyantha)	Colorado
Endangered	wild buckwheat, clay-loving (Eriogonum pelinophilum)	Colorado
Threatened	beardtongue, Parachute (Penstemon debilis)	Colorado
Threatened	Bladderpod, Dudley Bluffs (Lesquerella congesta)	Colorado
Threatened	Butterfly plant, Colorado (Gaura neomexicana var. coloradensis)	Colorado

Threatened	Cactus, Colorado hookless (Sclerocactus glaucus)	Colorado
Threatened	Cactus, Mesa Verde (Sclerocactus mesae-verdae)	Colorado
Threatened	Ladies'-tresses, Ute (Spiranthes diluvialis)	Colorado
Threatened	Mustard, Penland alpine fen (Eutrema penlandii)	Colorado
Threatened	Phacelia, DeBeque (Phacelia submutica)	Colorado
Threatened	Twinpod, Dudley Bluffs (Physaria obcordata)	Colorado
Threatened	Catchfly, Spalding's (Silene spaldingii)	Idaho
Threatened	Four-o'clock, MacFarlane's (Mirabilis macfarlanei)	Idaho
Threatened	Howellia, water (Howellia aquatilis)	Idaho
Threatened	Ladies'-tresses, Ute (Spiranthes diluvialis)	Idaho
Threatened	Catchfly, Spalding's (Silene spaldingii)	Montana
Threatened	Howellia, water (Howellia aquatilis)	Montana
Threatened	Ladies'-tresses, Ute (Spiranthes diluvialis)	Montana
Endangered	Buckwheat, steamboat (Eriogonum ovalifolium var. williamsiae)	Nevada
Endangered	Niterwort, Amargosa (Nitrophila mohavensis)	Nevada
Threatened	Blazingstar, Ash Meadows (Mentzelia leucophylla)	Nevada
Threatened	Centaury, spring-loving (Centaurium namophilum)	Nevada
Threatened	Gumplant, Ash Meadows (Grindelia fraxinipratensis)	Nevada
Threatened	Ivesia, Ash Meadows (Ivesia kingii var. eremica)	Nevada
Threatened	Ivesia, Webber (Ivesia webberi)	Nevada
Threatened	Ladies'-tresses, Ute (Spiranthes diluvialis)	Nevada
Threatened	Milk-vetch, Ash meadows (Astragalus phoenix)	Nevada
Threatened	Sunray, Ash Meadows (Enceliopsis nudicaulis var. corrugata)	Nevada
Endangered	Cactus, Knowlton's (Pediocactus knowltonii)	New Mexico
Endangered	Cactus, Kuenzler hedgehog (Echinocereus fendleri var. kuenzleri)	New Mexico
Endangered	Cactus, Sneed pincushion (Coryphantha sneedii var. sneedii)	New Mexico
Endangered	Ipomopsis, Holy Ghost (Ipomopsis sancti-spiritus)	New Mexico
Endangered	Milk-vetch, Mancos (Astragalus humillimus)	New Mexico
Endangered	Pennyroyal, Todsen's (Hedeoma todsenii)	New Mexico
Endangered	Poppy, Sacramento prickly (Argemone pleiacantha ssp. pinnatisecta)	New Mexico
Threatened	Cactus, Lee pincushion (Coryphantha sneedii var. leei)	New Mexico
Threatened	Cactus, Mesa Verde (Sclerocactus mesae-verdae)	New Mexico
Threatened	Fleabane, Zuni (Erigeron rhizomatus)	New Mexico

Threatened	Sunflower, Pecos (=puzzle, =paradox) (Helianthus paradoxus)	New Mexico
Threatened	Thistle, Sacramento Mountains (Cirsium vinaceum)	New Mexico
Threatened	Wild-buckwheat, gypsum (Eriogonum gypsophilum)	New Mexico
Threatened	Orchid, western prairie fringed (Platanthera praeclara)	North Dakota
Endangered	Daisy, Willamette (Erigeron decumbens)	Oregon
Endangered	Desert-parsley, Bradshaw's (Lomatium bradshawii)	Oregon
Endangered	Fritillary, Gentner's (Fritillaria gentneri)	Oregon
Endangered	Lily, Western (Lilium occidentale)	Oregon
Endangered	Lomatium, Cook's (Lomatium cookii)	Oregon
Endangered	Meadowfoam, large-flowered woolly (Limnanthes floccosa ssp. grandiflora)	Oregon
Endangered	Milk-vetch, Applegate's (Astragalus applegatei)	Oregon
Endangered	popcornflower, rough (Plagiobothrys hirtus)	Oregon
Endangered	Rock-cress, McDonald's (Arabis macdonaldiana)	Oregon
Endangered	Tuctoria, Greene's (Tuctoria greenei)	Oregon
Endangered	Wire-lettuce, Malheur (Stephanomeria malheurensis)	Oregon
Threatened	Catchfly, Spalding's (Silene spaldingii)	Oregon
Threatened	Checker-mallow, Nelson's (Sidalcea nelsoniana)	Oregon
Threatened	Four-o'clock, MacFarlane's (Mirabilis macfarlanei)	Oregon
Threatened	Howellia, water (Howellia aquatilis)	Oregon
Threatened	Lupine, Kincaid's (Lupinus sulphureus ssp. kincaidii)	Oregon
Threatened	Orcutt grass, slender (Orcuttia tenuis)	Oregon
Threatened	Paintbrush, golden (Castilleja levisecta)	Oregon
Threatened	Spurge, Hoover's (Chamaesyce hooveri)	Oregon
Threatened	Thelypody, Howell's spectacular (Thelypodium howellii spectabilis)	Oregon
Threatened	Orchid, western prairie fringed (Platanthera praeclara)	South Dakota
Threatened	roseroot, Leedy's (Rhodiola integrifolia ssp. leedyi)	South Dakota
Endangered	Ambrosia, south Texas (Ambrosia cheiranthifolia)	Texas
Endangered	Ayenia, Texas (Ayenia limitaris)	Texas
Endangered	Bladderpod, white (Lesquerella pallida)	Texas
Endangered	Bladderpod, Zapata (Lesquerella thamnophila)	Texas
Endangered	Cactus, black lace (Echinocereus reichenbachii var. albertii)	Texas
Endangered	Cactus, Nellie cory (Coryphantha minima)	Texas
Endangered	Cactus, Sneed pincushion (Coryphantha sneedii var. sneedii)	Texas
Endangered	Cactus, star (Astrophytum asterias)	Texas

Endangered	cactus, Tobusch fishhook (Sclerocactus brevihamatus ssp. tobuschii)	Texas
Endangered	Cat's-eye, Terlingua Creek (Cryptantha crassipes)	Texas
Endangered	Dawn-flower, Texas prairie (Hymenoxys texana)	Texas
Endangered	Dogweed, ashy (Thymophylla tephroleuca)	Texas
Endangered	Gladecress, Texas golden (Leavenworthia texana)	Texas
Endangered	Ladies'-tresses, Navasota (Spiranthes parksii)	Texas
Endangered	Manioc, Walker's (Manihot walkerae)	Texas
Endangered	Phlox, Texas trailing (Phlox nivalis ssp. texensis)	Texas
Endangered	Pitaya, Davis' green (Echinocereus viridiflorus var. davisii)	Texas
Endangered	Pondweed, Little Aguja (=Creek) (Potamogeton clystocarpus)	Texas
Endangered	Poppy-mallow, Texas (Callirhoe scabriuscula)	Texas
Endangered	Rush-pea, slender (Hoffmannseggia tenella)	Texas
Endangered	Sand-verbena, large-fruited (Abronia macrocarpa)	Texas
Endangered	Snowbells, Texas (Styrax texanus)	Texas
Endangered	Wild-rice, Texas (Zizania texana)	Texas
Threatened	Cactus, Chisos Mountain hedgehog (Echinocereus chisoensis var. chisoensis)	Texas
Threatened	Cactus, Lloyd's Mariposa (Echinomastus mariposensis)	Texas
Threatened	Cory cactus, bunched (Coryphantha ramillosa)	Texas
Threatened	No common name (Geocarpon minimum)	Texas
Threatened	Oak, Hinckley (Quercus hinckleyi)	Texas
Threatened	Rose-mallow, Neches River (Hibiscus dasycalyx)	Texas
Threatened	Sunflower, Pecos (=puzzle, =paradox) (Helianthus paradoxus)	Texas
Endangered	Bear-poppy, Dwarf (Arctomecon humilis)	Utah
Endangered	Bladderpod, kodachrome (Lesquerella tumulosa)	Utah
Endangered	Buttercup, autumn (Ranunculus aestivalis (=acriformis))	Utah
Endangered	Cactus, San Rafael (Pediocactus despainii)	Utah
Endangered	Cactus, Wright fishhook (Sclerocactus wrightiae)	Utah
Endangered	mallow, Gierisch (Sphaeralcea gierischii)	Utah
Endangered	Milk-vetch, Holmgren (Astragalus holmgreniorum)	Utah
Endangered	Milk-vetch, Shivwits (Astragalus ampullarioides)	Utah
Endangered	Phacelia, clay (Phacelia argillacea)	Utah
Endangered	Reed-mustard, Barneby (Schoenocrambe barnebyi)	Utah
Endangered	Reed-mustard, shrubby (Schoenocrambe suffrutescens)	Utah
Endangered	Ridge-cress, Barneby (Lepidium barnebyanum)	Utah

Threatened	cactus, Pariette (Sclerocactus brevispinus)	Utah
Threatened	Cactus, Siler pincushion (Pediocactus (=Echinocactus,=Utahia) sileri)	Utah
Threatened	cactus, Uinta Basin hookless (Sclerocactus wetlandicus)	Utah
Threatened	Cactus, Winkler (Pediocactus winkleri)	Utah
Threatened	Cycladenia, Jones (Cycladenia humilis var. jonesii)	Utah
Threatened	Ladies'-tresses, Ute (Spiranthes diluvialis)	Utah
Threatened	Milk-vetch, Deseret (Astragalus desereticus)	Utah
Threatened	Milk-vetch, heliotrope (Astragalus montii)	Utah
Threatened	Milkweed, Welsh's (Asclepias welshii)	Utah
Threatened	Primrose, Maguire (Primula maguirei)	Utah
Threatened	Reed-mustard, clay (Schoenocrambe argillacea)	Utah
Threatened	Sedge, Navajo (Carex specuicola)	Utah
Threatened	Townsendia, Last Chance (Townsendia aprica)	Utah
Endangered	Checkermallow, Wenatchee Mountains (Sidalcea oregana var. calva)	Washington
Endangered	Desert-parsley, Bradshaw's (Lomatium bradshawii)	Washington
Endangered	Stickseed, showy (Hackelia venusta)	Washington
Threatened	Bladderpod, White Bluffs (Physaria douglasii ssp. tuplashensis)	Washington
Threatened	Buckwheat, Umtanum Desert (Eriogonum codium)	Washington
Threatened	Catchfly, Spalding's (Silene spaldingii)	Washington
Threatened	Checker-mallow, Nelson's (Sidalcea nelsoniana)	Washington
Threatened	Howellia, water (Howellia aquatilis)	Washington
Threatened	Ladies'-tresses, Ute (Spiranthes diluvialis)	Washington
Threatened	Lupine, Kincaid's (Lupinus sulphureus ssp. kincaidii)	Washington
Threatened	Paintbrush, golden (Castilleja levisecta)	Washington
Endangered	Penstemon, blowout (Penstemon haydenii)	Wyoming
Threatened	Butterfly plant, Colorado (Gaura neomexicana var. coloradensis)	Wyoming
Threatened	Ladies'-tresses, Ute (Spiranthes diluvialis)	Wyoming
Threatened	Yellowhead, desert (Yermo xanthocephalus)	Wyoming

APPENDIX B – DOSE ASSESSMENTS

SECTION 6.0 DOSE ASSESSMENT

6.1 Introduction

Disa performed a dose assessment to estimate potential occupational and public doses from licensed operations. External and internal dose contributions were modeled using conservative estimates of parameters (e.g., occupancy, equilibrium, etc.) and expected maximum concentrations of source terms. Conservatism was incorporated into the models due to the uncertainty in many factors including the exact layout of process equipment, variable concentrations, and material densities (e.g., waste rock, slurry, reject, and product mixtures), and source volumes.

A comparison between expected external and internal doses from an existing waste rock pile to the expected doses of the reject pile was performed to show the estimated dose reduction benefit from this technology. Total doses consider both external (gamma) and internal (inhalation) contributions. External dose contributions were modeled using MicroShield (Grove Software, 2022) while the internal dose contribution was modeled using MILDOS (Argonne National Laboratory, 2020).

It is important to note that Disa presents maximum, mean, and median doses in this application. However, maximum doses are based on unreasonable scenarios, which require employees to be standing immediately adjacent to the source terms for extraordinarily long periods of time; this scenario is actually impossible. Mean and median doses are more reasonable but are still highly conservative.

6.2 Dose Assessment Modeling

6.2.1 External Dose

External doses were modeled using MicroShield (Grove Software, 2022). This software is able to model simple shapes and volumes of materials (both shielding and source materials) and provides external exposure rate and absorbed dose rate results. Modeled absorbed doses are related to the reported effective doses via factor 0.7. The nature of Disa's technology involves numerous pieces of complex machinery including a rock crusher, high-pressure slurry ablation unit, and centrifuges. Source material will also maintain a trailer onsite for storage of product source material prior to offsite transportation.

The dose assessment was performed by modeling each component individually, as simple cuboids (rectangular prisms), and then piecing the individual components together to create a spatial map of calculated effective dose rates. A 5 ft by 5 ft grid system (see Figure 6-1) was used to approximate the equipment dimensions and layout. External dose rates were calculated for a given grid by summing dose contributions from nearby components (see Figure 6-2). Modeled components are shown in Table 6-1. Table 6-2 provides details on the various source material types.

Table 6-1: Components Included in External Dose Model as Source Terms

Equipment	Approximate Size (L x W x H), ft[a]	Source Material Type
Crusher and 0.25" Screen	56.5 x 19 x 15.5	Input waste rock
HPSA Unit	30 x 9 x 11	Slurry
Product Centrifuge	16 x 9 x 10	Product stream
Reject Centrifuge	16 x 9 x 10	Reject stream
Transportation Truck Trailer	(24 x 8 x 5.6) x 2	Product Stream
Process Water Tank	24 x 12 x 13	Process water
Process Water Treatment Unit	11 x 8 x 8	Process water
Product Centrifuge Hopper	8 x 5 x 4	Product stream
Product Centrifuge Auger Conveyor	20 x 6 x 1	Product stream
Reject Centrifuge Stacker	35 x 2 x 2	Reject stream

[a] Components were considered rectangular parallelepipeds with the given dimensions.

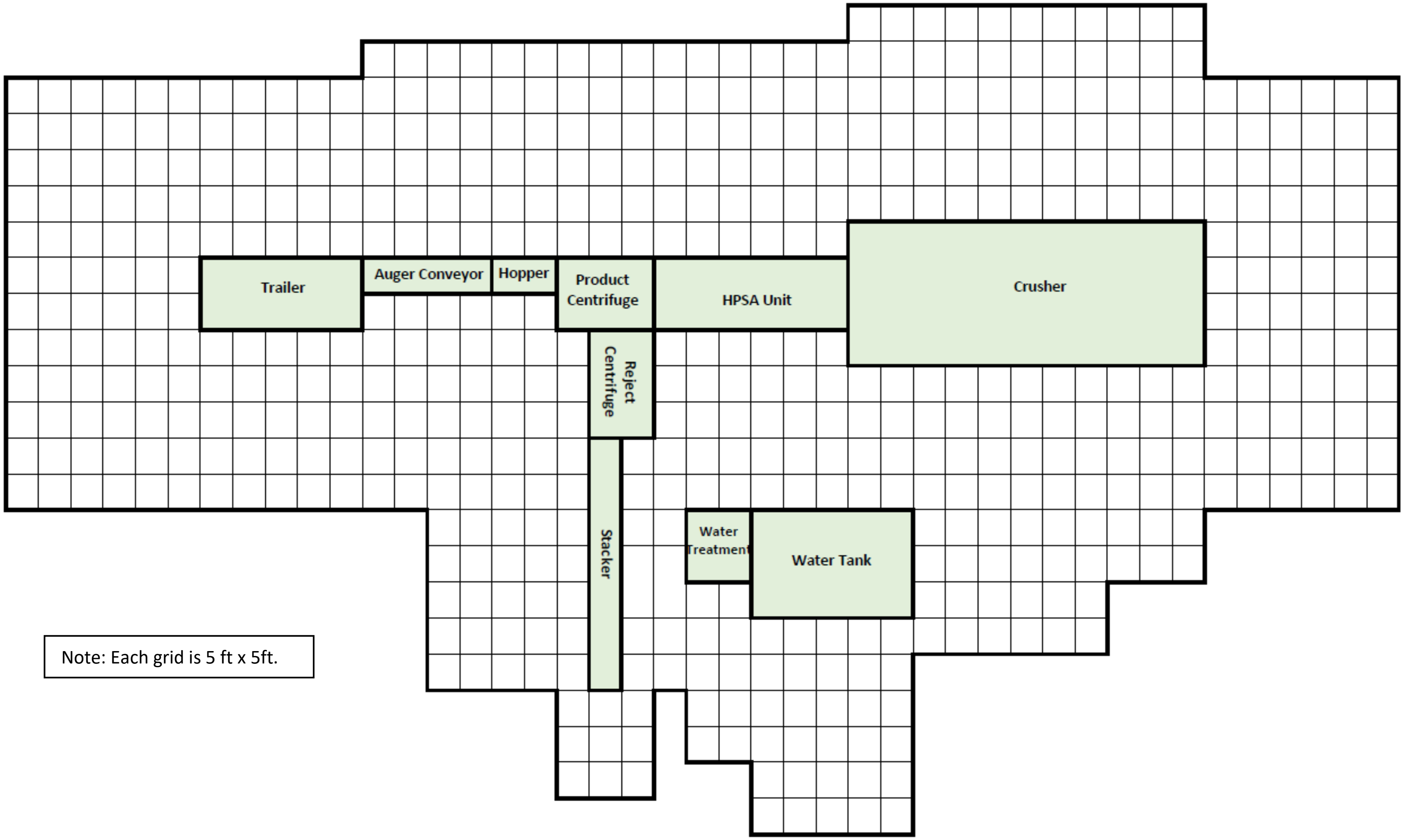
Table 6-2: Materials Used in the Model

Materials[b]			Activity		
Type	**Properties**	**Density**	**mg U/kg**	**µCi U/cm^3**	**pCi/g[a]**
Equipment	*Steel*	8	-	-	-
Input Waste rock	*Iron*	2.3	1500	2.34E-03	1.02E+03
Slurry	*Water*	1.3	1500	1.31E-03	1.02E+03
Product Stream	*Iron*	2.3	7000	1.09E-02	4.74E+03
Reject Stream	*Iron*	2.3	500	7.79E-04	3.39E+02
Process Water	*Water*	1	35	2.37E-05	2.37E+01

[a] Assumes specific activity of 0.677 µCi/g.

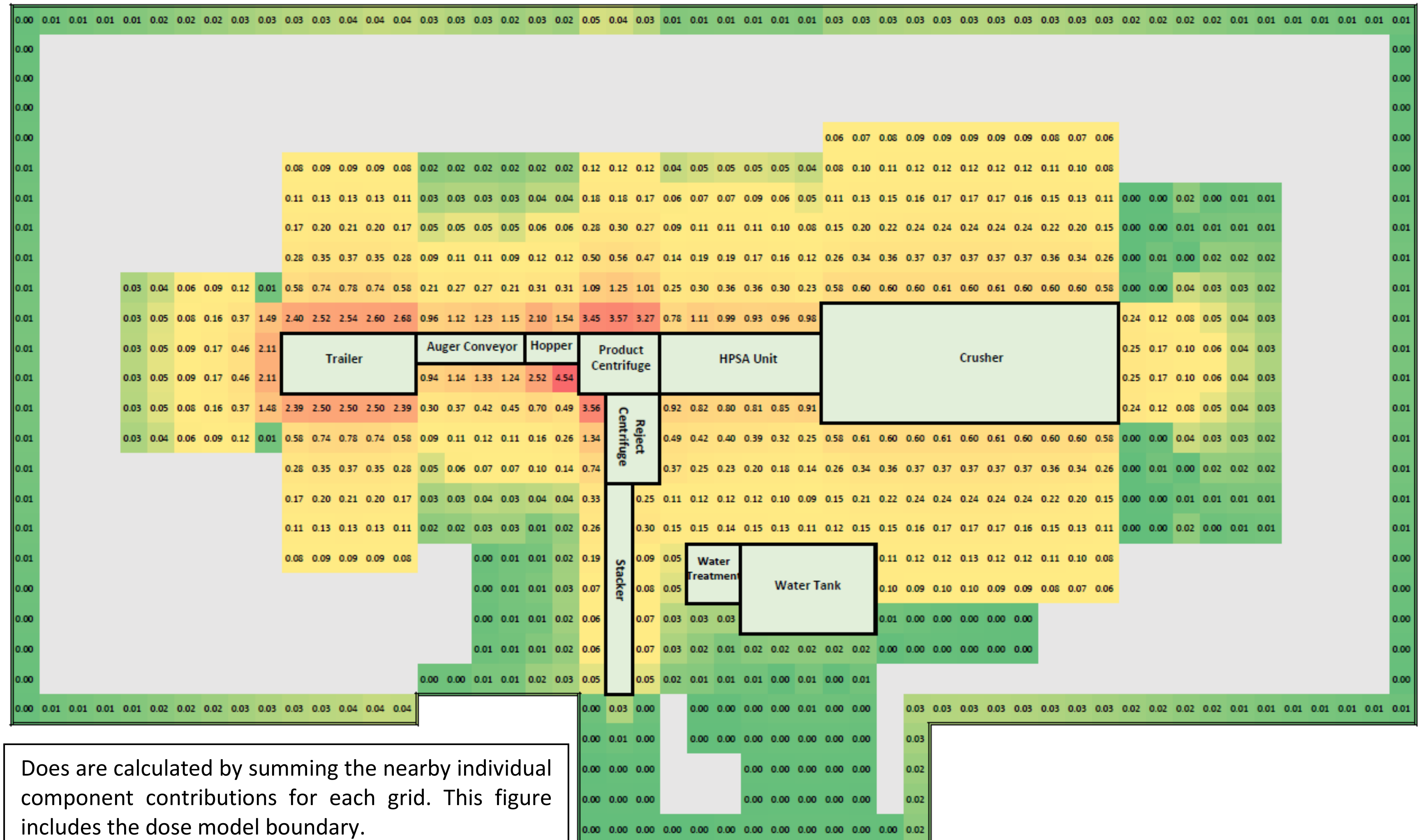
[b] Densities and activities are given or calculated.

Figure 6-1: Model Components and Grid System Dose Model



Note: Each grid is 5 ft x 5ft.

Figure 6-2: Modeled Dose Rates (mrem/hr)



Does are calculated by summing the nearby individual component contributions for each grid. This figure includes the dose model boundary.

Each component (source term) was modeled individually as a solid shape of source material at a particular concentration. Concentrations are dependent on where the source term is in the process. All equipment was assumed to be surrounded with 0.25 inches of stainless-steel shielding. Material properties are used by the software to approximate build-up factors and attenuation characteristics. Iron is a default material in MicroShield and was used as an analog for the waste rock material and process streams. The 40% density by mass solids slurry material was assumed to be similar to water.

6.2.2 Assumptions and Approximations

The following conservative assumptions and approximations were made. These assumptions ensure a large margin of safety in modeled results. Because of this, modeled results represent conditions that are maximum potential values. During normal operation, actual dose rates are expected to be much lower.

- Equipment and Process Layout - Due to the limitations of the modeling software and the grid-system used to combine the results from multiple modeled components, a very rigid layout of components was used. In general, the layout modeled is comparable to expected field conditions; the main process equipment will occur in a linear process train while the reject stream will be directed away from the main product stream. However, actual equipment positions will affect potential occupational and public doses.
- Source Terms - In all cases (internal and external models), it is assumed that uranium is in secular equilibrium with all of its decay progeny. Each source term is modeled as a solid block of source material at a specific concentration. While these dimensions are accurate for considering the footprint and overall volume of space occupied by each component, it is highly unlikely that the volume of source material within each component is accurately represented by the equipment dimensions.

  The actual volume of source material will be some fraction of this total volume. For this model, the source volume was assumed to be 75% of the total volume from Table 1. Equipment often has internal components that occupy space and provide additional shielding. Furthermore, smooth operations of this nature do not allow for components to be completely filled; otherwise, overtopping, or high backpressures could occur. Also, it is likely that the source material will be shielded by more than a single layer of 0.25 steel. However, for the sake of simplicity and conservatism, this factor is ignored.
- Concentrations and Densities - Concentrations of materials are the maximum values expected. These values were determined from field observation and lab-scale testing. Concentrations will vary in reality, but the concentrations used provide an upper bound on modeled dose rates.
- Modeling Extents - As seen in Figure 6-2, occupational dose rates were modeled up to about 20-30 feet from the surfaces of equipment. This is a limiting factor in the model results and is related to the software modeling capabilities. To model the potential public doses, an average distance of 50 feet from equipment was modeled. This distance varies slightly depending on the layout and size of the equipment. This distance represents a potential restricted area, beyond which no members of the public would be allowed access.
- Occupancy - Occupancy times for occupational and public exposures will be highly variable. For occupational doses, it is assumed that a worker will be exposed 8 hours a day, 7 days a week, for 9 months out of the year. Nine months was selected because mobilization, demobilization, time between projects, travel to project sites, weekends, and holidays, will reduce employees

time being exposed to radioactive materials. Consequently, assuming a full year of employee exposure, which is typically assumed, is physically impossible.

A member of the public will be exposed 8 hours a day, 7 days a week, for 6 months of the year. In reality, the occupancy times may be much less, particularly for the public, because this equipment will move from site-to-site. In addition, these sites are generally located in remote areas and may have additional site access controls to further reduce potential doses. Therefore, this occupancy assumption is highly conservative.

6.2.3 External Dose Results

Occupancy values used in calculations are provided in Table 6-3. Using these occupancy times, 3 different dose rates were used to calculate potential doses. These dose rates are the maximum dose rate, the average dose rate, and the median dose rate. The maximum dose rates were identified for both occupational dose and public dose. For the occupational worker, all modeled grids were included. For a member of the public, only the boundary grids were included, as members of the public will be restricted from entering the work zone. The maximum dose rate was then multiplied by the number of occupancy hours in Table 6-3 to give the annual external dose. Dose rates and annual external dose results are given in Table 6-4.

To ensure the public dose remains below 100 mrem/yr for this occupancy scenario, the effective dose rate at the boundary needs to be less than 0.07 mrem/hr. The public dose model has a maximum effective dose rate of 0.05 mrem/hr at a distance of 50 feet from the transportation truck (when full). This meets the requirements for compliance with the public dose limits. Routine exposure rate surveys (using a Ludlum Model 19, or similar) will be performed along the restricted area boundary to document and verify radiation levels.

Table 6-3: Occupancy Times for Members of the Public and Occupational Workers

Individual Type	Hours/ Day	Months	Days	Hours
Occupational	8	9	270	2160
Public	8	6	180	1440

Table 6-4: Modeled External Dose Rates and Annual Doses - Workers and Members of the Public

Case	Type	Dose Rate (mrem/hr)	Annual Dose (mrem)	Dose Limit (mrem)	% of limit
Maximum	*Occupational*	4.54	9808	5,000	196%
	Public	0.05	74	100	74%
Average	*Occupational*	0.40	870	5,000	17%
	Public	0.02	22	100	22%
Median	*Occupational*	0.11	246	5,000	5%
	Public	0.01	14	100	14%

As stated in Section 6.1, maximum doses to employees and the public are unreasonable, considering that the length of time required to be in close proximity to maximum dose rates will not occur, as a result of these operations. Average or median dose rates are significantly more likely scenarios. To ensure that public doses remain below the 100-mrem limit, Disa will utilize monitoring, access, and sampling procedures found in Appendix C.

6.3 Internal Dose

6.3.1 Modeling Approach

Internal doses were modeled using MILDOS. Four source terms were considered in the model. These four source terms and concentrations are given in Table 6-5. Other sources of particulate emission are considered negligible because downstream of the HPSA unit is considered wet processes. Dust control measures will also be used the waste rock pile and during crushing, but for modeling purposes these materials are considered dry. It is assumed that the uranium is in secular equilibrium with its decay progeny. In most cases, MILDOS default values for parameters are used. For example, particle size distributions, deposition velocities, wind rose patterns, and surface roughness default values were used. Radon release rates and outdoor equilibrium factors were calculated by MILDOS using the built-in Erosion Model for particulates. The model assumed no ingestion rate from vegetables, meat, or milk. Eight receptors were modeled at various locations around the sources. The occupancy factor was conservatively assumed to be 1 for outdoor occupancy for each receptor, i.e., the receptor is present at that location for 100% of the year. The maximum distance from source that a receptor was modeled is approximately 300 meters. The source and receptor arrangement are shown in Figure 6-3.

Table 6-5: Internal Dose Model Source Terms, Uranium Concentrations, and Particle Densities

Source Term	Concentration, mg U/kg	Particle Densities
Waste rock Pile	1500	2.3 g / cm^3
Reject Pile	500	2.3 g / cm^3
Crusher	1500	2.3 g / cm^3
HPSA Unit	7000	2.3 g / cm^3

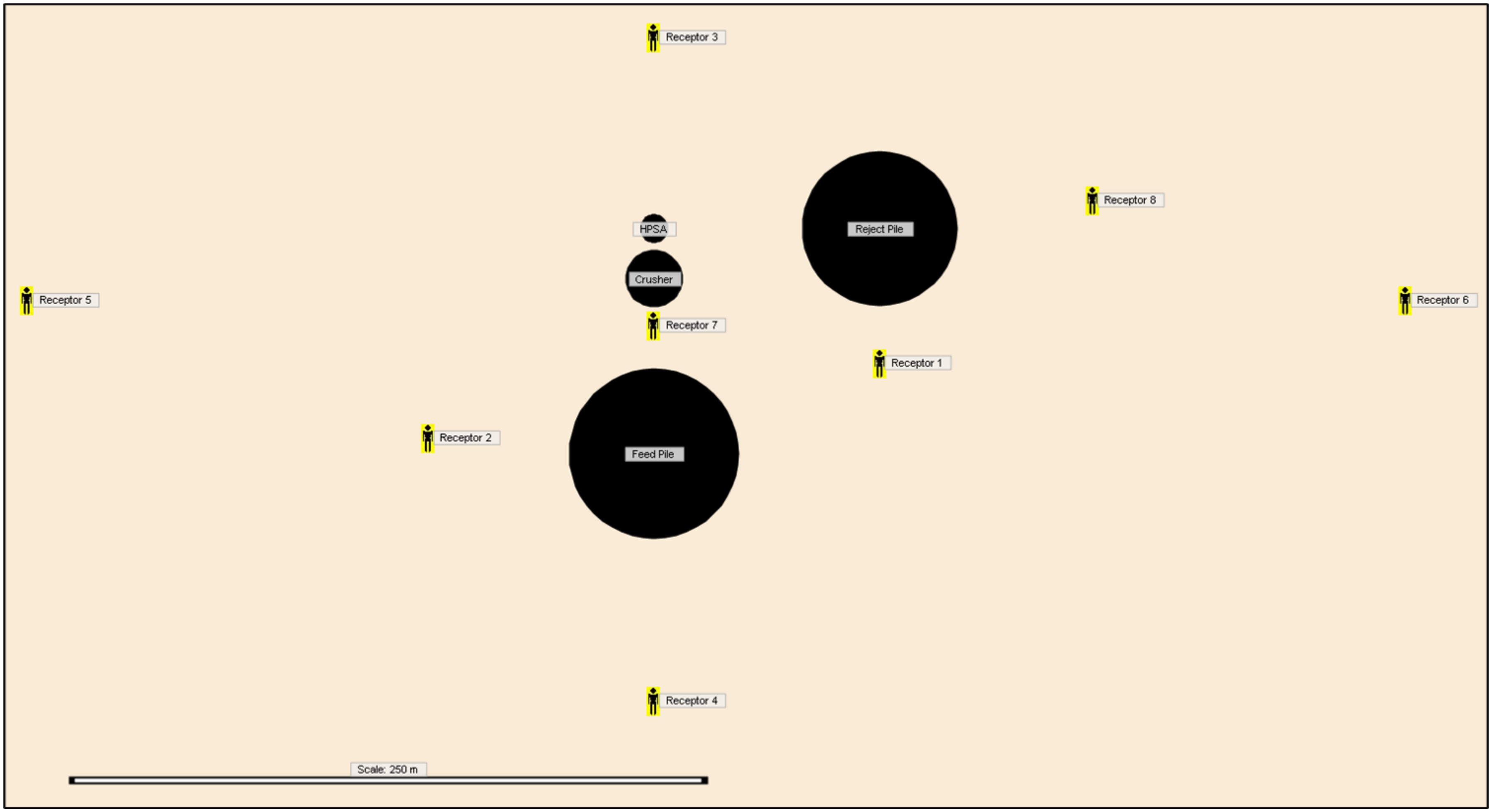
6.3.2 Internal Dose Results

Results for internal doses did not consider occupational or public doses explicitly. Receptors who would be located within a restricted area are representative of occupational doses, while the receptors outside of a potential restricted area would be representative of public doses. Results for each receptor are provided in Table 6-6. The maximum value of 22.3 mrem is attributed to Receptor 7, which is located in between the waste rock pile and the Crusher equipment. Receptor 1, located between the waste rock pile and reject pile, would receive a dose of 6.1 mrem. Results representative of potential public doses range from 0.4 to 2.4 mrem. These values suggest that internal doses will be negligible. Actual doses are likely to be less than those modeled due to the conservative occupancy factor use by MILDOS.

Table 6-6: Annual Internal Dose Results for each Modeled Receptor

Receptor	Total Annual Dose (mrem)
1	6.1
2	1.7
3	2.1
4	1.8
5	0.4
6	0.6
7	22.3
8	2.4

Figure 6-3: Source Term and Receptor Locations for MILDOS Internal Exposure Model.



6.4 Comparison of Dose from Waste Rock Material to Process Coarse

Simple external and internal dose modeling of the waste rock and clean coarse fraction were performed individually to investigate the potential benefit from dose reduction for materials that are present on these sites. The models are consistent with those included in the models above (size, volume, concentration). For the external dose, 6 receptors were modeled at 5 ft increments, started at 1 ft from the edge of the pile. For the internal doses, 4 receptors were modeled at distance of 254 feet (100 m) in the cardinal directions around each pile. The results of these models are provided in Table 6-7. From these results, it is clear there is a reduction in doses from onsite materials. The reduction in dose ranges from 59 to 72% with an average reduction in external dose of 67% and internal dose of 73%.

Table 6-7. Dose Reduction Comparison Between Waste Rock and Clean Coarse Fraction

	Receptor	Distance from Source (ft)	Waste Rock Dose, (mrem)	Clean Coarse Fraction Dose (mrem)	Reduction (%)
External	1	1	0.99	0.40	59
	2	5	0.46	0.15	68
	3	15	0.15	0.05	69
	4	25	0.07	0.02	70
	5	35	0.04	0.01	70
	6	45	0.02	0.01	66
Internal	1	254	3.08	0.83	73
	2	254	1.44	0.40	72
	3	254	1.94	0.52	73
	4	254	1.77	0.49	72

6.5 Summary

The external and internal doses were modeled using conservative assumptions and parameters. In general, these results represent conservative upper boundaries to potential doses. The external results indicate that expected occupational doses will remain below occupational dose limits, on average. However, the results also indicate there is a potential for workers to exceed their annual dose limit.

Based on the current external dose model and occupancy scenario, a member of the public will receive a dose of 74 mrem/yr if exposed to the maximum modelled dose rate. This scenario is unlikely and the average and median results show a comfortable margin of safety below public dose limits. At no point does any dose rate along the model boundary approach 2 mrem/hour. Routine exposure rate measurements and site access control will be used to ensure public doses remain ALARA.

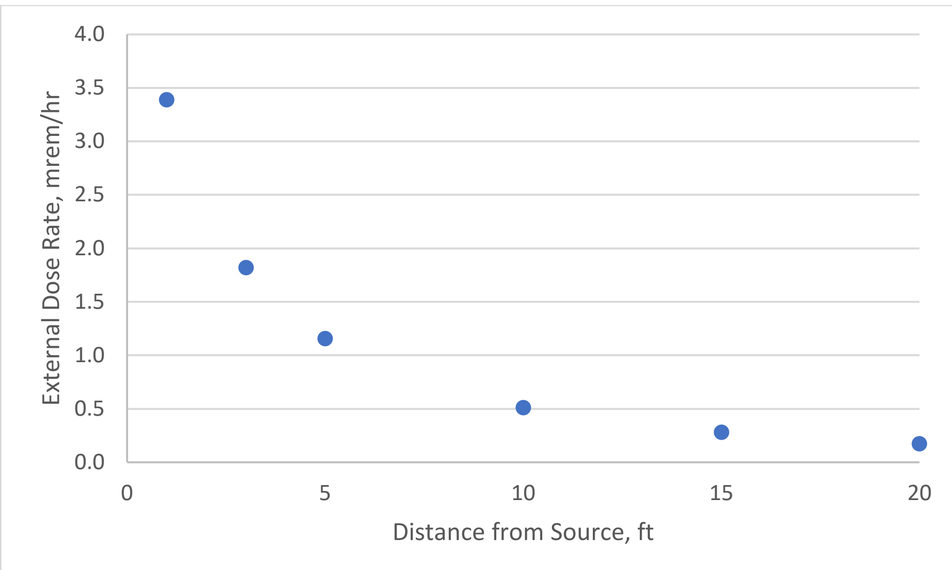
Finally, it is clear from the dose reduction comparison that there is a great benefit, both to the environment and to humans, from this process. While there is a short-term risk incurred during the operation of this equipment, there is a permanent reduction of approximately 70% in potential dose.

1.0 Direct Radiation Dose from Spill Cleanup

The volume of material being transported was modeled using MicroShield 9.07. Radiation dose is highly dependent on geometry, time, distance, shielding, material concentrations and amount of material. Conservative assumptions were made to estimate the effective dose rates and various distance from the entire volume of material. A cleanup likely would involve heavy equipment, a more dispersed source, and controls to reduce the amount of time individuals would be near the spill material. Therefore, dose rates are conservative.

The maximum dose rate for an individual standing a foot from the volume of material is 3.39 mrem/hr. The area would not be considered a radiation area. Cleanup using heavy equipment could reduce doses to workers by a factor of 2 from these unshielded results and keep individuals at a distance greater than a foot.

If we assume the average distance a worker is from the entire volume of material is 5 feet, and the worker is exposed and unshielded for 10 hours, this would result in a total external dose of 11.6 mrem.



2.0 Inhalation Dose

MILDOS 4.1 was used to simulate air concentrations from a dry pile of material. The pile of material modeled was slightly larger than the surface area of the two largest dimensions of the trailer carrying the material (300 m^2 total area). While respirators and dusk masks can reduce risks from particulate inhalation as well, this model assumes no respiratory protection is used. Additionally, the material is likely to be moist or wet which would greatly reduce any risk of suspension of spill material. Cleans up should also include dust suppression techniques and materials kept moist (not dry) during cleanup. Radon exhalation from the material could be a concern if the spill occurs indoors in an enclosed space. However, it is not likely a transportation accident would occur in an enclosed space. Radon rapidly dissipates in outdoor environments. For the modeling, a radon flux rate of 200 pCi/m^2/second was assumed. This high radon flux value can sometimes be seen from tailings wastes.

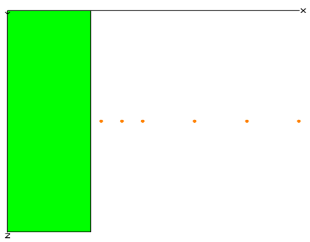
The modeling results indicate that a receptor at 15 feet from the spill would receive approximately 21.2 mrem/yr from inhalation dose (including radon). The occupancy time is assumed to be 10 hours (0.11% of the year). This would give a total inhalation dose of 0.02 mrem.

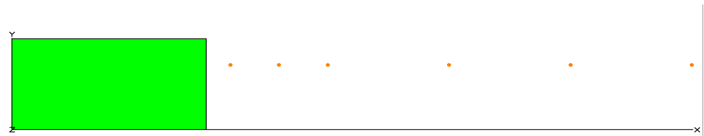
3.0 Ingestion Dose

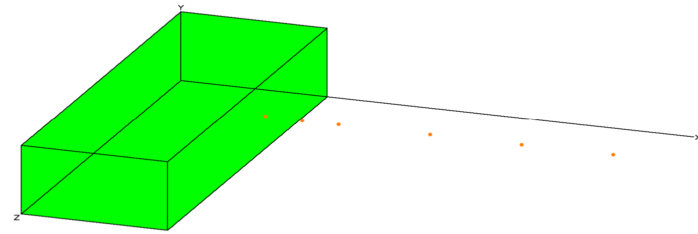
Ingestion dose from a spill cleanup can effectively be removed as a dose pathway by proper use of PPE (gloves, coveralls, etc.), contamination control procedures (e.g., personnel contamination surveys), and good industrial hygiene such as washing hands and face prior to eating, tobacco use, leaving the site, etc. Accidental ingestion is expected to be smaller than an inhalation dose and therefore negligible.

Equipment	Approximate Size	Length (ft)	Width (ft)	Height (ft)	Total Volume (cu.ft)	Volume Adjustment (75%) (cu ft)	Volume (cu cm)	Mass (g)	Activity (pCi/g)	Total Activity (pCi)	tal Activity (Ci)
Transportation Truck Trailer	24 x 8 x 5.6	24	8	5.6	1075.20	806.40	2.28E+07	5.25E+07	4740.00	2.49E+11	2.489E-01

*Values (trailer size, 75% full assumption, and activity concentration) from license application report text.







Source Dimensions	
Length	243.84 cm (8 ft)
Width	731.52 cm (24 ft)
Height	128.016 cm (4 ft 2.4 in)

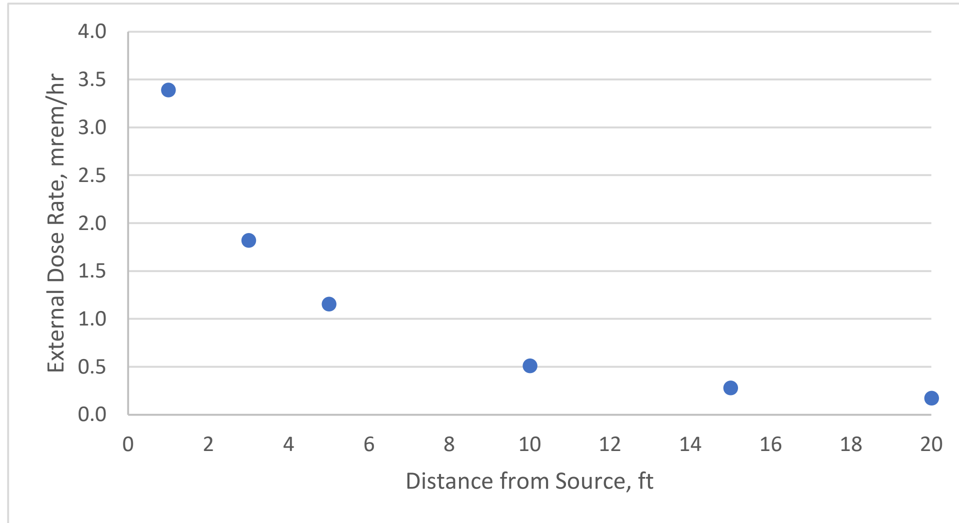
Dose Points

A	X	Y	Z
#1	274.32 cm (9 ft)	91.44 cm (3 ft)	365.76 cm (12 ft)
#2	335.28 cm (11 ft 0.0 in)	91.44 cm (3 ft)	365.76 cm (12 ft)
#3	396.24 cm (13 ft 0.0 in)	91.44 cm (3 ft)	365.76 cm (12 ft)
#4	548.64 cm (18 ft)	91.44 cm (3 ft)	365.76 cm (12 ft)
#5	701.04 cm (23 ft)	91.44 cm (3 ft)	365.76 cm (12 ft)
#6	853.44 cm (28 ft 0.0 in)	91.44 cm (3 ft)	365.76 cm (12 ft)

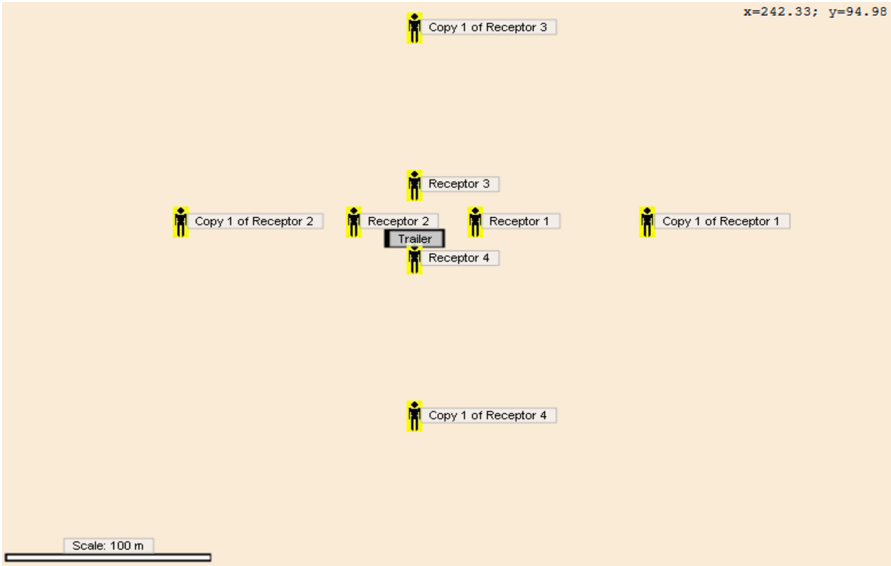
Shields

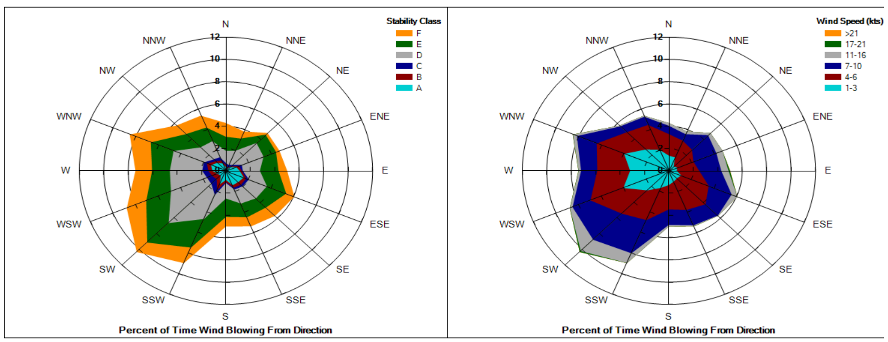
Shield N	Dimension	Material	Density
Source	806.4 ft³	Iron	2.3
Air Gap		Air	0.00122

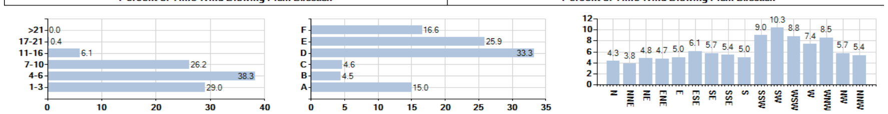
Point	Distance from Source (ft)	Absorbed Dose Rate mrad/hr With Buildup	Effective Dose Equivalent, mrem/hr
1	1	4.84E+00	3.39E+00
2	3	2.60E+00	1.82E+00
3	5	1.65E+00	1.16E+00
4	10	7.31E-01	5.11E-01
5	15	4.01E-01	2.81E-01
6	20	2.49E-01	1.74E-01



Using same met data, many default transport parameters, and default particule size distributions that were used in onsite dose assessment.
Assume area is slightly larger than 2 largest maximum dimensions (30 by 10 spill area)
Assumes material is dry. Likely will be moist/wet so transport highly unlikely. Spills should be kept moist.







Area Source Type

- Generic Area (selected)
- New ISR Well Field
- Land Application
- ISR Well Field

Area Source Type / Dimensions

- Circular — Radius (m) 31
- Rectangle (selected) — Length (m) 30 — Width (m) 10 — Rotation (0 - < 90) 0
- Polygon

point	x (m)	y (m)

Source Total Area: 300 m^2

Add Vertex | Delete Vertex

Area Source Term

Nuclide	Solubility Class	Concentration (pCi/g)
U-238	Year	4740
U-234	Year	
Th-230	Week	4740
Ra-226	Week	4740
Pb-210	Day	4740
Bi-210	Week	
Po-210	Week	
Th-232	Week	0
Ra-228	Week	0
Ac-228	Day	
Th-228	Week	0
Ra-224	Week	

Release Rates

Radon-222	200	pCi / m^2-s
Radon-220	0	pCi / m^2-s
Particulates	0	g / m^2-s

☑ Use Erosion Model for Particulates

Particulate Erosion Model

Tailing mass < 20 um (%)	3
Surface Roughness Ht. (m)	0.1
Particle density (g/m^3)	2300000
Water content (wt. %)	0.1
Saltating particle diameter (m)	0.0003

Done

Individual Receptor Information

Name / Description	No.	Age Group	Location (m) x	y	z	Occupancy Fraction Indoor	Outdoor
Receptor 1	1	Adult	45	5	1	0	1
Receptor 2	2	Adult	-15	5	1	0	1
Receptor 3	3	Adult	15	25	1	0	1
Receptor 4	4	Adult	15	-15	1	0	1
Copy 1 of Receptor 1	5	Adult	130	5	1	0	1
Copy 1 of Receptor 2	6	Adult	-100	5	1	0	1
Copy 1 of Receptor 3	7	Adult	15	110	1	0	1
Copy 1 of Receptor 4	8	Adult	15	-100	1	0	1

Receptor	Total	Groundshine	Cloundshine	Inhalation	IngestVeg	IngestMeat	IngestMilk
Receptor 1	2.12E+01	9.38E-03	9.18E-04	2.12E+01	0.00E+00	0.00E+00	0.00E+00
Receptor 2	7.58E+00	2.73E-03	2.27E-04	7.57E+00	0.00E+00	0.00E+00	0.00E+00
Receptor 3	2.10E+01	7.65E-03	6.20E-04	2.10E+01	0.00E+00	0.00E+00	0.00E+00
Receptor 4	1.76E+01	6.86E-03	5.94E-04	1.76E+01	0.00E+00	0.00E+00	0.00E+00
Copy 1 of Receptor 1	1.59E+00	1.28E-03	4.78E-04	1.59E+00	0.00E+00	0.00E+00	0.00E+00
Copy 1 of Receptor 2	8.17E-01	3.34E-04	9.32E-05	8.17E-01	0.00E+00	0.00E+00	0.00E+00
Copy 1 of Receptor 3	1.12E+00	6.29E-04	1.86E-04	1.12E+00	0.00E+00	0.00E+00	0.00E+00
Copy 1 of Receptor 4	1.15E+00	7.21E-04	2.29E-04	1.15E+00	0.00E+00	0.00E+00	0.00E+00

200 pCi/m2/s radon flux assumed

APPENDIX C – RADIATION PROTECTION PROGRAM

SECTION 5.0 RADIATION PROTECTION PROGRAM (FORM ITEMS 10 AND 11)

5.1 General

Disa is committed to the protection of its personnel, the public, and the environment from the effects of radiation. The Radiation Protection Program (RPP) presented in this document shall be implemented to provide radiation protection to employees, project personnel, the public, and the environment while working with radioactive materials on sites where Disa's technology is being used for reclamation/remediation purposes.

This program includes the radiation safety organization and responsibilities, occupational health physics monitoring, exposure control measures, internal and external exposure protection, radiation safety training, radiation work permits, controlled area designation, and record keeping. This program complies with applicable requirements set forth in 10 CFR 20 and 40.

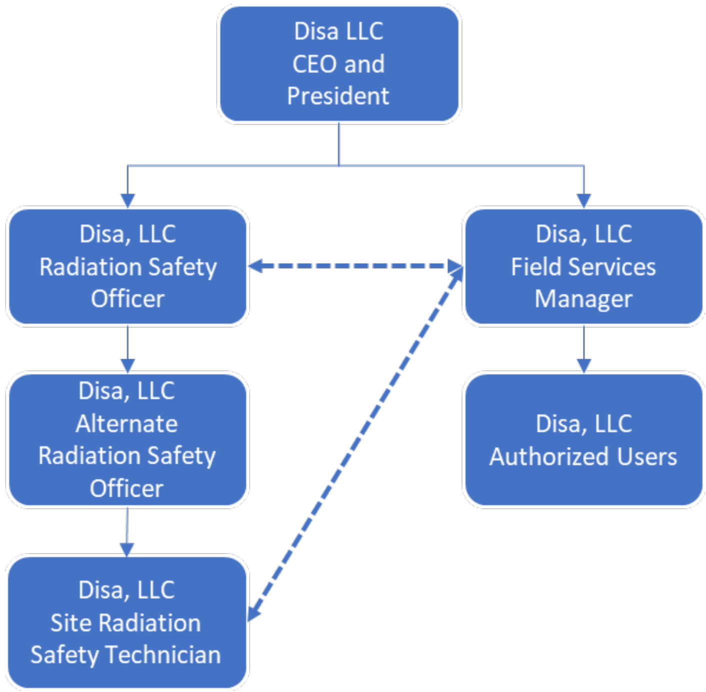
5.2 As Low As Reasonably Achievable (ALARA) Policy

Disa's policy is to maintain radiation exposure to personnel and the general public to levels that are "As Low As Reasonably Achievable" (ALARA) from the maximum limits specified in 10 CFR 20. Disa shall implement its ALARA policy by training all personnel for radiation safety, implementing SOPs, using appropriate control measures, Radiation Work Permits (RWPs), good housekeeping practices, administrative control limits, and radiation protection equipment, as needed. These elements of the ALARA policy are integrated in this Radiation Protection Program to maintain the radiation exposure ALARA.

5.3 Radiation Safety Organization

All Disa personnel and contractors shall adhere to the RPP and the ALARA policy. All individuals involved with radiation-related activities have responsibility for radiation safety. The Radiation Safety Organization will include the CEO/President of Disa, the RSO, ARSO (when one is appointed), Field Services Manager (FSM), and Authorized Users (AUs). Figure 5-1 is an organization chart for Disa's Radiation Safety Organization. As shown in Figure 5-1, the RSO and the FSM both report to the CEO/President; however, both will communicate regarding the implementation of the RPP. Furthermore, the RSO has independence and authority to implement appropriate radiation procedures and controls.

Figure 5-1: Organization Chart



5.4 Qualifications of Radiation Protection Staff

Qualifications for the radiation protection staff are based on Regulatory Guide 8.31, Revision 1 (RG 8.31) (NRC, 2002).

5.4.1 Radiation Safety Officer

- Education: A bachelor's degree in the physical sciences, industrial hygiene, or engineering from an accredited college or university or an equivalent combination of training and relevant experience in facility radiation protection. Two years of relevant experience are generally considered equivalent to 1 year of academic study.
- Health Physics Experience: At least 1 year of work experience relevant to radiation operations in applied health physics, radiation protection, industrial hygiene, or similar work. This experience should involve actually working with radiation detection and measurement equipment, not strictly administrative or "desk" work.
- Specialized Training: At least 1 week of specialized classroom training in health physics specifically applicable to managing source material and RSO training. In addition, the RSO should attend refresher training on source material facility health physics every 2 years.
- Specialized Knowledge: A thorough knowledge of the proper application and use of all health physics equipment used in a source material facility, the chemical and analytical procedures used for radiological sampling and monitoring, methodologies used to calculate personnel exposure to uranium and its daughters, and a thorough understanding of the HPSA process and

equipment used in the facility and how the hazards are generated and controlled during the source material process.

Disa understands that the RSO and ARSO specialized training requirement is less than that stated in RG 8.31 (NRC, 2002). However, Disa determined that its operations are substantially simpler than uranium recovery facilities, for which RG 8.31 was written. Because of Disa's relatively simple operations, a lower degree of specialized training is suitable and warranted. Disa requests the ability for its Safety and Environmental Review Panel to appoint the RSO and ARSO. For the first RSO appointment, Disa will utilized the services of a contract Certified Health Physicist (CHP) to approve the RSO appointment.

5.4.2 Alternate Radiation Safety Officer

- Education: A bachelor's degree in the physical sciences, industrial hygiene, or engineering from an accredited college or university or an equivalent combination of training and relevant experience in facility radiation protection. Two years of relevant experience are generally considered equivalent to 1 year of academic study.
- Health Physics Experience: At least 1 year of work experience relevant to radiation operations in applied health physics, radiation protection, industrial hygiene, or similar work. This experience should involve actually working with radiation detection and measurement equipment, not strictly administrative or "desk" work.
- Specialized Training: At least 1 week of specialized classroom training in health physics specifically applicable to managing source material and RSO Training. In addition, the RSO should attend refresher training on source material facility health physics every 2 years.
- Specialized Knowledge: Knowledge of the proper application and use of some health physics equipment used in a source material facility, methodologies used to calculate personnel exposure to uranium and its daughters, and knowledge of the HPSA process and equipment used in the facility and how the hazards are generated and controlled during the source material process.

5.4.3 Site Radiation Safety Technician

At least one Disa employee will serve as the Site Radiation Safety Technician (RST) during any operation. This person shall have one of the following combinations of qualifications:

1. Combination 1

- Education: An associate degree or 2 or more years of study in the physical sciences, engineering, or a health-related field;
- Training: At least a total of 4 weeks of generalized training (up to 2 weeks may be on-the-job training) in radiation health protection applicable to HPSA processes; and,
- Experience: One year of work experience using sampling and analytical laboratory procedures that involve health physics, industrial hygiene, or industrial safety measures to be applied in a source materials facility.

2. Combination 2

- Education: A high school diploma;

- Training: A total of at least 3 months of specialized training (up to 1 month may be on-the-job training) in radiation health protection relevant to source material facilities;
- Experience: Two years of relevant work experience in applied radiation protection; and,
- The health physics technician should demonstrate a working knowledge of the proper operation of health physics instruments used in the HPSA process, surveying and sampling techniques, and personnel dosimetry requirements.

5.4.4 Authorized Users

Disa will also assign Authorized Users who will implement the Radiation Protection Program on a project site. Authorized users may be authorized and/or removed by the Disa RSO upon review of their qualifications.

5.5 Responsibilities

All personnel are responsible for radiation protection and implementation of ALARA policy. Personnel will direct responsibility for implementing the Disa license and maintaining compliance with the NRC regulations are the RSO, ARSO, the Field Services Manager, and Authorized Users.

5.5.1 Management

Disa's management will have the following responsibilities, based on RG 8.31 (NRC, 2002):

- Expressing in writing, a strong commitment to and continuing support for the development and implementation of the radiation protection and ALARA program;
- Providing information and policy statements to employees, contractors, and visitors;
- Implementing a periodic management audit program that reviews procedural and operational efforts to maintain exposures ALARA;
- Implementing a continuing management evaluation of the radiation safety (health physics) program, its staff, and its allocation of adequate space, and money; and,
- Providing appropriate briefings and training in radiation safety, including ALARA concepts for all remediation employees in the facility and, when appropriate, for contractors and visitors.

5.5.2 Radiation Safety Officer

The Disa RSO ("license-designated RSO") has the following responsibilities:

- Serving as the primary point-of-contact on the license;
- Primarily responsible for overseeing and implementing the RPP and ALARA policy at each Disa temporary project site;
- Communicating responsibilities with the FSM and AUs;
- Developing and implementing training programs for the AUs and RSTs;
- Ensuring all training is current;

- Maintaining records in accordance with NRC regulations after the completion of work at temporary project sites;
- Investigating incidents and serving as the primary point-of-contact for all incidents;
- Review the RPP and its implementation annually;
- Properly handling, management, and offsite shipment of all source material;
- Review the RPP and its implementation annually;
- Establish occupational health physics and radiological monitoring procedures for site activities;
- Review radiological monitoring data to evaluate exposures and assure that any radiation exposures are ALARA;
- Provide the exposure and monitoring data to the appropriate regulatory agencies and the individual in accordance with applicable rules or regulations; and,
- Implement and maintain an effective respiratory and bioassay program, as required.

5.5.3 Alternate Radiation Safety Officer

The Disa ARSO will support the RSO in execution of the RPP and ALARA program at each Disa temporary project site. The ARSO's responsibilities will be those delegated by the RSO, which could include:

- Implement the RPP and the ALARA Policy;
- Communicating responsibilities with the FSM and AUs;
- Developing and implementing training programs for the FSM and AUs;
- Ensuring all training is current;
- Maintaining records in accordance with NRC regulations after the completion of work at temporary project site;
- Investigating incidents and serving as the primary point-of-contact for all incidents;
- Review the RPP and its implementation annually;
- Properly handling, management, and offsite shipment of all source material;
- Establish occupational health physics and radiological monitoring procedures for site activities;
- Review radiological monitoring data to evaluate exposures and assure that any radiation exposures are ALARA;
- Implement and maintain site-specific dosimetry programs; and,
- Implement and maintain an effective respiratory and bioassay program, as required.

Regardless of the responsibilities delegated to the ARSO, the RSO maintains ultimate responsibility for the compliance with the license, implementing the RPP, and implementing the ALARA policy.

5.5.4 Field Services Manager

The FSM will be an AU on all project sites. The FSM shall have the primary responsibility for overseeing and implementing the RPP and ALARA policy on project sites. Specific responsibilities are, as follows:

- Coordinate with the RSO, ARSO, and Site Radiation Safety Technician to ensure compliance with RPP procedures, license conditions, emergency plans, training requirements, etc.;
- Coordinate with the Site Radiation Safety Technician to implement the RPP, along with radiation safety procedures;
- Coordinate with Site Radiation Safety Technician to evaluate control measures with appropriate managers to maintain radiological exposures ALARA;
- Advise and instruct personnel concerning performance of their radiation safety responsibilities;
- Observe site activity to ensure compliance with the RPP and the ALARA policy; and,
- Maintain records of radiological monitoring and exposures during the duration of a project.

5.5.5 Site Radiation Safety Technician

- Implement and oversee the RPP, along with radiation safety procedures;
- Implement ALARA policy;
- Review radiological monitoring data to evaluate exposures and assure that any radiation exposures are ALARA;
- Implement and maintain a dosimetry program;
- Perform radiological contamination surveys of equipment and materials released to the unrestricted areas;
- Assure that decontamination and release of equipment and material complies with the requirements;
- Stop work activity if there is a potential for inadvertent excessive radiation exposure to personnel, the general public, or the environment;
- Maintain records of radiological monitoring and exposures during the duration of a project; and,
- Assure that all radiation survey instruments are properly calibrated.

5.5.6 Authorized Users

Each AU is responsible for understanding and adhering to the RPP and the ALARA policy, and pursuant to the Disa Health and Safety Program all employees have Stop Work Authority. Personnel shall be required to understand, by training, the radiological conditions of the specific site or area to which they are assigned. Individuals shall stop working if situations or conditions arise that might adversely affect radiation exposures and must notify the FSM and the RSO/ARSO for evaluation of the situation or condition prior to resuming work. Each individual shall be required to report any condition that may lead to a violation of the RPP to the FSM or the RSO/ARSO. Personnel shall be advised of their rights 10 CFR 19, such as instructions, notifications, reports, and request for inspections. Any violation of the RPP by any individual may result in disciplinary action.

5.6 Safety and Environmental Review Panel

Because Disa is seeking a performance-based license, Disa will establish a Safety and Environmental Review Panel (SERP) to oversee changes, tests, and experiments to be performed under Disa's license. Disa's SERP will consist of at least three individuals:

- The Chief Operating Officer, or another higher-level operations person, will be a member of the SERP and will have expertise in operations and/or construction and will have responsibility for implementing any operational changes.
- The Chief Executive Officer, or a higher-level manager, will be a member of the SERP and will have expertise in management and will be responsible for implementing managerial and financial changes.
- The RSO will be a member of the SERP with the responsibility for assuring that changes conform to radiation safety and environmental requirements.

Additional members may be included in the Safety and Environmental Review Panel, as appropriate, to address specific technical issues such as health physics, ground-water hydrology, surface-water hydrology, and specific earth sciences or other technical disciplines. Temporary members may include consultants. A description of when additional members will be used is provided. Disa will prepare a procedure that describes the manner in which the SERP will operate.

5.7 Radiation Dose Limits

5.7.1 Occupational Dose Limits

Consistent with 10 CFR 20.1201, the dose limits from occupational exposure to radiation are as follows:

- The annual limit is the more limiting of:
- The total effective dose equivalent equal to 5 rem.
- The sum of the deep-dose equivalent and committed dose equivalent to any individual organ equal to 50 rem.
- The annual limits to the lens of the eye and to the skin are:
- An eye dose equivalent of 15 rem.
- A shallow-dose equivalent of 50 rem to the skin or to any extremity.

5.7.2 Occupational Dose Limits to Minors

Pursuant to 10 CFR 20.1207, the annual occupational dose limits for a minor (under the age of 18 -years) are 10 percent of the annual dose limits for an adult as set forth in 10 CFR 20.1201. The Disa RSO shall review minors' work assignments to assure that any exposures are maintained ALARA.

5.7.3 Dose Limit to an Embryo/Fetus

Pursuant to 10 CFR 20.1208, the radiation dose limit to an embryo/fetus during entire pregnancy, due to occupational exposure of a declared pregnant woman, shall be 0.5 rem (500 mrem). Disa shall inform all female personnel of their right to notify the Disa RSO in writing of their pregnancy immediately upon knowledge or suspicion of pregnancy. The RSO, ARSO, and FSM shall review work assignments of any declared pregnant woman to assure that the embryo/fetus dose does not exceed the 0.5 rem limit and is maintained ALARA.

5.7.4 Planned Special Exposures

Due to low levels of radioactivity associated with Disa's licensed material and with the project sites on which Disa works, no planned special exposures are expected. If circumstances warrant a planned special exposure, the Disa RSO shall authorize such exposures consistent with the requirements of 10 CFR 20.1206.

5.7.5 Summation of External and Internal Doses

Pursuant to 10 CFR 20.1502, if it is determined that both the internal radiation dose from air sampling measurements, and the external radiation dose from dosimeters, is likely to exceed 10 percent of the limit, the committed effective dose equivalent (CEDE) and Deep Dose Equivalent (DDE) shall be summed. This shall demonstrate compliance with Total Effective Dose Equivalent (TEDE) limit.

If routine air sampling and dosimeter results indicate that the dose from either internal or external radiation exposure could exceed 10 percent of the limit, the summation requirements of internal and external radiation doses under 10 CFR 20.1202. The sum of the DDE (mrem, as determined by dosimeter) divided by 5000 (mrem, TEDE) and the total number of Derived Air Concentration (DAC) hours for all radionuclides divided by 2,000 may not exceed one.

5.7.6 Determination of Prior Occupational Dose

If any individual is likely to receive in one year an occupational dose in excess of 10 percent of the limit, Disa shall determine the individual's prior occupational dose as follows:

- A determination shall be made based on information on the nature and the amount of prior occupational dose disclosed in a signed statement from the individual or from the individual's most recent employer for work involving radiation exposure for the current year.
- Disa shall attempt to obtain the records of life-time cumulative occupational radiation dose in the NRC Form 4 or an equivalent form, signed by the individual and countersigned by an appropriate representative of the most recent employer for any work involving radiation exposure.

5.7.7 Radiation Dose Limits for Individual Members of Public

The dose limits for individual members of the public shall be consistent with 10 CFR 20.1301, as follows:

- Total effective dose equivalent of 0.1 rem (100 mrem) per year to individual members of public; and
- Maximum dose rate of 0.002 rem/hour in the unrestricted area from external radiation sources.
- If any member of the public enters any controlled area, which is isolated outside the restricted area, the above dose limits shall apply.

5.7.8 Compliance with Dose Limits for Individual Members of Public

Normal operations and activities at Disa project sites are not expected to expose members of the public or release effluents. Where required, compliance shall be achieved through the monitoring of airborne particulate and gases released from a site, as well as direct gamma radiation measurements from environmental dosimeters, where appropriate. Disa shall demonstrate compliance with dose limits for individual members of the public as specified in 10 CFR 20.1302.

5.8 Radiation Safety Training (Form Item 8)

Disa requires that all individuals working in or frequenting any portion of a restricted area shall be:

- Kept informed of the storage, transfer, or use of radioactive materials or of radiation in such portions of the restricted area.
- Instructed in the health protection problems associated with exposure to such radioactive materials or radiation, in precautions or procedures to minimize exposure, and in the purposes and functions of protective devices employed.
- Instructed in, and instructed to observe, to the extent within the individual's control, the applicable provisions of NRC regulations and licenses for the protection of personnel from exposures to radiation or radioactive materials occurring in such areas.
- Instructed of their responsibility to report promptly to the licensee any condition which may lead to or cause a violation of NRC regulations and licenses or unnecessary exposure to radiation or to radioactive material.
- Instructed in the appropriate response to warnings made in the event of any unusual occurrence or malfunction that may involve exposure to radiation or radioactive material.
- Be advised as to the radiation exposure reports which personnel may request pursuant to 10 CFR 19.

The extent of these instructions shall be commensurate with potential radiological health protection problems in the restricted area.

The RPP is most effective when each individual is aware of radiation hazards. All individuals shall be trained based on their work assignments. The following topics shall be included in the radiation safety training for personnel completing field work:

- Fundamentals of Health Protection
- Radiological and toxic hazards of exposures to radioactive materials
- Pathways of radioactive material into the body
- ALARA policy for exposure to radioactive materials
- Radiation Protection and Personal Hygiene
- Protective clothing
- Proper use of respirators
- Eating, drinking, smoking, and chewing in designated clean areas only

- RWP and access controls
- Methods of personnel decontamination
- Ventilation system and efficient control measures
- Engineering controls
- Health Physics Monitoring
- Airborne radioactive material measurement
- Bioassay
- Material and personnel contamination surveys
- External exposure rate survey and personal dosimetry
- Radiation Protection Regulations
- Regulatory authority of NRC
- Worker rights in 10 CFR Part 19
- Radiation protection requirements in 10 CFR Part 20
- Emergency Procedures

All individuals shall be tested for comprehension of radiation safety training by a written test and must pass the test in order to work in the restricted area. The FSM shall assure personnel have passed the test before the individual is permitted into the work restricted area. AUs under Disa's radioactive materials license will be trained to the level required under the license, and as stipulated in the license application.

5.9 Radiation Work Permit

If there is a potential for significant exposure to radiation during non-routine activities within the restricted area for which no SOP exists, the work shall be conducted under a Radiation Work Permit (RWP). RWPs control radiation exposure by radiological protection and monitoring to maintain radiation exposures ALARA. An RWP shall be requested by the FSM for the activity to be performed and shall be authorized and approved by the RSO/ARSO. The FSM shall assure that any activity that requires an RWP is not performed until an RWP is obtained.

Personnel involved with the activity shall be given specific instructions for that activity so that they shall be aware of the hazards and understand the use of special radiation protection equipment. Radiological data from prior activity and other operational surveys shall be used for preparing the RWP. The RWP shall include the location and description of activity, name of the FSM that requested the RWP, and all individuals involved, radiological protection equipment, special monitoring, special instructions, date of issue and expiration, radiation surveys and levels, and approval of the RSO. Only the RSO/ARSO can terminate an RWP prior to the expiration date and only after determination that the radiological levels are below the control limits and are stable.

The area where the activity is conducted under the RWP shall be designated as a controlled area and may be isolated within the restricted area. Access shall be limited to those individuals who are trained in and involved with the activity work in order to control exposures and minimize the spread of radiological contamination.

5.10 Release of Equipment and Material

The release of facilities, equipment, and material to an unrestricted area shall comply with Disa SOP, ***Radiological Contamination Surveys and Decontamination***. All materials and equipment used for work in the restricted area shall be presumed contaminated unless the surface contamination levels meet the criteria for release to the unrestricted area.

5.11 Health Physics Monitoring Procedures and Calibration

All procedures used by Disa for radiation surveys and health physics monitoring shall have sufficient sensitivity requirements to meet the objectives of the survey or monitoring. Radiological field and laboratory analysis instrumentation shall be calibrated using National Institute of Standards and Technology traceable standards.

Procedures require calibrations to be performed on an annual basis and function checks to be performed for each day of use. Where licensed radioactive material (i.e., a Th-230 check source) is used for function checks of alpha radiation detection instrumentation, the licensed material will not be removed from the site and will be under the control of the RSO, the ARSO, or an AU. Licensed sources will be stored in a secured and locked location (e.g., safe, or locked building) when not in use.

Personnel who are likely to receive in one year an occupational dose from sources external to the body, a dose in excess of 10% of the applicable regulatory limits in to 10 CFR 20.1201, will be monitored by personnel dosimetry (whole body and extremity if needed). Personnel dosimetry shall be provided by a NVLAP accredited supplier. Personnel will be responsible for wearing dosimetry as directed by the RSO (normally front torso of the body for whole body). The RSO shall conduct dose investigations whenever dosimetry badges are lost, or results have been compromised or are unexpectedly elevated. Area radiation surveys, restricted area access logs, and personnel dosimetry results (including those of co-workers as applicable) may be used for dose investigations.

Female workers who become pregnant are encouraged to declare their pregnancy. A female worker may declare her pregnancy by submitting in writing to the RSO a statement declaring her pregnancy with the estimated date of conception with a signature and date of declaration. Disa will institute radiation control measures to limit the radiation exposure to the unborn fetus to less than 500 mrem for the entire gestation period. Disa's program to provide instructions to females of childbearing age and to control prenatal exposure ALARA will comply with the applicable sections of US NRC Regulatory Guides 8.13 and 8.36.

Additional provisions are as follows:

- No individual under the age of 18 years will be assigned radiation worker duties.
- Workers who have received occupational exposure prior to employment at Disa shall provide their radiation exposure history or request their radiation exposure from previous employers.
- Annual notification of occupational exposure will be provided to radiation workers. The annual notification will be equivalent to the information in NRC Form 5.

5.12 Public Dose and Effluent Monitoring at Project Sites

Members of the public are not permitted to work in restricted areas at project sites at which work is being performed under this license. Radiation exposures to the public will be maintained below 100 mrem/yr total effective dose equivalent (TEDE). Dose rates in unrestricted areas will be less than 2 mrem in any one hour. Public doses will be measured using calculation methods and measurement techniques approved in NUREG-1556, Volume 12, Appendix J (NRC, 2018b). Dose to the public as a result of airborne effluent (excluding radon) will be limited to 10 mrem/yr TEDE.

5.13 Transportation of Radioactive Materials

Transportation of radioactive (Class 7) material will follow the USDOT regulations. Personnel performing hazardous material shipping will receive initial training in accordance with 49 CFR 172 and recurrent training every three years. Packages containing radioactive material shall be surveyed for radiation levels and contamination as specified in regulations and Disa SOPs (***Shipping UN2910 Radioactive Material, Transport of Uranium Source Material as LSA-1,*** and ***Radioactive Material Receipt***). Labeled radioactive material packages (except for special form and gases) must be surveyed within 3 hours of receipt if the package is received during normal working hours or within 3 hours for the beginning of the next scheduled workday if delivered after working hours.

5.14 Radioactive Waste Management (Form Item No. 11)

Depending on the client, Disa will either generate one waste stream or no waste streams. The complete list of materials generated and an assessment of whether the materials are waste or not is presented below in Table 5-1.

Table 5-1: Disa Materials Output and Waste Designation

Material	Radioactive Waste (Y/N)	Rationale
Isolated Mineral Fraction	Both	Yes, if the material is disposed of a low-level radioactive waste. No, if the material is utilized as alternate feed.
Clean Coarse Fraction	No	Material is inert and can be used onsite for reclamation.
Water	No	Water is treated to 10 CFR 20, Appendix B standards and discharged.
Water Treatment Solids	Both	Yes, if the material is disposed of a low-level radioactive waste. No, if the material is utilized as alternate feed.

A review of Table 5-1 indicates that two streams could be radioactive waste is the customer mandates that materials be disposed at a low-level radioactive waste facility instead of being utilized as alternate feed. Regardless of the final fate of all streams, Disa's radioactive waste management program will consist of transporting the product at a licensed uranium recovery facility, treating and discharging water, or transporting liquids and solids to licensed disposal facilities. Liquids treatment will be designed to meet

10 CFR Part 20, Appendix B effluent standards, and Disa will not discharge treated water directly to surface water. Waste will be managed in accordance with Disa SOP ***Radioactive Materials and Waste Storage***.

Isolated mineral fraction will be collected in a lined dump trailer or lined roll-off container and stored in restricted areas, under the direct control of the FSM and AUs. Disposal/utilization of source material will be through commercial licensed waste disposal facilities. The primary destination for all source material a licensed uranium recovery facility, for utilization as an alternate feed. In the event a licensed uranium recovery facility not available, then the source material will be disposed at a licensed, low-level radioactive waste disposal facility. Collection, packaging, labeling, and transportation of wastes will be in accordance with USDOT regulations. The RSO, ARSO, or FSM are responsible for oversight of proper waste packaging, labeling, transportation, and disposal record maintenance.

Contaminated liquids will be stored in the Process Water Tank. The primary option for disposing of contaminated water is to treat the water, collect samples, and release the water to the ground surface. If this is not possible, water will be transported to a licensed disposal facility. The total amount of water utilized for each project varies based on the size of the HPSA unit deployed. Each unit that is deployed will be engineered to use as little water as possible. Water loss occurs during the dewatering stage as moisture in the isolated mineral fraction and the clean coarse fraction (~20%). Therefore, water is added on a continuous basis. Because dewatering will involve filter presses and centrifuges, no free liquids will remain in the clean coarse fraction.

If Disa chooses to discharge the water, the amount of radioactivity that can be discharged will be determined from 10 CFR 20, Appendix B effluent standards. Water samples will be analyzed during each project to determine compliance with the Appendix B standards. Disa will only discharge water that complies with the effluent standards and will not discharge any water to surface water bodies. Records of the disposal will include dates, radionuclide concentrations, and other constituent concentrations (as needed) based on the analysis of treated water.

Disa will secure the offsite shipment of all source material and liquid waste prior to completely demobilizing from a project site. No long-term storage of source material or liquid waste will occur at a project site. When disposing/utilizing source material or liquid waste offsite, Disa will verify that the licensed recipient is authorized to receive the radioactive material prior to shipping. Disa will provide all information required in NRC's Uniform Low level Radioactive Waste Manifest and transfer this information to the recipient. Disa will also obtain the necessary permits from the Rocky Mountain Low Level Radioactive Waste Board to export radioactive waste, if necessary.

Material and equipment that has been decontaminated will be surveyed for unrestricted release and/or disposal in an authorized disposal facility. All radioactive material signs will be removed or obliterated from material and equipment that have been released prior to disposal.

5.15 General Guidelines for Waste Management

1. All radioactivity labels must be defaced or removed from containers and packages prior to disposal into ordinary "non-radioactive" waste streams. If waste is compacted, all labels that are visible in the compacted mass must be defaced or removed.
2. Remind workers that nonradioactive waste, such as leftover reagents, boxes, and packaging material, should not be mixed with radioactive waste.
3. Radioactive waste must not be stored near explosive materials.

4. Occasionally review all procedures to ensure that radioactive waste is not created unnecessarily. Review all new procedures to ensure that waste is handled in a manner consistent with established procedures.
5. In all cases, consider the entire impact of various available disposal routes. Consider occupational and public exposure to radiation, other hazards associated with the material and routes of disposal (e.g., toxicity, carcinogenicity, pathogenicity, inflammability), and costs.

5.16 Records and Reports

Records of radiological monitoring, surveys, exposures, calibrations, reports, inspections, training, investigations, corrective actions, and records of reports shall be maintained according to requirements in 10 CFR 20 and 40.

5.16.1 Personnel Exposure and Dosimetry Records

Personnel records will be maintained for the life of the company, and personnel may review their file or request copies of information within their files. The licensee for which work is performed will be provided individual exposure information as required by their license or applicable regulations. The personnel records that will be maintained include:

- A record of individual radiation exposure received during previous employment will be maintained by requesting personal exposure information from previous employers where the individual worked with radioactive materials.
- A record of personnel dosimetry results during the course of Disa work assignments.
- If a personal dosimeter is lost or damaged, an exposure investigation will be performed, and an exposure will be assigned for the monitoring period.
- If the air concentration in the work area exceeds 10% of applicable 10 CFR 20, Appendix B DAC values, air samples and bioassay samples may be used to estimate and document internal exposures received by the worker.

5.16.2 Survey Records

Survey records collected during site surveys, remediation/decontamination activities, and radiological characterization activities will be maintained by the project radiation safety staff.

5.16.3 Waste Disposal and Material Transfer

Radiation survey records, shipping manifests and certifications generated for a licensee's shipment of radioactive materials to a licensed disposal site shall be maintained by the project radiation safety staff.

5.16.4 Reporting to the NRC

The NRC staff will be notified of defects and non-compliance in accordance with Table 5-2. This table provides notification time frames for both telephone notification and written report.

Table 5-2: Reporting Requirements for NRC Notification

Event	Telephone Notification	Written Notification
Theft or loss of material	Immediate	30 days
Whole body dose greater than 0.25 Sv (25 rem)	Immediate	30 days
Extremity dose greater than 250 rem	Immediate	30 days
Whole body dose greater than 5 rem	24 hours	30 days
Extremity Dose greater than 50 rem	24 hours	30 days
Dose to an individual member of the public greater than 100 mrem	None	30 days
Defect in equipment that could create a substantial safety hazard	2 days	30 days
Filing a petition for bankruptcy under 11 U.S.C.	None	Immediately after filing petition
Expiration of License	None	60 days
Decision to permanently cease all licensed activities at an entire site	None	60 days
Decision to permanently cease licensed activities in any separate building or outdoor area that is unsuitable for release for unrestricted use	None	60 days
No principal activities conducted for 24 months at an entire site	None	60 days
No principal activities conducted for 24 months in any separate building or outdoor area that is unsuitable for release for unrestricted use	None	60 days
Event that prevents immediate protective actions necessary to avoid exposure to radioactive materials that could exceed regulatory limits	Immediate	30 days
Equipment is disabled or fails to function as designed when required to prevent radiation exposure in excess of regulatory limits	24 hours	30 days
Unplanned fire or explosion that affects the integrity of any licensed material or device, container, or equipment with licensed material	24 hours	30 days

5.16.5 Standard Operating Procedure List

Table 5-3 contains a list and a description of the standard operating procedures. This list may be updated as necessary for additional SOPs. SOPs may be updated and revised via RSO/ARSO approval. Appendix C contains the SOPs.

Table 5-3: Standard Operating Procedures

Title	Summary of Content
ALARA	Program and methods for reducing exposures to ionizing radiation and radioactive material to levels that are as low as reasonably achievable (ALARA)
Operational Checkout of Single-Channel Detector with Meter	Instructions ensuring instruments are operating appropriately.
Operational Checkout of Dual-Channel Alpha/Beta Detector with Meter	Instructions ensuring instruments are operating appropriately.
Guidelines for Handling Radioactive Material	Instructions for handling and using licensed materials.
Radiological Area Access and Posting	Steps to control access to work sites and appropriate posting and signage requirements.
Radiation Contamination Surveys and Decontamination	Methods for conducting radiological contamination surveys for personnel and equipment and appropriate decontamination methods.
Emergency Response	Steps to take and whom to contact when an emergency occurs.
Air Sampling	Procedure for collecting general air sampling and breathing zone air samples.
External Dosimetry	Instructions for issuing and exchanging TLDs / OSLs and dose result handling.
Shipping UN2910 Radioactive Material	Instructions for shipping radioactive materials (e.g., samples) as UN2910, Radioactive Materials, Excepted Package – Limited Quantity of Material.
Transport of Uranium Source Material as LSA-1	Instructions for conducting required surveys to support haul trucks transporting uranium source material as LSA-1 material.
Removable Contamination Swipe and Air Sampling Filter Analyses	Instructions for counting of removable contamination swipes and air sample filters.
Radioactive Materials and Waste Storage	Guidance for storage of radioactive materials and wastes including segregation of materials.
Radiation Safety Training	Describes radiation safety training requirements.
Radioactive Material Receipt	Instructions for surveying and opening radioactive packages upon receipt.
Site Mobilization and Demobilization	Instructions for mobilizing equipment and demobilizing equipment from each site.

5.16.6 Additional Protocol

Pursuant to 10 CFR 40.31, Disa will provide the required information for the Additional Protocol. Required information for the Additional Protocol is found in 10 CFR 75.11, and Form DOC/NRC AP-1 will be used to document this information.