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2 ALTERNATIVES

2.1 DESCRIPTION OF ALTERNATIVES

NRC regulations 10 CFR Part 51 and guidance at NUREG-1569 require this chapter to provide realistic alternatives to the Proposed Action of the proposed Ludeman Project (proposed project). These alternatives include but are not limited to (1) the No-Action Alternative; (2) the Proposed Action; (3) reasonable alternatives although deemed not suitable.

Currently, the process of evaluating potential alternatives within the confines of the 10 CFR Part 51 involves the consideration of two (2) types of alternatives: (1) primary and (2) secondary.

For purposes of this ER, the alternatives assessed, and the data and analyses included herein are identical to those discussed in Section 8 of the TR.

2.1.1 No-Action Alternative

Under the provisions of the National Environmental Policy Act (NEPA), as implemented by NRC in 10 CFR Part 51, Uranium One is required to assess the No-Action alternative. Under the No-Action alternative, NRC would not approve the Proposed Project combined Source and 11e.(2) Byproduct Materials License Application to construct, operate, and decommission the Proposed Project. Uranium ISR would not occur at the Proposed Project site and, accordingly, none of the associated potential impacts identified and analyzed as part of the Proposed Action would occur.

The No-Action alternative will result in significant negative financial impacts to Uranium One, and the loss of significant financial benefits to Converse County, Wyoming and the surrounding communities. Uranium One has invested significant resources to develop the Proposed Project that will be irretrievably lost under the No-Action alternative. In addition, the No-Action alternative will adversely affect the economic growth of Campbell Natrona and Converse Counties. As discussed in further detail in ER Section 8, the Proposed Project is expected to provide significant positive economic impacts to the local and State economies, including stakeholders with which Uranium One has surface leases and which own the mineral rights in the Proposed Project area.

A decision to not issue an NRC combined Source and 11e.(2) Byproduct Materials License to Uranium One would leave a large resource unavailable for domestic energy production. Uranium One is continuing to develop estimates of the reserves at the proposed Ludeman Project and currently estimates the resource is 6.3 million pounds of uranium.

According to the U.S. Energy Information Administration (EIA), the total domestic production of U_3O_8 in the first quarter of 2011 was only 1.06 million pounds, down 7 percent from the previous quarter. In 2010, total domestic production was only 4.23 million pounds in contrast with domestic demand for approximately 47 million pounds U_3O_8 (EIA 2011). The proposed project represents an important new source of domestic uranium supplies that are essential to provide a continuing source of fuel to power generation facilities. This additional domestic uranium production will help alleviate U.S. dependency on foreign suppliers located in Canada, Russia, Kazakhstan and Australia among others.

Under the No-Action Alternative, baseline conditions will be influenced by natural processes and by other industrial, commercial, and residential development in the area. Groundwater in the ore-bearing zone will remain unsuitable for drinking due to the high levels of naturally occurring radionuclides and other constituents described in Section 2.7 of the TR.

2.1.2 Proposed Action

As described in Section 3 of the TR, the Proposed Action involves Uranium One utilizing ISR processes and methodologies to recover uranium from known ore bodies. The ISR process is accomplished by installing a series of injection and production wells. Utilizing the injection wells, a carbonate leaching solution, or barren lixiviant, is injected into the ore body. To promote flow across the mineralized areas, corresponding production wells are used to pump water from the ore body, and allow for the collection of the uranium bearing carbonate leach, or pregnant lixiviant, solution. Once the pregnant lixiviant reaches the Satellite facility, the uranium is removed from the lixiviant through the use of pressurized downflow ion exchange (IX) columns. Once the resin in an individual exchange column can no longer hold additional uranium molecules, the resin from that vessel is moved to another vessel where the uranium molecules are eluted from the resin. After the elution process is complete, the resin is moved back into the ion exchange column and re-introduced to the ion exchange process. After the lixiviant has passed through the ion exchange system, the solution is re-fortified with a concentrated carbonate solution, making barren lixiviant, and can then be recycled to the injection wells for further uranium recovery.

The next phase of the process is the further concentration of the uranium rich solution to create a marketable product. Uranium from ion exchange resins at the proposed Ludeman Satellite facilities will be transported and subsequently processed at the Willow Creek Central Processing Facility, located in Johnson County. This is accomplished by precipitating the dissolved uranium out of the eluant solution, dewatering the uranium solids, and drying the uranium slurry. The dried uranium product, yellowcake, is then packaged to allow safe transportation.

Initial wellfield(s) for the Proposed Action are developed concurrently with construction of the proposed Satellite facility and ancillary ISR facilities. Groundwater restoration will take place in the initial wellfield(s) when the uranium resource has been adequately depleted and, simultaneously, additional sequential wellfield developed will occur. The goal of groundwater restoration will be to return the concentration of an identified constituent in the production zone to an NRC-approved background concentration or to a relevant Maximum Concentration Limit (MCL), whichever is higher, or to an Alternate Concentration Limit (ACL) approved by NRC pursuant to 10 CFR Part 40, Appendix A, Criterion 5(B)(5) using Best Practicable Technology (BPT). Successful groundwater restoration was demonstrated within the proposed project area by the Leuenberger pilot ISR facility. A detailed description of the Proposed Action is presented in Section 3 of the TR.

Following groundwater restoration activities, all injection and recovery wells will be reclaimed using mandated plugging and abandonment procedures. In addition, a sequential land reclamation and re-vegetation program will be implemented on the site. This surface reclamation (i.e., decommissioning and decontamination (D&D) will be performed on all disturbed areas, including the Satellite facilities, wellfields, ponds and roads such that upon license termination, the site will be released for unrestricted use. Uranium One will maintain financial responsibility for groundwater restoration, facility decommissioning and surface reclamation until NRC approves license termination and site release. Financial assurance is discussed in Section 6 of the TR.

2.1.3 Reasonable Alternatives Considered But Rejected

2.1.3.1 Conventional Uranium Milling and Underground Milling

As a part of the alternatives analysis conducted by Uranium One, three uranium recovery alternatives were considered:

1) Underground mining with conventional milling facilities;

2) Open pit mining with conventional milling facilities; and
3) Underground and open pit mining with heap leach facilities.

These represent the three currently available alternatives to ISR operations for uranium deposits in the Proposed Project area. These alternatives were eliminated based on economics, potential health, safety, and environmental impacts.

Conventional uranium recovery methods are less suitable for the recovery of lower grade ores due to the significant capital costs associated with the construction and operation of a conventional mine and associated mill. Further discussion of conventional mining/milling methods is provided below.

2.1.3.2 Open Pit Mining

Open pit mining requires the removal of all material covering the orebody. This overburden must be removed and stockpiled to allow removal of the uranium-bearing ore. Once removed, the ore must be transported to a conventional uranium mill for further processing and uranium extraction.

Open pit mining of the relatively low grade proposed project ore would require a capital investment that is not supported by the current uranium market. The nearest conventional mill with an operating license that could receive uranium ore for toll milling is the Denison Mines White Mesa Mill located in Blanding, Utah, nearly 600 miles away. The combination of capital costs to develop an open pit mine at the proposed project, the operating and maintenance costs to mine the ore, and the transportation costs to Blanding, Utah far exceed the current value of the ore as a feedstock for White Mesa. The nearest conventional uranium mill, Kennecott Uranium Corporation’s Sweetwater Mill, located in the Great Divide Basin in Wyoming, is currently licensed for operations but is on standby status. However, if the Sweetwater Uranium Mill was currently licensed for operation, similar economic factors would preclude mining the proposed project deposit under current and future reasonably projected uranium market conditions.

In addition to the economic factors, environmental factors associated with open pit mining must also be considered. Open pit mining produces large piles of byproduct rock and, even with reclamation, would permanently alter the topography of the Proposed Project site. In addition, substantial dewatering of the pit on the order of several thousand gpm would be required to depress the potentiometric surface to allow mining. Large quantities of groundwater with naturally elevated ^{226}Ra and uranium would be discharged requiring treatment and necessary subsequent disposal of a radioactive solid 11e.(2) byproduct. Moreover, large volumes of groundwater would be consumed by this necessary dewatering process.

2.1.3.3 Underground Mining

Underground mining of the Proposed Project deposit would involve sinking mine shafts to the vicinity of the orebodies, horizontally driving crosscuts and drifts to the ore bodies at different levels, physically removing the ore and transporting the mined ore to a conventional uranium mill for further processing. The economic factors involved with this alternative are similar to those for ores mined from an open pit; although depending on depth to the deposit can be significantly more costly and dangerous for workers.

Additionally, from an environmental perspective, underground mining in conjunction with the associated milling process involves significantly higher risks to employees, the public, and the environment. Radiological exposure to the personnel in these processes is increased, not only from the mining process but also from milling and the resultant mill tailings. The milling process generates a significant amount of waste relative to the amount of ore processed. Extensive mill tailings impoundments are needed for the disposal of these wastes. The potential non-radiological health and safety risks to workers as well as the environmental impacts associated with underground mining are recognized as being considerably greater than those associated in ISR operations.

2.1.3.4 Heap Leaching

As an alternative to conventional milling, uranium is extracted from low-grade ore by heap leaching. This may be done if the uranium content is too low for the ore to be transported to and economically processed at a uranium mill. The low-grade ore is crushed ore then mounded above grade on a leaching pad with a liner. The heap leaching pads must be constructed with the same standards as conventional mill tailings impoundments including a double liner per 10 CFR Part 40, Appendix A. A sulfuric or alkaline leaching agent is introduced on the top of the pile via a sprinkler or drip system which percolates down until it reaches the liner below, where it is captured and pumped to a processing facility. After completion of the leaching process (within months to years), the leached ore is either left in place, or removed to a disposal site, and new ore is placed on the leach pad (so-called on/off scheme, or dynamic heap leaching). Though impacts from heap leaching may be less than those from conventional mining, the impacts from an associated underground or open pit mine remain substantial. For these reasons, this alternative was deemed not suitable for the Proposed Project.

2.1.4 Satellite Facilities versus Central Processing Facility

Shipping uranium-laden resin is a standard industry practice for Satellite facilities in conjunction with central processing facilities. However, the option of processing and drying on site versus shipping resin for processing and drying to a CPP was eliminated for the following reasons:

- Environmental Health and Safety: A CPP will potentially create more 11e.(2) and non-11e.(2) wastes than a Satellite facility. This would require more waste to be transported and disposed at a licensed facility; and
- Operating Cost: The costs associated with the construction and operations of a CPP outweigh the costs associated with that of a Satellite facility. Uranium One's Willow Creek CPP has the capacity for toll processing of resin which will make the construction of a CPP for the proposed Ludeman Project gratuitous.

2.1.5 Multiple Satellite Facilities versus One Satellite Facility

The number and location of satellite facilities was evaluated from the standpoint of both potential economic and environmental impacts. Three separate locations within the project boundary were identified as candidates for siting of the facilities. The number of satellites was also compared with options for either three smaller satellite facilities or one larger facility. Based on this review it was determined that one a single larger facility at one location would both be more economic and also create less potential environmental impacts.

- Economic: A single facility will require less capital investment and may be constructed faster than three separate facilities maximizing opportunity to react to market conditions.

Environmental: A single facility would have less long term impacts as a single site would be disturbed. Less access road and utilities would need to be built to service a single facility. These benefits would be greater than the negative short term impacts of running trunk lines from the single satellite facility to the wellfields, which would allow recovery from those areas without building the additional satellites.

2.1.6 Lixiviant Chemistry

Uranium One proposes to use a sodium bicarbonate lixiviant which is an alkaline solution. Where the groundwater contains carbonate, an alkaline lixiviant mobilizes fewer potentially deleterious constituents from the ore body and requires chemical addition than an acidic lixiviant. Also, test results at other, similar uranium ISR projects indicate only limited success with acidic lixiviants, while the sodium bicarbonate has proven highly successful at commercial ISR recovery operations in Wyoming to date. Another alternate leach solution is an ammonium carbonate solution which has been used in ISR programs at other locations; however, operators have experienced difficulty in restoring and stabilizing the aquifer. Therefore, these solutions were excluded from Uranium One consideration for the Proposed Project.

2.1.6.1 Acidic Leach Solutions

Acid-based lixiviants, such as sulfuric acid, have been used in the United States and are widely used internationally. Acid leach has historically produced a majority of the world’s ISR production. Acid-based lixiviants generally achieve a higher degree of recovery (70-90%), better leaching kinetics, and a shorter leaching period. However, acid-based lixiviants dissolve heavy metals and other solids associated with uranium in the host rock and other chemical constituents that may require additional remediation (International Atomic Energy Agency, 2001).

In the United States, acid-based lixiviants have been used only for small-scale research and development operations. At the Nine Mile test site in Wyoming, test patterns were developed using acid-based and carbonate-based lixiviants. The acid-based pattern developed two significant problems. During uranium recovery operations, gypsum precipitated on well screens and within the aquifer, plugging wells and reducing the efficiency of wellfield circulation. Restoration efforts had limited success, apparently due to gradual dissolution of the precipitated gypsum following restoration, resulting in increased salinity and sulfate levels in the affected groundwater (Mudd, 2000).

The commercial use of alkaline lixiviants in the United States has been related to the need to restore affected groundwater and alkaline mine sites are recognized to be technically easier to restore. For this reason, a commercial ISR facility using an acid-based lixiviant has not been developed in the United States and Uranium One determined an acid-based lixiviant was not a suitable alternative for the Proposed Project.

2.1.6.2 Ammonia-based Lixiviants

Ammonia-based lixiviants have been used in the United States, in Texas and Wyoming. However, operational experience has shown ammonia tends to adsorb onto clay minerals in the subsurface and then desorbs slowly from the clay during restoration, therefore requiring that a much larger volume of groundwater be removed and processed during aquifer restoration (Mudd, 2000). In addition, concerns arose in the early 1980s over the potential post mining oxidation of ammonia in the groundwater to form nitrate and nitrite species. When combined with the slow desorption from clay this potential difficulty resulted in a movement away from ammonia-based lixiviants including an outright ban on their use in Texas. Due to the additional consumptive use of groundwater to meet groundwater restoration requirements, Uranium One determined that an ammonia-based lixiviant is not a suitable alternative for the proposed project.

2.1.6.3 Other Potential Lixiviants

Other lixiviants which have been evaluated in laboratory scale and limited field tests include potassium based lixiviants, a range of oxidants including air, iodine, potassium permanganate, and a variety of trace additives such as clay stabilizing agents to increase the selective oxidation and mobilization of uranium minerals. To date, these alternatives have consistently proven to be far less economical than the planned oxygen-sodium bicarbonate system.

2.1.7 Groundwater Restoration

The groundwater restoration techniques proposed by Uranium One have been successful at other ISR operations in Wyoming. Groundwater sweep, permeate/reductant injection and groundwater treatment have successfully restored the groundwater to pre-mining quality or designated regulatory limit. No practicable alternative(s) to the groundwater restoration method noted herein currently is available. The NRC and the WDEQ consider the method currently employed as the Best Practicable Technology available.

2.1.8 Alternate Waste Management Options

Liquid 11e.(2) byproduct generated from production and restoration activities generally are managed at ISR facilities by solar evaporation ponds, deep well injection, land application or some combination thereof. The combined use of evaporation ponds and surface water discharge is considered by Uranium One to be the best alternative to dispose of these types of byproducts. The three alternatives considered for 11e.(2) byproduct disposal at the Ludeman project include:

- Combined evaporation/permeate ponds and land application (Proposed Action);
- Combined evaporation/permeate ponds and deep disposal wells (Alternative 1); and
- Deep Disposal Wells and associated surge ponds (Alternative 2).

Uranium One has considered a wide range of liquid treatment/disposal methods for use at the proposed project. The alternatives analysis considered three primary waste streams from ISR operation:

- Facility eluant;
- Wellfield purge water; and
- RO reject produced during wellfield restoration.

A "design basis influent" was developed for the three typical ISR wastewater streams to be managed as well as the projected water quality characterization for blending the waste streams. The alternatives analysis was completed stepwise with the development of a common evaluation basis, screening of potentially applicable treatment technologies, development of candidate treatment trains, and technical and cost evaluation of the treatment trains. The initial screening of treatment technologies included evaluation of each technology for implementability, flexibility, maintainability, and relative capital and operating costs. The retained technologies were developed into treatment options and then the comparative evaluation of each option was conducted in parallel for each waste stream. Both capital and annual operating costs were developed for each option in order to calculate a net present value. The costs developed were comparative order-of-magnitude estimates intended for comparison purposes and were based on an ISR model case that could then be scaled to a particular operation. Costs that were common to all options such as regulatory reporting, project management, and administrative costs were not included.

Land application is practicable and historically has been used at some ISR facilities as a wastewater treatment/disposal method, generally in conjunction with deep well disposal and/or spray/solar evaporation. Discharge water will be treated through a RO system to meet surface water quality standards and soil concentration limits prior to land application. This will prevent potential for future environmental liability due to accumulation of contaminants in the soil or groundwater below the land application surface area.

The following discussion provides a description of each treatment/disposal method considered and the relevant characteristics that led to the selection of deep well injection as the preferred alternative.

2.1.8.1 Deep Well Disposal

Deep well injection is permitted primarily on the condition that potential Underground Sources of Drinking Water (USDW) cannot be adversely impacted by disposal operations, rather than by the quality and characteristics of the liquid 11e.(2) byproduct injected. NRC, however, requires characterization of the liquid 11e.(2) byproduct stream with respect to worker health and safety and analyses of potential consequences of leaks or spills. Accordingly, deep well "discharge standards" as incorporated into a permit are based on the mine operator's characterization of the liquid 11e.(2) byproduct stream. This method was considered potentially suitable for all ISR liquid 11e.(2) byproduct streams.

Approval for deep well injection permits has been under increased scrutiny by the public and state agencies recently. As a result there are uncertainties regarding operating pressures and the correlated injection rates, making the deep disposal wells a high risk option as anticipated disposal capacities by deep disposal well option is questionable. The costs associated with installing additional wells to make up for reduced injection rates further reducing the viability of this option. Uranium One has therefore decided that deep disposal wells is not a preferred alternative for liquid 11e.(2) byproduct disposal.

2.1.8.2 Mechanical Evaporation

Mechanical evaporation utilizing equipment that requires either gas or electric power was considered. Evaporation is energy-intensive, but produces the smallest possible volume of liquid 11e.(2) byproduct for disposal. Disposal costs per unit volume can be evaluated against the evaporator operations cost to determine the economic viability of evaporation as a post-treatment step. For this evaluation it is assumed that a volume reduction of approximately 95% is achieved. This method was considered potentially suitable for all ISR liquid 11e.(2) byproduct streams.

2.1.8.3 Chemical Precipitation and Reverse Osmosis

Chemical precipitation and reverse osmosis which can utilize the chemical precipitation step to either pre-treat the wastewater for more efficient operation of the reverse osmosis system or use the chemical precipitation step to treat the brine was considered. Both brine residual and sludge are formed. This method was considered potentially suitable for all ISR liquid 11e.(2) byproduct streams.

2.1.8.4 Spray/Solar Evaporation

Spray/solar evaporation utilizing natural evaporation and enhancing the rate by spraying water to increase the surface area, which was assumed to provide a 95 percent volume reduction for this evaluation, is considered a preferred alternative for this project. The evaporation rate and length of the evaporation season was considered in parallel with the flow rate of water to be treated. Evaporation pond size was adjusted to consider flow rates in the locations high evaporation rate climate. If sprayers are used for evaporation enhancement, overspray due to high winds is easily managed with automatically adjusting sensory controls. Additional considerations with evaporation ponds include windblown accumulations of dust and dirt, and the eventual need to remove salts and accumulated solid 11e.(2) byproduct material.

Table 2-1 provides a summary of the technical and cost evaluation of candidate water treatment and management options for a combination of the process wastewaters. For each of the alternatives considered, the table lists the advantages and disadvantages, the chemicals required, residues storage capacity, required offsite shipments, power requirements, labor requirements, environmental and safety considerations, capital cost, and 20-year Net Present Value (NPV). For capital cost and 20-year NPV, the deep disposal well alternative is considered the base case and the capital cost and 20-year NPV for the other alternatives are scaled from it.

As shown by Table 2-1, the NPV for the Deep Well Alternative and the Spray/Solar Evaporation Alternative were the most favorable (lowest estimated life cycle cost), with the Deep Well Option as the lowest overall cost. The Deep Well option presents additional environmental, safety and health benefits including the following:

- Minimize worker exposure to concentrated brine streams that may contain uranium and byproduct material;
- Minimize the required footprint and therefore land disturbed by the system;
- Minimize the residual, either solid or liquid, stored onsite and also shipped offsite. There is no offsite transportation of residual required with a deep well; and
- Minimize the requirement for chemicals and other commodities.

Based on this comparative evaluation the spray/solar evaporation water management alternative for ISR wastewater provides clear economic and environmental advantages. All solid wastes will be properly managed.

2.1.9 Uranium Processing Alternatives

2.1.9.1 Higgins Loop

In coordination with the NRC GEIS, Uranium One's Proposed Action includes the use of pressurized down-flow ion exchange system. With this ion exchange system the radon present in the barren recovery solution is forced back underground in the re-fortified groundwater which, thereby, provides for significantly reduced potential for occupational and/or public exposure to radon and its progeny of pressurized down-flow ion exchange columns.

An alternative considered by Uranium One was to utilize a Higgins Loop ion exchange system. The Higgins Loops is a closed-loop system in which uranium-laden resin advances through the system in the different stages of adsorption, backwash, regeneration, and rinse in preparation for another adsorption cycle. The ion exchange system is a vertical cylindrical loop, containing a packed bed of resin that is separated into four operating zones by butterfly, or "loop" valves. These operating zones, adsorption, regeneration, backwashing and pulsing, function like four separate vessels thus increasing the resin loading efficiency.

The Higgins loop resin exchange process is disadvantageous as it results in significant attrition of the resin. The flow system used to load and strip the resin of uranium generates a significant back pressure. The back pressure results in excessive compressive forces on the resin itself and results in damage to the resin particles. The damage resin particles will often increase the back pressure in the system, resulting in accelerated damage to the resin. Additionally, the cycling of the resin between the loading chamber and the stripping chamber results in damage to the resin as the resin particles experience significant physical impact with other resin particles, the chamber walls and plumbing, valves, etc. The damage to and loss of the resin results in significant additional costs for replacement resin. If it is determined that advances in resin and valve technologies negate the damage to the resin this process alternative may be re-evaluated and potentially implemented.

2.1.9.2 Central Processing Facility

At a Central Processing Facility ion exchange resin loaded with uranium is pumped into the elution (stripping) column. The resin is then treated with eluant (stripping solution) composed of water, salt (to add chloride) and soda ash (to maintain high pH and carbonate levels). The uranium on the resin is exchanged for the chloride ions in the stripping solution and is complexed by the carbonate. It is then precipitated from the stripping solution with hydrochloric acid and ammonia. The resulting uranium bearing slurry is washed, dewatered and dried

Uranium One will utilize the Willow Creek Central Processing Facility (SUA-1341) for further processing of uranium loaded resin produced from the proposed Ludeman Satellite facility. The use of these Central Processing facilities led to the selection of a Satellite facility as the preferred alternative for the proposed Ludeman Project.

Table 2-1: Treatment Alternatives Comparative Evaluation Matrix – 150 gpm ISR Wastewater

Evaluation Factor	Deep Well	Mechanical Evaporation	Chemical Precipitation/RO	Spray/Solar Evaporation	Land Application
Advantages	No residuals so no onsite storage or offsite transport required, no concentrated chemicals required, minimal operating requirements, minimal space requirements, disposal rate dependent upon injection pressures and formation properties.	Produces very low volume brine for disposal or further processing by solidification or to dry salt for zero liquid discharge, produces treated water with essentially zero contaminants (distilled water), can be operated campaign style.	Broadly applicable to metals and common anion contaminants, chemical precipitation pretreatment allows operation of RO system to produce less brine, produces high quality treated water stream for reuse or discharge.	Primary treatment is simple system consisting of ponds, pumps, piping and nozzles. No complicated equipment, low capital cost. Commonly used for management of brine in arid climates. Can allow complete evaporation to dryness or remove low volume brine for solidification and offsite disposal.	Primary treatment is simple. Low capital cost. Capable of treating large quantities for low energy input.
Disadvantages	Site geology will dictate feasible disposal flow rate. Site hydrogeology (presence of potential drinking water aquifers) will dictate disposal well depth. Permitting process may be lengthy. Attention to water chemistry and need for antiscalent is required to minimize wellscreen scaling and fouling issues. Changes in water chemistry may require re-permitting. No recovery of treated water.	Long equipment lead, distillate is corrosive and would need conditioning for reuse or discharge, high capital and power cost, concentrates radionuclides into the evaporator brine by 20 times or more.	Produces both liquid and solids residues with higher volume liquid residues that other options. Highest labor. Requires bulk concentrated chemicals. Highest truck traffic of options evaluated for chemical deliveries and residuals transport.	Weather may impact evaporation rates. Controls must be implemented to prevent birds and other wildlife from contacting water Evaporation ponds require more land surface space than some alternatives.	Land application is restricted to restoration water. Precautions must be taken to prevent ground and surface waters.

Evaluation Factor	Deep Well	Mechanical Evaporation	Chemical Precipitation/RO	Spray/Solar Evaporation	Land Application
Chemicals Required	None to minimal. Antiscalent may be required depending on water characteristics.	Minimal for evaporator and limited to antiscalent compounds and some cleaning products. Lime, soda ash, and polymer required for solidification.	Lime Concentrated acid Polymer, antiscalent and RO cleaning chemicals. Lime, soda ash and polymer for solidification.	Lime, soda ash, and polymer for solidification.	None to minimal.
Environmental /Safety	Small carbon footprint with low operating power requirement and no truck traffic. No residuals stored onsite, no potential for wildlife exposure to holding ponds. No requirement for chemicals. No potential exposure to concentrated residues.	Large carbon footprint with over 10 times the power requirement of a deep well and 20 times the power requirement of the RO/precipitation option. Requires high operating temperatures and pressures. Low to moderate footprint primarily for brine storage tanks. Requires storage of brine as feed to solidification system and offsite transportation of solidified brine stream. High chemical requirements for solidification chemicals. High operating temperature and pressure.	Moderate carbon footprint with the lowest operating power requirement but the most truck traffic of any option evaluated. Handling of highest quantity of residues required including onsite storage and offsite disposal. Higher labor requirements with more potential for exposure to chemicals and residuals during sludge dewatering operations and residuals management.	Low carbon footprint with similar power required to a deep well and some truck traffic for offsite brine disposal. Uses solar and wind energy to efficiently evaporate liquids from the 11e.(2) byproduct. Low potential for wildlife exposure from ponds provided mitigations are properly implemented.	Low carbon footprint. Beneficial use to wildlife of irrigated vegetation. Low potential for ground or surface water impacts

2.2 COMPARISON OF THE PREDICTED ENVIRONMENTAL IMPACTS

As discussed above, Uranium One has identified and developed the Proposed Action as the best approach to recovering uranium resources from the proposed project. Table 2-2 provides a summary of the potential environmental impacts for the No-Action Alternative (Section 2.1.1), the Proposed Action (Section 2.1.2), and the reasonable alternatives considered but rejected (Section 2.1.3). The predicted impacts for the Uranium One recovery alternatives discussed in this section are not included for comparison because these alternatives were eliminated due to potential significant environmental and economic impacts. Section 4 of this ER provides a more detailed discussion of potential environmental impacts of the Proposed Action and No-Action Alternatives.

Table 2-2: **Comparison of Predicted Environmental Impacts**

Potential Impact	Alternative	Potential Impacts
Potential Land Surface Impacts	Proposed Action	Surface disturbance will range from short term for construction of well pads and utility corridors that will be reclaimed after construction to long term for roads, buildings, parking areas, and evaporation/permeate ponds evaporation ponds and/or land application areas that will remain until final D&D. All disturbance will be reclaimed to be suitable for pre-construction uses.
	No Action	None
	Conventional Mining/Milling Including Heap Leach	Open-pit mining would result in significant surface disturbance due to the pit overburden stockpiling and would create permanent topographic changes, increase fugitive dust, and the potential for subsidence. Both heap leaching and open-pit mining methods require crushing the ore and disposing of the tailings, creating long term or permanent 11e. (2) byproduct material.
	CPP versus Satellite Facility	Satellite facility would result in a smaller surface disturbance due the smaller facility size than the proposed central processing facility.
	Use of Alternate Lixiviants	Same as Proposed Action
	Alternate Waste Management	Disposal in surge ponds would result in slightly less surface disturbance than the proposed evaporation/permeate ponds.
	Uranium Processing Alternatives	Same as the Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Land Use Impacts	Proposed Action	Small impacts on agricultural production (livestock grazing) and hunting on controlled areas for duration of the Proposed Project.
	No Action	None
	Conventional Mining/Milling Including Heap Leach	Area used for pit, ramps, haul roads, overburden stockpiles, and topsoil stockpiles would be restricted from any other uses for the duration of the proposed project.
	CPP versus Satellite Facility	Same as Proposed Action
	Use of Alternate Lixiviants	Same as Proposed Action
	Alternate Waste Management	Same as Proposed Action although less land use impact from installation of deep disposal wells/surge ponds.
	Uranium Processing Alternatives	Same as Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Transportation Impacts	Proposed Action	Approximately 40 acres will be disturbed to construct infrastructure access roads. A small risk of spills of process chemicals and small quantities of 11e. (2) byproduct material during the project life.
	No Action	None
	Conventional Mining/Milling Including Heap Leach	Conventional mining methods would require more employees which will increase traffic on local roads.
	CPP versus Satellite Facility	A Satellite facility would increase the traffic volume due to the shipment of loaded resin to a central processing facility
	Use of Alternate Lixiviants	Same as Proposed Action
	Alternate Waste Management	Same as Proposed Action
	Uranium Processing Alternatives	Same as Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Geology and Soil Impacts	Proposed Action	No significant impacts on geology. Approximately 909 acres will be disturbed for construction of infrastructure. Topsoil will be stockpiled and seeded with a temporary seed mix to protect from erosion until it is replaced during reclamation. Once replaced the soil will be revegetated and support pre-construction land use.
	No Action	None
	Conventional Mining/Milling Including Heap Leach	Open pit mining would have significant impacts on geology and soil since all overburden from the surface to the ore zones would be removed. The overburden would be stockpiled and seeded with a temporary seed mix to protect form erosion until replaced during reclamation.
	CPP versus Satellite Facility	Same as the Proposed Action
	Use of Alternate Lixiviants	Same as the Proposed Action
	Alternate Waste Management	Deep disposal wells/surge ponds will require a smaller surface area disturbance than the Proposed Action resulting in less topsoil removal and stockpiling.
	Uranium Processing Alternatives	Same as the Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Surface Water Impacts	Proposed Action	Surface disturbance may pose a small risk of increased sediment load to ephemeral drainages. Minimal risk of fuel or chemical spills.
	No Action	None
	Alternate Milling Method	Open pit mining would alter the surface drainage network requiring the restoration of all drainages during reclamation. The surface disturbance is significantly increased from the Proposed Action and would pose a larger risk of sediment load to surface waters. In addition, the potential for large amounts of groundwater to be discharged from the open pit would impact ephemeral drainages that only see flow during runoff or storm events.
	CPP versus Satellite Facility	Same as the Proposed Action
	Use of Alternate Lixiviants	The potential spill of an acid or ammonia based lixiviant would have more of an adverse effect on surface water than a sodium-bicarbonate based lixiviant.
	Alternate Waste Management	Deep disposal wells/surge ponds will would disturb less surface area resulting in the reduced risk of sediment load to drainages.
	Uranium Processing Alternatives	Same as the Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Groundwater Impacts	Proposed Action	Excursion of lixiviant may have a small potential to contaminate adjacent aquifers. Minimal risk of fuel or chemical spills leaching to shallow aquifer. Small net withdrawal of water from the ore zone aquifer to contain fluids. Water consumed will naturally recharge with time.
	No Action	None
	Alternate Milling Method	Open-pit and underground mining would drastically alter the hydrogeology of the area. All aquifers from the bottom of the ore zone to the surface would be exposed. Groundwater exposed in pit would need to be discharged altering surface water flow.
	CPP versus Satellite Facility	Same as the Proposed Action
	Use of Alternate Lixiviants	The potential migration of an acid or ammonia based lixiviant would have more of an adverse effect on groundwater than a sodium-bicarbonate based lixiviant.
	Alternate Waste Management	Same as the Proposed Action
	Uranium Processing Alternatives	Same as the Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Ecological Impacts	Proposed Action	BMPs will minimize wildlife access to lined retention ponds and storage facilities. No threatened or endangered species will be impacted. Loss of habitat will be minimal and temporary.
	No Action	None
	Alternate Milling Method	Open pit mining would disturb much more habitat by increased surface disturbance.
	CPP versus Satellite Facility	Same as the Proposed Action
	Use of Alternate Lixiviants	Same as the Proposed Action
	Alternate Waste Management	Deep disposal wells/surge ponds will have less habitat loss could result due to decreased disturbance area.
	Uranium Processing Alternatives	Same as the Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Air Quality Impacts	Proposed Action	Slight increases in fugitive dust will occur, primarily during construction. An increase in fugitive dusts over baseline levels will occur during the life of the project. Combustion and greenhouse gases will be minimal and offset by the recovered uranium.
	No Action	None
	Alternate Milling Method	Open-pit mining would increase fugitive dust emissions by exposing much more disturbed soil surface. Large equipment would increase gaseous greenhouse emissions. Tailings would increase risk of airborne contaminants, including radioactive materials.
	CPP versus Satellite Facility	The potential for impact to air quality increases with a CPP due to the potential exposure to dried yellowcake particulates from an accident.
	Use of Alternate Lixiviants	Same as Proposed Action, possibly for an extended amount of time if alternate lixiviant requires more time for restoration.
	Alternate Waste Management	Same as Proposed Action
	Uranium Processing Alternatives	Same as Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Noise Impacts	Proposed Action	Noise will increase over background levels. Nearest residence could experience increased noise levels during construction.
	No Action	None
	Alternate Milling Method	Increased noise levels would result from open-pit mining due to heavy equipment operation.
	CPP versus Satellite Facility	A CPP would potentially produce less noise with the absence of resin shipping trucks.
	Use of Alternate Lixiviants	Same as Proposed Action, possibly for an extended amount of time if alternate lixiviant requires more time for restoration.
	Alternate Waste Management	Same as Proposed Action
	Uranium Processing Alternatives	Same as Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Historical and Cultural Impacts	Proposed Action	Potential impacts will be minimal, since NRHP eligible sites do not exist on the proposed project site. A stop-work provision will be used if any previously undiscovered cultural resources are found.
	No Action	None
	Alternate Milling Method	Open-pit mining disturbs more area than that of ISR facilities increasing the chance of disturbing unknown cultural resources.
	CPP versus Satellite Facility	Same as Proposed Action
	Use of Alternate Lixiviants	Same as Proposed Action
	Alternate Waste Management	Same as Proposed Action
	Uranium Processing Alternatives	Same as Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Visual/Scenic Impacts	Proposed Action	Minimal visual impacts will result from new structures and equipment but will remain consistent with the BLM visual resource classification of the area.
	No Action	None
	Alternate Milling Method	Open-pit mining would create a significant visual impact with large stockpiles and a large tailings impoundment.
	CPP versus Satellite Facility	Similar to the Proposed Action
	Use of Alternate Lixiviants	Same as Proposed Action, possibly for an extended amount of time if alternate lixiviant requires more time for restoration.
	Alternate Waste Management	Same as Proposed Action
	Uranium Processing Alternatives	Same as Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Socioeconomic Impacts	Proposed Action	Most of the workforce is expected to come from the local area minimizing impacts on housing and local services. Project would have slight, positive benefit to the State on severance tax, royalty, and sales and use tax collections and moderate benefits to Campbell County on property and production taxes. Remoteness of the site might slightly increase the need for increased emergency services (fire and ambulance service).
	No Action	None
	Alternate Milling Method	Conventional mining and milling methods require more employees than ISR facilities. Revenues to the State, which are based on production, would be similar to Proposed Action, but Campbell County revenues from property taxes would be more due to additional equipment required for conventional mining.
	CPP versus Satellite Facility	A CPP would require more employees than a Satellite facility which would have a direct positive impact on the local economy
	Use of Alternate Lixiviants	Same as Proposed Action, possibly for an extended amount of time if alternate lixiviant requires more time for restoration.
	Alternate Waste Management	Same as Proposed Action
	Uranium Processing Alternatives	Same as Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Non-Radiological Impacts	Proposed Action	Minimal risk of public exposure through chemical leaks and spills will be mitigated by employing BMPs.
	No Action	None
	Alternate Milling Method	Conventional mining and milling methods have an increased risk and more severe accidents compared to that of the Proposed Action. Safety hazards are compounded due to the depths of the mineral ore to be recovered.
	CPP versus Satellite Facility	A CPP has additional equipment and chemicals that could present safety hazards not found in a Satellite facility
	Use of Alternate Lixiviants	Similar to Proposed Action; acid or ammonia-based lixiviant would introduce additional non-radiological health risks.
	Alternate Waste Management	Same as Proposed Action
	Uranium Processing Alternatives	Same as Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Radiological Impacts	Proposed Action	The estimated radiological impacts resulting from routine site activities will be compared to applicable public dose limits as well as naturally occurring background levels.
	No Action	None
	Alternate Milling Method	Radiological exposure to the personnel in these processes is increased, not only from the mining process but also from milling and the resultant mill tailings. The milling process generates a significant amount of waste relative to the amount of ore processed. Extensive mill tailings impoundments are needed for the disposal of these wastes.
	CPP versus Satellite Facility	Same as Proposed Action
	Use of Alternate Lixiviants	Same as Proposed Action
	Alternate Waste Management	Same as Proposed Action
	Uranium Processing Alternatives	Same as Proposed Action

Table 2-2: Comparison of Predicted Environmental Impacts (Continued)

Potential Impact	Alternative	Potential Impacts
Potential Waste Management Impacts	Proposed Action	Evaporation ponds accumulate salts and windblown material such as dust that will need eventual removal increasing the risk for potential impacts during transport to an off-site facility.
	No Action	None
	Alternate Milling Method	Conventional mining and milling creates considerably more waste than ISR, including tailings, which would be 11e.(2) byproduct material, and residue left from the treatment of water.
	CPP versus Satellite Facility	A CPP will potentially create more 11e.(2) and non-11e.(2) wastes than a Satellite facility requiring more waste to be transported and disposed at a licensed facility.
	Use of Alternate Lixiviants	Same as Proposed Action
	Alternate Waste Management	Deep injection well(s) will isolate liquid wastes generated by the project from any underground source of drinking water. A slight risk of exposure to the public during transportation exists though will be minimized by employing BMPs.
	Uranium Processing Alternatives	Same as Proposed Action

2.3 REFERENCES

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