

Case Study: Completion of a Removal Site Evaluation for an Abandoned Uranium Mine in Northern Arizona



Mining



Infrastructure & Development



Water



Power & Energy



Industrial & Aerospace

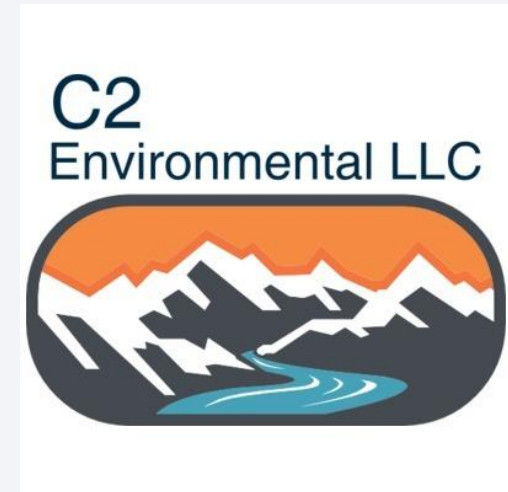
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Acknowledgements



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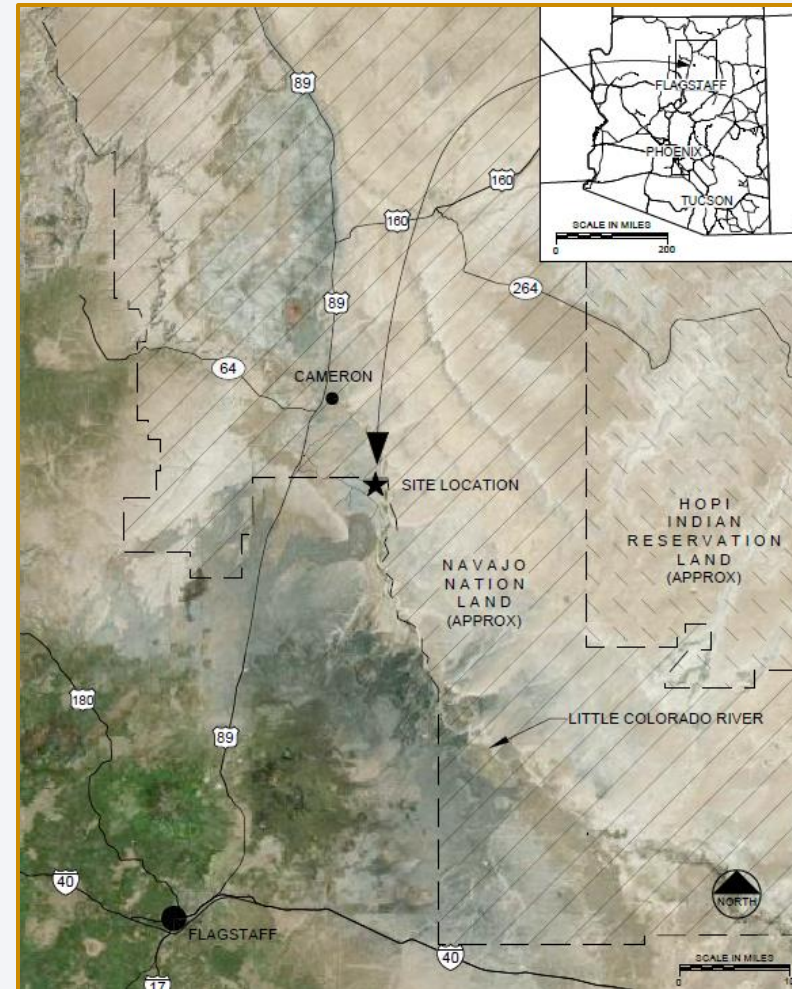


Project Scope

- Engineering Analytics, Inc. (EA) was the lead consultant for development of the removal action related to historic uranium mining activities on land currently under the control of Babbitt Ranches.
- The site consists of abandoned mining units within two sections of land that were under an Agreement and Order of Consent (AOC) with USEPA Region IX for Interim Removal Action.
- External agencies Arizona DEQ, Arizona State Lands, Bureau of Reclamation, and the Navajo Nation.
- The AOC included three phases of work:
 - Phase I: Cultural Resources Surveys, Biological Survey, and Signage.
 - Phase II: Background Determination, Gamma Survey, and Soil Correlation.
 - Phase III: Removal Site Evaluation, Vertical Profiling, Risk Evaluation, and Removal Volume Calculations.

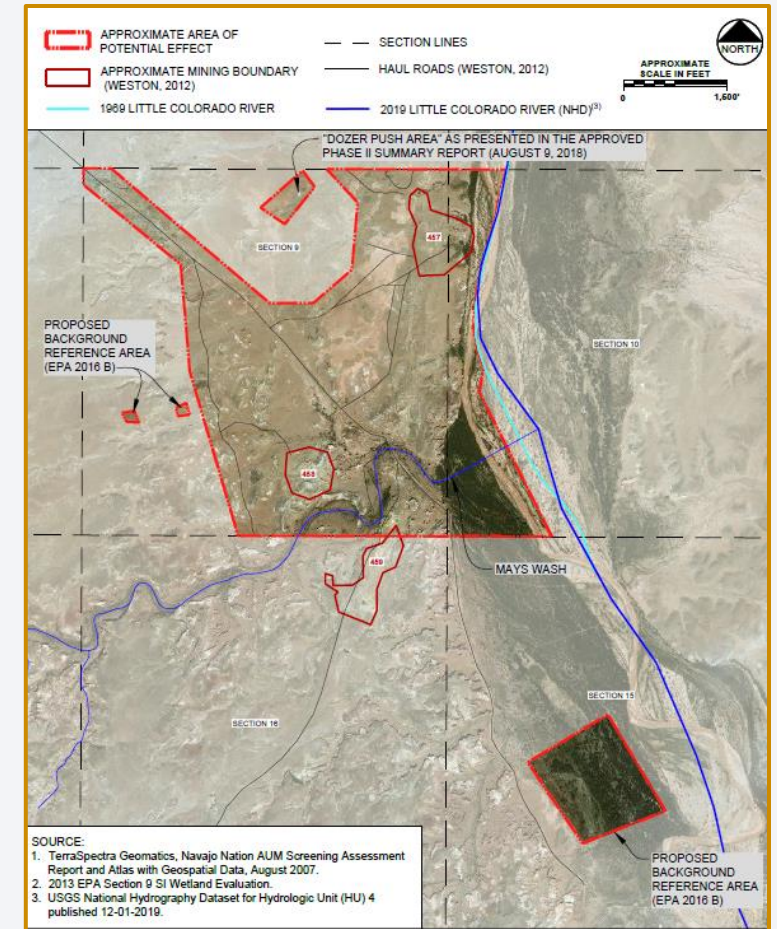
Site Location

- The project area is located in the Little Colorado River Valley in Coconino County, Arizona.



Site Features

- Three abandoned uranium mines (AUMs) were identified at the site.
 - AUM 457 comprises approximately 16.5 acres and is located approximately 0.2 miles west of the Little Colorado River.
 - AUM 458 comprises approximately 9.3 acres and is located approximately 0.25 miles west of the Little Colorado River.
 - AUM 459 comprises approximately 13.3 acres and is located approximately 1,000 feet west of the Little Colorado River.
- Shallow mine pits, waste rock piles, mine access haul roads, concrete foundations, and walls of former mine structures were identified at the sites.



Site History

- Uranium was first reported in the Cameron area in 1950, and mining ceased by 1963.
- Mining occurred on Section 9 from 1957 to 1961. Ore was shipped from the site to the Tuba City mill.
- In 1959, a small processing plant known as a “Benson Upgrader” was built in the northeast part of Section 9, near one of the former pits (AUM 457). They claimed the Benson Upgrader would separate the waste rock from previous mining activities into a “sellable” higher grade slime fraction and a lower grade sand fraction.
- Section 9 has been deed restricted as of July 22, 2019.

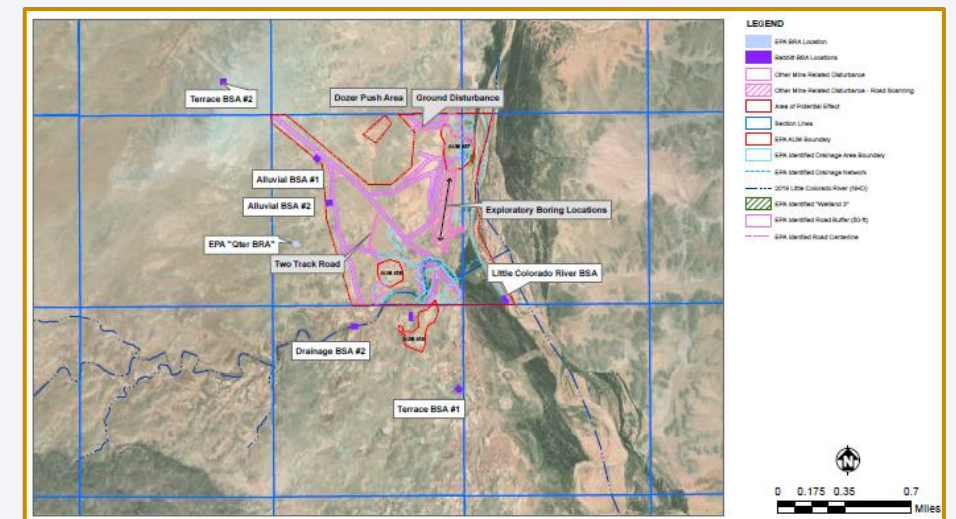
Geologic Setting

- Geologic deposits at the Site consist of:
 - Terrace deposits
 - Playa deposits
 - Alluvial and eolian deposits
- Both mineralized and unmineralized outcrops of the Chinle Formation (Petrified Forest and Shinarump members) are present at the Site.
- Uranium mineralization occurs in a thin zone of the Shinarump member.



Site Mapping

- **Development of Background Study Areas (BSA).**
 - Geological materials in the BSA were selected to have similar physical, chemical, and geological as those encountered in the AUM.
 - The BSAs were selected with the objective that the radioactivity present in a BSAs would be comparable to geological material in the AUM.
 - Locate BSAs with no anthropogenic disturbance or TENORM.
 - BSA were about 0.5 acres.
- **Field Reconnaissance to confirm the selected the project needs.**
 - Confirmation of proposed BSA locations.
 - Confirmation of mining-related TENORM.
 - Geologic mapping of AUM 457 and 458.



Gamma Survey

■ BSA Gamma Scanning

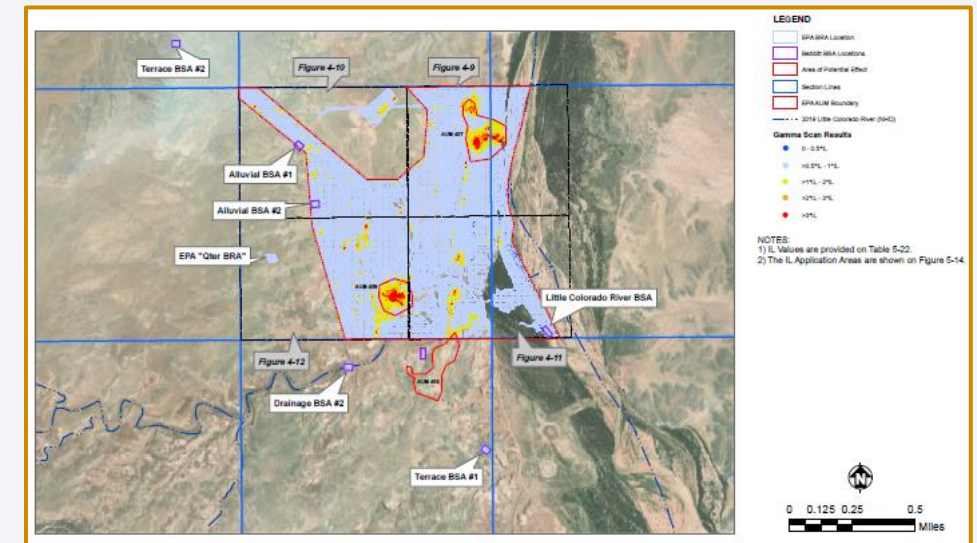
- Model 44-20 three-inch by three-inch sodium-iodide detector paired with either a Ludlum Model 4612 multi-zone single channel analyzer or a Model 2221 ratemeter.



Gamma Survey

■ Area of Potential Effect Scanning

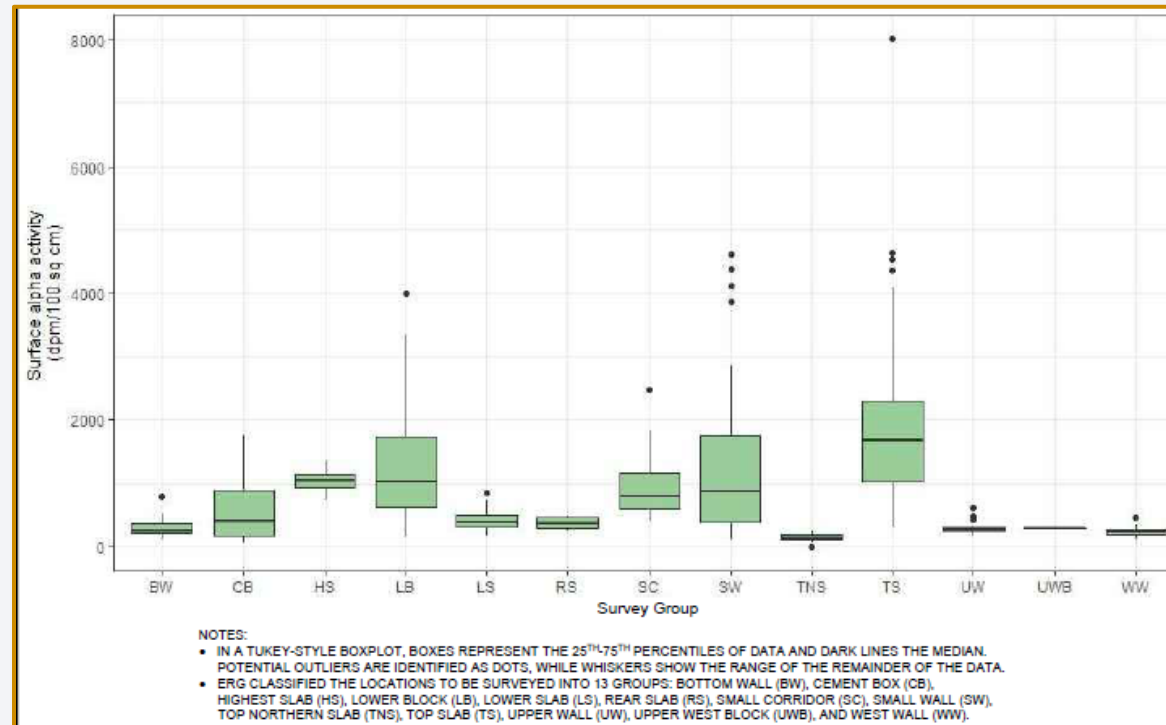
- Three-foot transects within the AUM boundaries (100 percent coverage).
- Six-foot transects within the mine disturbance areas.
- Twelve-foot transects within the drainage areas; or throughout the thalweg with 12-foot transects out to an elevation change of no less than two feet if the thalweg could be visibly verified.
- Fifteen-meter (approximately 45 feet) transects within the remaining non-surveyed area of the APE.
- All areas were surveyed at a speed between 0.5 to 1.0 meters (approximately 1.5 to 3 feet) per second, with the detector approximately 0.5 meter above the ground surface.



Gamma Survey

■ Concrete Surface

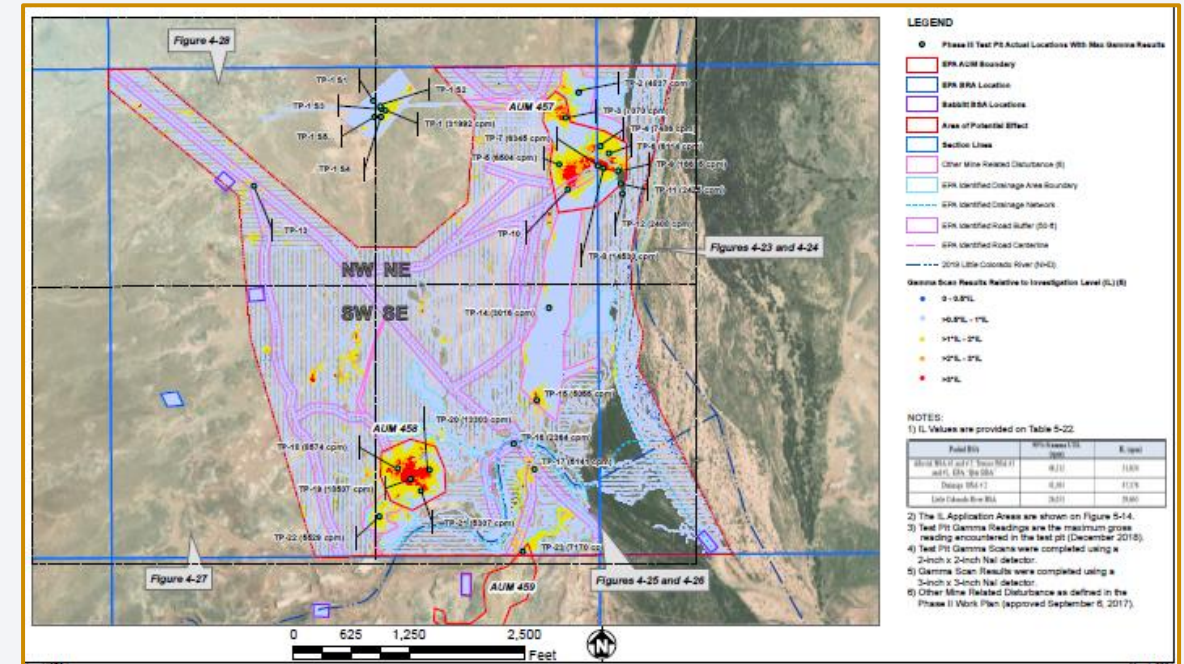
- The upgrader foundation was surveyed using direct measurements on a one-meter square grids to quantify alpha and beta surface activity per unit area.
- The measurements were made using Ludlum Model 43-93 detectors paired with Ludlum Model 2360 ratemeter/scalers.



Soil Sampling

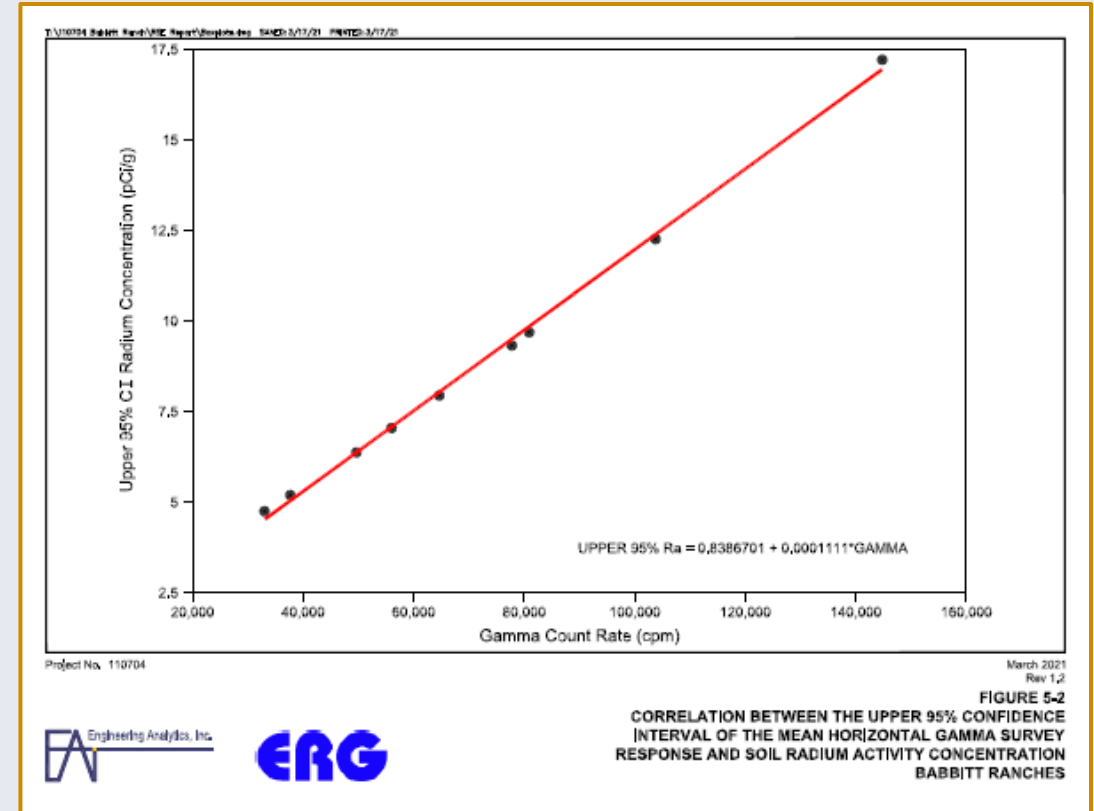
■ Subsurface Profiling

- Excavation of test pits with hand auger and/or backhoe at 21 locations (up to 7 feet deep).
- Collection of soil and sediment samples at 6 inch intervals.
- Measurements of gamma emissions of each 6 inch soil fraction (60 sec count with a 1 liter Marinelli beaker).
- Determination of the contact between disturbed material and the underlying undisturbed material.
- Geotechnical analyses of grain size for use in the Streamlined Human Health Risk Evaluation.



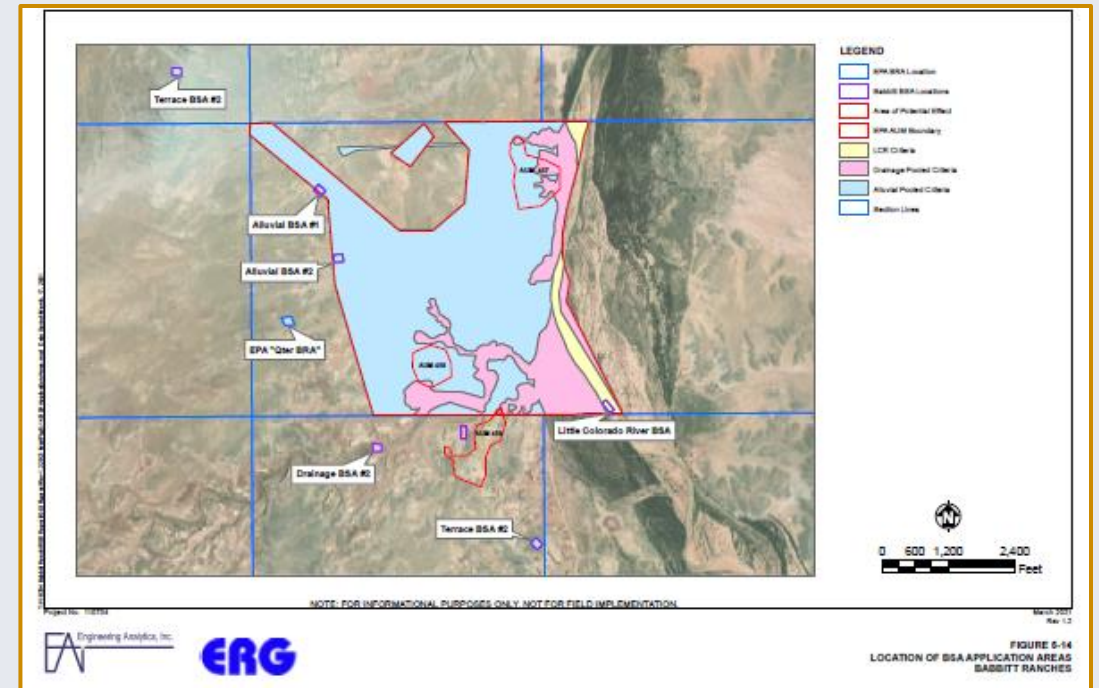
Laboratory and Correlation Study

- The team collected 160 soil samples (131 originals and 29 field duplicates) and generated 16 aqueous equipment rinseate blank (ERB) samples during the field investigations.
- Two correlations were established using data from the high-pressurized ion chamber (HPIC):
 - A correlation between exposure rate and static gamma count rate.
 - A correlation between exposure rate and Ra-226 concentration in soil.
- None of the analyzed metals appear to be significantly correlated with the Ra-226 data



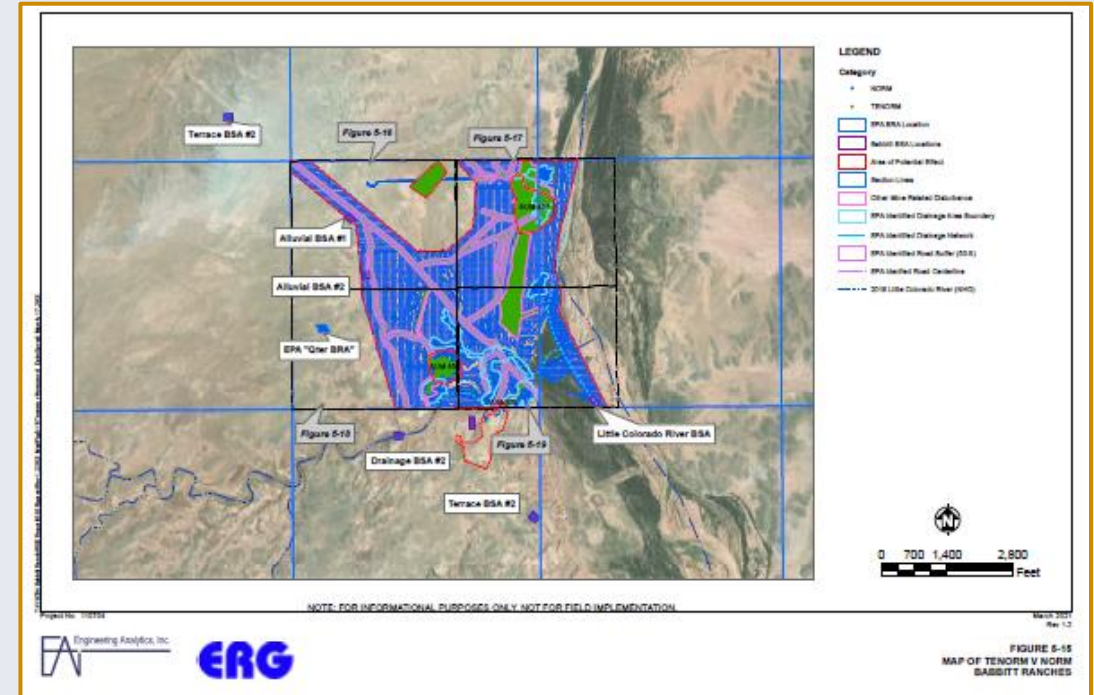
Background Study Area Pooling

- To delineate the investigation level (IL) for the horizontal gamma survey, it was necessary to determine which BSA would represent specific portions of the Site. The three pooled BSAs represent:
 - Little Colorado River floodplain.
 - Drainages upgradient of the LCR.
 - Other locations/Alluvial.
- The IL for radium-226 (Ra-226) is 1.24 picoCurie per gram (pCi/g) above background.



TENORM Identification

- TENORM versus naturally occurring radioactive material (NORM) was completed for the gamma survey data points.
- The delineation of TENORM was based upon aerial photography and topographic features.
- Areas that were above the IL and topographically downgradient of an area that contained TENORM, which was above the IL, were considered to be TENORM.
- Data points above the IL that were not related to surface disturbance areas above the IL or connected by drainage pathways to areas that were above the IL were not considered TENORM.

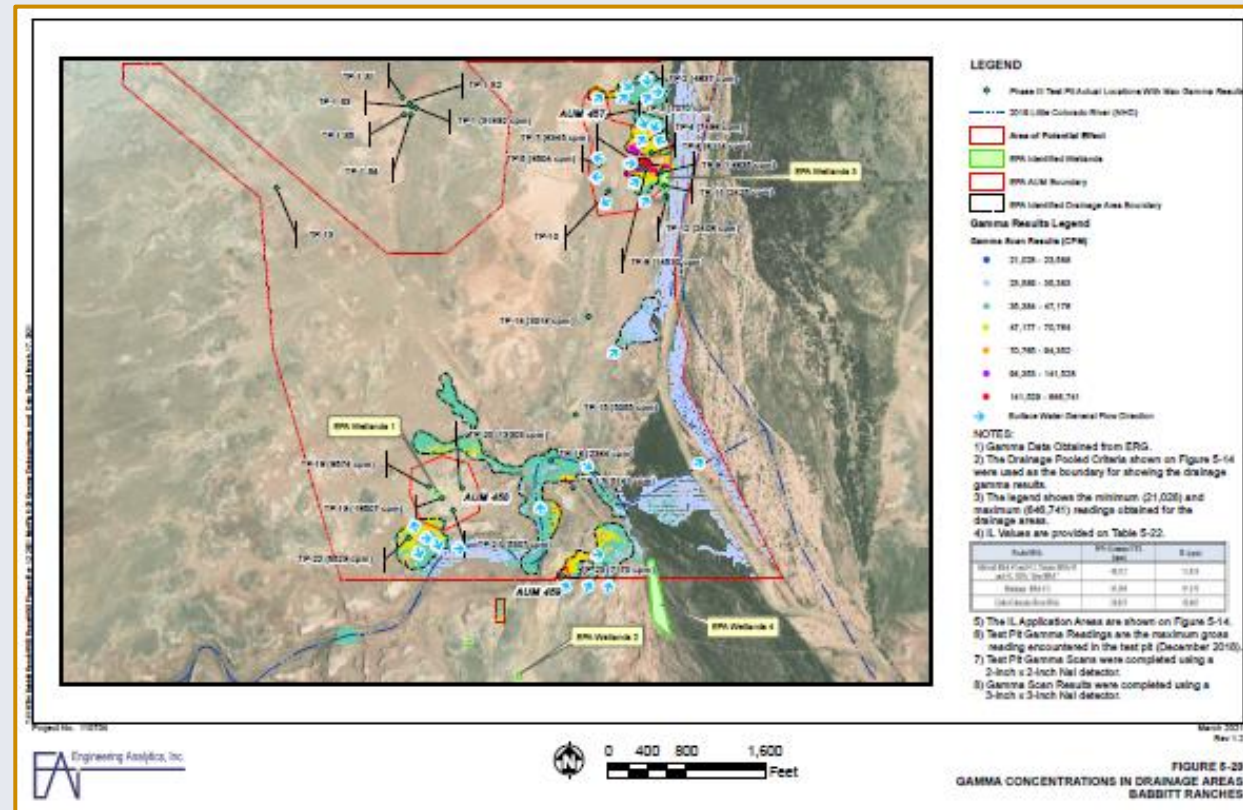


Investigation Limit

- The resulting IL was calculated for three landforms within the APE:
 - Little Colorado River (LCR) (2.76 pCi/g)
 - Drainage (6.07 pCi/g)
 - Alluvial (6.59 pCi/g)
- The estimated volume of TENORM material exceeding the IL within the APE is 31,550 cubic yards (CY).

Potential Material Migration

- Based on review of the Site topography, gamma survey and soil analytical results there is the potential for migration from the Site to the LCR from two areas: The Upgrader Area at AUM 457, and the Drainage North of AUM 459.



Human Health Streamlined Risk Evaluation

- Given the streamlined nature of the HHSRE and the deed restriction that prohibits future uses of the section an exhaustive analysis of all potential receptors and exposure pathways was completed. The selection of receptors included the following receptor groups or activities:
 - On-Site Adult Worker
 - Long Term Adult Recreator (24 years of exposure)
 - Child Recreator (2 years of exposure)
 - Combined Long Term Adult and Child Recreator (26 years of exposure)

Ecological Streamlined Risk Evaluation

- The key ecological setting relevant to the Ecological Streamlined Risk Evaluation (EcoSRE) is as follows:
 - The Site is very dry, with temperatures below freezing in the winter (average minimum approximately 21°F) and very hot in the summer (average maximum temperature of approximately 97°F).
 - There are two named watercourses on or near the Site: an ephemeral reach of the Little Colorado River (LCR) along the eastern boundary of the Site and Mays Wash located on the south side of the Site.
 - There is vegetation in the riparian habitats along the LCR and Mays Wash, and within drainages and depressions in the upland areas.

Ecological Streamlined Risk Evaluation

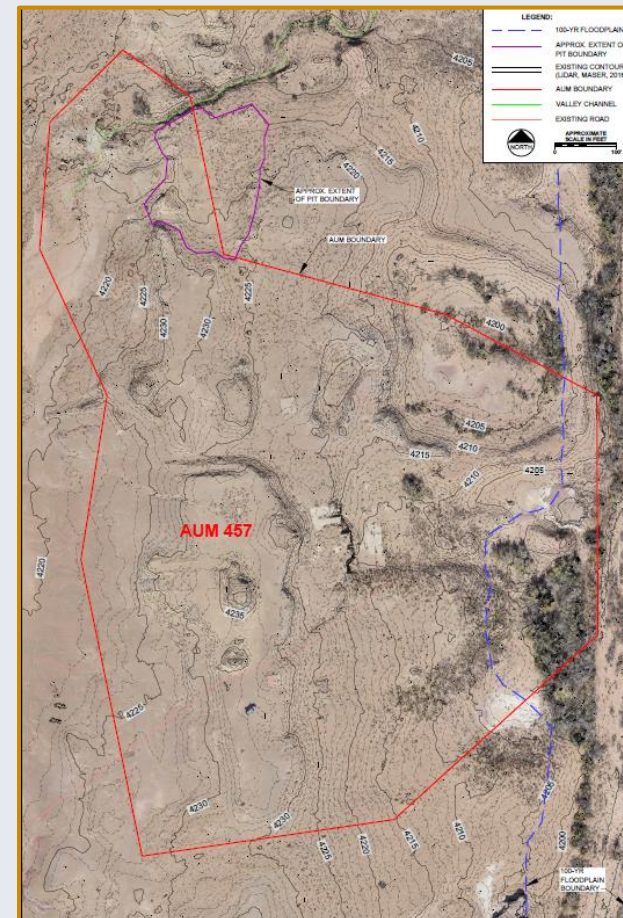
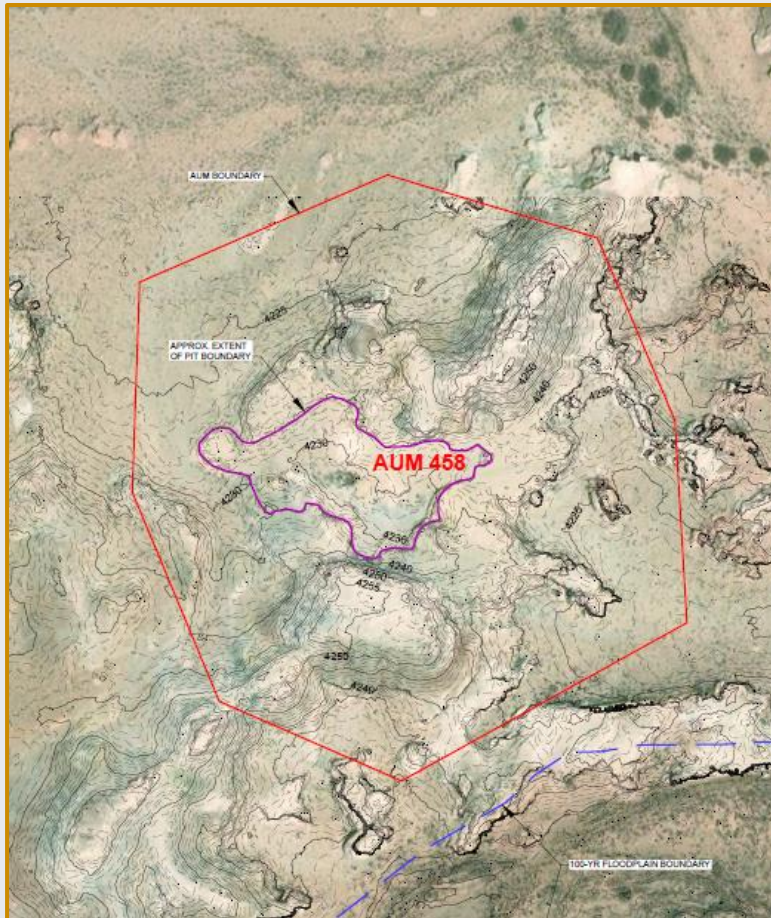
- The receptors proposed in the Phase III Work Plan were evaluated in the EcoSRE.
- In the upland areas (e.g., the AUMs) under the Dry and Wet Condition Scenarios the following receptors were evaluated:
 - Plants
 - Insectivorous mammal: Desert shrew
 - Insectivorous bird: Rock wren
 - Herbivorous mammal: Deer mouse
 - Insectivorous bird: American kestrel
 - Carnivorous bird: Golden eagle
- In the riparian areas (e.g., along the LCR) Dry and Wet Condition Scenarios the following receptors were evaluated:
 - Plants
 - Insectivorous mammal: Desert shrew
 - Insectivorous bird: Rock wren
 - Herbivorous mammal: Deer mouse
 - Herbivorous bird: Mourning dove
 - Omnivorous mammal: Coyote
 - Carnivorous bird: Golden eagle

Proposed Risk Based Action Level

- The HHSRE showed potential cancer and non-cancer risks for the non-radiological PCOCs were below or within the acceptable EPA cancer risk range (i.e., range less than or equal to 1×10^{-6} to 1×10^{-4} risk), and were below the OSWER risk value (i.e., 3×10^{-4}), for all areas of the Site except for AUM 458.
- The rbAL for Ra-226 for the receptors presented in were determined to range from 12 pCi/g (Long Term Adult Recreator and Child) to 160 pCi/g (On-Site Worker).

Repository Locations

- EA used high resolution LiDAR topographic data to develop volumes of the mine pits associated with AUM 457 and AUM 458.



Waste Volumes

- *“Waste Volumes: Respondents shall calculate the volumes of contaminated soil and sediment with concentrations above the screening levels and with concentrations above the proposed risk based action levels.”*
- Only the soils deemed as TENORM were used to determine volumes.
- Conceptual on-Site repository designs were developed for Abandoned Uranium Mine (AUM) 457 and AUM 458:
 - The pit at AUM 457 has an estimated capacity of 1,560 CY.
 - The pit at AUM 458 has an estimated capacity of 5,670 CY.

Quadrant	Volume Above IL (CY)	Volume Above 160 pCi/g (CY)	Volume Above 12 pCi/g (CY)
NW	4,087	0	1,166
NE	10,209	0	2,688
SW	7,818	940	5,535
SE	9,436	2	647
TOTAL	31,550	942	10,036

Summary

- Gamma Scanning was completed for the APE and AUMs
- Risk based action levels were developed for an On-Site Adult Worker, Long Term Adult Recreator (24 years of exposure), Child Recreator (2 years of exposure), and Combined Long Term Adult and Child Recreator (26 years of exposure)
- Soil clean up volumes were developed for:
 - IL - 31,550 cy
 - 160 pCi/g – 942 cy
 - 12 pCi/g – 10,036 cy
- Conceptual onsite repositories were developed.
- The final RSE and associated reports and data were approved by the EPA and the AOC was closed out.
- A Draft EE/CA is being developed by the EPA.

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