



Shirley Basin Investigative Geotechnical Drilling Design and Construction

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Site Location and History

Shirley Basin, WY

- Located approximately 40 miles southeast of Casper, WY in Carbon County
- Uranium mining was conducted as early as 1960s
 - Remaining spoil materials
 - Acid forming materials/radioactive material concerns
- Original reclamation conducted in 1990s
 - Erosion formed over past 30 years leading to deeper rills and gullies on the 400, 500, and 600 piles
 - This creates a hazard to the public and the quality of the surrounding Little Medicine Bow River
- New reclamation started in 2021
 - 400 pile reclamation completed in 2022.
 - 500 pile initial subsurface investigation conducted in 2023 and is currently ongoing.
 - 600 pile initial subsurface investigation planned for 2024-2025.



Project Challenges and Goals

Current Conditions vs. Reclamation Goals

Original Mining Challenges – Prior to 1977

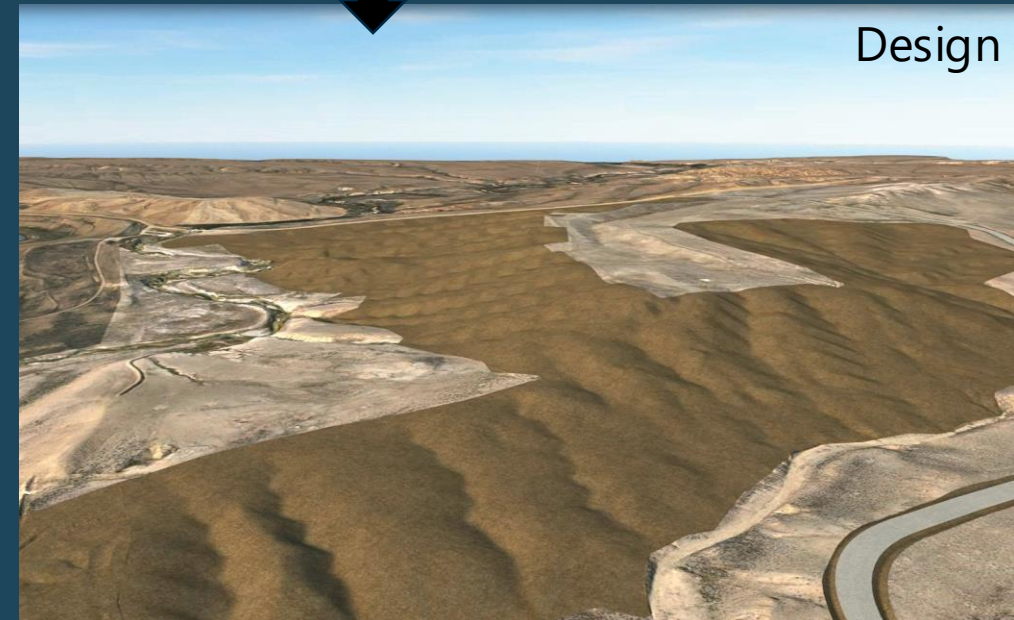
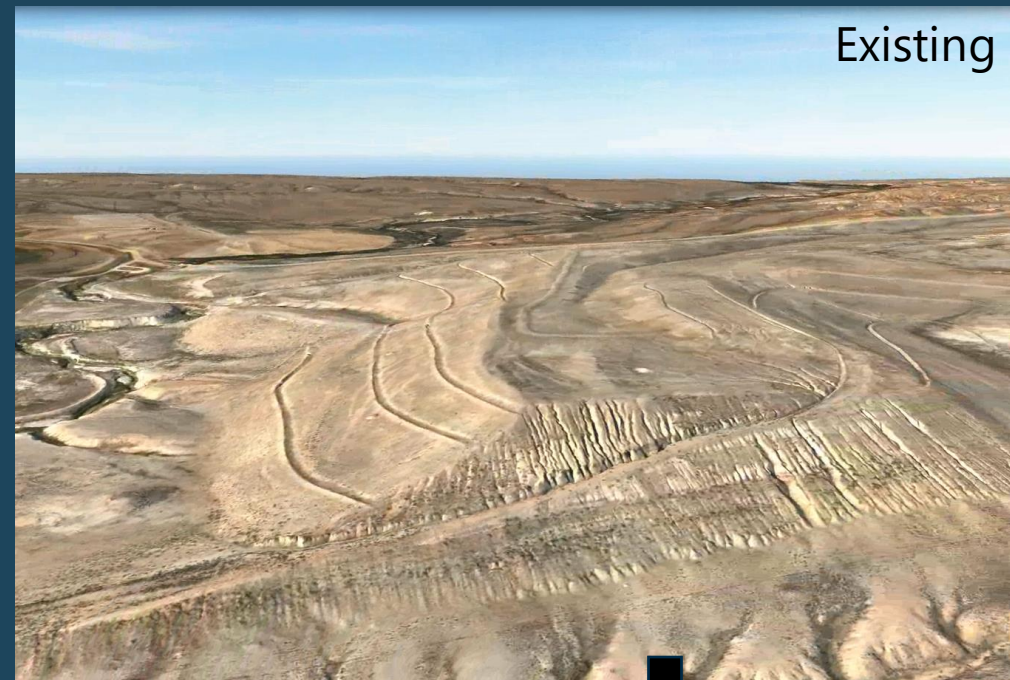
- Poor topsoil management and salvage practices
- Poor material management and planning
- Incomplete reclamation and abandonment

Previous Reclamation Challenges – 1990s

- Standard 3:1 slopes
- Variable material placement
- Limited cover soil resources for revegetation efforts

Current Reclamation Challenges & Goals (WY AML Project 86)

- Material has been handled twice at this point
- Need to identify surface/subsurface cover soil quantities at site as best as we can
- Redesign contours based on natural landform regrading
- Design seed mix specific to variable moisture content in the soil profile



WY AML Contract 64NC - 400 Pile Investigation

Planning

- Locate suitable cover soils for vegetation (goal of 2 ft of cover soil)
- Locate and encapsulate radioactive material
 - 20 pCi/g Radium 226 determined hazardous per WDEQ standards (100 μ R/hr with a Ludlum 19 unit)
 - Segregated and buried at site with a minimum of 10 ft. of cover

Soil Classification (major factors)

- Suitable – pH >5.5 and <8.5; Radiometric <80 μ R/hr
- Unsuitable – Radiometric >100 μ R/hr
- Unclassified – Materials between suitable/unsuitable, generally closer to 5.0 pH
 - Texture based assessment
 - Partial use for fill (pH <5), partial use for cover (pH >5)
 - Unclassified materials salvaged for cover was placed on top of fill, but below suitable

Results

- Total cover depths ranged from 1.4 ft – 1.9 ft across the site
- Only recovered approximately 35% of planned subsurface salvage volumes
 - Amendments were used to bolster salvage volumes where possible
 - We want to improve upon our estimates moving forward

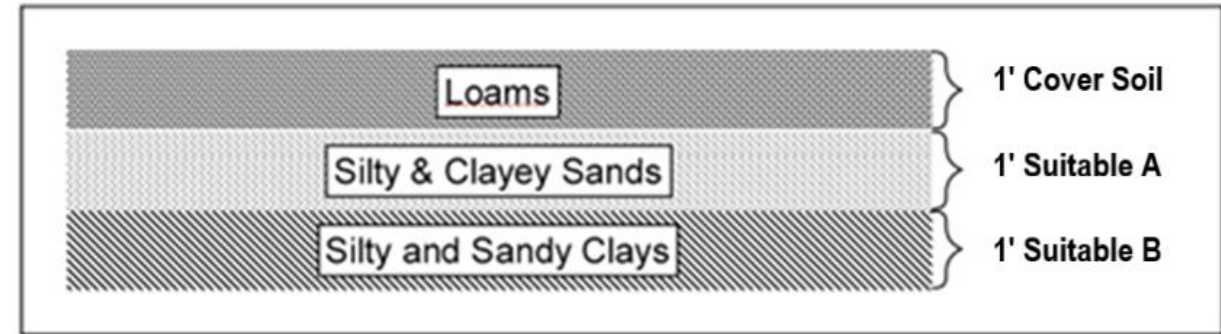
WY AML Project 86 – 500/600 Pile Investigation

Planning

- Desktop reconnaissance on established vegetation on previously reclaimed areas.
- Drilling locations based on cut depths from grading design
- Radioactive materials delineated to plan for unsuitable material placement

Soil classification (major factors)

- Cover Soil – Best material available on site. Generally top 6-12".
- Suitable A – Suitable plant growth media, pH > 5.5 and < 8.5; Rad < 20 pCi/g
- Suitable B – Composed of some unclassified and subgrade cover salvage. Suitable for root growth.
- Unsuitable - < 5.0 pH, Rad 226 > 20 pCi/g
 - Segregated and isolated above water table with a min. of 10 ft cover.
- Unclassified – Between 5.0 - 5.5 pH, Rad 226 < 20 pCi/g, generally clayey
 - Will be our primary source of fill material



Goals

- Improved classification of suitable soils will promote longevity of the soil profile and prioritize fast germination
- Determine unique soil amendments to be placed in layers throughout the soil profile.
- Immobilizing acid forming materials found in subgrade profile of the material at site.
- Additional sampling for material meeting criteria to better understand the reclamation challenges with the soils at the site

Borrow Area Planning 500 Pile

WY AML Contract 64NC

- Borrow areas were identified using observed vegetation cover of previously reclaimed areas
- Target areas included
 - 100, 200, and 300 piles
 - 500 pile surrounding areas
- Borehole Placement (10 ft. depth)
 - Create Fishnet tool (ArcGIS Pro)
 - Borrow polygon extent
 - Cell size of 295 ft
 - Clip output to borrow polygons
- These borrow areas are to be considered as a last resort source of cover material.
 - Alternatives are supported based on the model of volume quantities.



Geoprocessing ⌵ ⌵ ✕

Create Fishnet ⊕

Parameters **Environments** ?

* **Output Feature Class** 📁

* **Fishnet Origin Coordinate**
X Y

Template Extent
🗺️ 📁 🔄
➤ X and Y Extent
➤ Extent Coordinate System

* **Y-Axis Coordinate**
X Y

* **Cell Size Width**

* **Cell Size Height**

* **Number of Rows**

* **Number of Columns**

Opposite corner of Fishnet
X Y

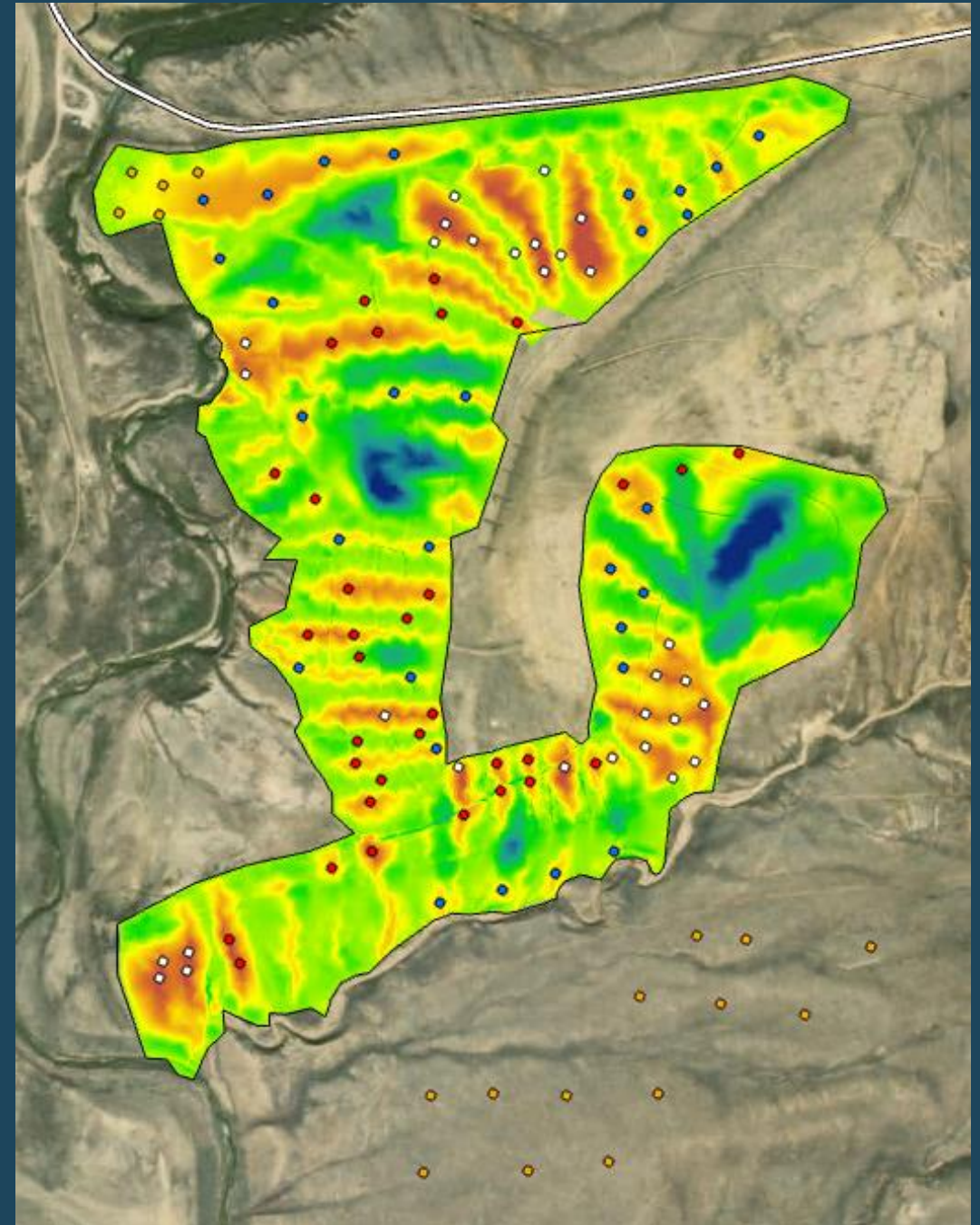
☒ **Create Label Points**

Geometry Type
Polyline ⌵

Design Area Planning 500 Pile

WY AML Contract 64NC

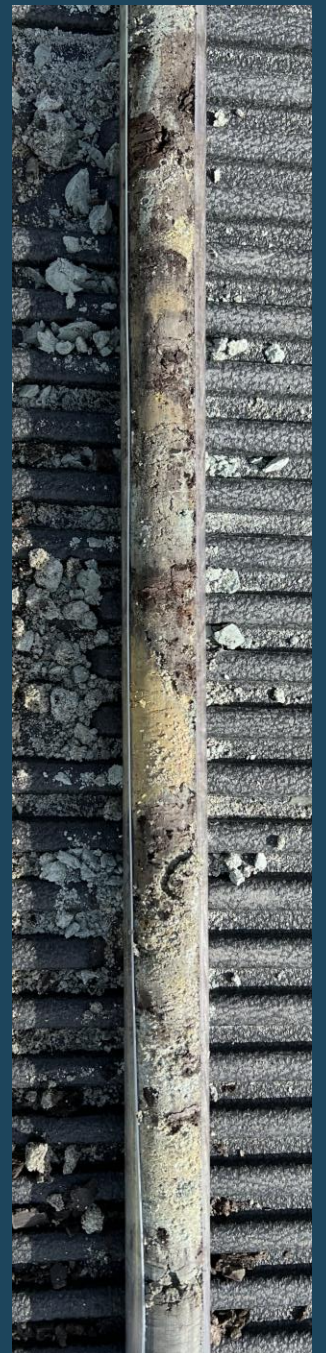
- Borehole depths of 10 ft, 15 ft, 25 ft, and 45 ft based on depth of proposed cut depths
 - Deeper holes placed correlating to increased likelihood of interaction with the material profile
 - Shallower holes placed where primary focus is on cover soil salvage and bad materials are not anticipated
 - Overall area and depths are larger than 400 pile
- Boreholes to be drilled in increments of 5 ft, with the first 2 ft of each hole being segregated and tested separately
- Reference boreholes in surrounding native area



Investigative Drilling 500 Pile

WY AML Contract 64NC

- Locations marked via painted stakes correlating to target depths
- Drilling began on the previously reclaimed 100, 200, 300 piles, and progressed to the 500 pile
- 185 holes drilled at a total of 3,429 feet
 - 5,315 feet originally planned.
- Truck-mounted rig used for entire operation, with an additional track-mounted rig brought for final two weeks to drill holes on steeper slopes
- Field logging was conducted to document texture, color, changes, and consistency through the profile
 - pH via meter and probe, radiometric via handheld Ludlum
- Samples collected were bagged for lab analysis if material met predetermined qualities for further testing

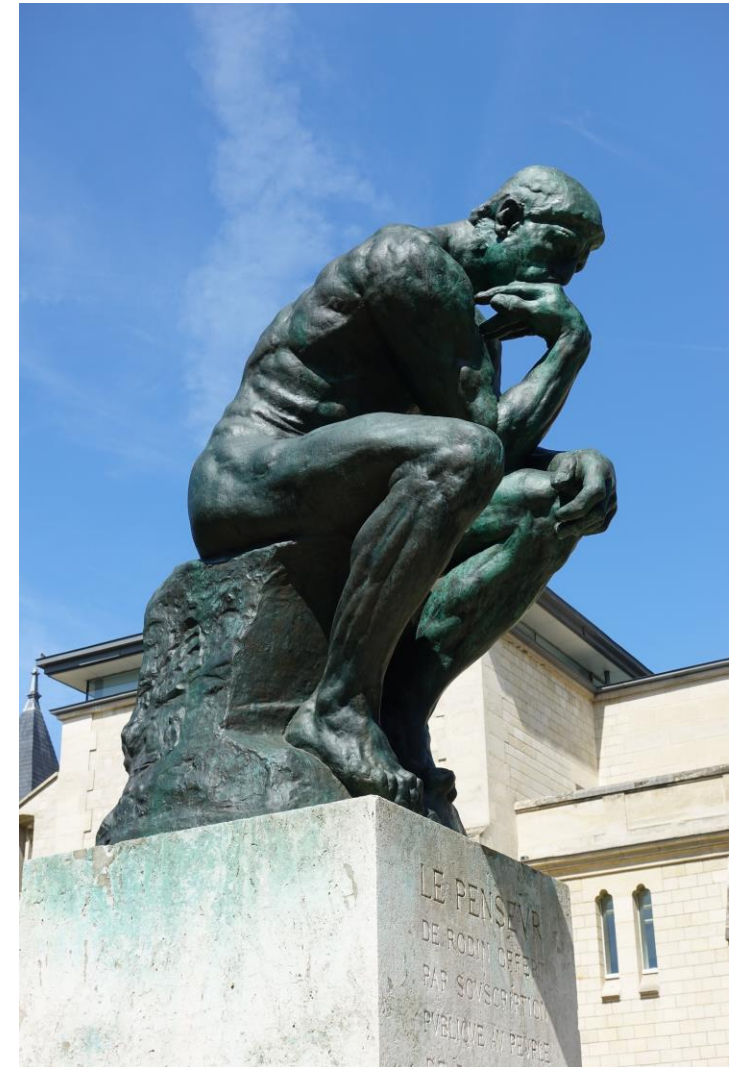


Lessons Learned – 500 Pile Planning and Drilling

This process is an iterative process, and our goal is to learn from each iteration to constantly improve and refine this program.

Key Takeaways

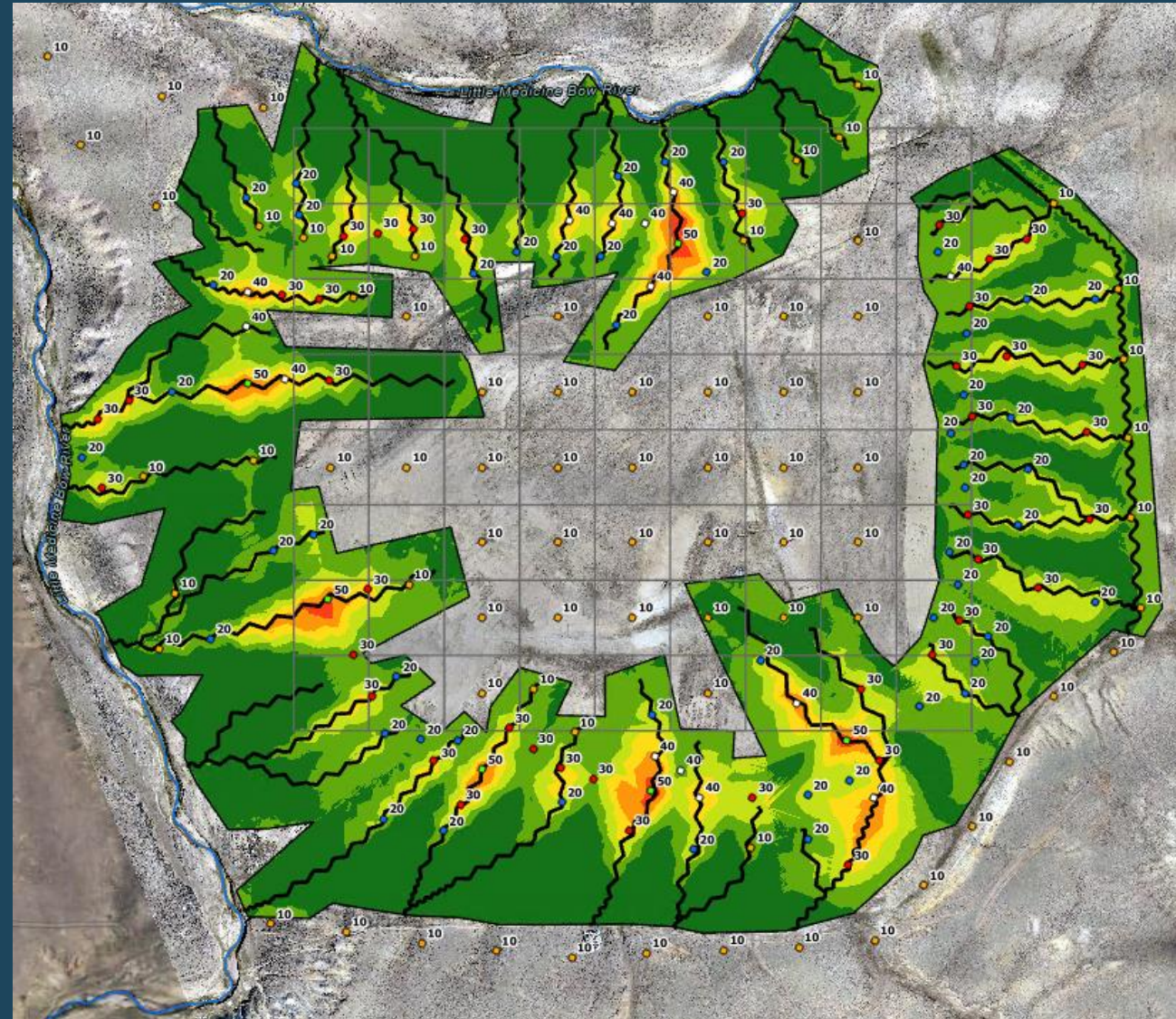
- Borehole placement
 - Slope – Steep slopes inoperable by drill rig
 - Erosion – Instability jeopardizes safety of drilling
 - Density – Some areas needed more points to better estimate materials
- Surface sampling
 - Collecting more surface soil samples would better inform surface characterization specific to cover soil and suitable A/B soil classes



Design Area Planning 600 Pile

WY AML Project 86

- Utilizing methods developed during 100, 200, 300, and 500 pile borehole planning and design.
 - Gridding areas for uniform data collection
 - Deeper boreholes in areas of deeper cuts
 - Surrounding reference boreholes
 - Borehole placement accounts for limitations based on conditions of existing surface and topography
- Borehole depths of 10 ft, 20 ft, 30 ft, 40 ft and 50 ft based on depth of proposed cut depths
 - Deeper holes correlating to increased likelihood of interaction with the existing materials
 - Shallower holes where primary focus is on cover soil salvage and bad materials are not anticipated
 - Overall area and depths are larger than 500 pile

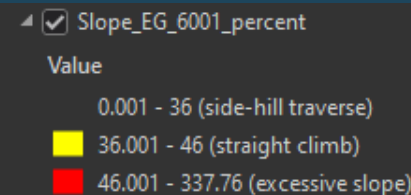


Slope/Terrain Analysis 600 Pile

WY AML Project 86

- Using desktop-based approach to filter out problematic areas prior to on-site bid tours with contractors.
 - Slope and terrain evaluation based on a DEM of the existing surface
 - Erosion evaluations based on high resolution orthophotos
 - Exclusion zones mapped based on a combination of above parameters
- Requesting equipment operators on bid-tours

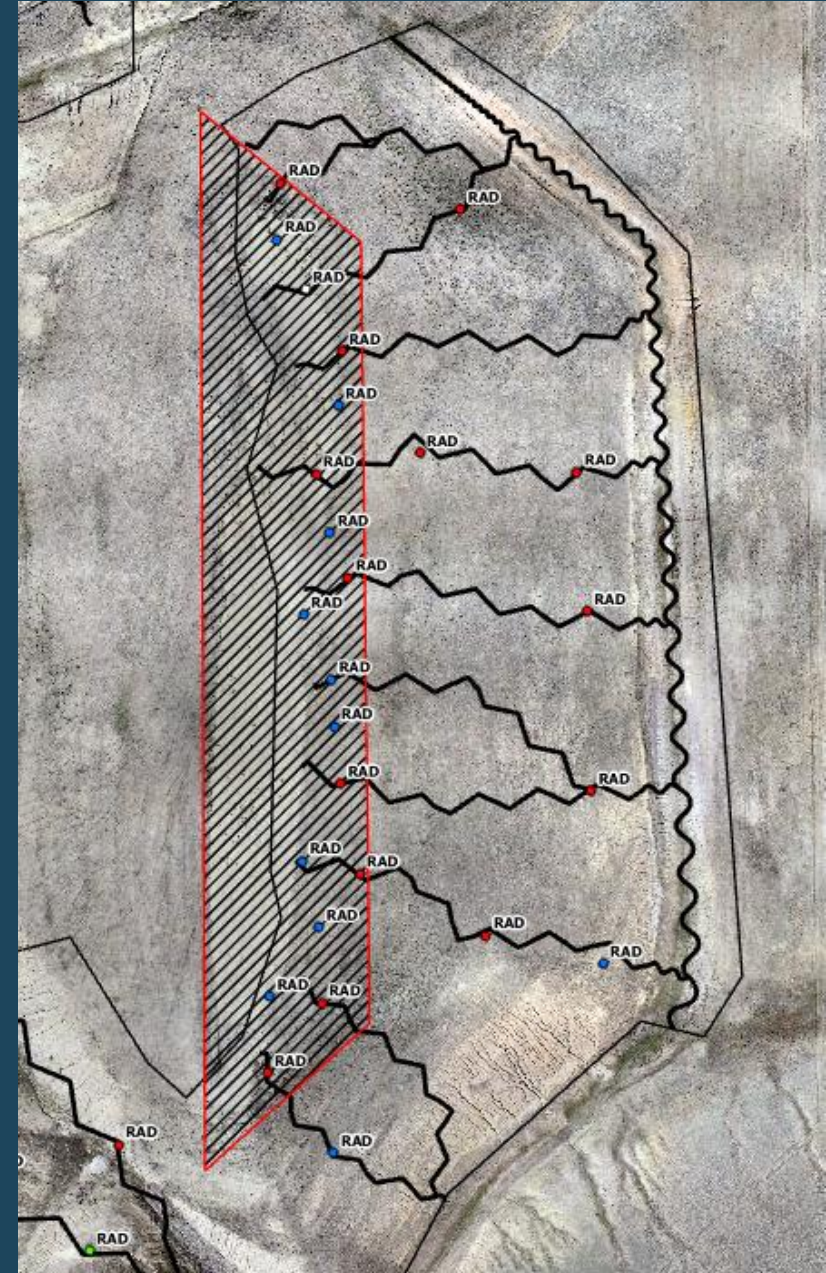
Our goal is to better plan for in-field challenges and create a better pathing network across the site prior to commencement of the operation.



Radiometric Logging 600 Pile

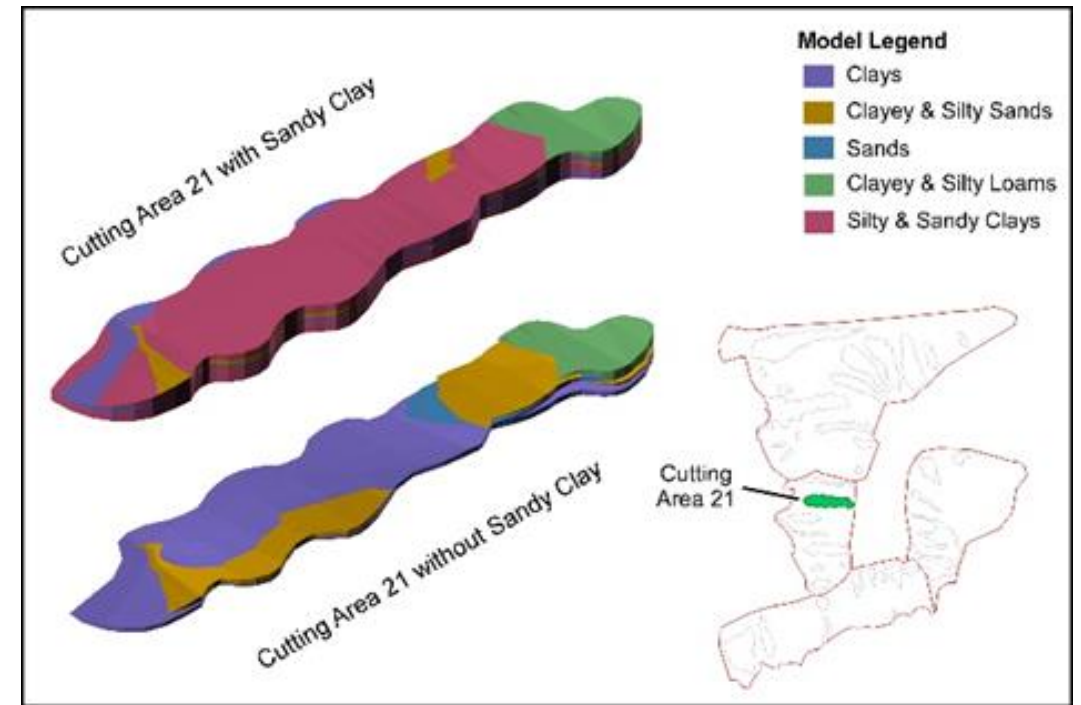
WY AML Project 86

- Confirmation of cover soil quantities necessary to complete reclamation work.
 - Drilling 500 pile for radiometric logs.
 - Including radiometric logging on 600 pile
- Previously identified encapsulation zones
 - No previous zone delineated for burial of radioactive material on the 500 pile.
 - Zone is identified on the 600 pile, and borehole density and depths account for this area.
- Radiometric log boreholes are placed in locations where interactivity with the subsurface profile is highest, or where the highest concerns are
- Robust drill plan in comparison to previous efforts
 - Not every hole needs a radiometric log
 - 96 radiometric holes planned.
 - Cost vs. benefit tradeoff.
 - Wider diameters to fit logging tool.
- Develop a correlation curve in accordance with DEQ guidelines and practices



What is next?

- Now that we have gathered valuable data and information regarding subsurface conditions, we need to conglomerate the data in a manner that promotes informed decision making.
- Working towards developing 3D classifications methods to provide accurate mapping of subsurface profile
 - Qualitative and quantitative estimates
 - Drives our next steps in the reclamation process
 - We will continue to build model as information is gathered for a comprehensive assessment of the 500 and 600 piles.
- Seth will be presenting on this model.



Thank you!

Private Landowners

- Heward 7E Ranch
- Q-Creek Land & Livestock Co.
- Medicine Bow Energy Partners

Agencies/Organizations

- Wyoming Game and Fish Dept.
- Medicine Bow Conservation District
- Wyoming DEQ-AML

Teaming Partners

- Trihydro
- Rockwell Science
- Kirol Applied Ecological Research

Questions?

Contact: csloan@herrerainc.com



**KIROL APPLIED
ECOLOGICAL RESEARCH**