McKinley Mine
A Commitment to Stable Land Forms and Geomorphic Principles

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Chevron

Golder Associates

Project Team

Chevron Mining Inc.

McKINLEY MINE

Golder Associates

Water & Earth TECHNOLOGIES

Kiewit

McKinley Mine History

- McKinley Mine opened in 1962
- 1st large surface coal mine in New Mexico
- Employed 600 people in its peak
- Sold 175,000,000 tons over lifespan
- Entered final reclamation in 2010

Location

- McKinley Mine is located NW of Gallup, New Mexico

- Overview of active reclamation area

Project Challenges

- Handle the interface between existing conventional reclamation and geomorphic reclamation
- Incorporate runoff from large up-gradient watersheds onto disturbed areas
- Highly erosive environment
  - Average annual precipitation of 11.5 inches
  - Rainfall typically occurs over a one-month period in July / August
  - 70% of design rainfall event falls in 30-minute period

Geomorphic vs. Conventional Grading

Geomorphic Graded Slope

- Small watersheds are created by incorporating designed ridges and slopes to produce stable landform
- Creates topographic diversity

Conventional Graded Slope

- Utilizes low gradient terraces to divert water to a drop structure
- Terrace clean out is necessary
- Slope stabilizes over time

Geomorphic Design Methodology

- Create a long term stable product that requires little to no maintenance
- Accomplished by grading concave to convex slopes, inclusion of swales and sub ridges to break up watersheds and channel sinuosity to increase drainage length

Project Team and Roles

- Water and Earth Technologies
  - Performed geomorphic design
    - Post Mining Topography
    - Channel design
- Chevron Mining Inc.
  - Performed rough grading work
- Marston / Golder Associates Inc.
  - Construction design and oversight
    - Revised construction designs
    - Construction oversight and management
- Kiewit New Mexico
  - Performed final detailed construction
    - Geomorphic grading
    - Channel construction

Multi-Software Design

- Carlson Natural Regrade
  - Utilized to develop final post mining topography incorporating conventional reclamation work, native drainage density, soil characteristics and any other unique site specifics
- RUSLE 1.06c
  - Used to calculate and model soil erosion / detachment rates
- SEDCAD 4
  - Used to determine and evaluate channel stability and riprap lining requirements
- AutoCAD Civil 3D
  - Used to develop detailed drawings for permit submittals and for construction

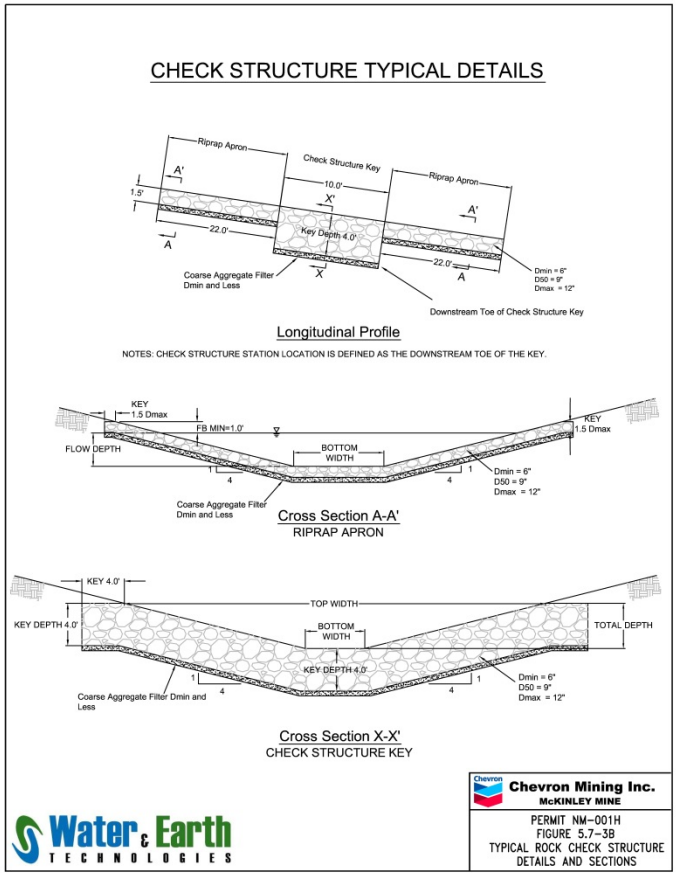
Design Parameters

- Design Storm Event
  - 50-year, 6-hour Storm Event for watersheds less than 640 acres
  - 100-year, 6-hour Storm Event for watersheds greater than 640 acres
- New Mexico Type II Storm Distribution
- Limiting soil stability velocity of 5 fps for unlined channels

Channel Stabilizing

Check Structure

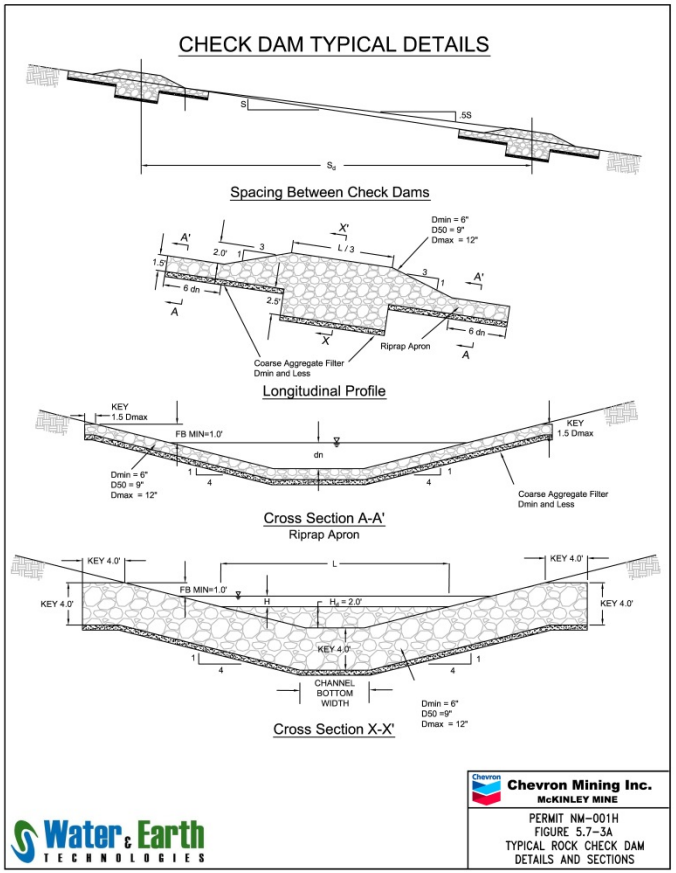
- Used as grade control
- Composed of a large center key to prevent channel head cutting
- Apron at either side to transition into channel



Channel Stabilizing (cont'd)

Check Dam

- Used to reduce channel gradient
- Composed of center dam designed to reduce channel gradient through channel silting in
- Effective way to reduce gradient of large watersheds when slope is less that 3%



Construction

- Drainage construction duration was approximately 2 years
- Detailed construction required small, specialized equipment; mining equipment was too large
- Required highly skilled operators used to detailed work

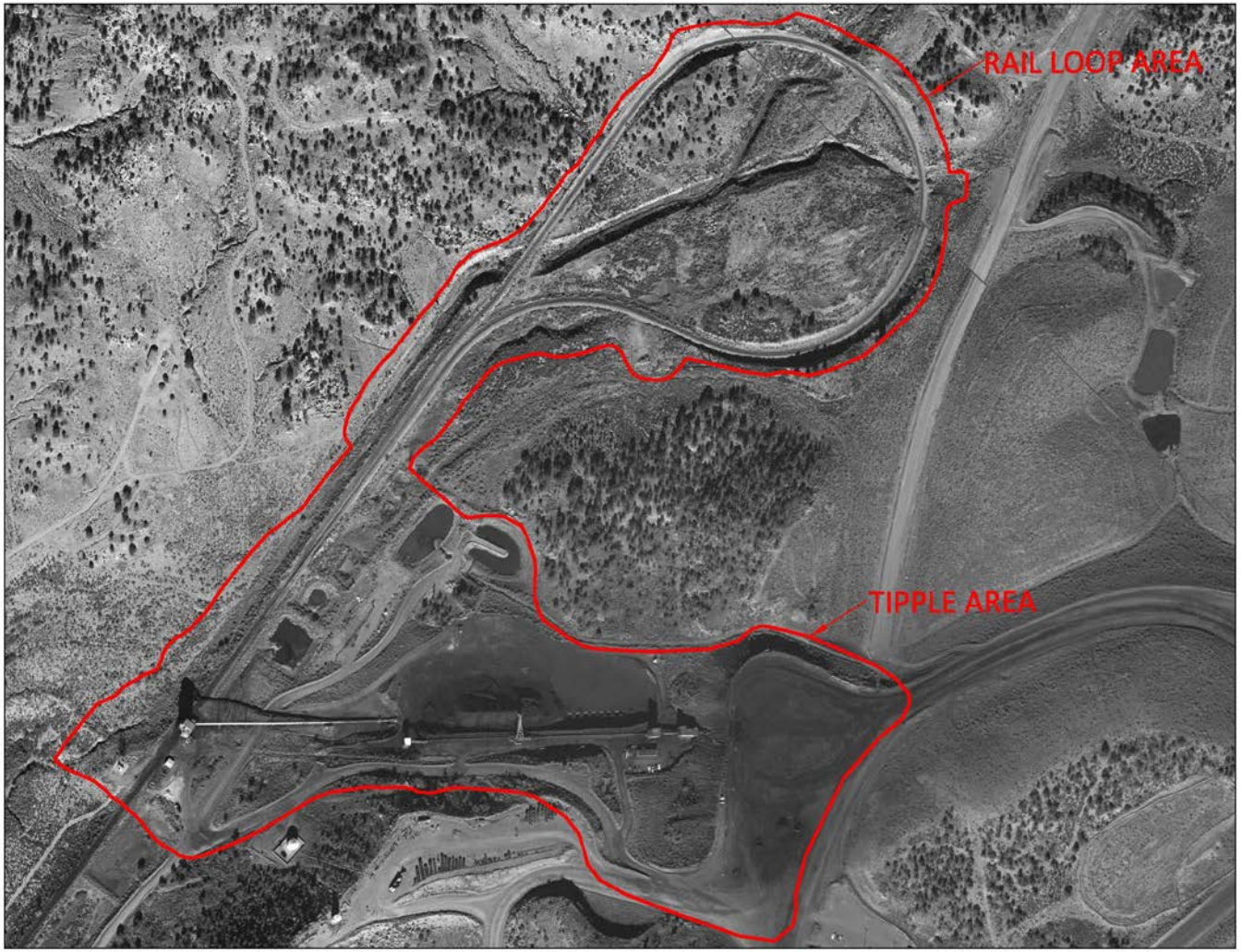
Construction (cont'd)

- A professional team of engineers and supervisors worked continuously to develop designs during construction
- Success factor was a collaborative team effort between operations and engineering

Tipple Area

- Composed of two different areas presenting differing challenges
  - Hopper and load out facilities
    - Structure removal
    - Minimum cover requirements on unsuitable material
    - Steep slopes
    - Large cut / fill balance
  - Rail loop corridor
    - Large earthwork mass balance
    - Blending of geomorphic reclamation with surrounding undisturbed areas
    - Reconstruction of natural wash with watershed > 5,000 acres

Tipple Area (Cont'd)



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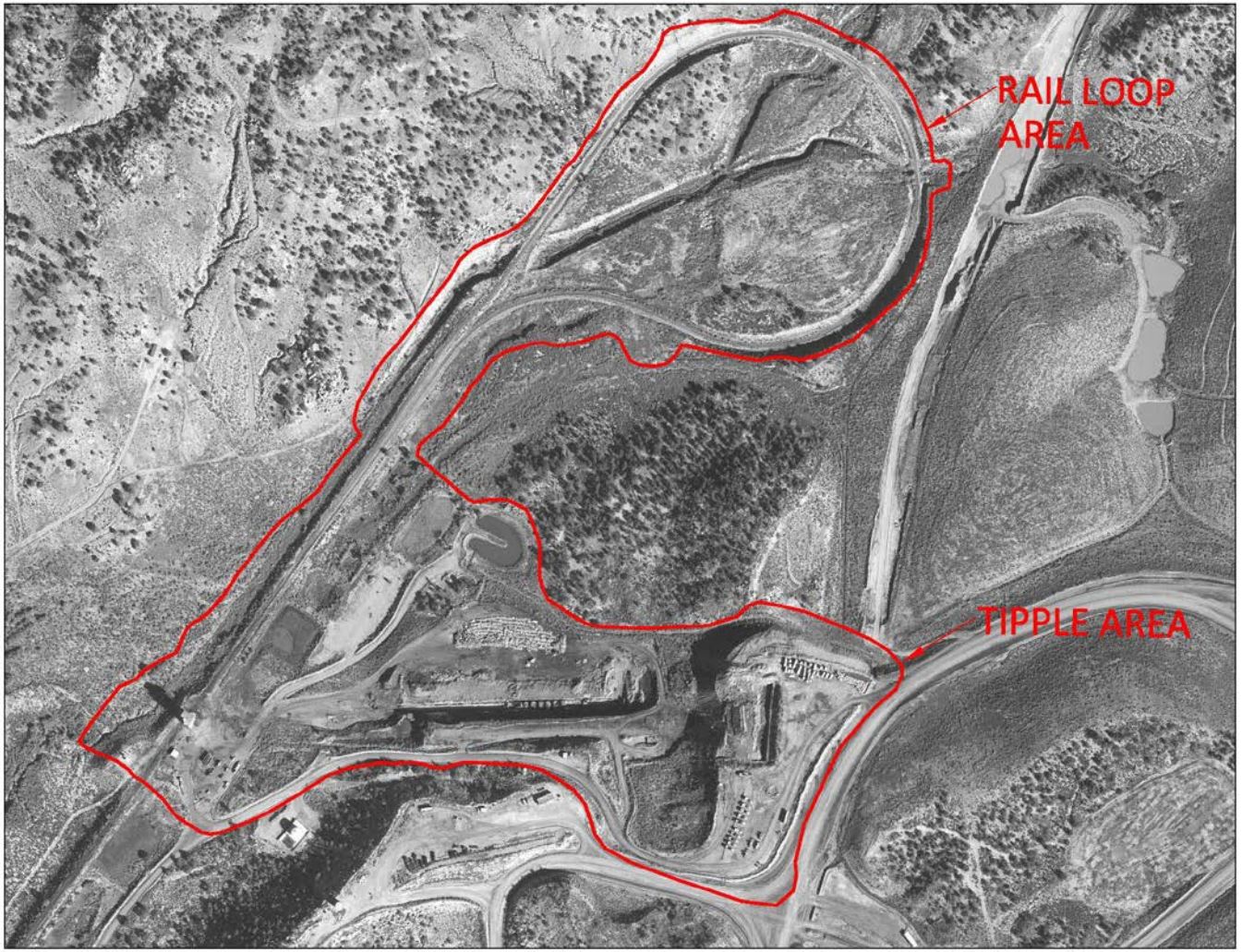

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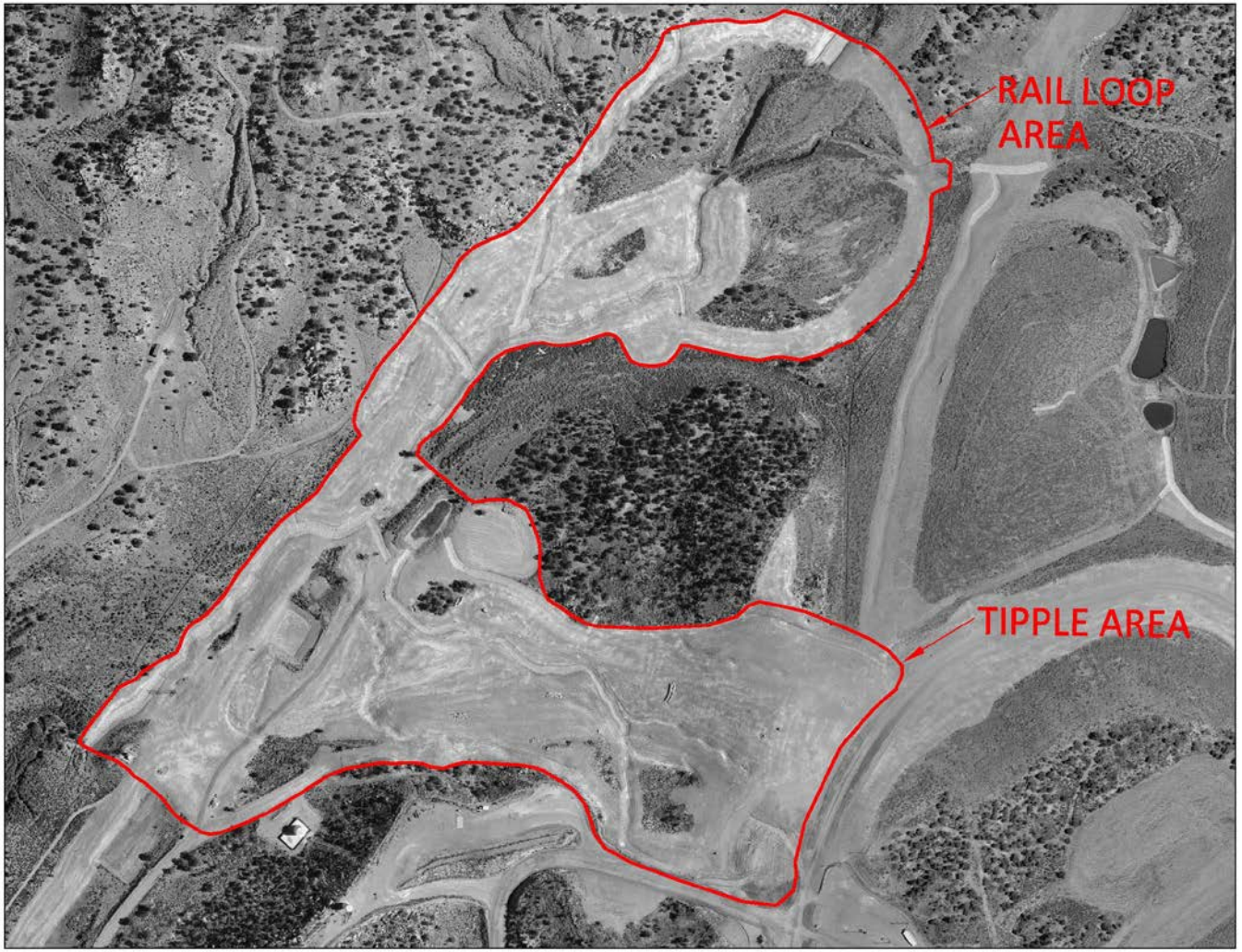

Tipple Area (Cont'd)

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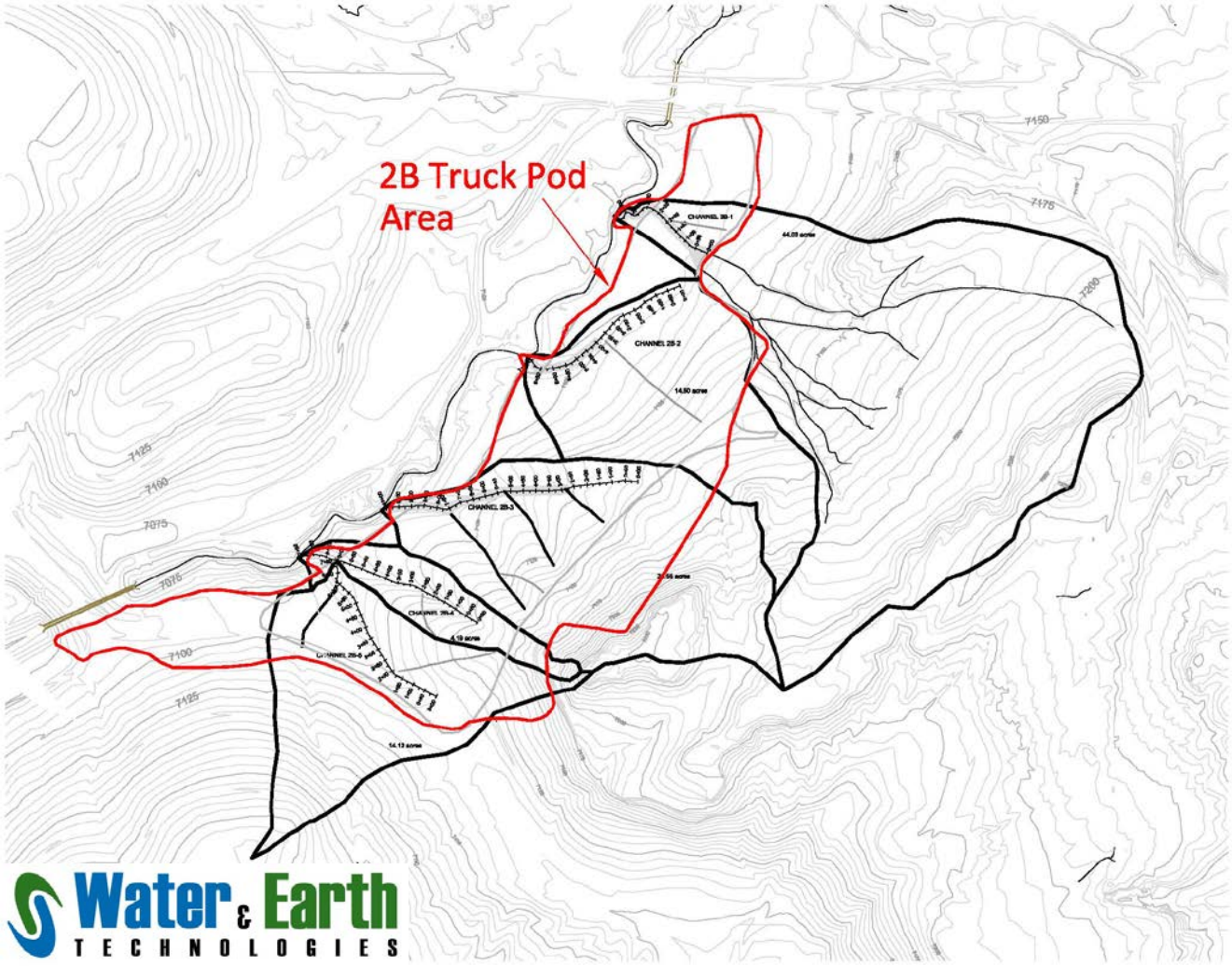
Tipple Area (Cont'd)

2B Truck Pod

- Small parcel in the overall mine mined using truck and shovel that is limited on one side by a significant wash and a ridge on the other side that limited coal recovery
- Mining was completed in 2009 and the reclamation completed in 2012
- Reclamation created a unique situation due to the gradient transition from the ridge to the natural wash within a small area
- Geomorphic principals were used to grade the slopes into a convex configuration with ridges and swales to break up the area and create a stable landform.
- Blending of large hill at edge of disturbance to overall grading plan

2B Truck Pod (Cont'd)



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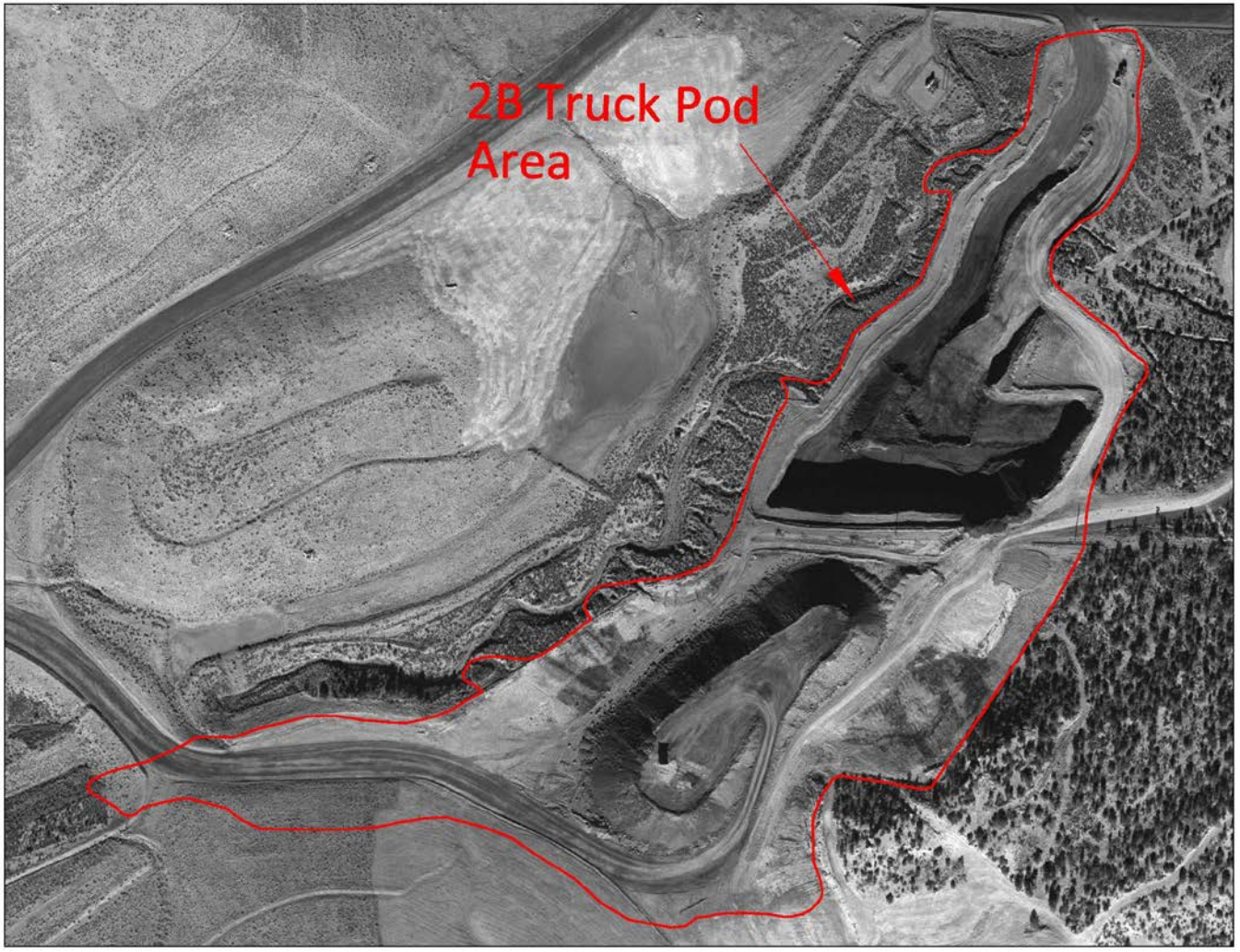
2B Truck Pod (Cont'd)



2B Truck Pod (Cont'd)

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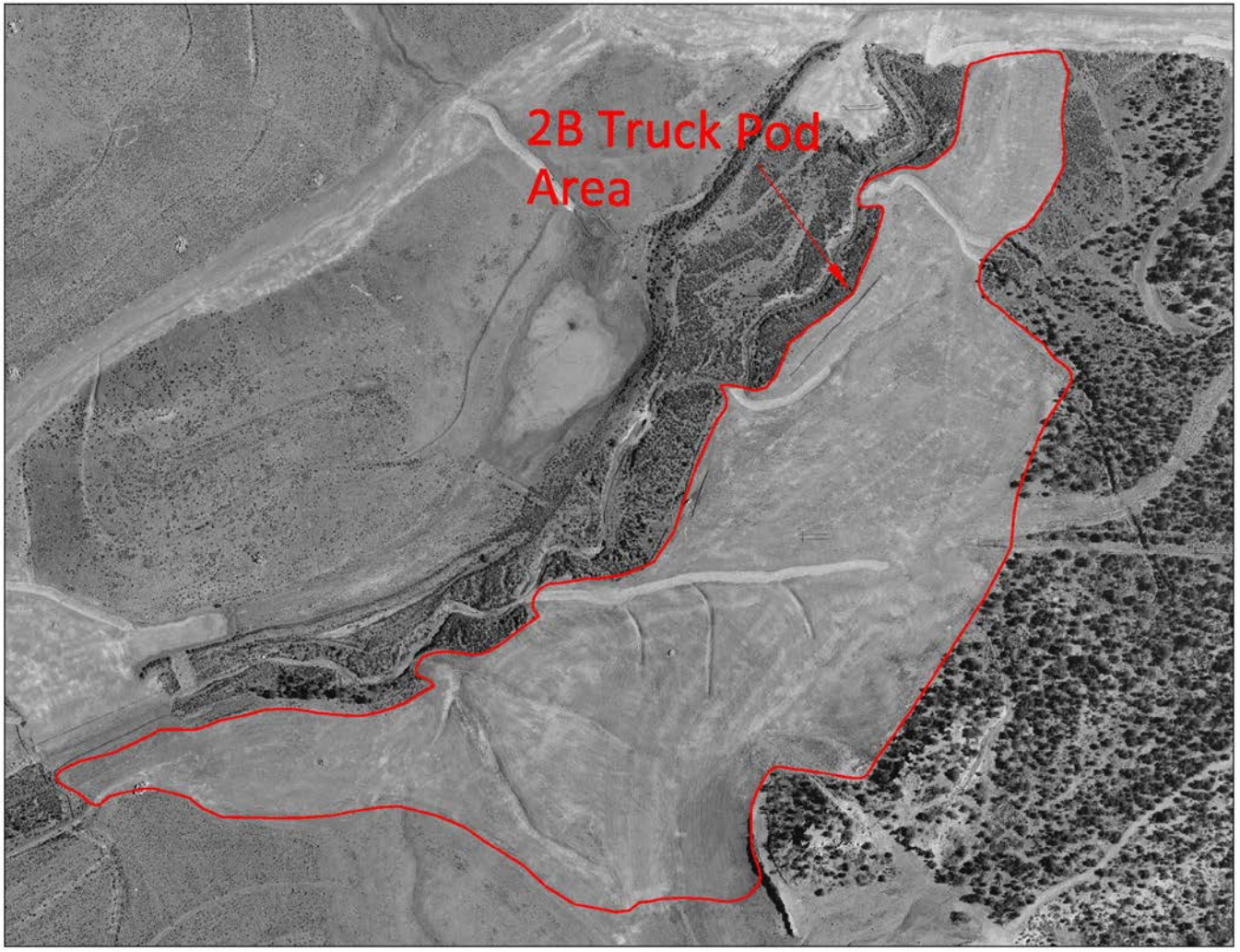
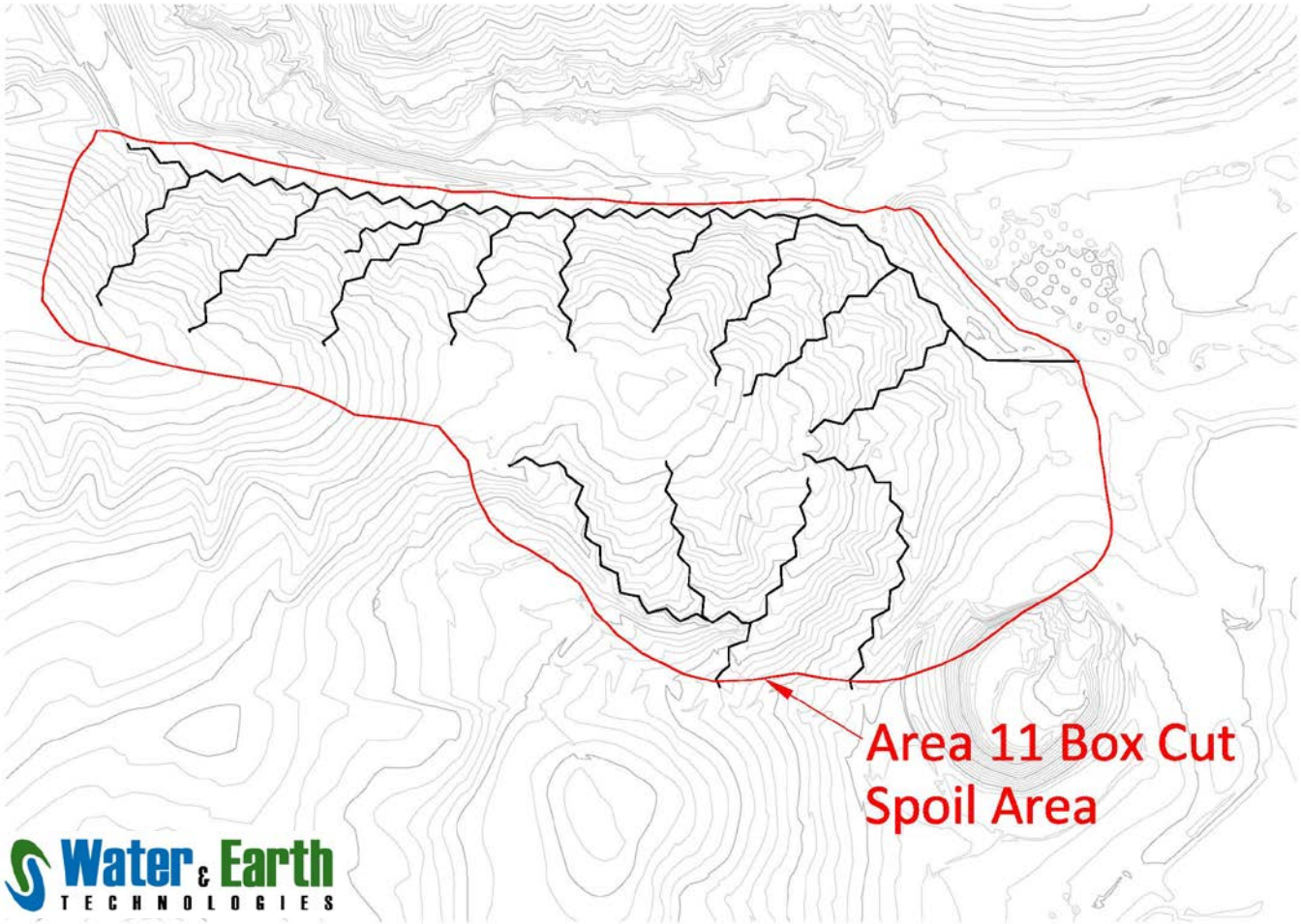


2B Truck Pod (Cont'd)

Area 11 Box Cut Spoil

- A material cut / fill balance was created to ensure optimum cost effectiveness of grading plan while created stable landform
- Long convex slopes were created with ridges, sub ridges and swales to break up the watersheds
- The flow was concentrated at the toe of the slope and armored with rip rap to prevent future erosion
- Final configuration is stable and will require minimal maintenance during the Extended Responsibly Period (ERP)

Area 11 Box Cut Spoil (Cont'd)



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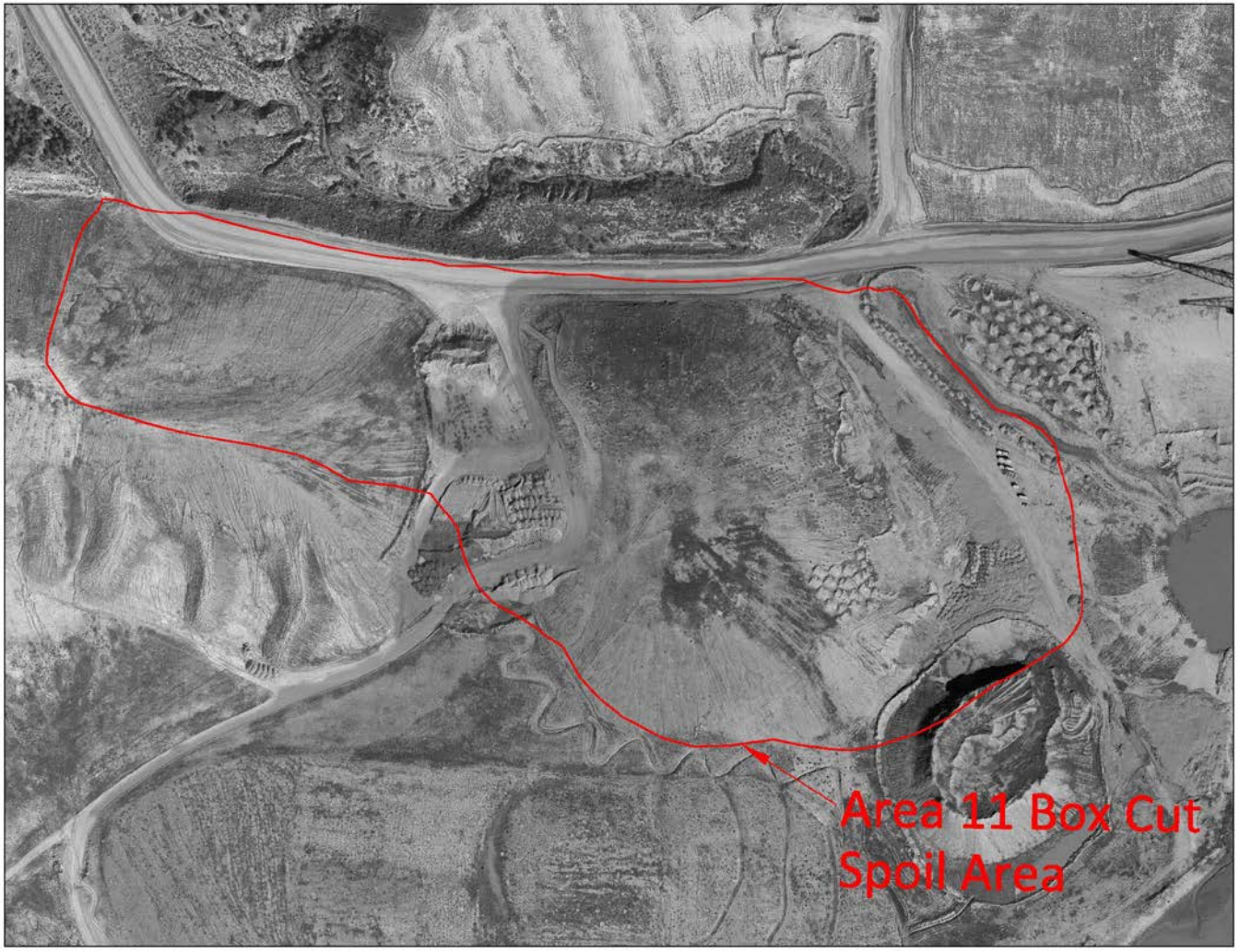

Area 11 Box Cut Spoil (Cont'd)

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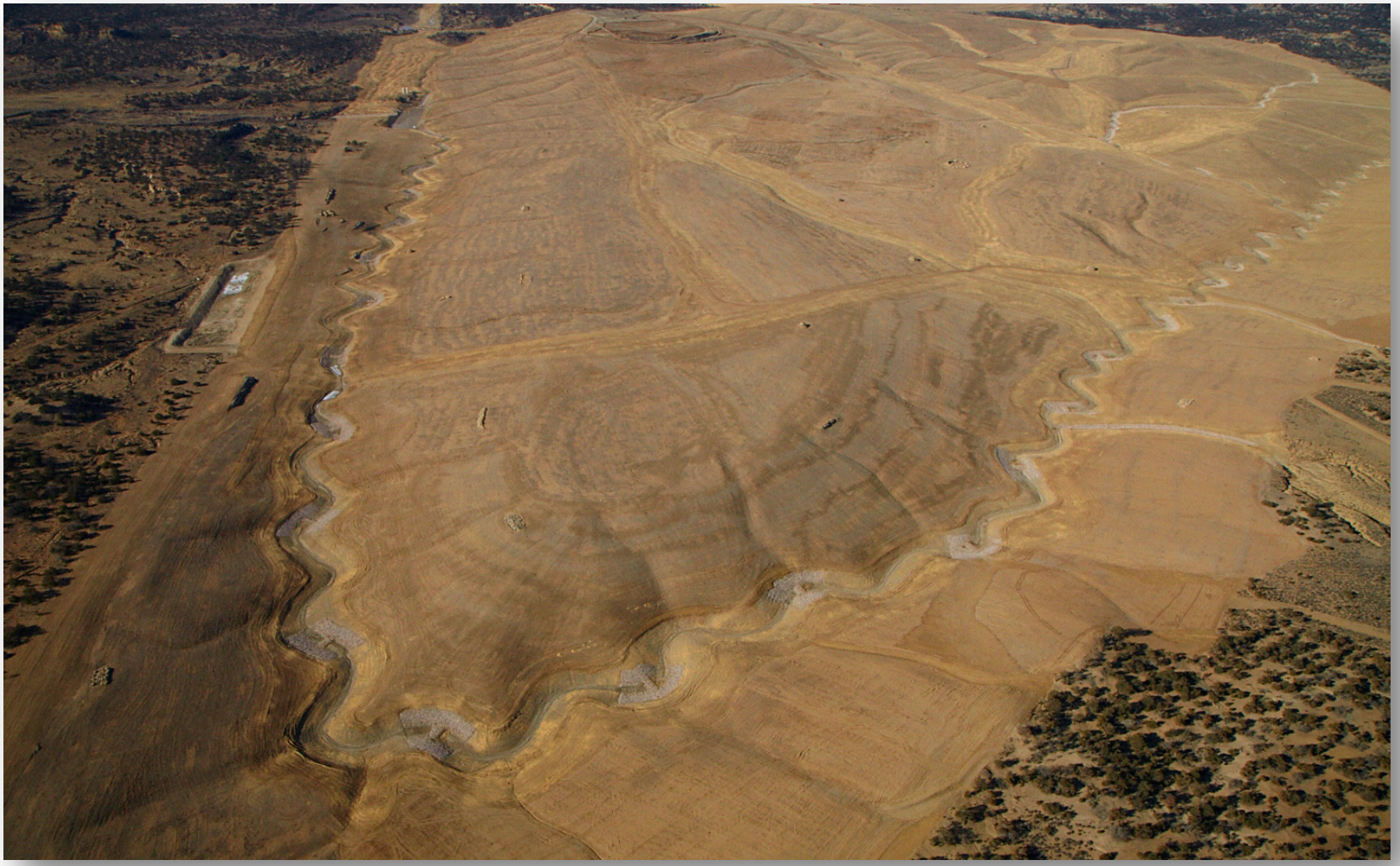
Area 14/15 Final Pit Channel (Cont'd)

- Channel is approximately 13,500 ft long
- Watershed area of approximately 1,800 acres
  - 50% of watershed area is from undisturbed offsite drainage
- Utilizes high sinuosity channel to reduce gradient
- Contains 36 check dams to further reduce grade

Area 14/15 Final Pit Channel



Area 14/15 Final Pit Channel (Cont'd)

Questions

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