LANDFORM DESIGN IN MINE RECLAMATION: IS THIS THE FUTURE?

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June 7, 2023

40th ASRS Annual Meeting
Boise, ID, June 4-7, 2023

A Dynamic and Evolving Landscape

Landscape Altering Processes

- Climatological
  - Thermal variations
  - Aeolian
  - Extreme events
- Biological
  - Flora and fauna (i.e., biota)
  - Anthropogenic
- Hydrological
  - Precipitation
  - Flooding
- Tectonic
  - Seismic
  - Gravitational

The Mine Reclamation Conflict

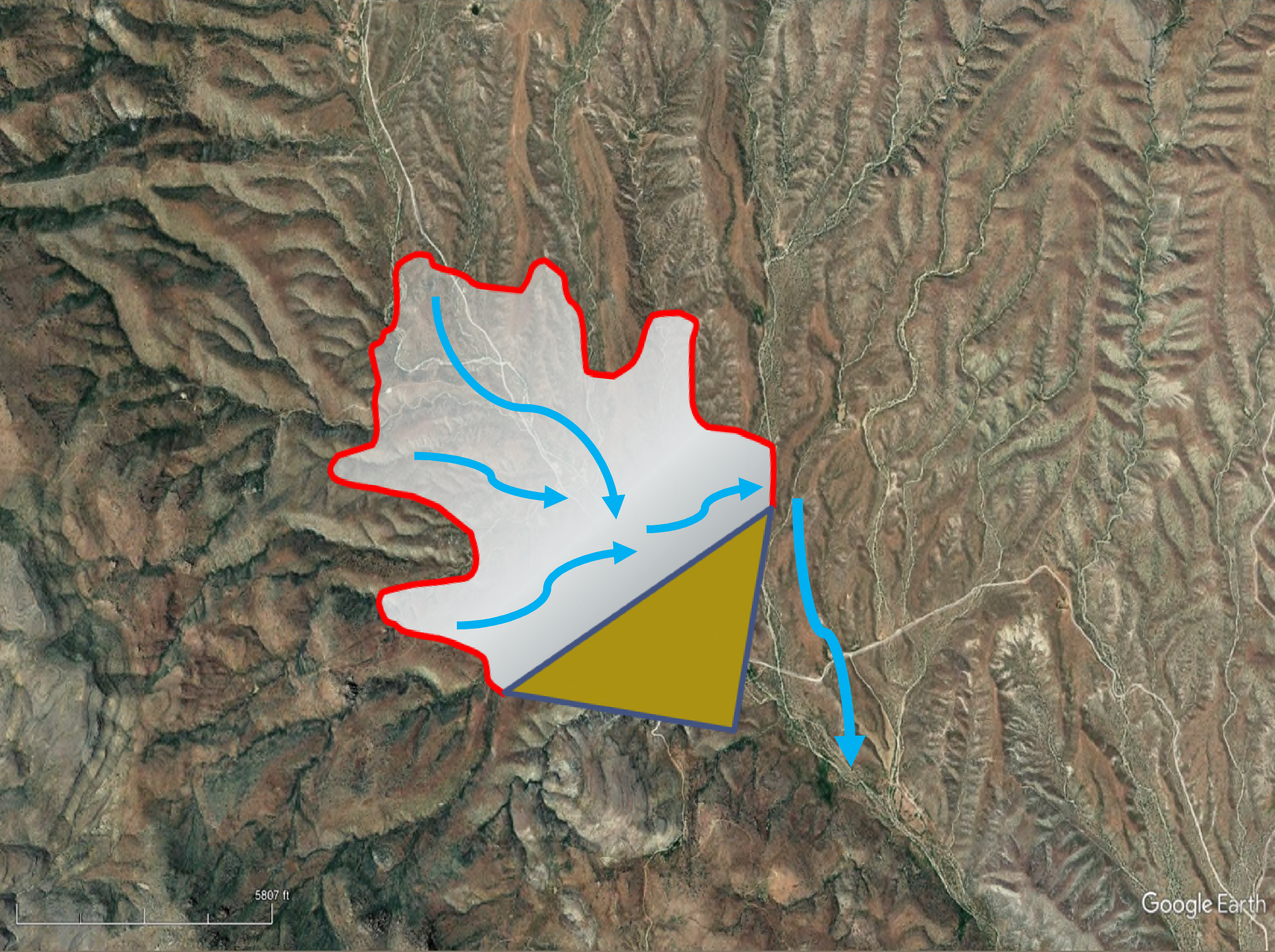
Engineered Systems

- Underdrains
- Water Balance Covers
- Seepage Collection Systems
- Surface Water Diversion Ditches
- Sediment Ponds
- Geosynthetics
- Electronic Monitoring Systems

A Dynamic Landscape

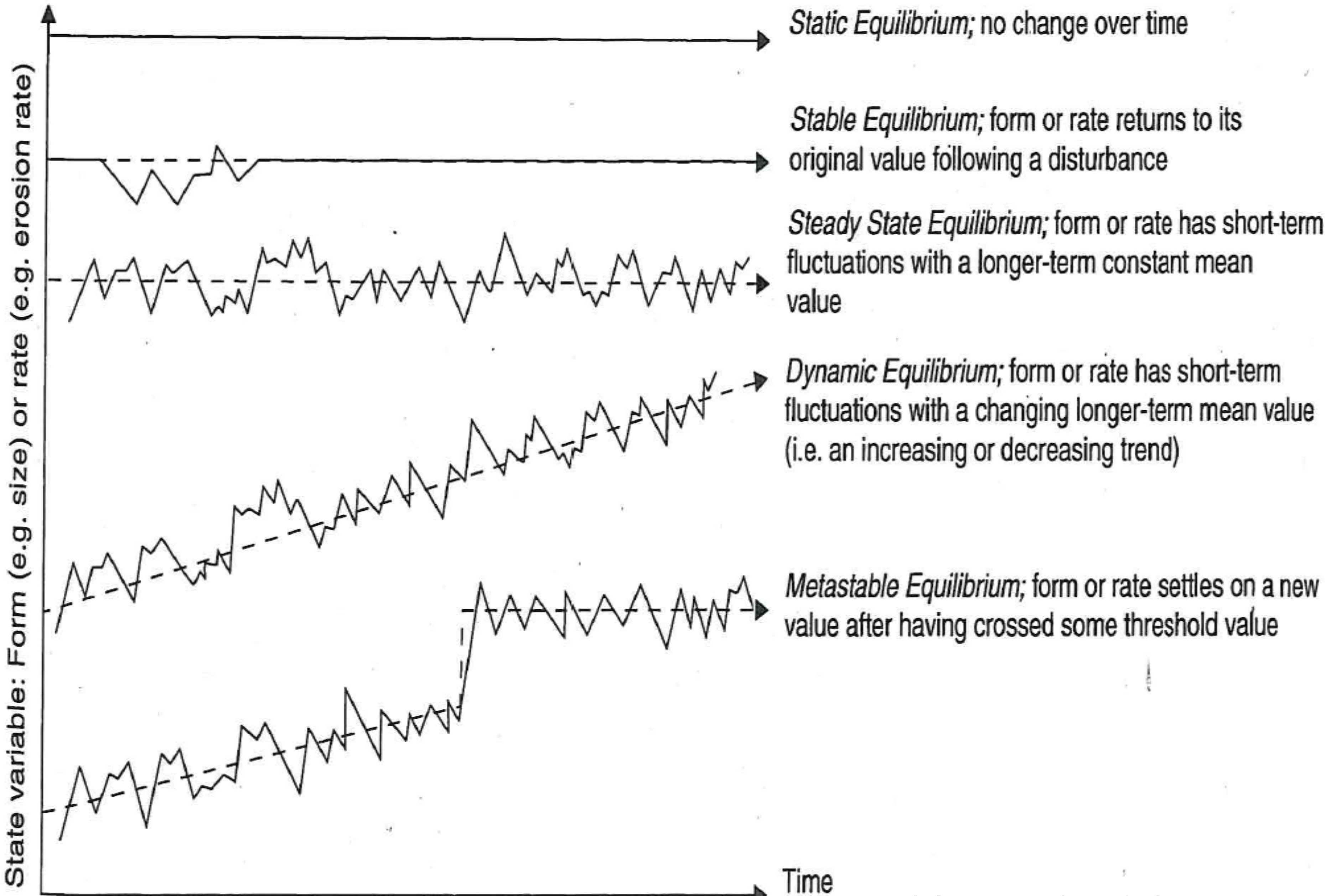
- Rain Events
- Flooding
- Slope Creep (i.e., gravity)
- Freeze-Thaw
- Wind Erosion
- Wildfire
- Drought
- Animal pertubations


Image Landsat / Copernicus
Google Earth


5807 ft
Google Earth

Landscape Equilibrium

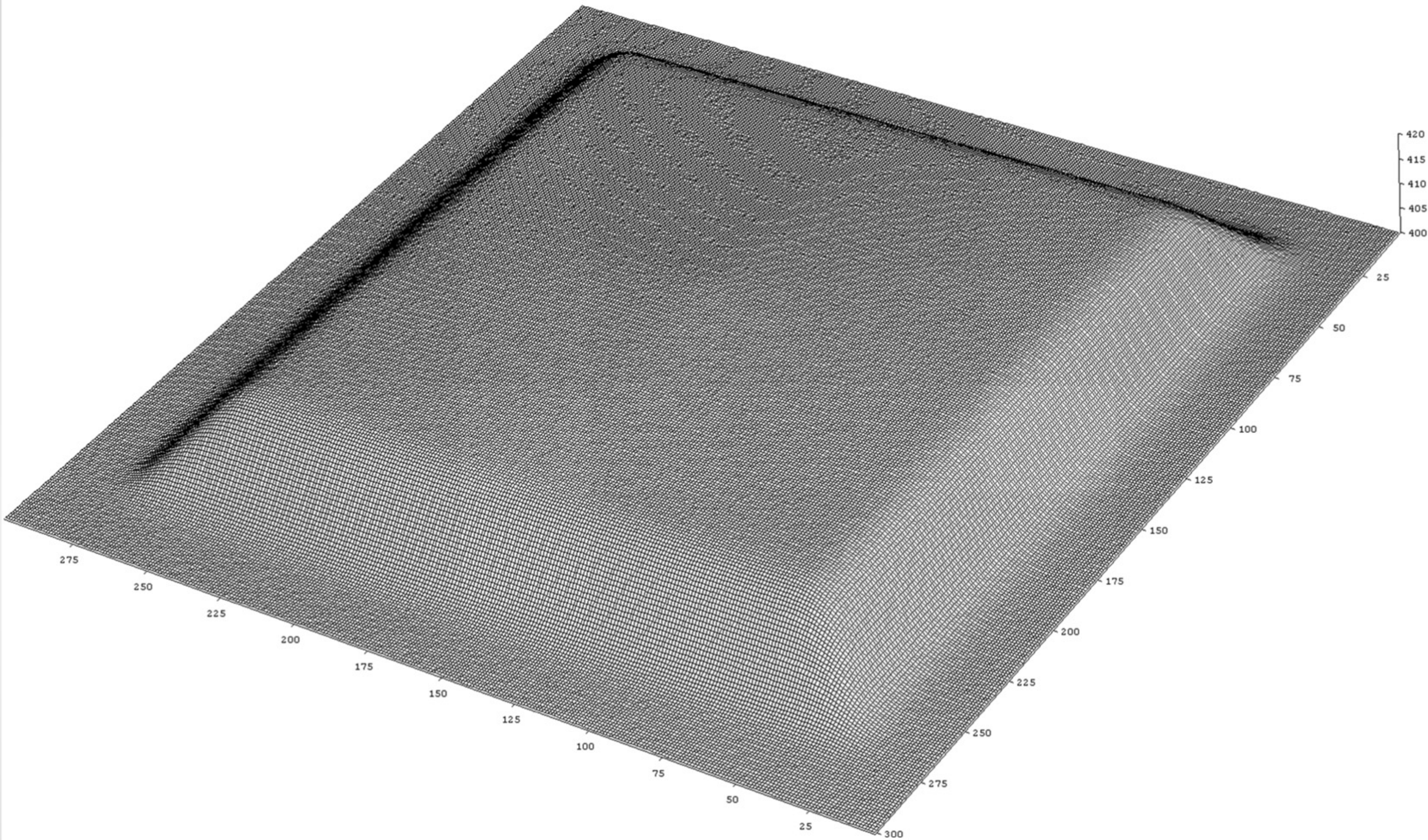
- A landscape evolves in response to imposed natural forces.
- A landscape evolves based on the geological, environmental, and climatological conditions unique to that area.
- Change can be measured on a micro-scale or on a macro-scale.
- A landscape is in a continuous re-equilibration cycle of force vs. resistance, process vs. response.
- Change may be slow or in response to extreme events; landscape change can be measured over years, decades, or millennia.
- End result: Landscape equilibrium



(after Kennedy and Chorley, 1971, in Fookes et al., 2007)

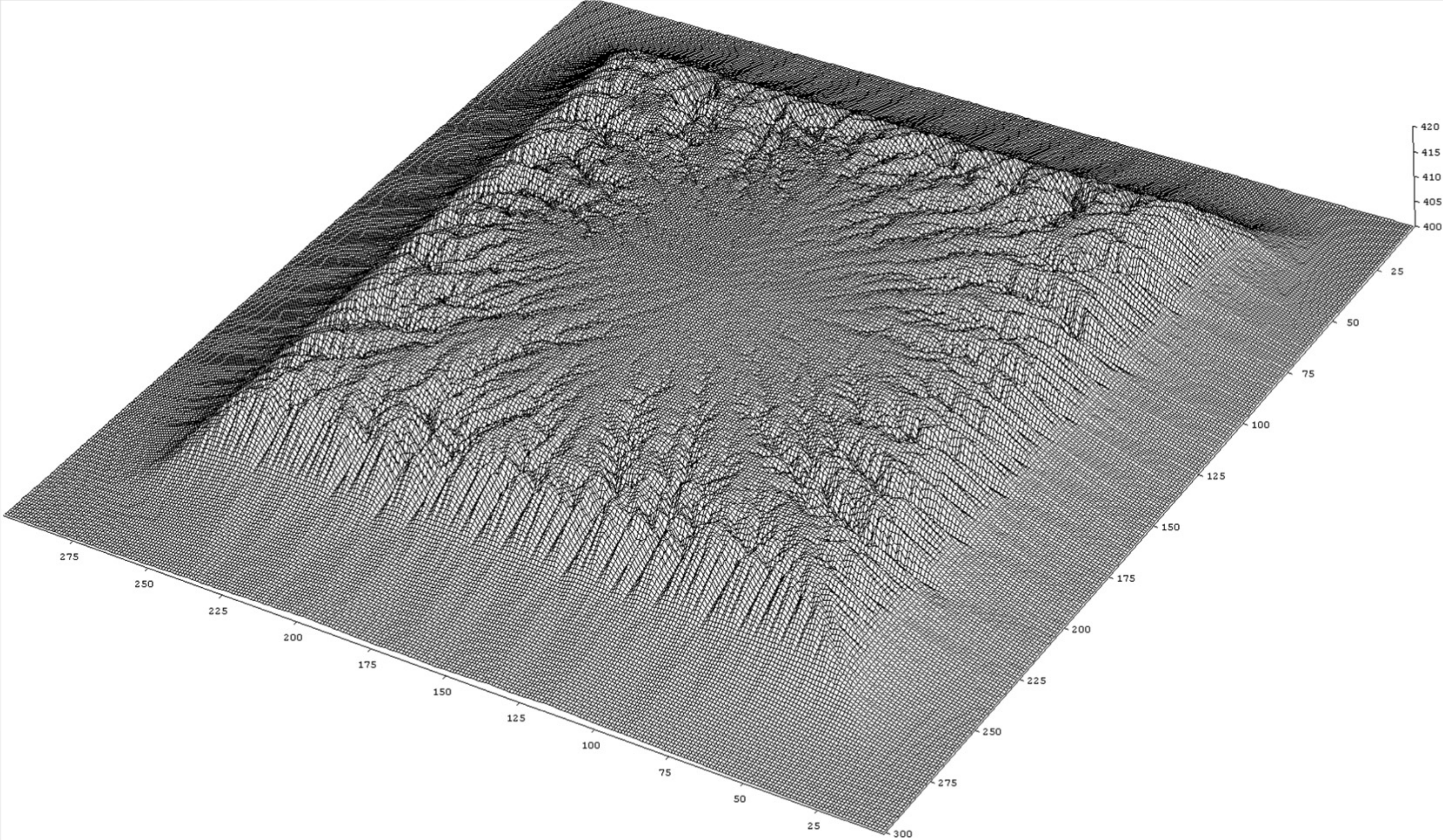
Landform Evolution Models (LEMs)

- Computer-aided modelling of topographic surface change through time
- Discretized landform surface
- Measure sediment erosion and deposition
- Precipitation, soil attributes, vegetation are input parameters
- Model single events or long-term time horizons
- Can model soil loss (tons/ac/yr), method of erosion (sheet vs. rill or gully), surface elevation changes through time, and response to climate fluctuations.



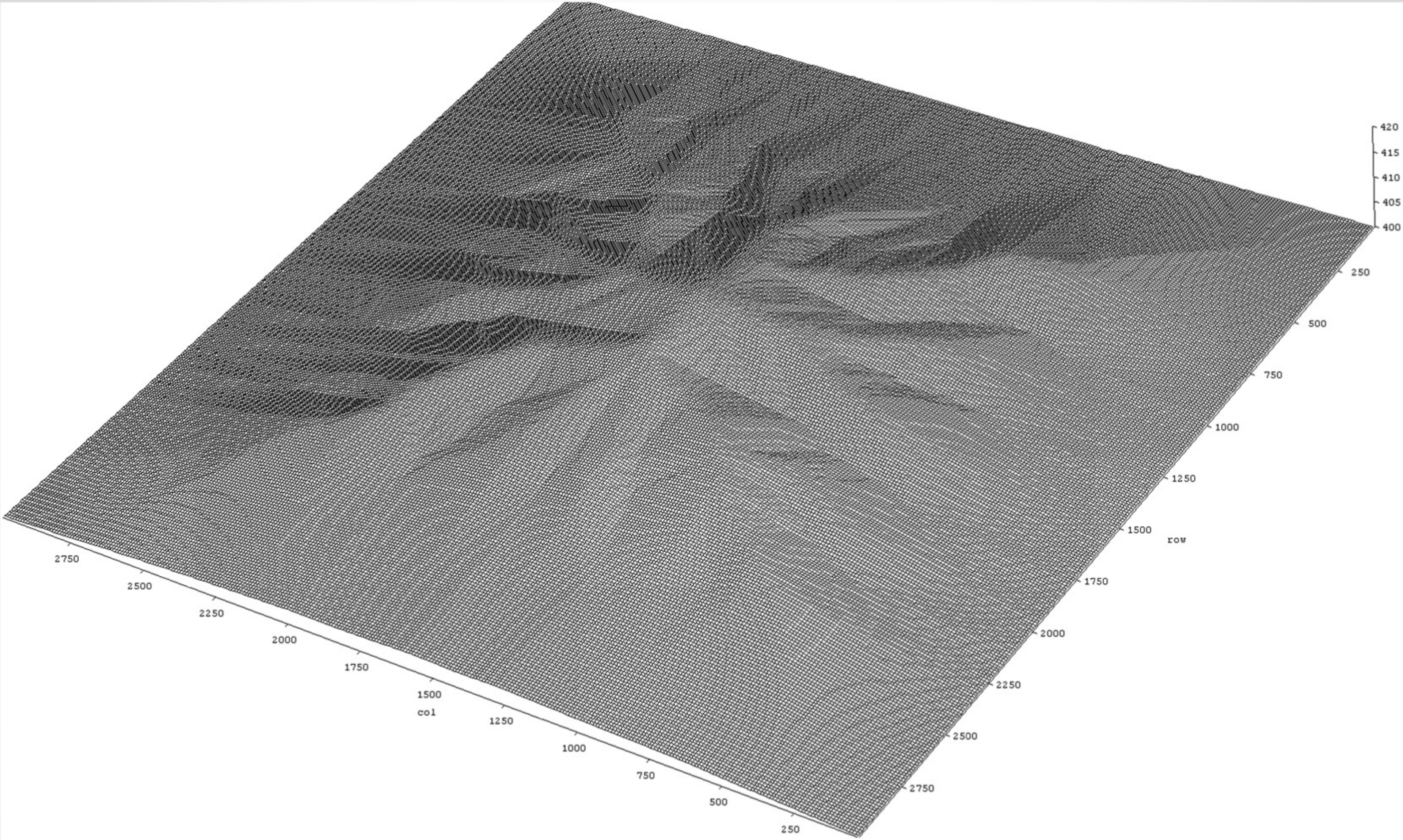
LEM of a TSF at Year 0

Adapted from, “A method for assessing the long-term integrity of tailings dams”, by G.R. Hancock, 2021, *Science of the Total Environment, 779.*



LEM of a TSF at Year 1,000

Adapted from, “A method for assessing the long-term integrity of tailings dams”, by G.R. Hancock. 2021, *Science of the Total Environment, 779.*



LEM of a TSF at Year 100,000

Adapted from, "A method for assessing the long-term integrity of tailings dams", by G.R. Hancock, 2021, *Science of the Total Environment, 779.*

Reclamation Success and the Natural System

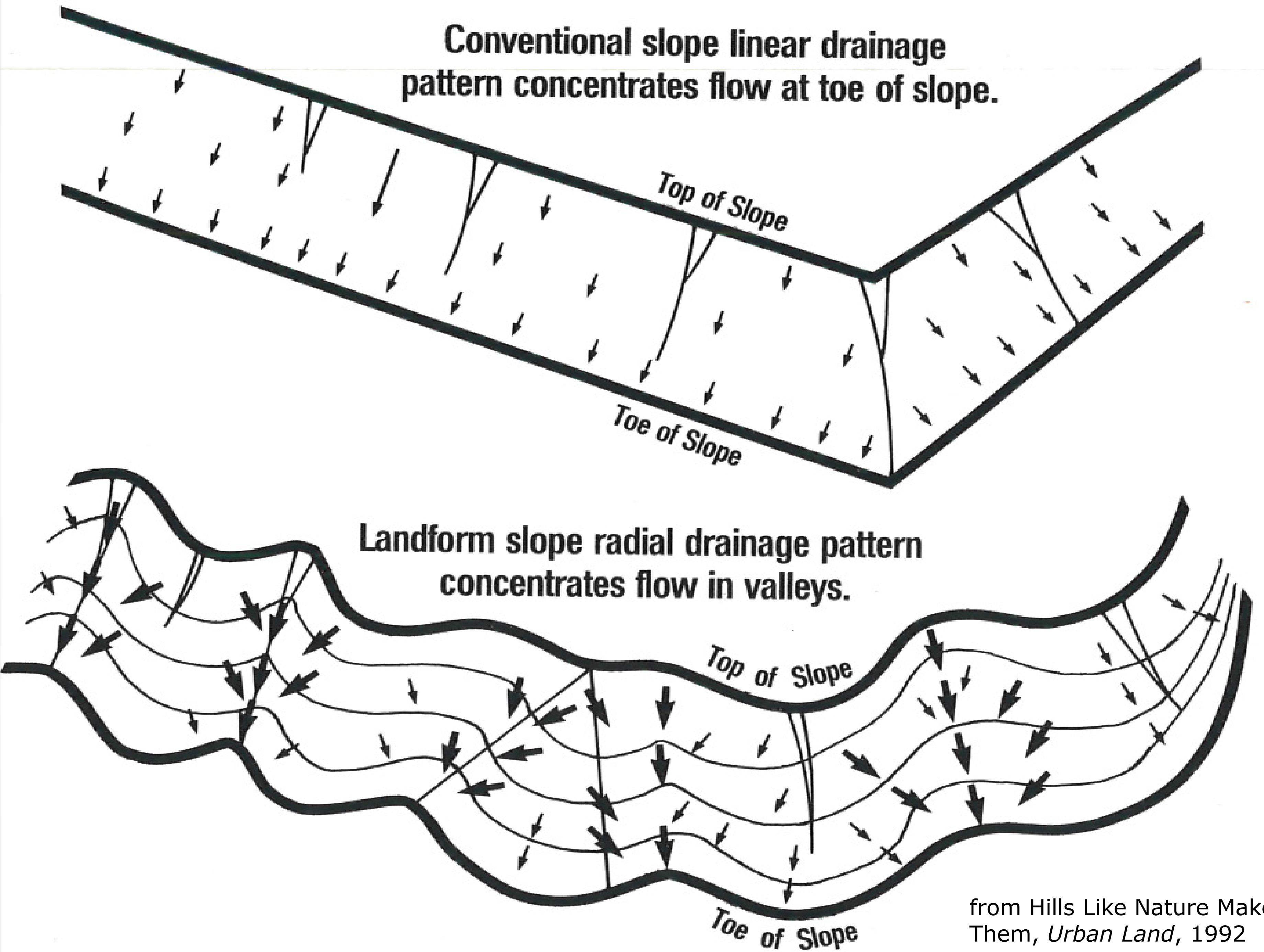
- Balance of natural processes vs. system resistance (sed + water input vs. ability to transport)
- Ability to adapt to system upset (from both extreme event and chronic stressors)
- System resilience
- Re-establish a steady state condition, *leading to…*
- Stable, sustainable, and functional ecosystem

USDA

FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

Read the Landscape

- Use natural landscape as an analogue
- Landscape has evolved in response to climatological, environmental, and natural processes unique to the area
- Geology has much to do with final landscape
- Drainage patterns and channel geometry
- Soil type, properties, and distribution
- Vegetation types and pattern



from Hills Like Nature Makes Them, *Urban Land*, 1992

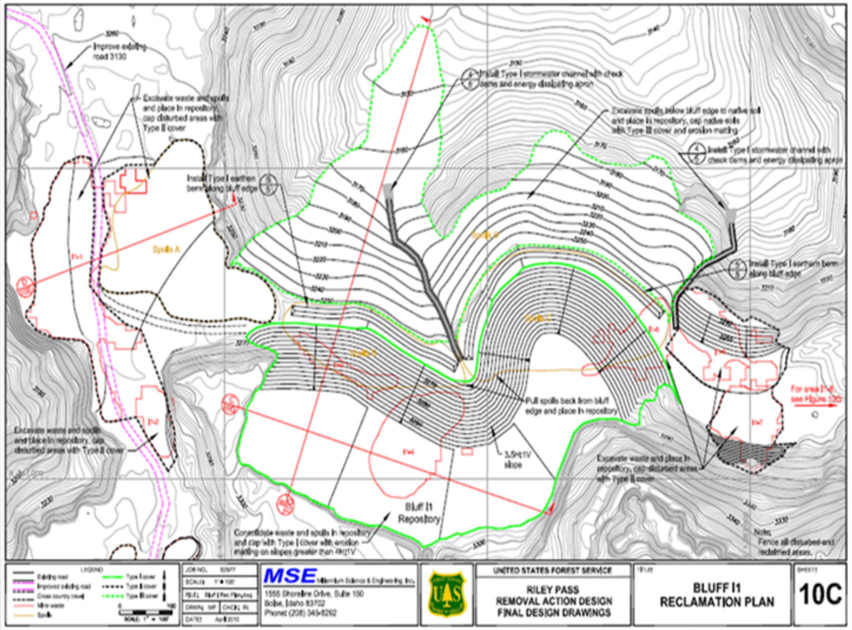
Traditional Mine Reclamation

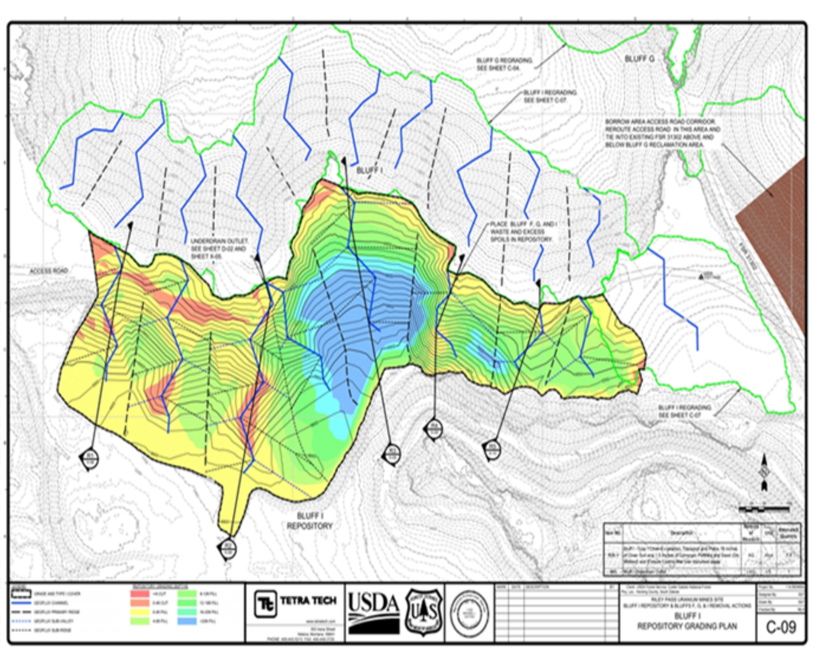
- Geometric shapes and forms
- Uniform slope angles
- Linear features such as on-contour surface water ditches and mid-slope benches
- Use of non-native design elements (e.g., rock lined ditches, sediment basins, and check dams)

Landform Reclamation

- Informed by existing natural landscape
- Complex slopes: convex crest, concave toe
- Topographic diversity
- Variable slope aspect
- Multiple, small drainage basins (catchment)
- Natural channel morphology (increasing channel cross-section downstream; steeper channels as move up slope, multiple order channels in catchment)
- Strategic veg planting

Conventional vs. Landform Reclamation





Landform Reclamation Benefits

- Increased Landscape Stability
  - Geomorphologically compatible
  - Ability to heal
- Risk Reduction
  - Prolonged stability reduces re-exposure
  - Reduce maintenance requirements
  - Financial benefits
- Aesthetically Pleasing


Comments?