Preventing Breakthroughs of Impounded-Coal-Waste-Slurry into Underground Mines

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Variations in impoundment status

Variations in impoundment construction

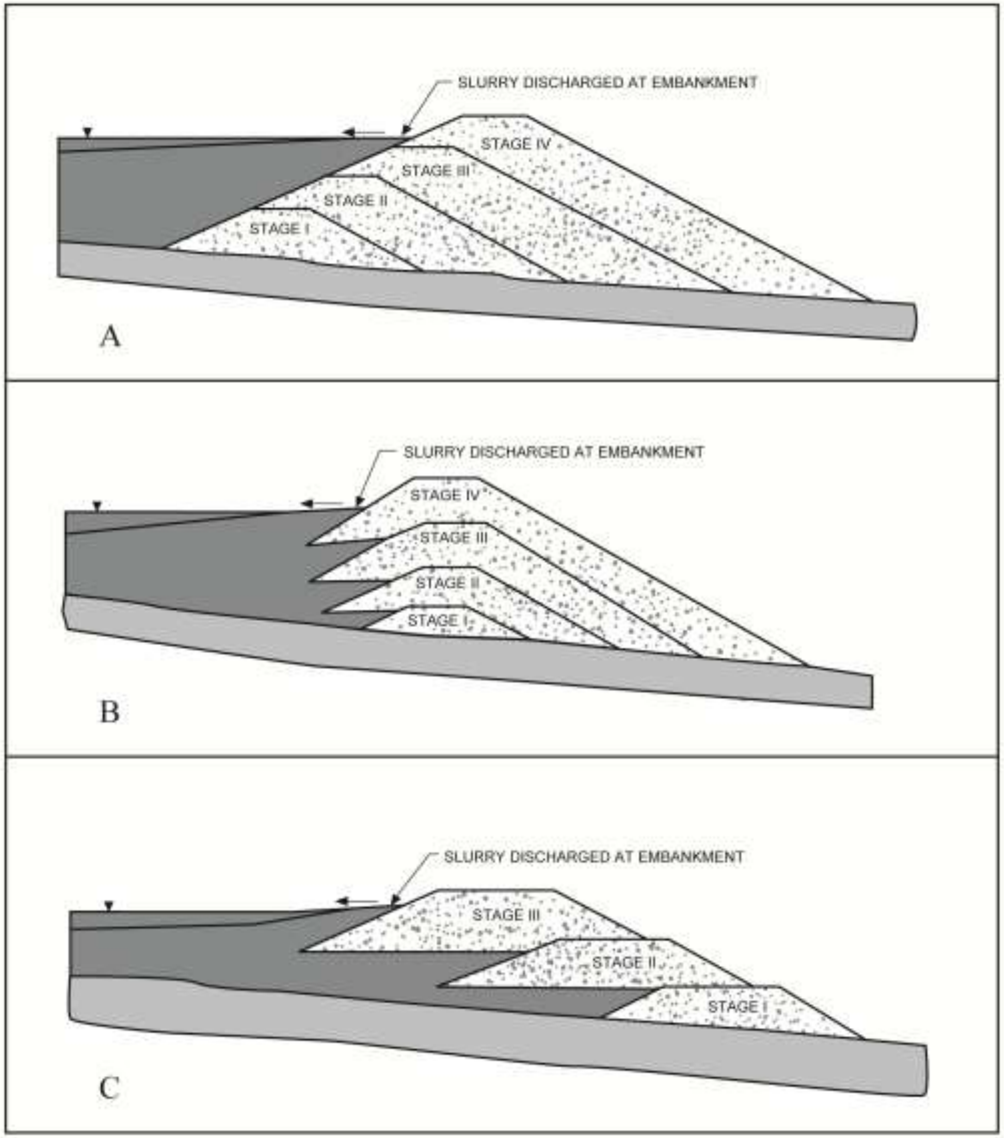
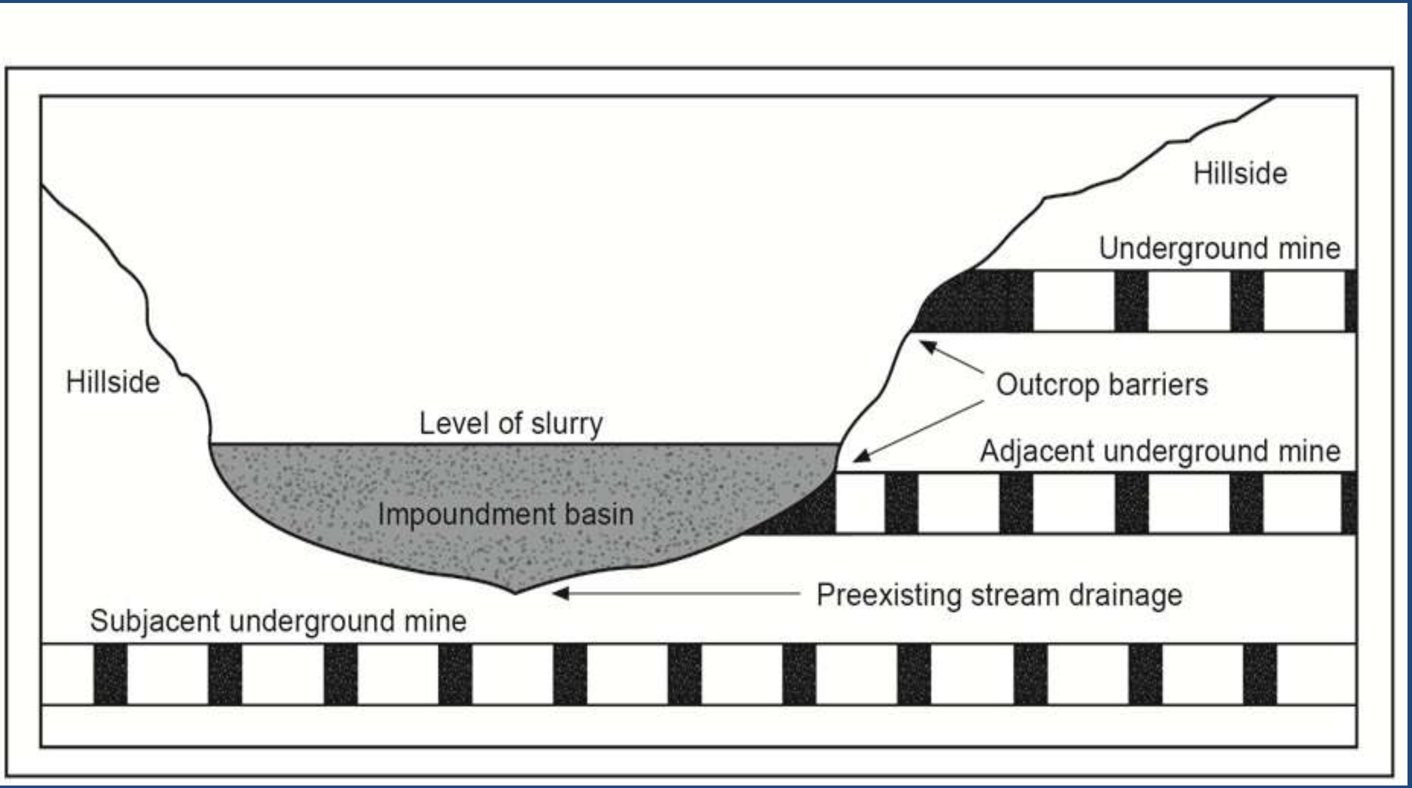
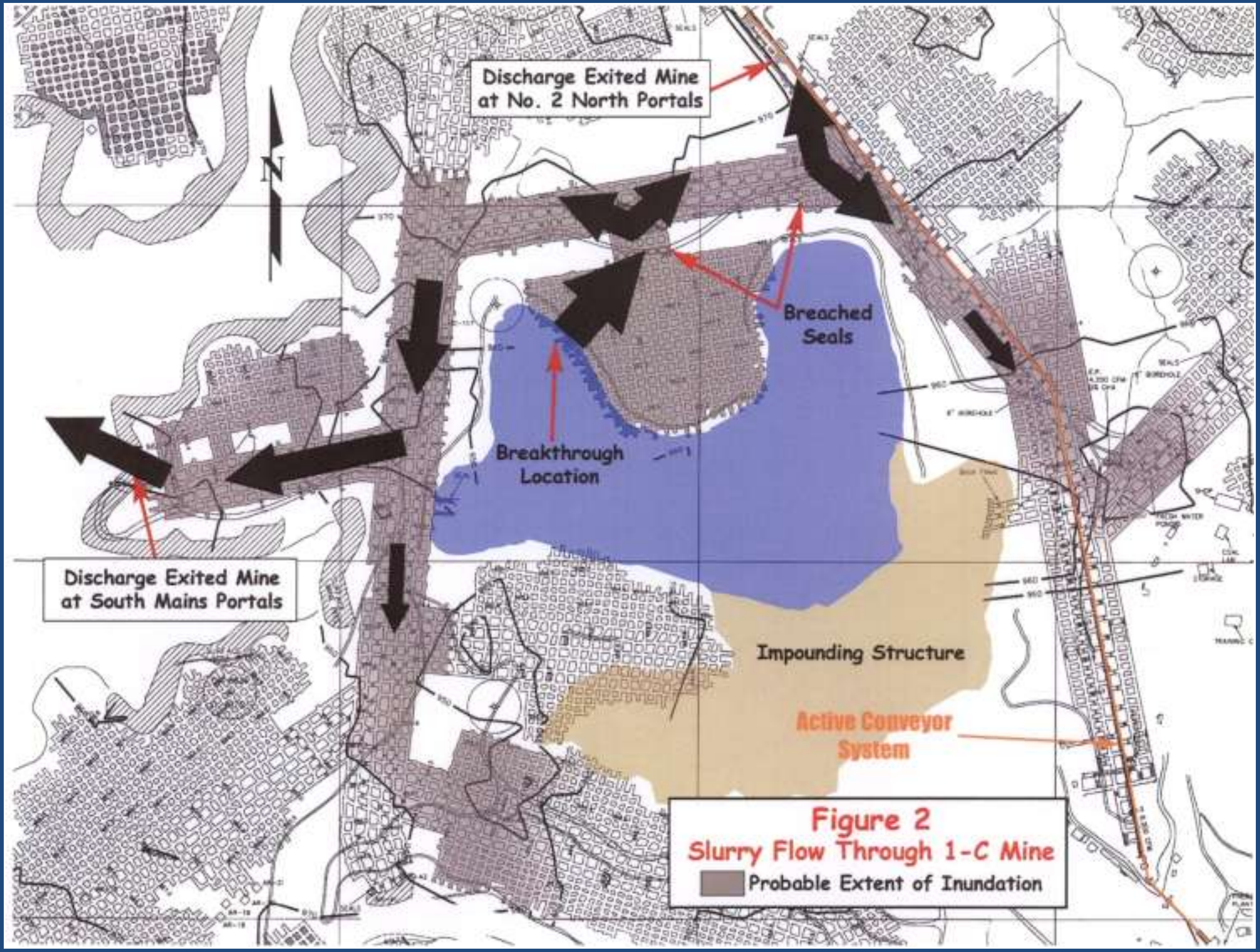


Figure 2: Schematic cross sections of downstream (A), centerline (B), and upstream (C) slurry-impoundment-construction methods. (Diagrams from D'Appolonia, 2009)

Adjacent and Subjacent Coalbeds



Schematic depiction of a slurry impoundment basin, and adjacent and subjacent coal mine workings. (Diagram from NRC, 2002)



October 11, 2000 breakthrough at the Big Branch slurry impoundment in Martin County, KY (MSHA, 2001).

Two Principle Unknowns

1. Existence and location of workings in the vicinity of the impoundment (site-specific)
    - If workings are present, then condition of barriers between the mine and the impoundment.

2. Flowability of the impounded fine coal refuse slurry (general and site specific)

Most Recent and Ongoing OSM Studies

"Technical Position Paper: Potential of Impounded-Fine-Coal-Waste Breakthroughs into Underground Mines: Issues and Answers," 2011

West Virginia "Oversight Report: Coal Slurry Impoundment Breakthrough Potential (Phase III)," 2013

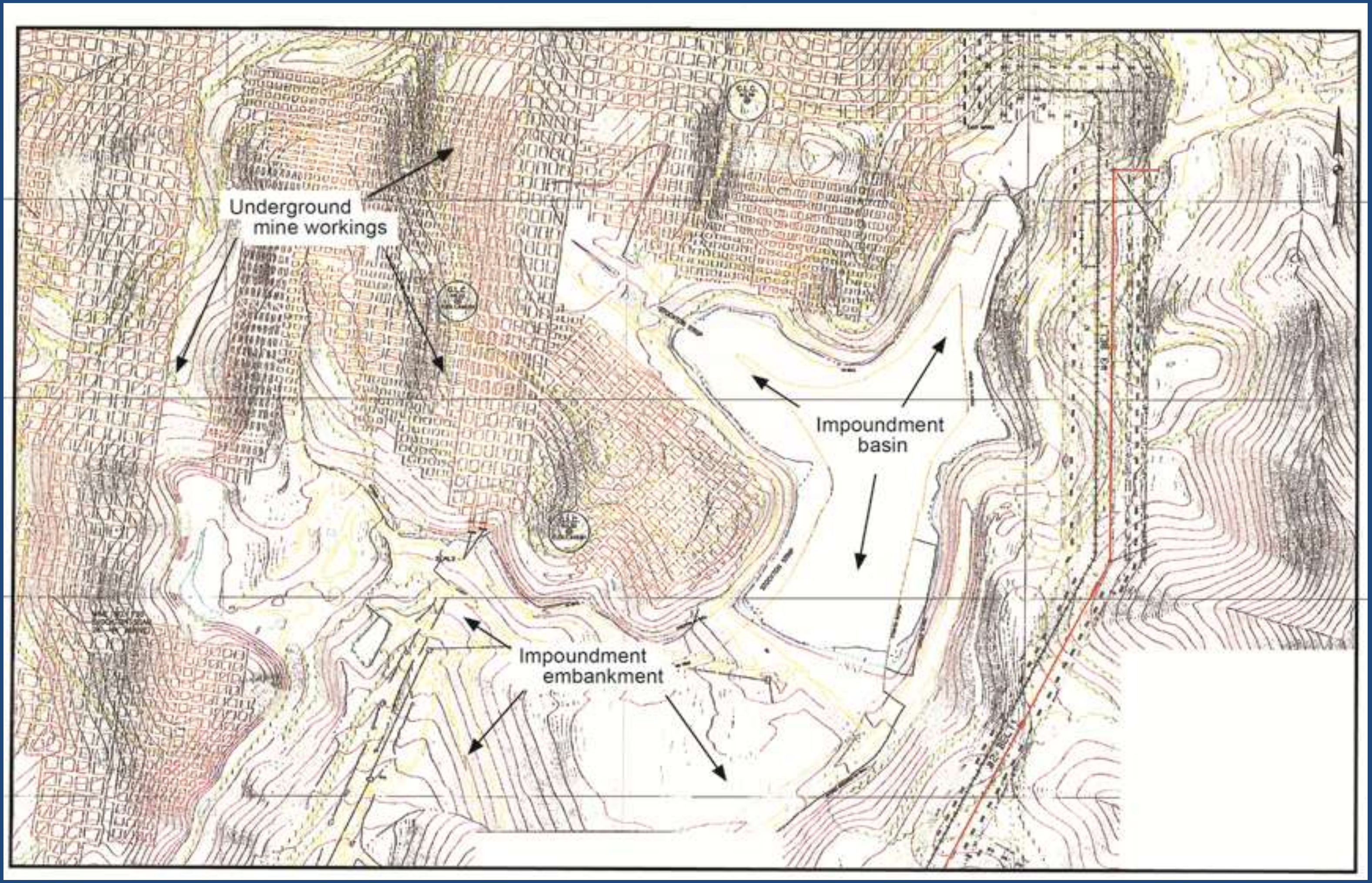
Appalachian Region Evaluation (Oversight Studies of other Appalachian State Programs), 2016 - 2017

Applied Science Study: "Geotechnical Properties and Flow Behavior of Coal Refuse under Static and Impact Loading," 2015

Impoundment Breakthrough Issues

1. What is a minable seam?
2. Can we trust mine maps to give us all the mining-related information we need?
3. How can we determine whether minable seams have been mined?
4. What do we know about the flowability of fine refuse slurry in active, inactive, capped impoundments; and capped impoundments below multiple layers of slurry cells?
5. How can we test the impounded slurry for its flow characteristics?
6. What precautions and restrictions should we recommend to prevent breakthroughs?
7. If an underground mine that intersects or lies below an impoundment is below drainage, should we still be concerned about breakthrough potential? Mines described as “below drainage” occur in coal seams that do not crop out at the surface.

Extent of Underground Mining



Why should mine Maps—or their absence—be verified?

- Old Mines
  - Inaccurate, not up-to-date survey methods.
  - Maps are unavailable, lost, or never generated.
  - Maps may be out of date.
  - Maps are often very difficult to geo-reference.
- Newer (e.g. Post-SMCRA) Mines
  - Even their maps must be verified for accuracy.

Contrast in the documented location of the same mine workings.

Others ways to determine if minable seams have been mined

- Interviews with old miners and the local population
- Visual field reconnaissance for undocumented mine entries
- Horizontal/vertical drilling
- Down-hole camera inspections
- Sonar/laser mine mapping
- Shallow-subsurface geophysics

But how much is enough !@#$%*

- Professional judgment based on site-specific conditions.

- Reliance on mine maps is not enough

Will It Flow?

Consolidation in Impounded Coal Refuse

Concerns:

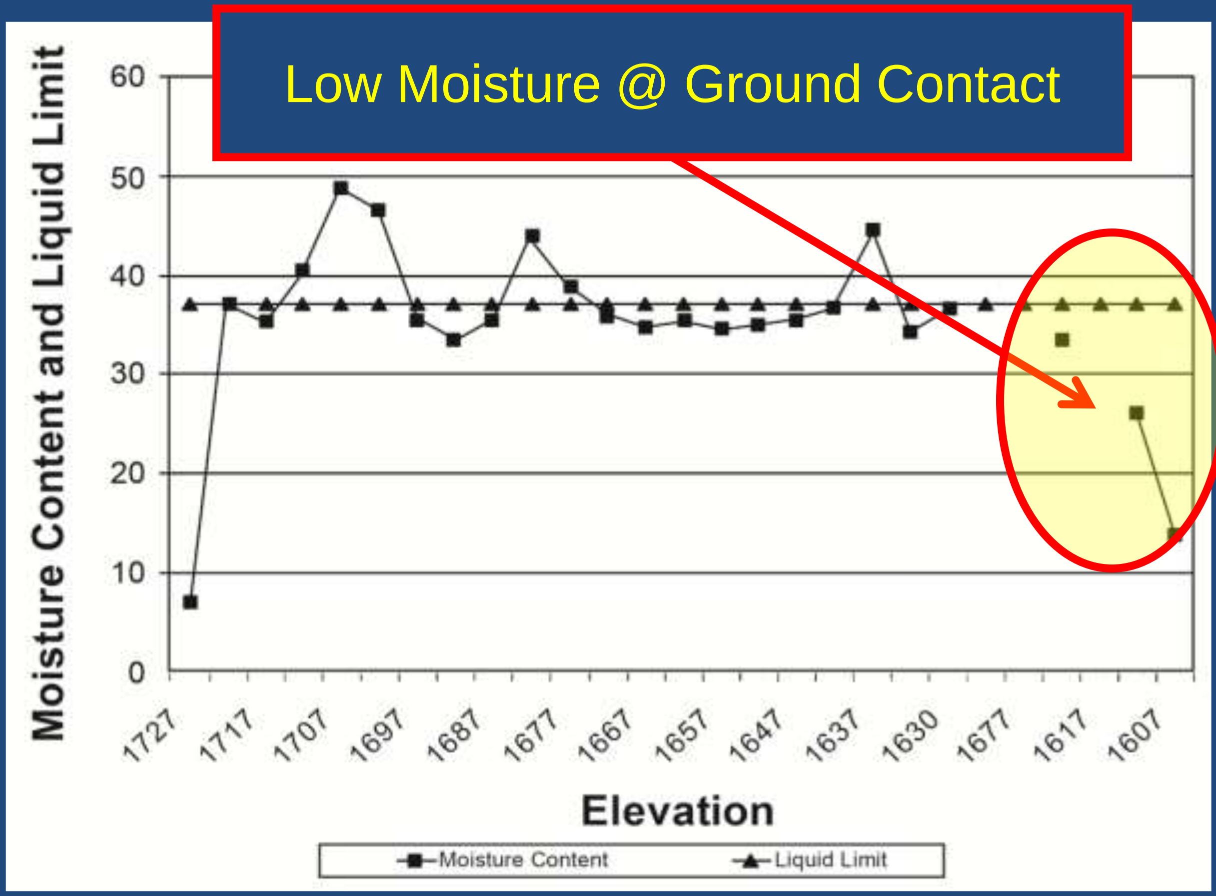
- Low hydraulic conductivity or permeability
- High void ratio
- Slow rate of consolidation
- High void ratio even after full consolidation
- Moisture contents above Liquid Limit

Overview of the Trace Branch Impoundment. 30 acre pool, center left.
5 acre pool, lower right from 30 acre pool.

Below: solid crust at edge of the 30 acre pool.

Above: broad view of 30 acre pool.

??-Liner Formation-??



Liquefaction

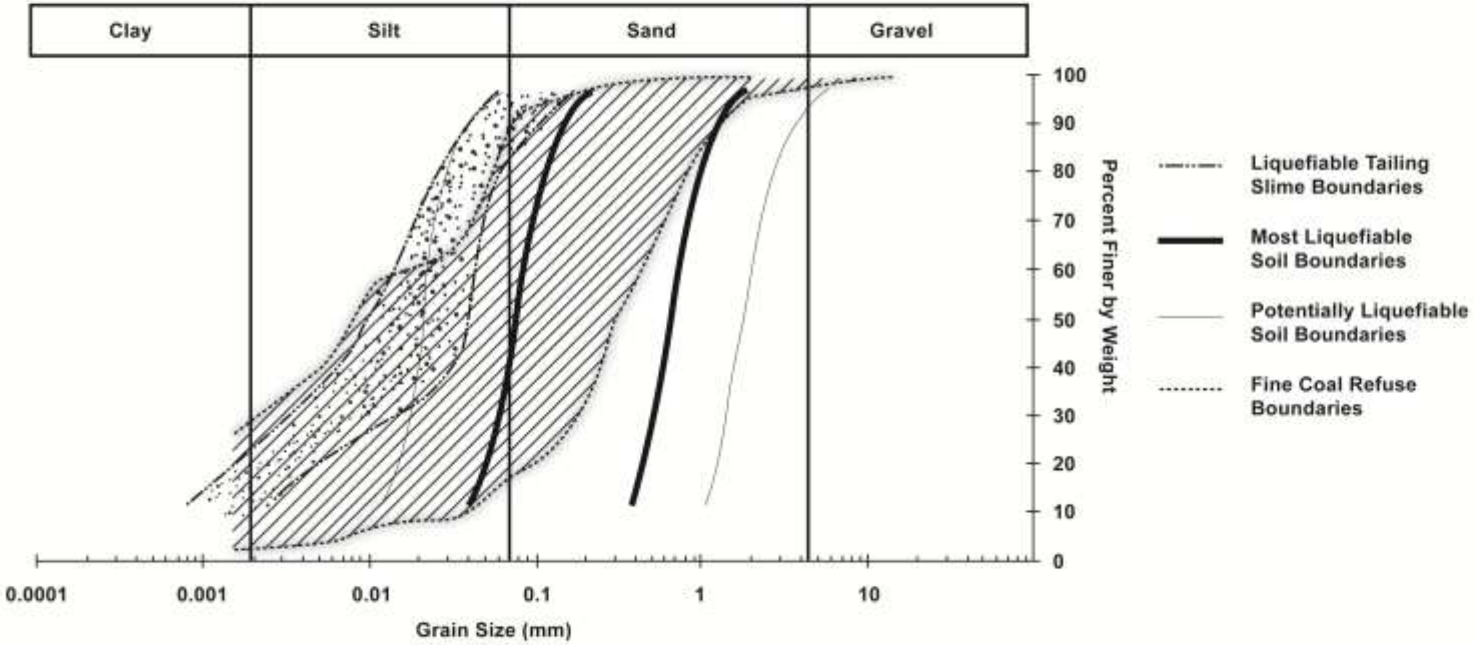
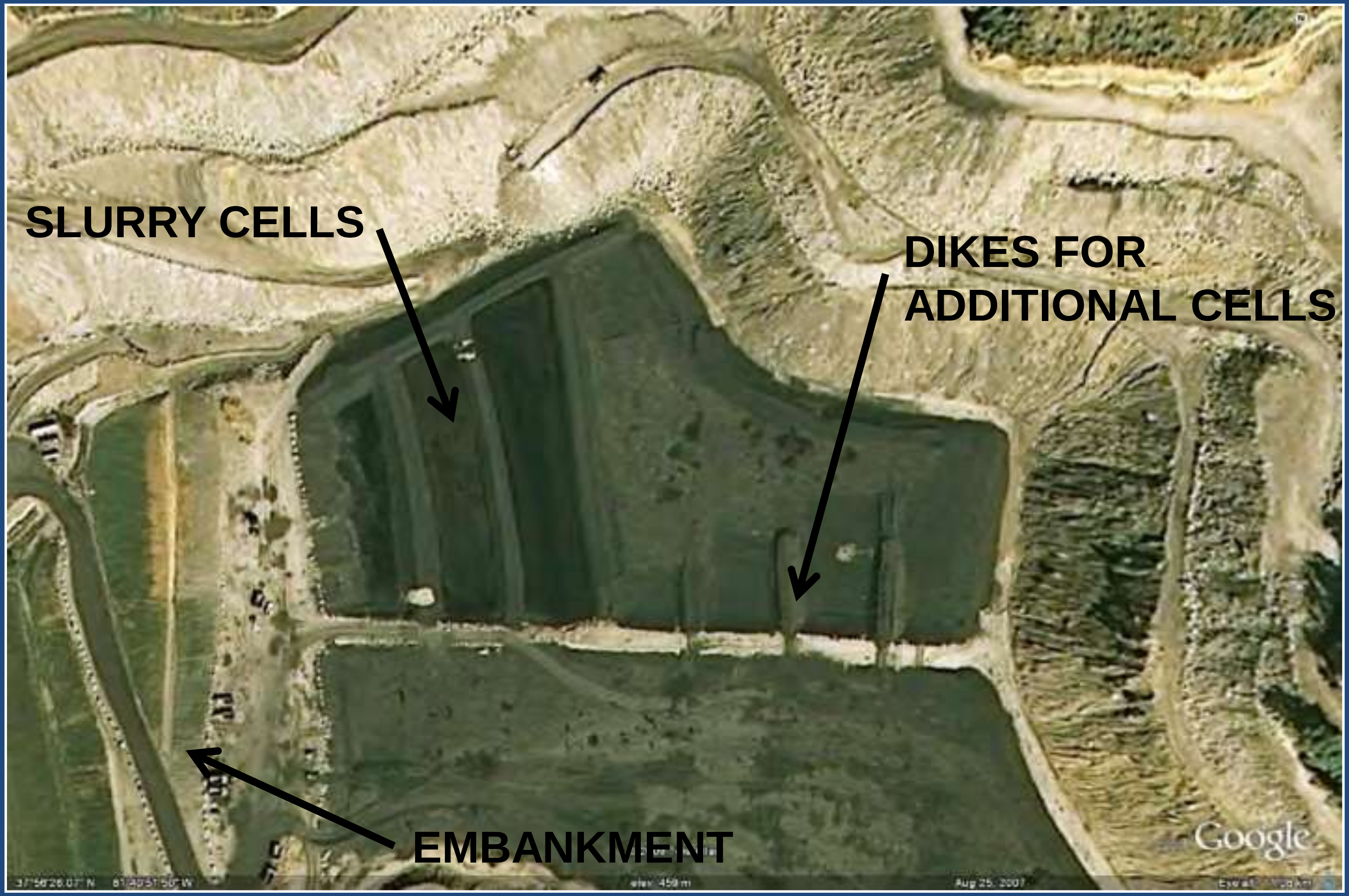


Figure 9: Gradation curves defining boundaries for liquefiable soils, liquefiable tailings, and fine coal refuse. (Modified from Terzaghi et al., 1996; and D'Appolonia, 2009)



Aerial view of coal refuse slurry cells.

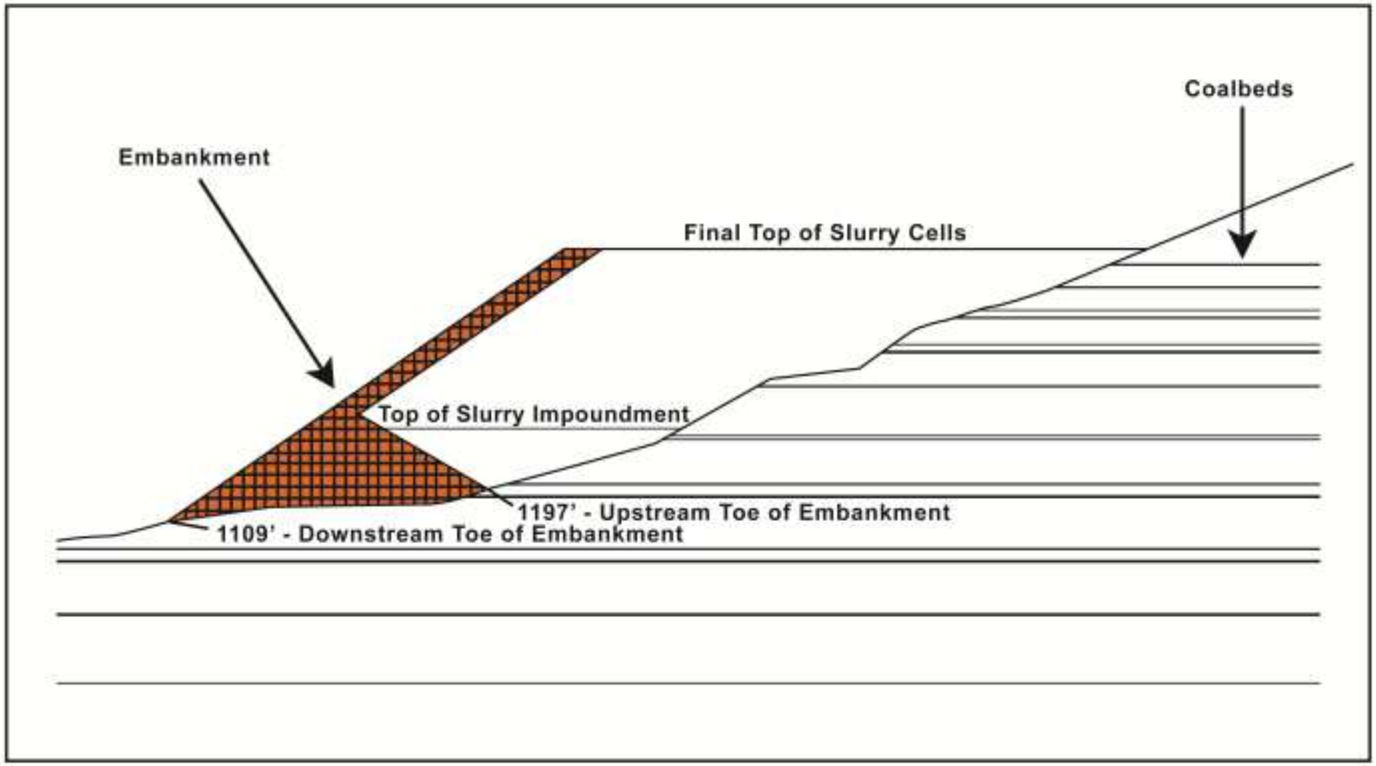
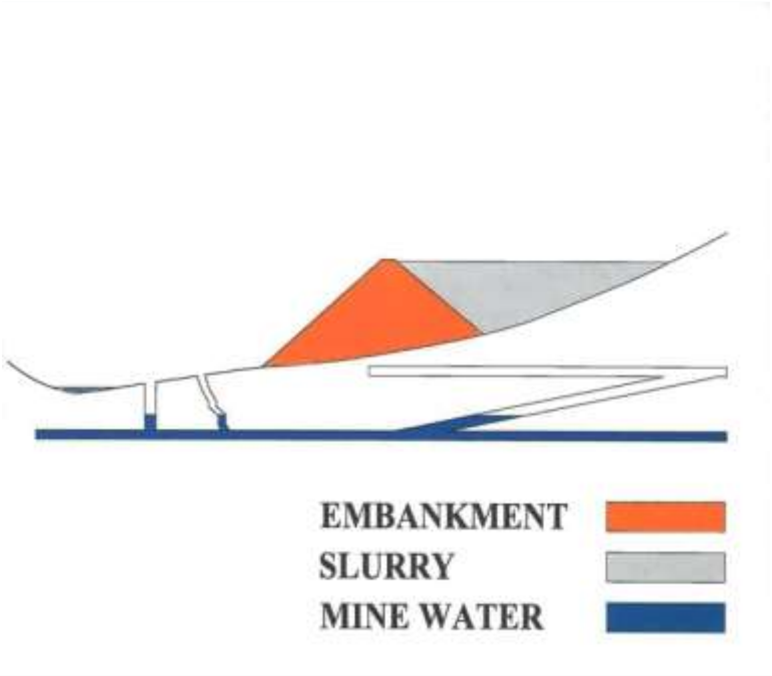
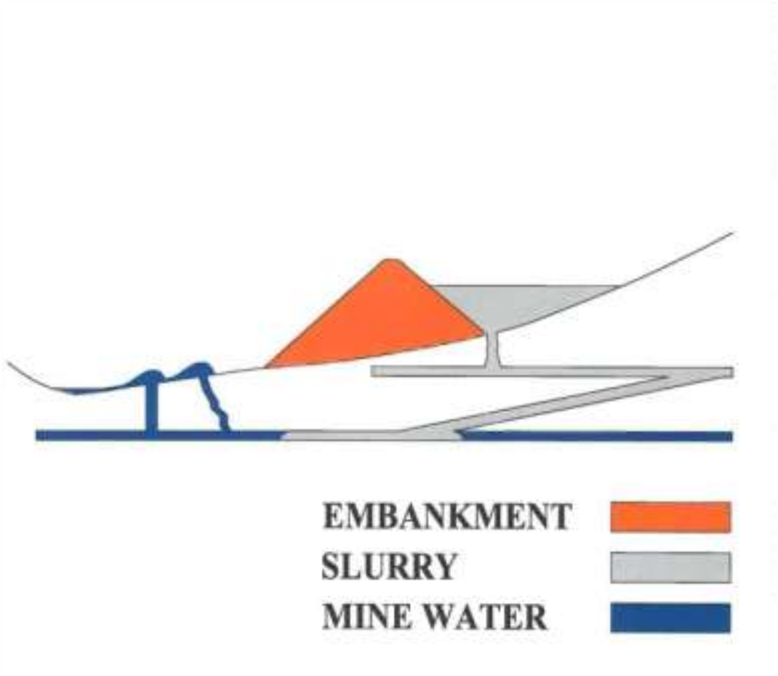


Figure 7: Cross section depicting of slurry cell construction above capped impoundment and coal seams subjacent to, and below the structure.





Schematic longitudinal sections of flooded below-drainage mine (left) and artesian mine-water breakouts in response to slurry breakthrough into the mine (right).

Recommendations

1. Special studies/research.

2. **Site specific investigations in support of impoundment design :**

    (a) Extent of underground mines, e.g. mine maps, mine adits, drilling. (for coal beds intersecting the basin: if you don’t know, mine coal 200 ft. and construct your barrier).

    (b) Properties of fine refuse slurry (if MC > LL, do not add load to existing impoundment level until MC is reduced).

Thank you!!