

# What an EPA Responder Should Know About Mine Bulkheads

or

My mine site has a bulkhead, what do I do with it?

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**Mining Engineer, Principal**

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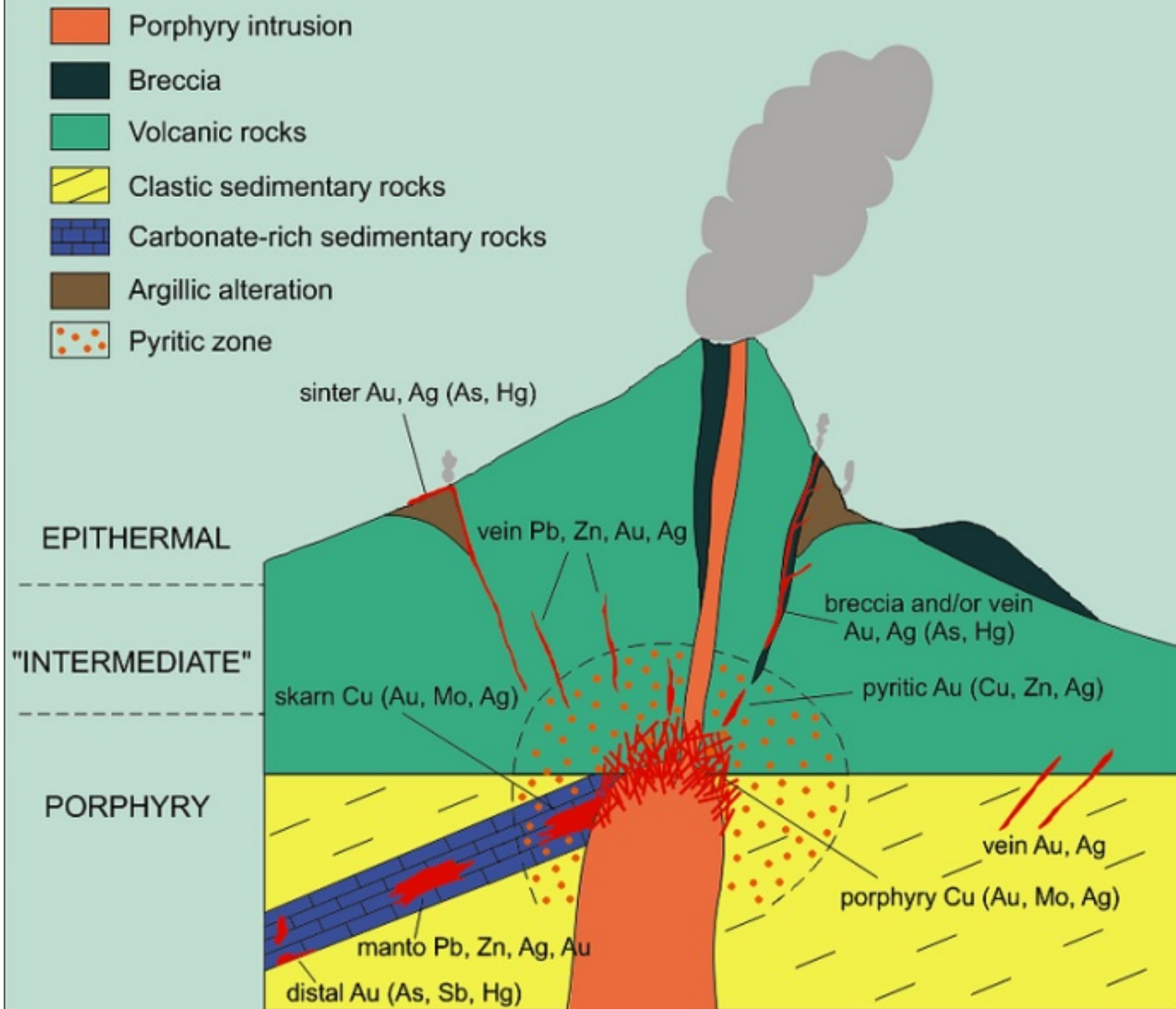


# Outline

- Hard rock mine cycle overview
- What is a bulkhead?
- Bulkhead risks
- Integrating a bulkhead into the site plan
- Post Bulkhead Installation (care and feeding of your bulkhead)

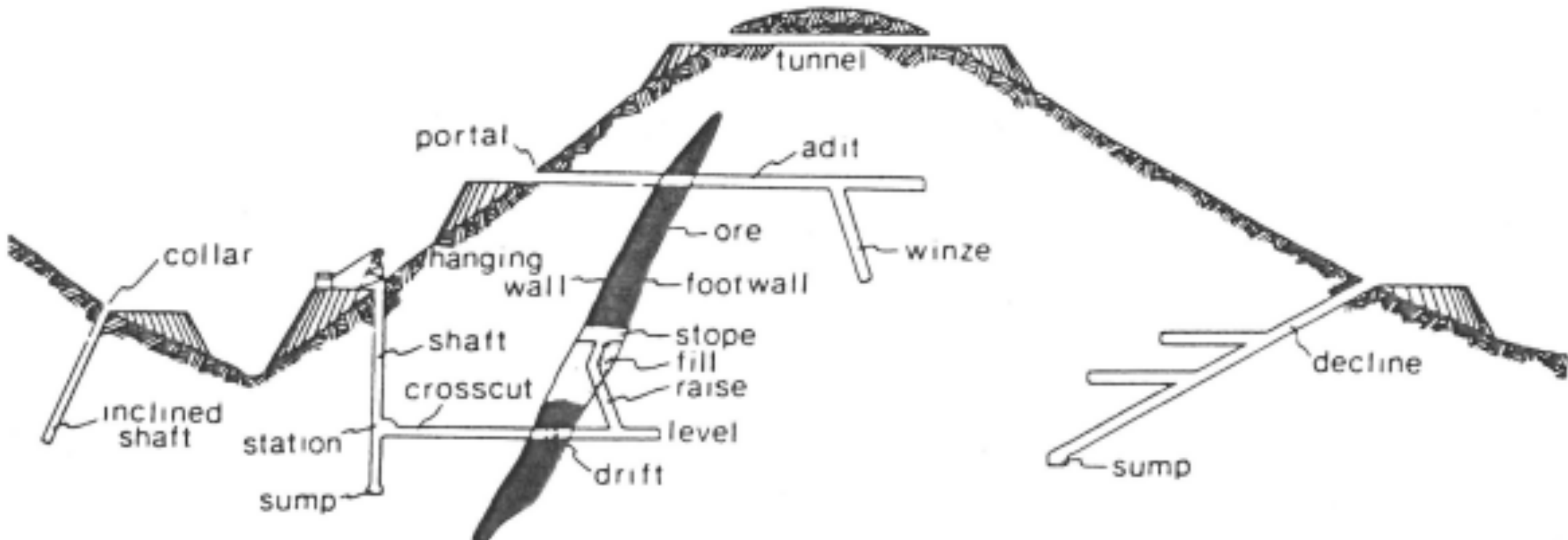


# Typical Source of Metal Mineralization



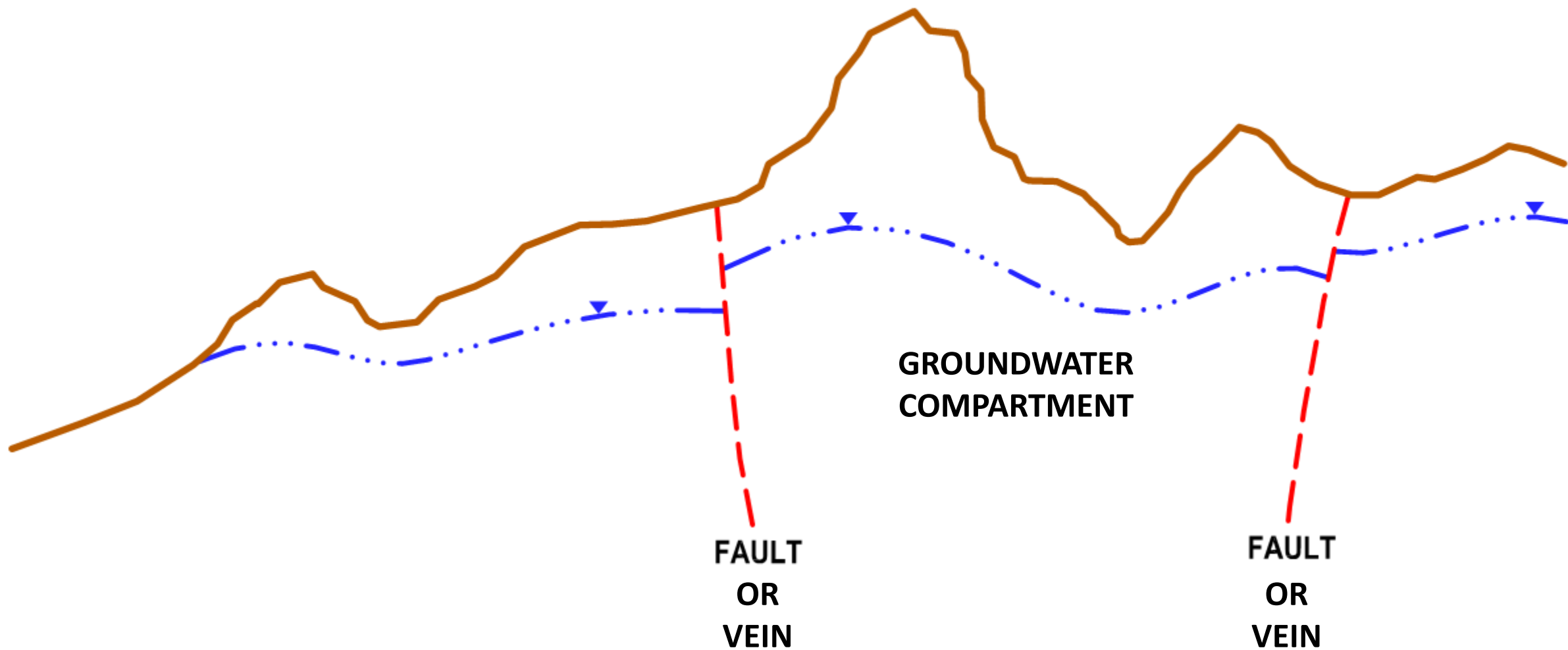


# Underground Mining Terminology



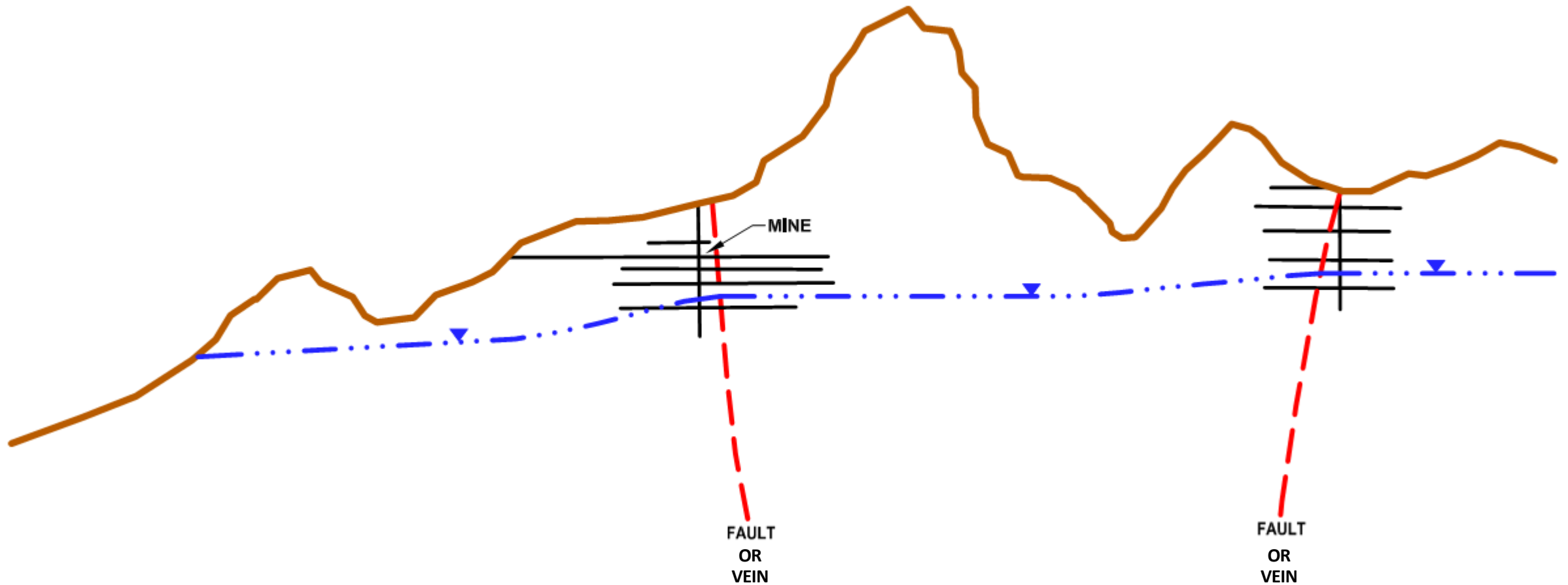


# Pre-Mining Cross Section

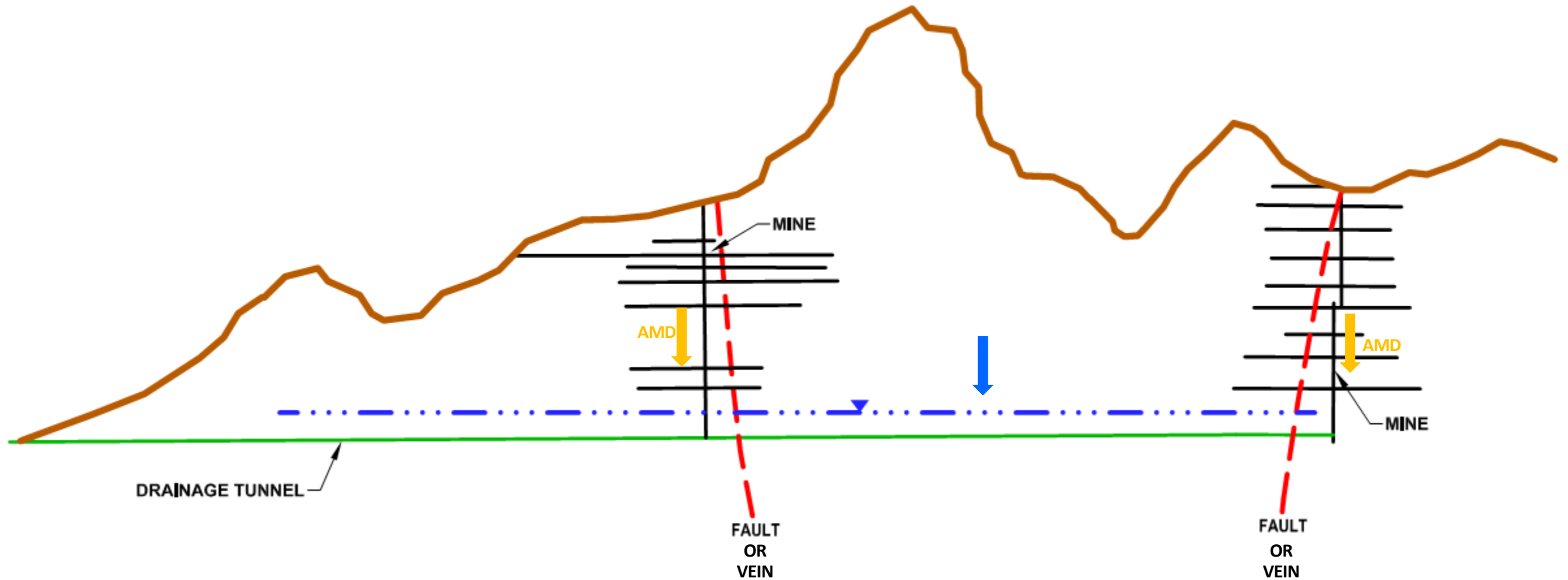




# Early Phases of Mining Cross Section



# Late Phases of Mining Cross Section





# End of Mining

- Mines abandoned
- Low drainage tunnels continue to drain
- Oxygen in mines reacts with pyrite to form sulfuric acid and dissolve metals: AMD
- Metal precipitate, bacterial ooze, and other material builds up
- Blockages from roof falls create temporary dams that eventually overtop resulting in surges from the portal
- Portal collapses and water flows unchecked through debris





# Sludge Behind Portal





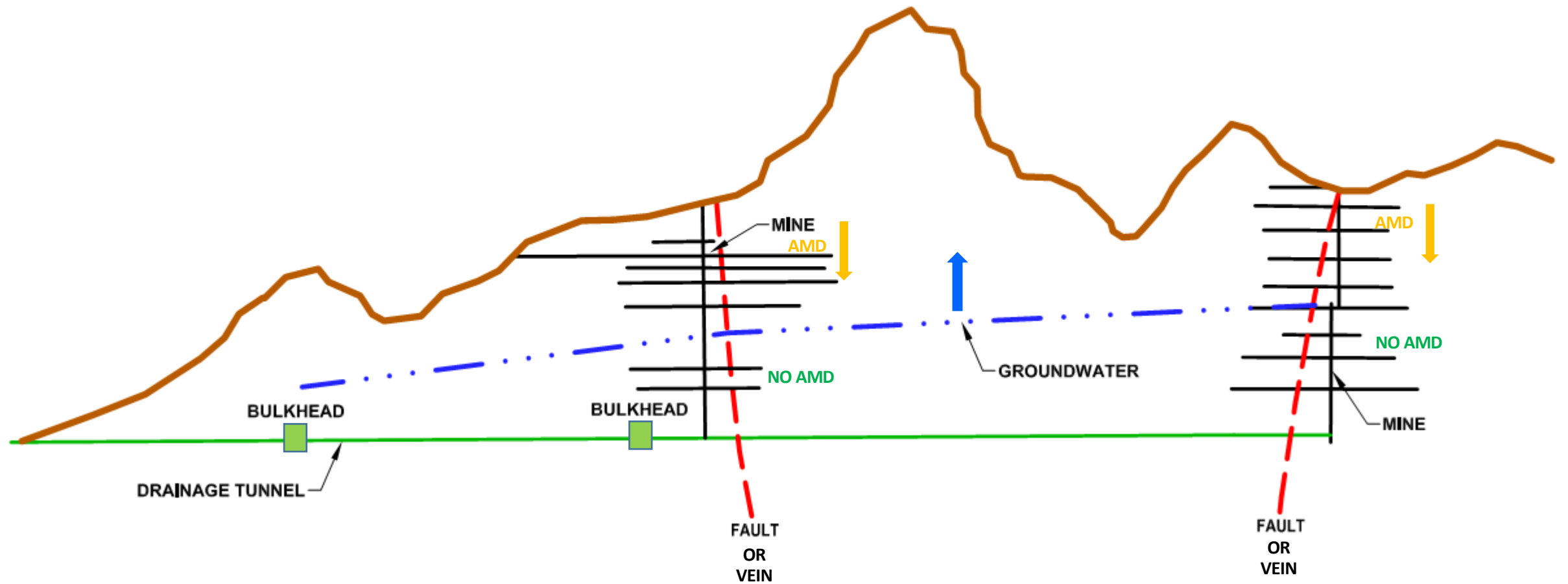
# Post Mining Evaluation

- Is the drainage a problem for water quality?
- If so, two general solutions exist
  - Maintain drainage tunnel and treat water in perpetuity
  - Install bulkheads (underground dams)





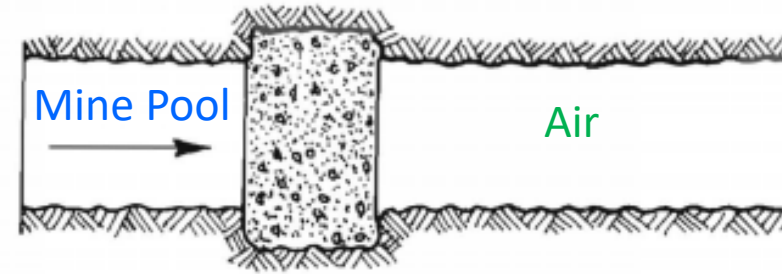
# Post-Mining Cross Section with Bulkheads



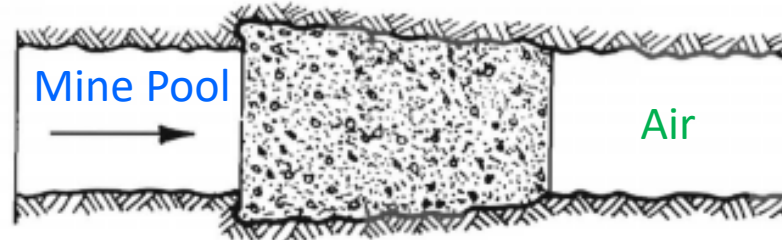


# What is a Bulkhead?

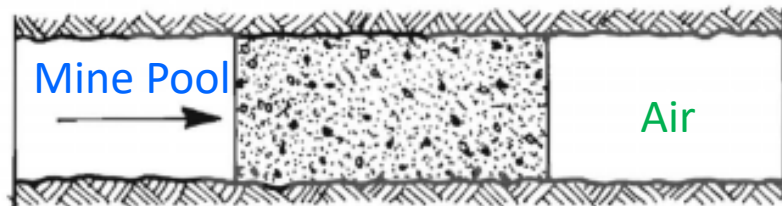
- Engineered concrete plug designed to hold back water long term
- Common in mines and hydroelectric tunnels



Slab keyed into walls



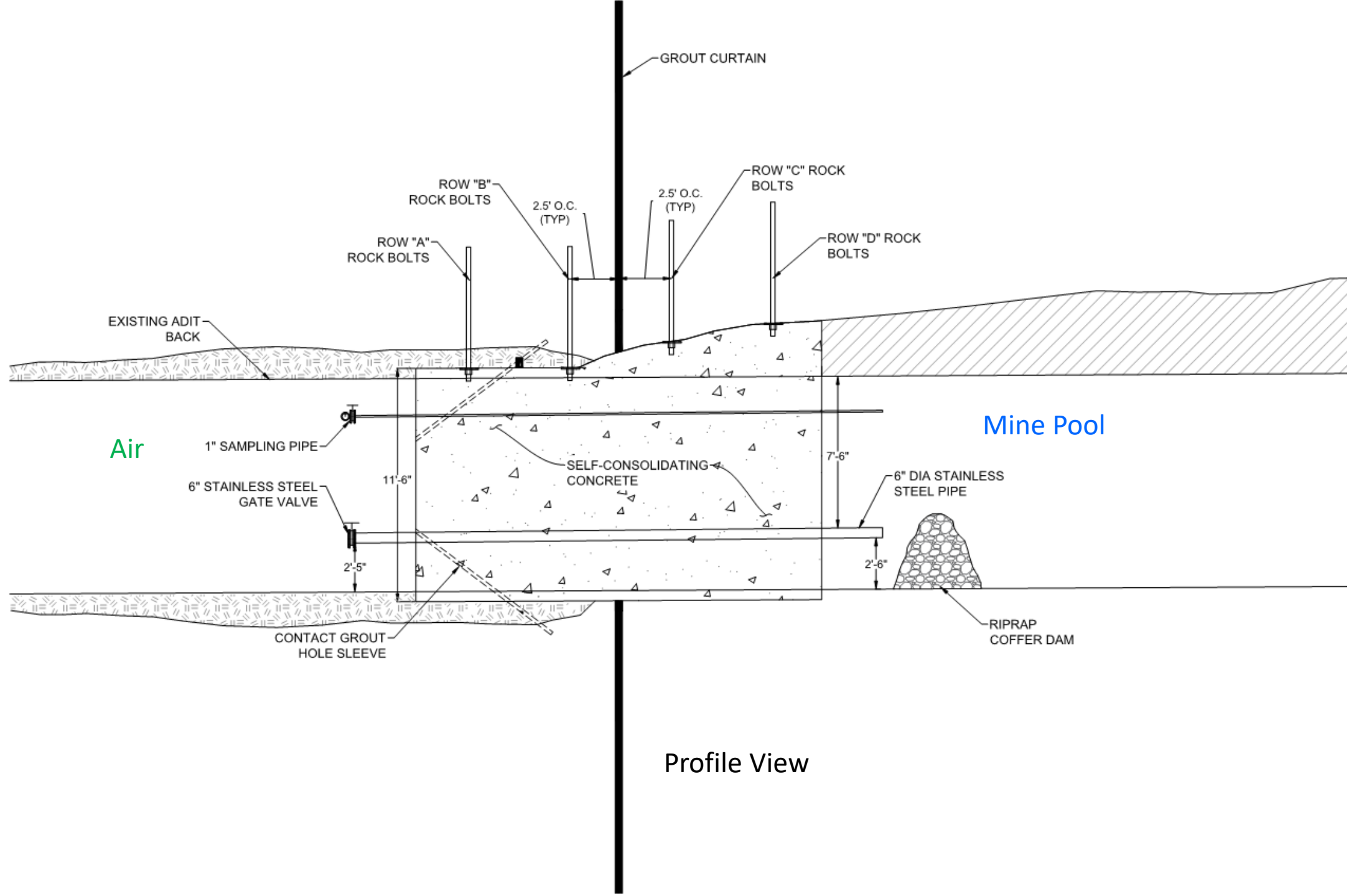
Taper plug



Parallel plug

Plan and Profile Views

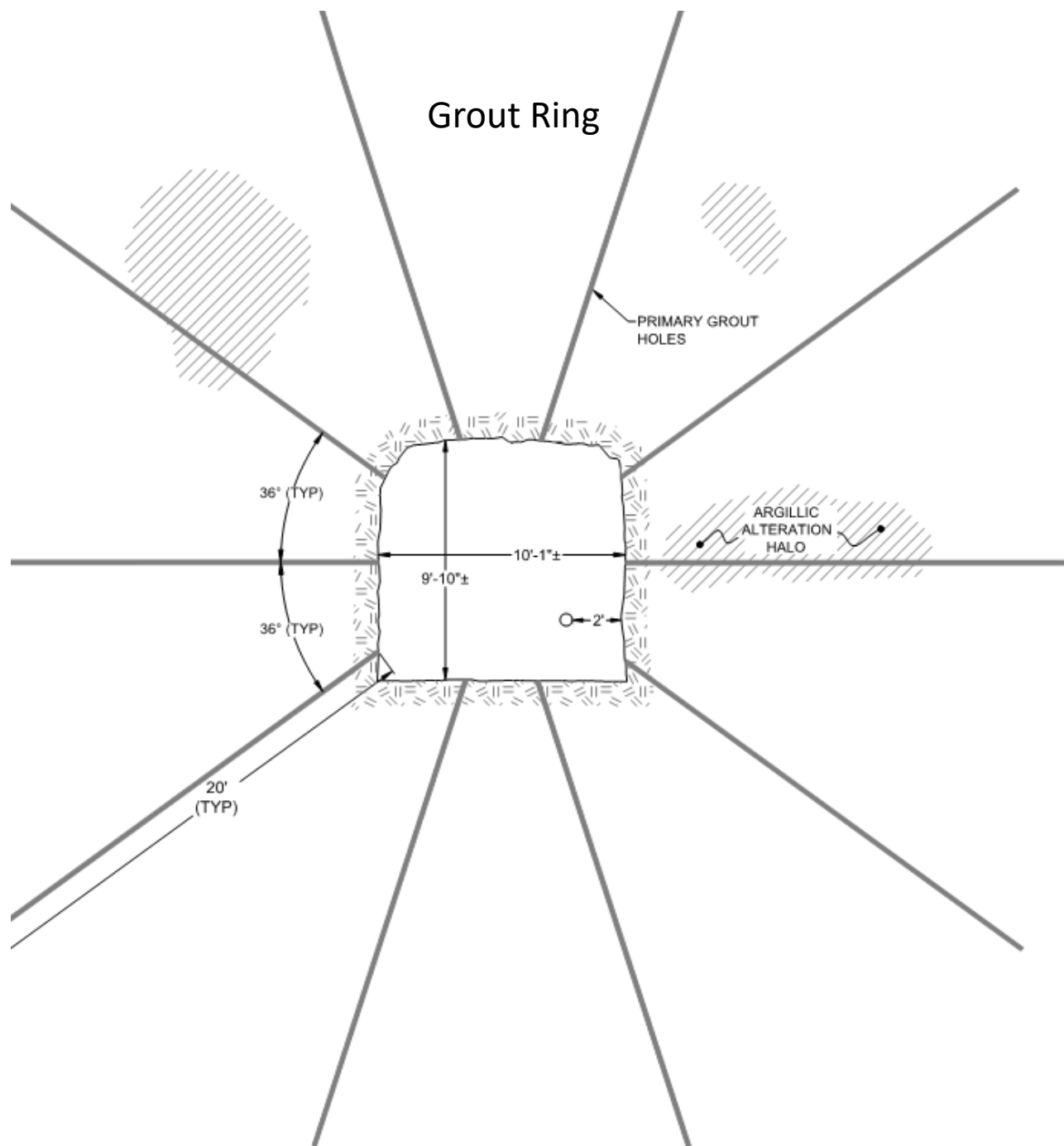
Modified from Chekan 1985



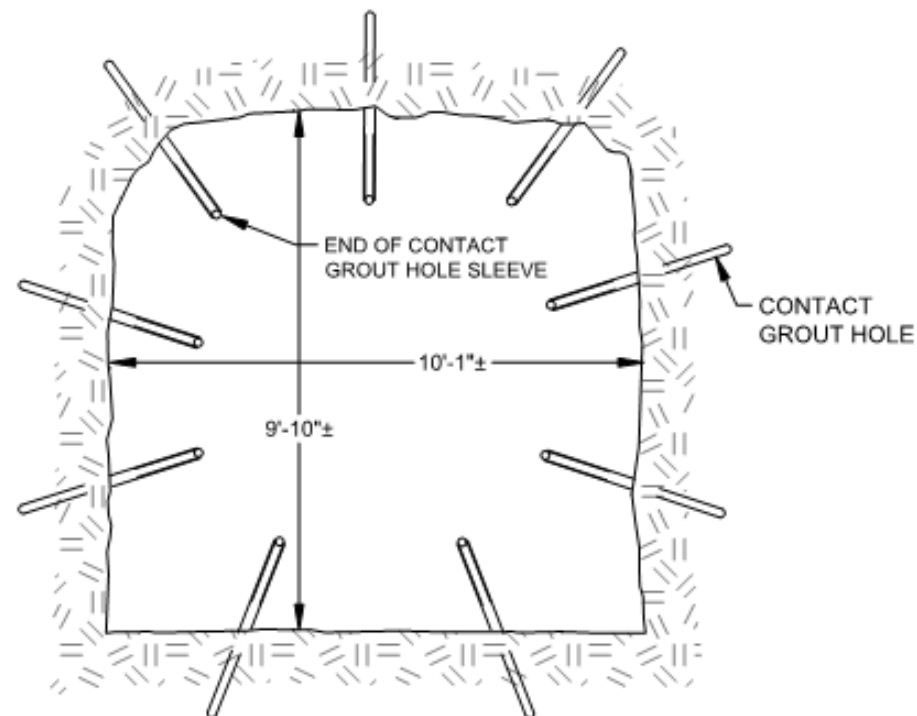
Profile View



## Grout Ring



**TYPICAL GROUT HOLE PATTERN**



**Cross Section Views**





Collapsed Portal...Not a Bulkhead

The image shows a cross-section of a tunnel where a rock portal has collapsed. The surrounding rock is a light tan color, while the collapsed area reveals darker, layered rock strata. Debris, including rocks and sand, is piled up around the opening. In the foreground, several wooden beams, likely part of a support system, are visible, some leaning against the rock. A white pipe or cable runs along the bottom right of the frame. The text 'Collapsed Portal...Not a Bulkhead' is overlaid in the center-left of the image.



Collapsed  
Tunnel

Not a  
Bulkhead






This is a  
bulkhead





A photograph of a rusted metal bulkhead in a tunnel. The bulkhead is a rectangular structure made of dark, heavily corroded metal plates, showing significant rust and peeling paint. It is set within a rough, uneven tunnel wall made of large, reddish-brown rock blocks. The floor of the tunnel is filled with dark, still water. A small, circular, metallic object, possibly a vent or a light fixture, is visible on the right side of the bulkhead, partially submerged in the water. The lighting is dim, with some highlights on the wet surfaces of the rock and metal.

This is a  
bulkhead



# Bulkhead Placement

- Under enough cover (deep in mine)
- In good ground
- In pairs?
- At lowest level and moving up to plug levels that will be inundated
  - Includes other mines in area that are hydrologically connected
    - Workings
    - Veins
    - Drill holes
  - Must understand hydrogeology and extents of impacted area
  - Do not stop half way

# Bulkhead Myths

- Myth: Bulkheads are the right solution for every mine site
  - *Fact: poor choice if ground is too permeable or there are too many openings*
- Myth: Bulkheads will eliminate all mine water drainage
  - *Fact: can reduce flows perhaps by 90%*
- Myth: Bulkheads can be installed and forgotten (maintenance free!)
  - *Fact: need regular inspection and monitoring*
- Myth: Bulkheads only affect individual mines
  - *Fact: Must be part of holistic solution, can affect other mine workings through natural fractures*
- Myth: Bulkheads always improve water quality
  - *Fact: Typically yes, since flooded mines reduce oxygen for pyrite reaction but water quality may decrease as salts are mobilized (temporary storage)*



# Bulkhead Risks

## Real

- Leakage past bulkhead requires additional grouting or second bulkhead
- Water flows out of other mine workings (known and unknown)
- Seeps develop in surrounding area
- Water seeping past bulkhead still requires some form of treatment
- Piping failure around bulkhead
- Liability for flooding adjacent mines

## Imagined

- Backed up water squirts out of the top of the mountain
- Bulkhead concrete blows out explosively and shoots out of the adit like a cannon ball

# Integrating a Bulkhead Into the Site Plan

- One component of site solution
- Used in conjunction with
  - *Sitewide monitoring and sampling*
  - *Flumes*
  - *Stream gages*
  - *Ponds*
  - *Passive treatment*
  - *In-situ treatment*
  - *Treatment plants?*
- Bulkheads Can be used in various ways



# Flow Control Structure

- No long term storage
- Manage surges or mine “burps”
- Adjust flows to what active or passive treatment can handle
- Requires cleaning and maintenance





# Temporary Storage

- Use mine pool as underground reservoir to store water until it can be treated
- Allow time for in-situ treatment



2001. 6. 18



# Permanent Seal

- Return groundwater to pre-mining conditions (sort of)
- Treat seeps with passive means if needed
- Monitor bulkhead regularly (condition, head)
- In situ treatment





# Post Bulkhead Installation

- Keep permanent access to bulkhead for monitoring
  - Seepage past bulkhead
  - Water level behind bulkhead
- Develop and execute filling and monitoring plan
  - Flow rates
  - Water chemistry
  - Bulkhead and adit
  - Surrounding mines
  - Surrounding seeps
  - Nearby streams





# Bulkhead Inspection & Evaluation

- Condition of concrete face
- Condition of pipes and valves
- Condition of instruments
- Concentrated flows around bulkhead
- Concentrated flows downstream of bulkhead
- Condition of ground and support in access tunnel



# Concluding Thoughts

- Bulkheads may or may not be the right solution for your site
  - Bulkhead should only be installed after significant study and design
  - Adjacent mines may be affected
  - Monitoring and maintenance needed after installation
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- To learn more about mine bulkheads, join the CLU-IN webinar on October 25, 2019
  - <http://www.clu-in.org/conf/tio/Mining-Bulkhead/>





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