Active mine water treatment and recycling

Energizing the core

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Mine Water Management and Treatment

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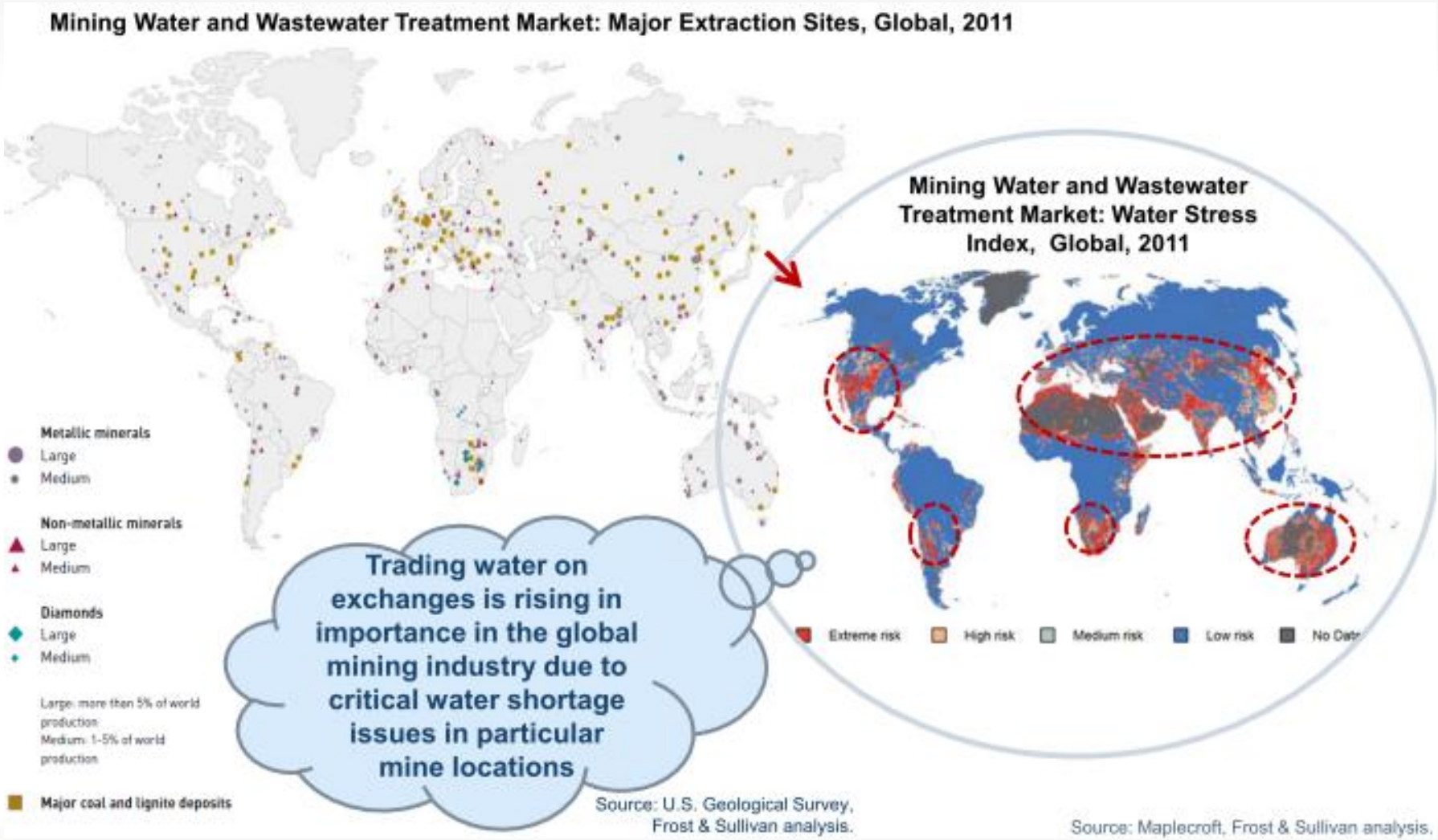
- Background & drivers
- Active mine treatment
- Reuse
- Summary

Mining activities and increasing water stress



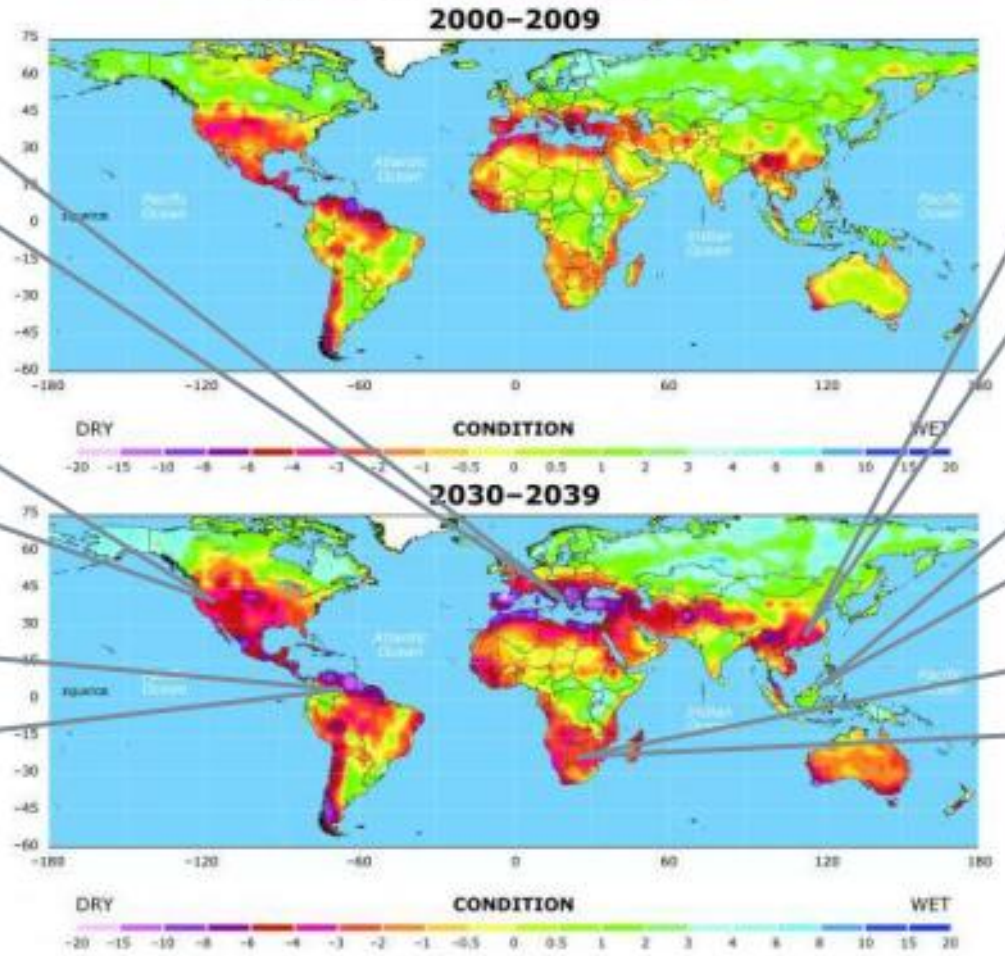
Mining activities and climate change

Mining Water and Wastewater Treatment Market: Comparison of Water Conditions Resulting from Climate Change, Global, 2000–2009 and 2030–2039

Regions bordering the Mediterranean Sea expected to become especially dry

Most of the western U.S. projected to be significantly drier by 2030

Increasing risk of droughts in Latin America



Large parts of Southwest Asia with increased dry regions and Southeast Asia, including China and neighboring countries

Increased flooding projected for East Asia and Indonesia

Droughts expected in most of Africa and Australia

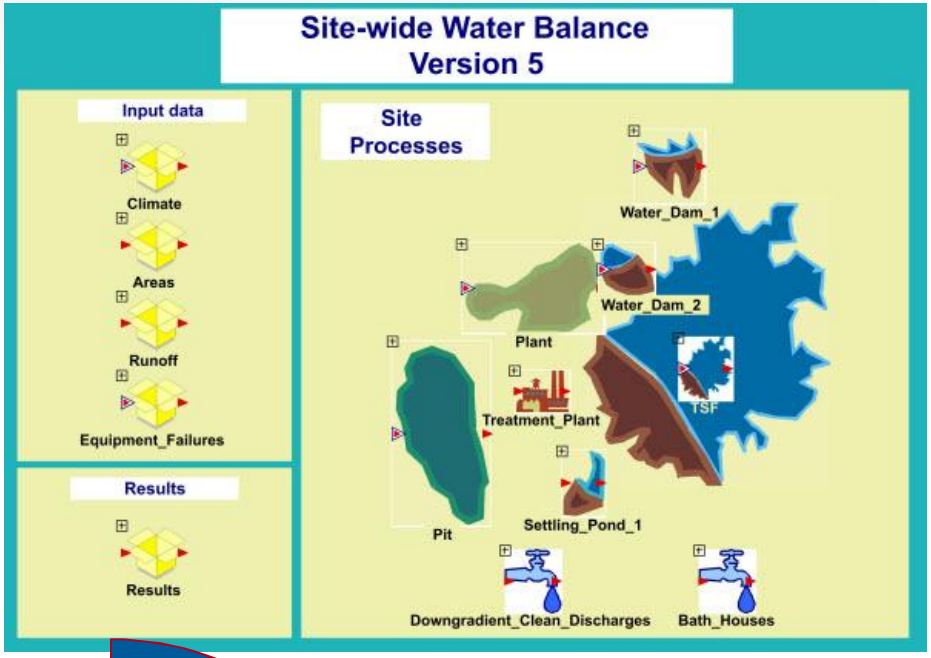
Source: ecoSanity.org, Frost & Sullivan analysis.

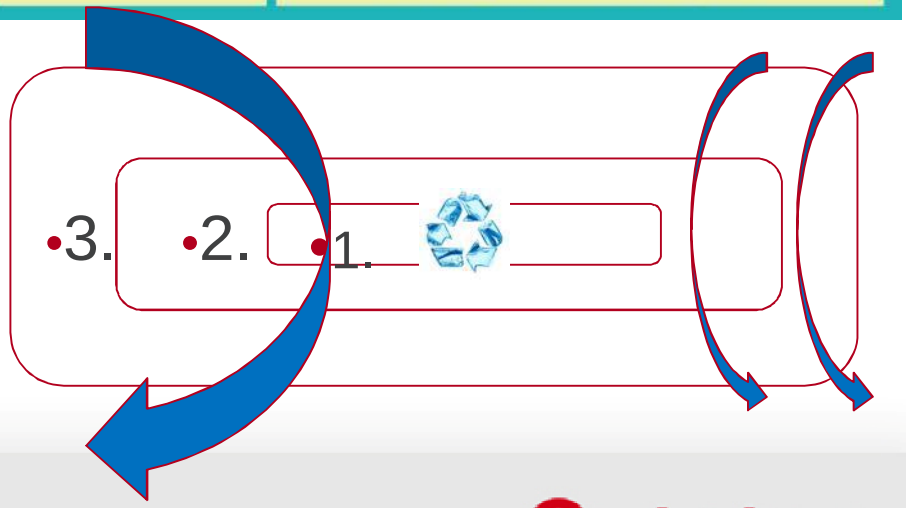
Challenges in mining water mining

- **Water supply & balance:** Positive or negative water balance
  - Negative => water scarcity
  - Positive => discharge treatment / water management needed
- **Water mgmt:** Reuse for improvement water management and energy savings
  - Reduction of total water volumes
  - Reduction of CAPEX and OPEX
  - Effect of raw water quality to the process efficiency
  - New online monitoring / analyzing needed
- **Effluent treatment:** Links to water reuse, metal recovery and meeting the new discharge limits
  - Volumes, Fine particles, Arsenic, Cyanide compounds, Ammonium ,Nitrate, Sulfur (especially SO_4), Selenium, TOC/COD and Metals: Cd, Cu, Ni , Pb and Sb
- **Metal recovery:** Mine tailings are known metal reserve, that can be turned to revenue streams
  - Tailings must be treated and discharged appropriately
  - Process optimization to maximize metal recovery and profit
- **Environmental legislation**
  - Getting just stricter

Mine Water Balance leads to WQM Strategies

- Very few mines have Zero Water Balances
- Negative water balance (e.g. Chilean mines)
  - Strategy: source & conserve
    - Desalination or grey water supply
    - Seawater for process use
    - Reclaim / reuse
    - Tailings dewatering
    - Dry stacking
    - Storm water Collection and use
- Positive water balance mines (e.g. Scandinavian mines)
  - Strategy : Dispose
    - Tailings pond water treatment and reuse
    - Salt disposal
    - Trace contaminant removal
    - Storm water management and disposal





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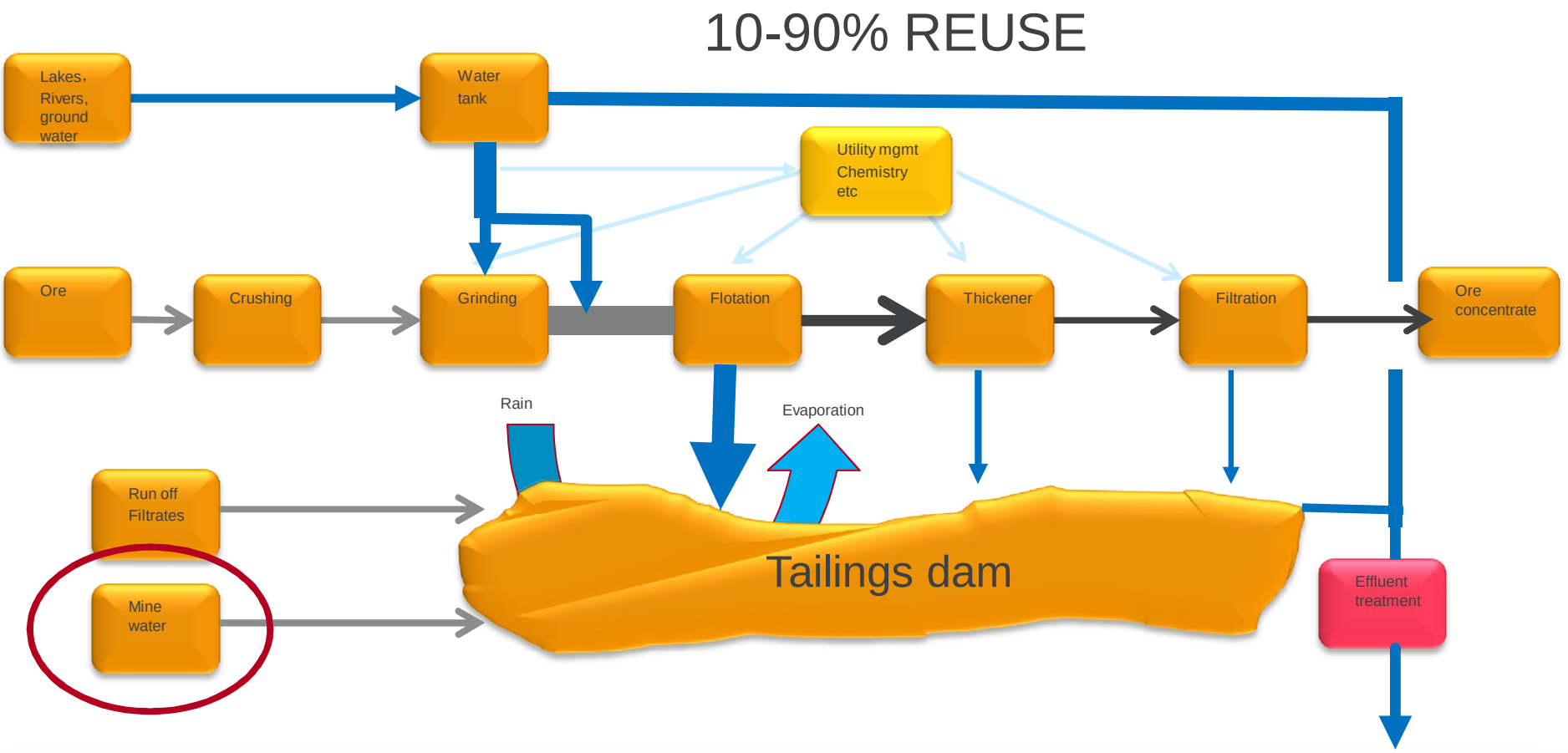
Majority of concentrator processes today…



Key drivers of treating mines waters

- EU Dangerous Substances Directive
  - requires *consented* discharges for all sites abandoned after 1981 where the minewater contains listed substances
- EU Groundwater Directive
  - requires *consented* discharges from mine waste where leachate contains listed substances
- Contaminated Land Regulations (EU country specific)
  - requires *remedial* action where a significant pollutant linkage is identified

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Todays drivers

- EU Water Framework Directive
  - Consolidates a number of directives, including the dangerous Substances and Groundwater Directives.
  - Environmental objectives will need to be set for ALL water bodies in terms of chemical and ecological quality.

- EU Mining Wastes Directive
  - Will require exchange of technical information on best available techniques with a view to developing methods to identify and remedy “closed waste facilities”

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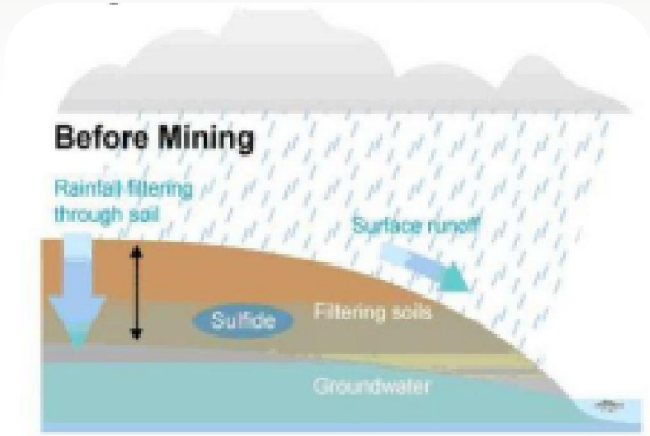
Active mine water treatment - Terms

- Acid Mine Drainage (AMD)
  - Water that is polluted from contact with mining activity
- Acid Rock Drainage (ARD)
  - Natural rock drainage that is acidic
- Pyrite weathering
  - $4FeS_2 + 14\ H_2O + 15\ O_2 \rightarrow 4Fe(OH)_3 + 8\ SO_4^{2-} + 16\ H^+$
- Results in
  - Increased acidity = decreased pH
  - Increased metal concentrations
  - Increased sulfate
  - Increased suspended solids



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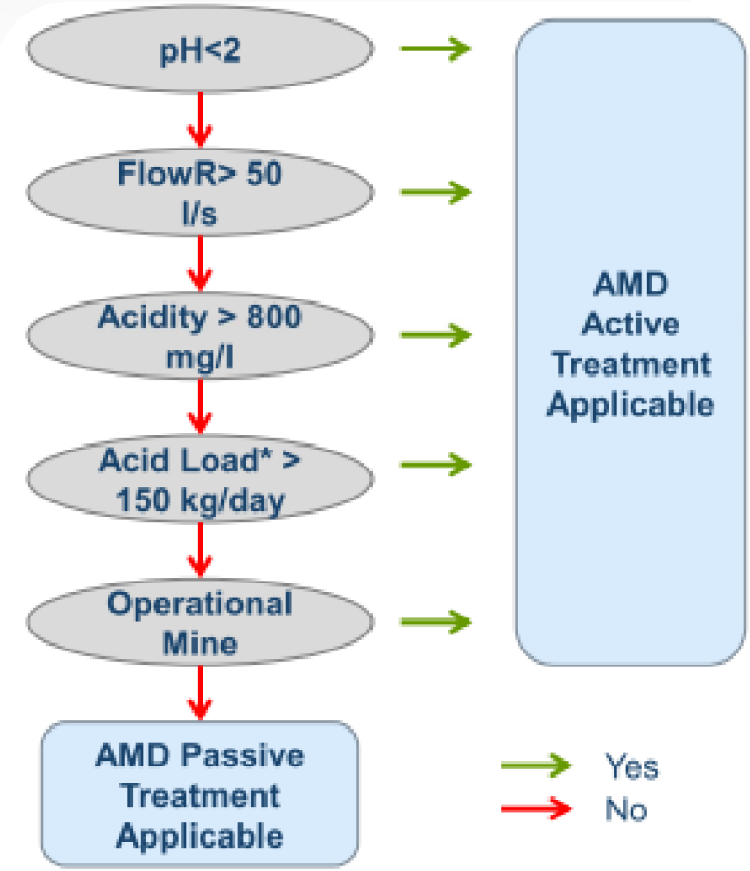
Active Mine Control Strategies

- Active treatment
  - Requires long terms and continuous treatment
  - For big volumes and loads
  - Very successful

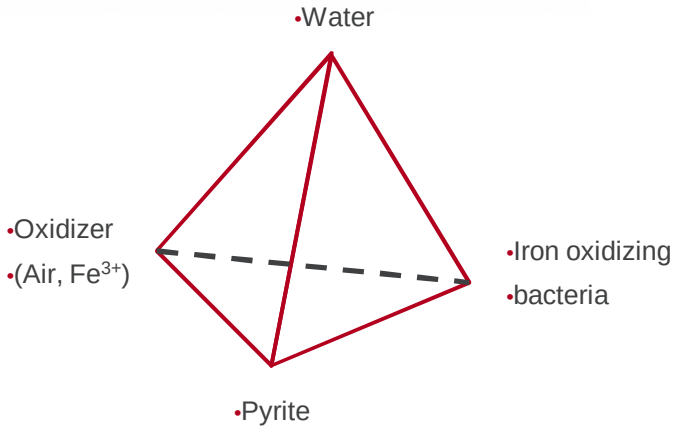
- Passive treatment
  - Less expensive (CAPEX)
  - Less operation intensive (OPEX)
  - Not as effective as active
  - For small volumes, loads and big spaces
  - Can be used to complete active treatment

- * Acid load refers to acidity (mg/l) * Q (l/s) * 0,0864



Active Mine Control Strategies – at site

- #1.Minimize iron sulphide oxidation
  - by limiting O2 concentration
  - Surface lining (the walls)
  - Inhibit or displace iron oxidizing bacteria
  - Keeping reductive conditions
- #2. Improve surface and ground water management
- #3.Treat the residual water
  - within the mine



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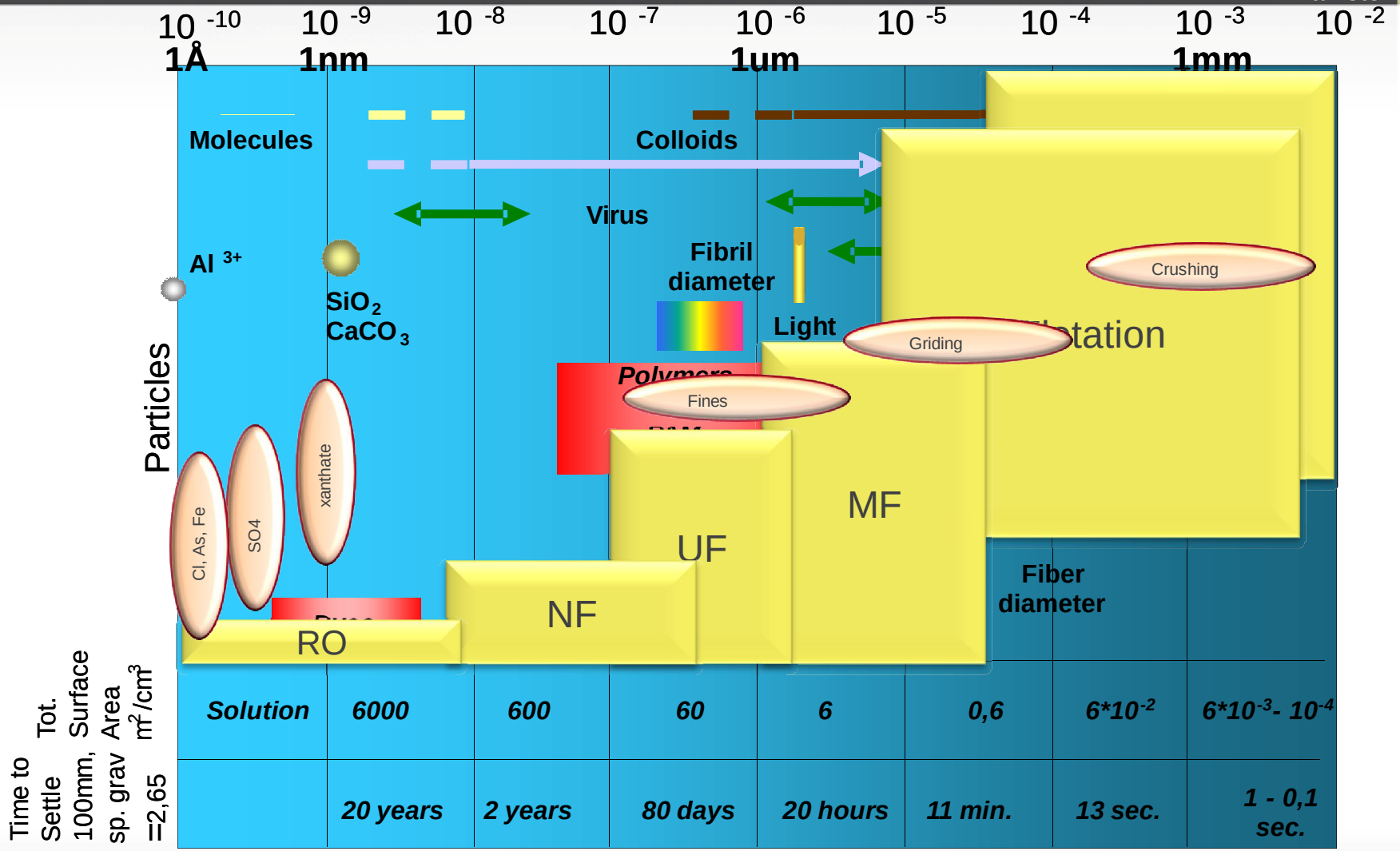
Removal of impurities in waters

Sedimentation

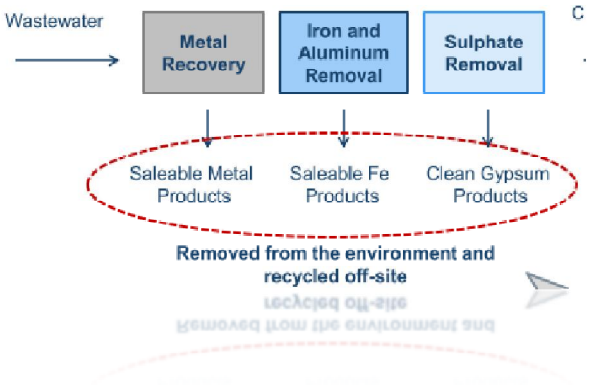


Active Mine Control Strategies – on site

- Physical (Drinking water quality)
  - Membranes
    - Removal of ions + colloids
  - Drawbacks
    - Concentration handling
    - Energy needs
    - Possible fouling (Ca, SO_4), OPEX
    - Pretreatment needed (RO)
  - Evaporation
    - Removal of ions + colloids
  - Benefits
    - Big volumes
    - Can be used to crystallize impurities
    - ”No stop process”
  - Drawbacks
    - Energy consumption

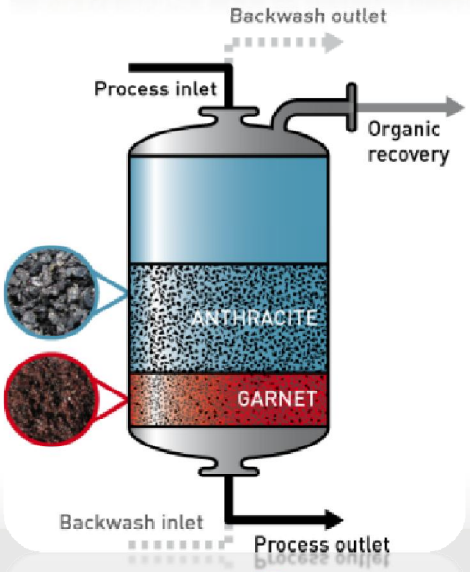
Active Mine Control Strategies – on site

- Biological (anaerobic)
  - Removal of SO_4 and metals (sulphide precipitation) to very low levels
  - Benefits
    - Relatively low CAPEX
    - Removal of SO_4 to S^0 possible (typically S^{2-})
    - Recovery of metals (needs S^{2-}) & byproducts
    - Can handle large flows
    - Low energy needs
    - Small waste generation
  - Drawbacks
    - Slow
    - Sensitive to influent variations (load, pH, mV, uS) and temperatures
    - Needs C source (and N, P)



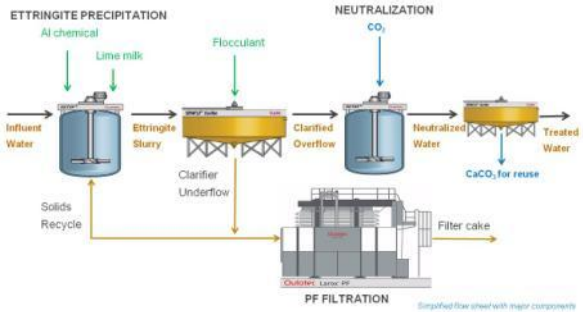
Active Mine Control Strategies – on site

- Adsorbents / Ion exchange (Drinking water quality)
  - Removal (and recovery) of specific metals from streams to very low levels
    - E.g. Ni, Cu, Fe, U, As
  - Mainly as polishing step
  - Organic polymer resins, GAC, FeOOH .
  - Benefits
    - Specific ion removal with high removal rate removal
    - Can be valuable concentrate/ adsorbent mass
    - Removal target can ”easily” be changed
  - Drawbacks
    - Needs pretreatment (also to to reduce regeneration of the resin)

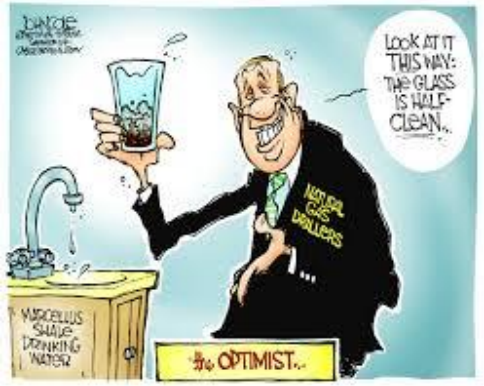


Active Mine Control Strategies – on site

- Chemical
  - Neutralization
    - Of acidic pH and removal metals (oxidation)
    - Recovery of metals (sulphite)
  - Ettringite
    - Removal of SO_4 plus major part of the of the metals (as hydroxide)-”adjustable”
  - Benefits
    - Fast and good performance regardless of the seasonal variations
    - Easy to apply & control
  - Drawbacks
    - Sludge volumes generated
    - pH sensitive



REUSE



100% REUSE

Lakes, rivers, ground water

Water tank

Ore

Crushing

Concentrator

Ore concentrate

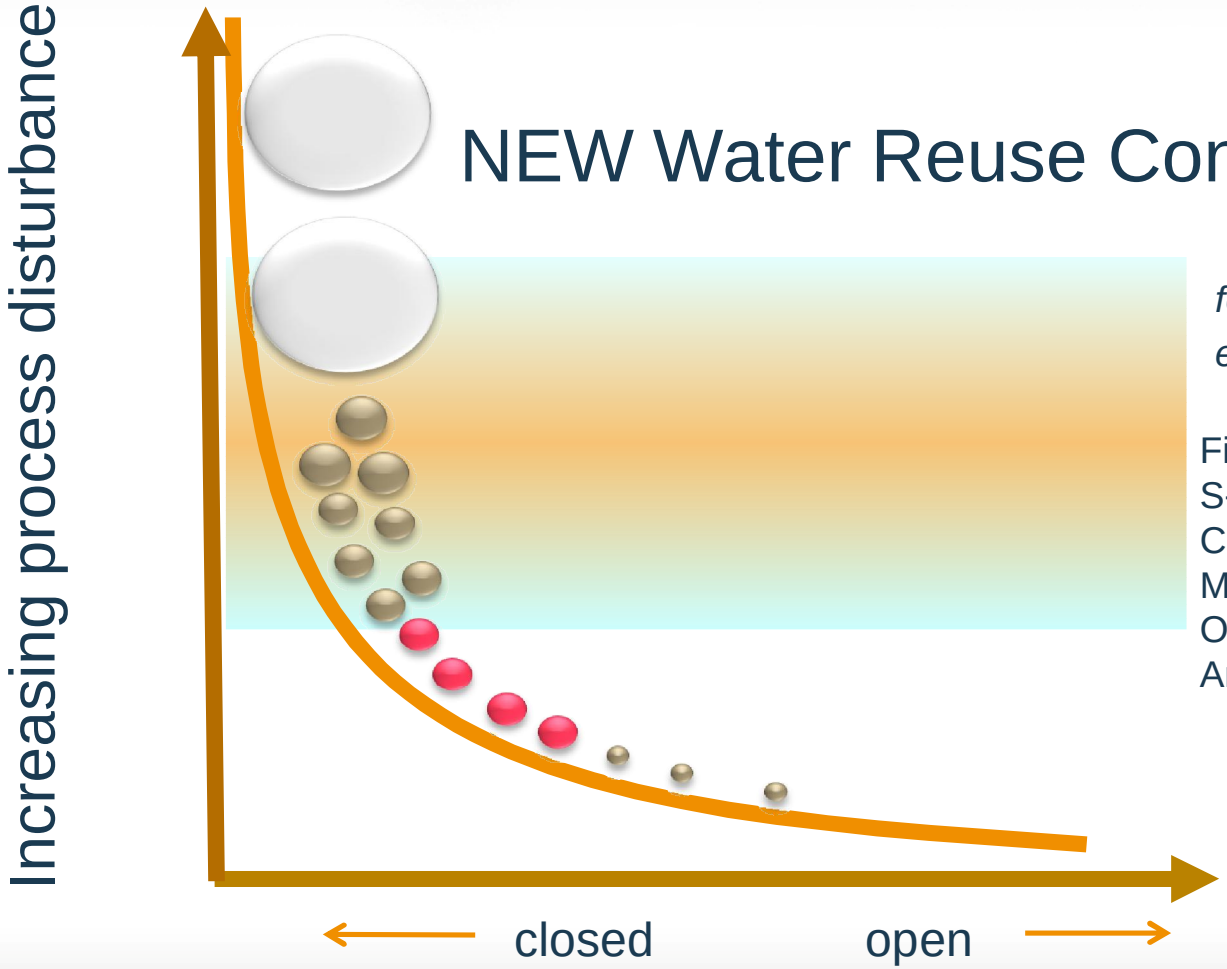
Rain

Evaporation

Tailings dam

Mine water

Closing the water loop – what kind of water is needed



Summary – reuse and

- **Don’t mix the clean water with dirty one**
- **Reduce the water volumes as much as possible**
- **Always treat the effluent as close to the place it is generated**
- **Keep simplicity and robustness in mind**
- **FOCUS to improve our mineral & metals industry to world class**
- **Environmental legislation will just get stricter**

Sustainable use of Earth's natural resources

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