A Review of Sulphate Treatment Technologies for Mine Drainage

1. Overview

INAP
International Network for Acid Prevention

LORAX ENVIRONMENTAL

Rationale and Objective

- ARD Treatment focused on Acidity and Trace Metals
- Less Attention on Sulphate Treatment
- Elevated Levels of Sulphate (> 2000 mg/L)
- Increasing Concern from Regulatory Agencies
- Sulphate Treatment Processes poorly Documented
- International Exchange of Information and Knowledge

INAP: "Present Summary of current State of the Art in Sulphate Treatment Processes for ARD"

To: Share and Exchange Information
Guide Future Treatment Developments

INAP International Network for Acid Prevention

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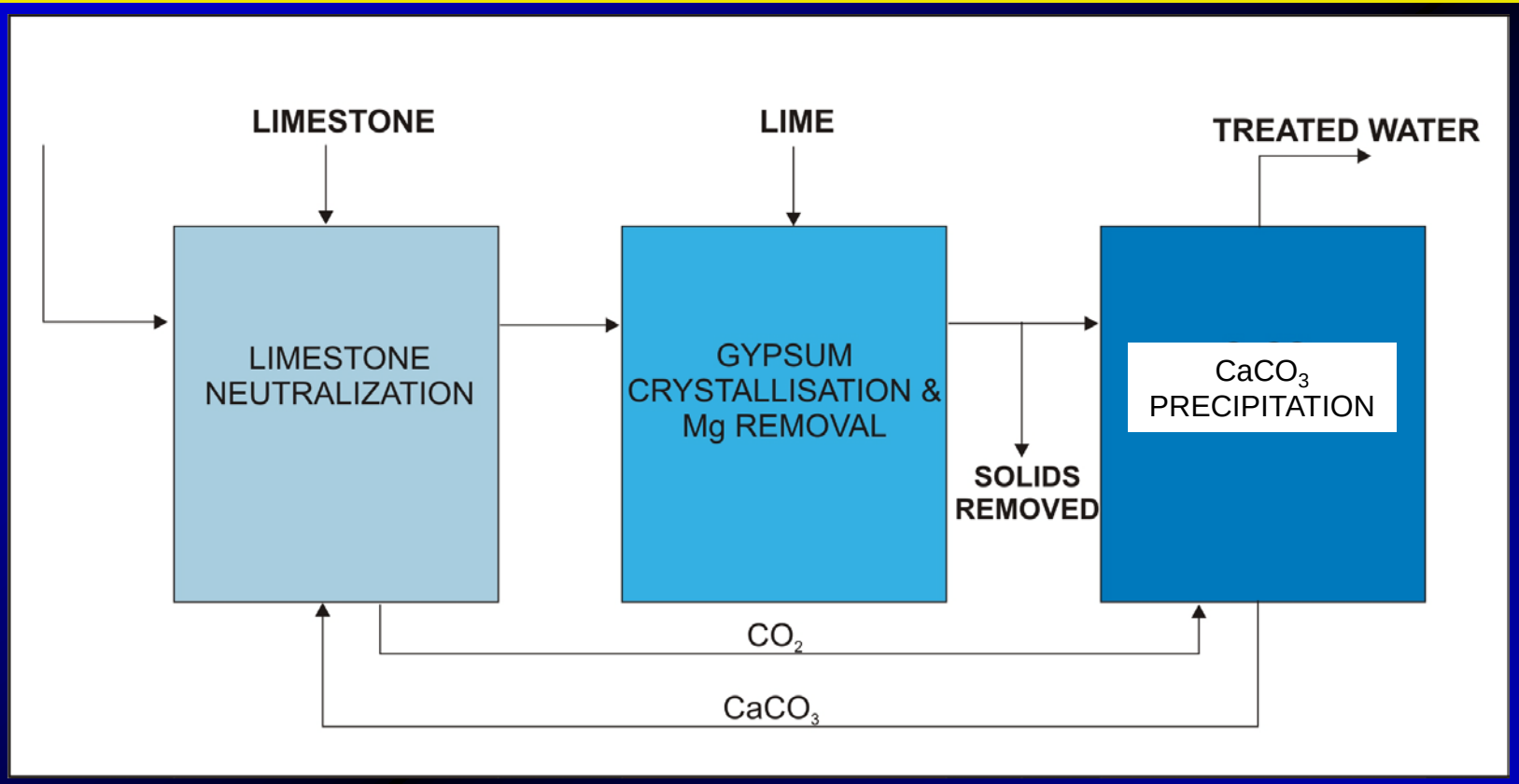
Sulphate Treatment Technologies

- Chemical Treatment with Mineral Precipitation
- Membranes
- Ion-Exchange
- Biological Sulphate Removal

Chemical Treatment with Mineral Precipitation

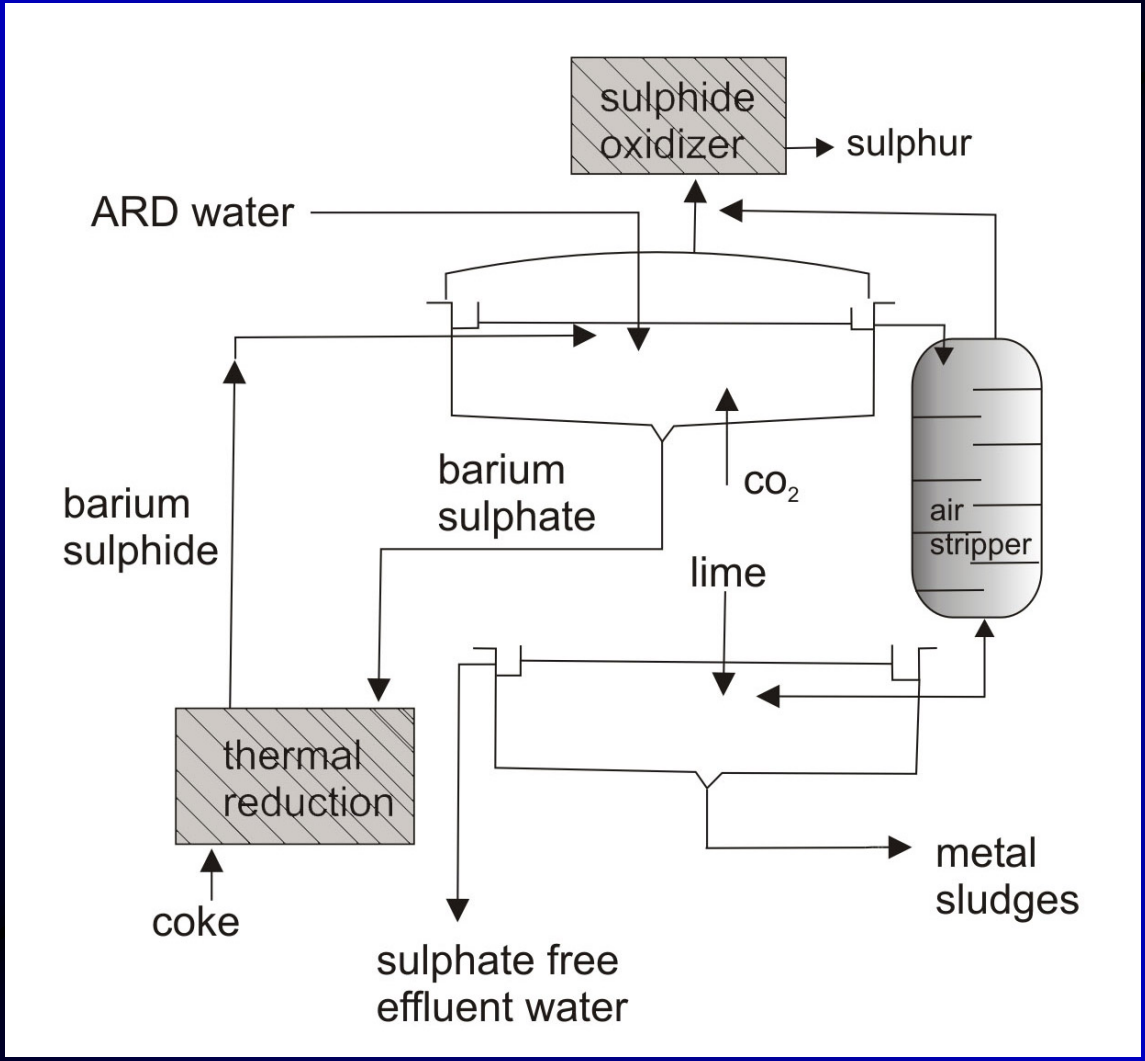
- Limestone/Lime
- Barium Salts
- SAVMIN
- CESR (a.k.a. ‘Walhalla’)

Limestone/Lime



- neutralization to pH 7, CO_2 production and gypsum precipitation
- liming to pH 12, $Mg(OH)_2$ precipitation, gypsum 'crystallization'
- pH adjustment with CO_2 and $CaCO_3$ precipitation

Barium Salts (BaS)

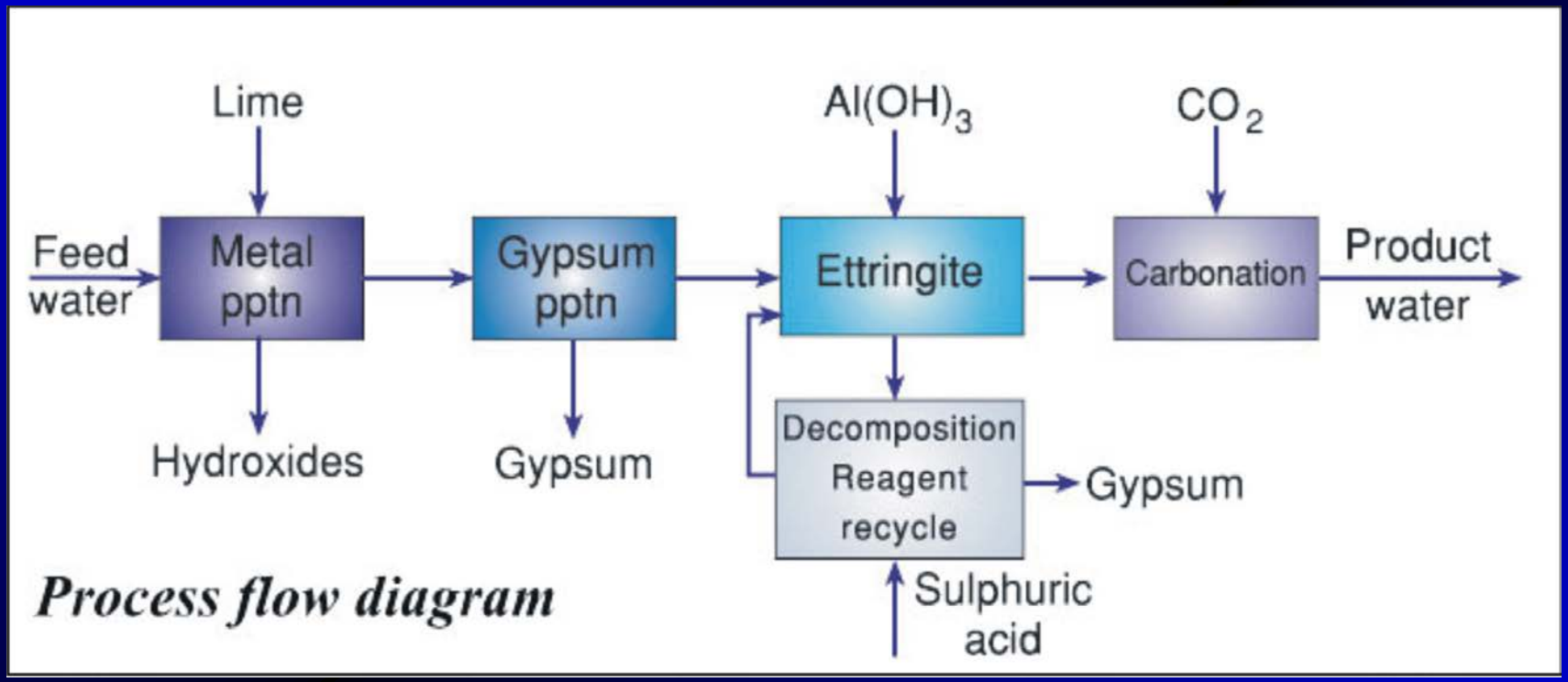


Barium Salts (BaS)

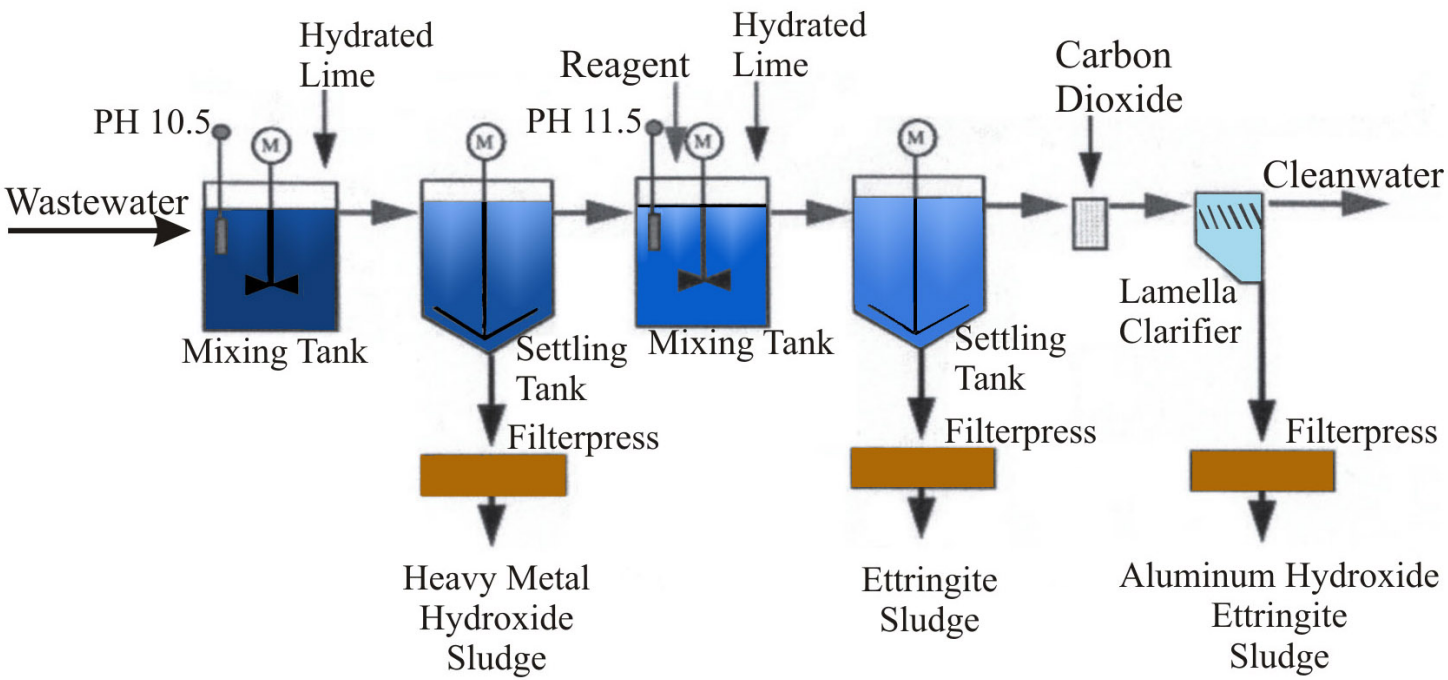
- ARD water + BaS(s) at constant pH by CO_2(g)
- $BaSO_4$(s) precipitation
- Thermal Reduction of $BaSO_4$(s) → BaS(s)

- H_2S(g) stripping
- H_2S(g) oxidation → elemental S(s)
- Sulphide-free water + lime → metal precipitation

SAVMIN


Lime
Al(OH)3
CO2
Feed water
Metal pptn
Gypsum pptn
Ettringite
Carbonation
Product water
Hydroxides
Gypsum
Decomposition Reagent recycle
Gypsum
Sulphuric acid
Process flow diagram

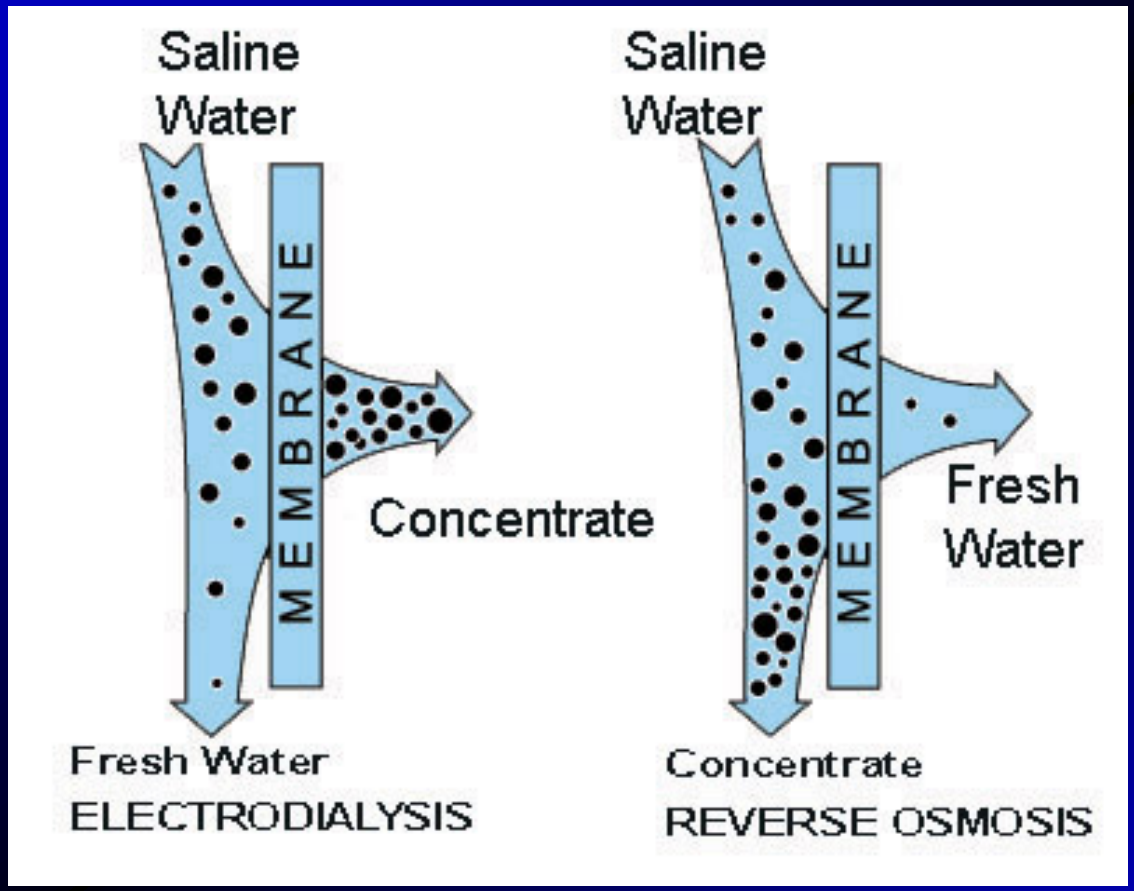
CESR: Cost-Effective Sulphate Reduction



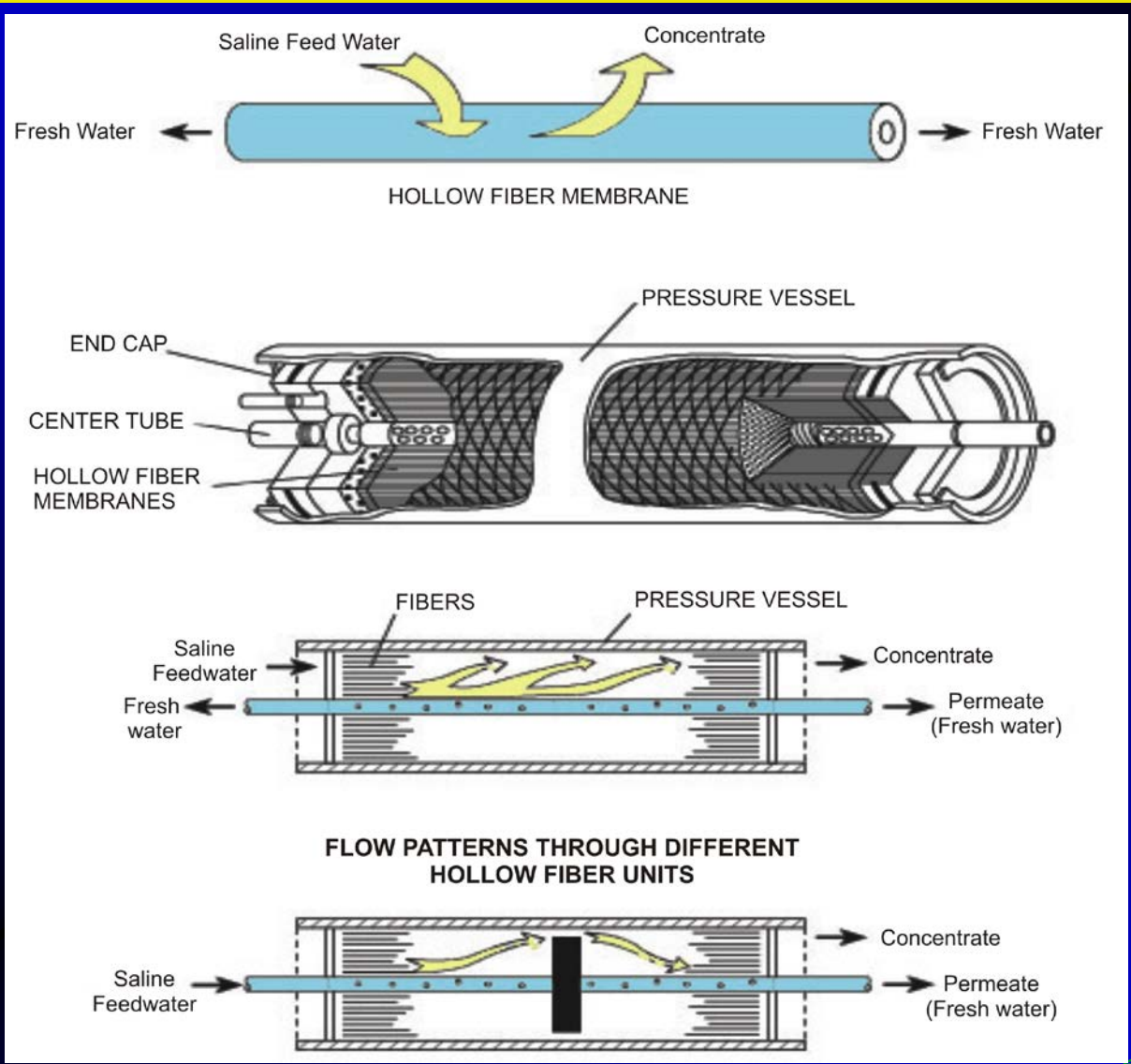
Membranes

- Reverse Osmosis
- SPARRO
- EDR

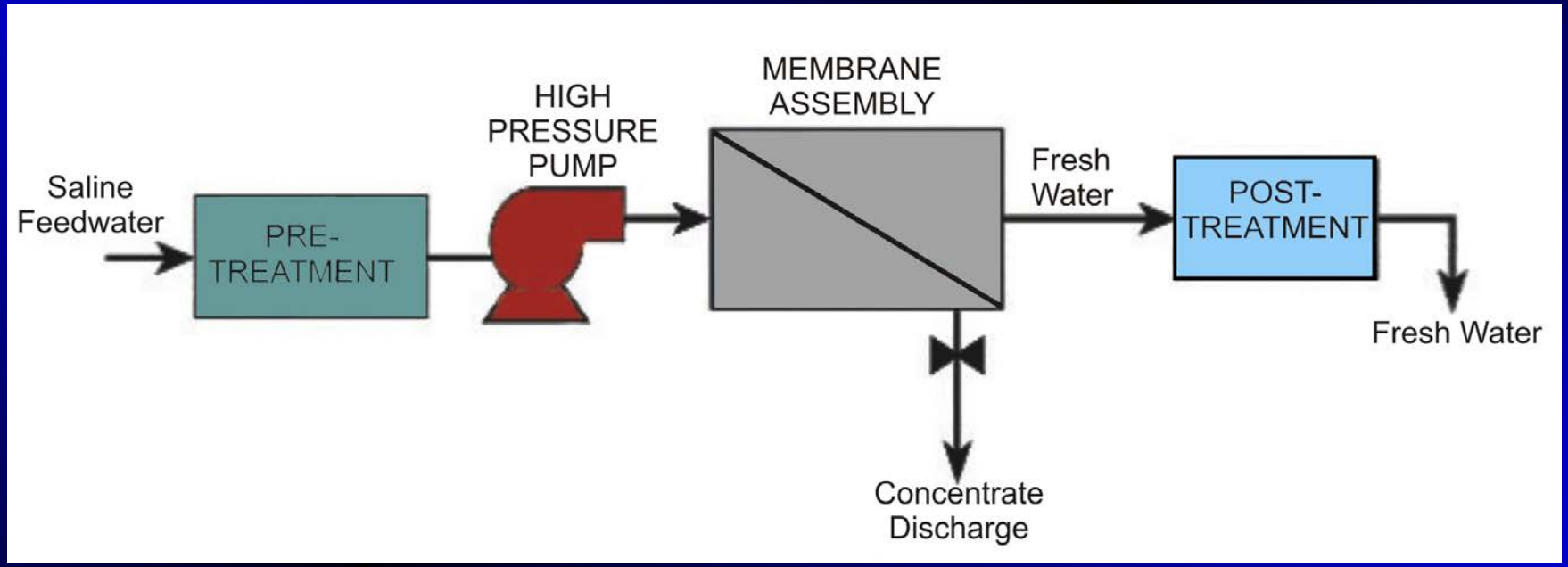
Basic Principle of Reverse Osmosis and Electrodialysis



Hollow Fiber Membrane Assembly Reverse Osmosis

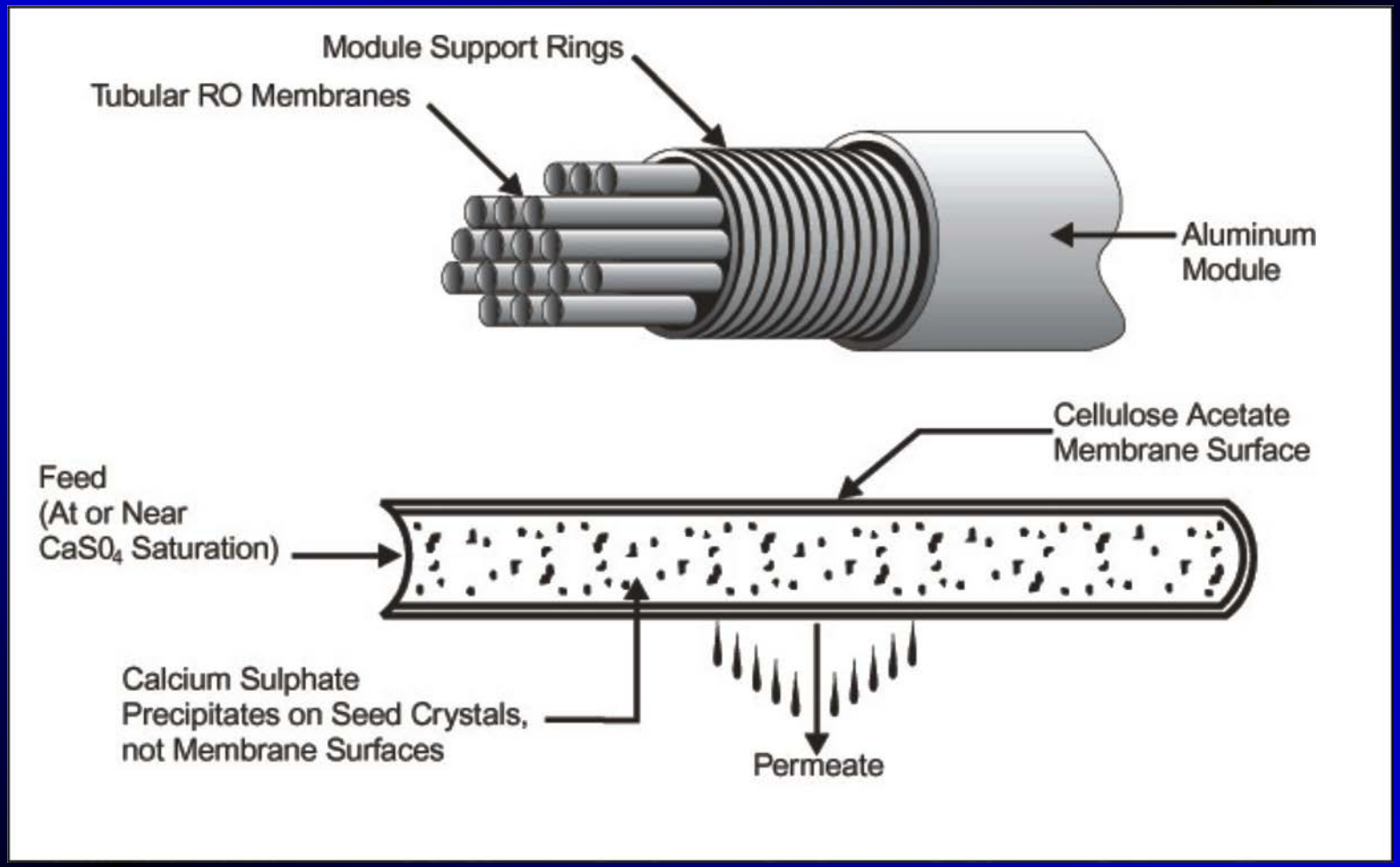


R.O. Plant Schematic

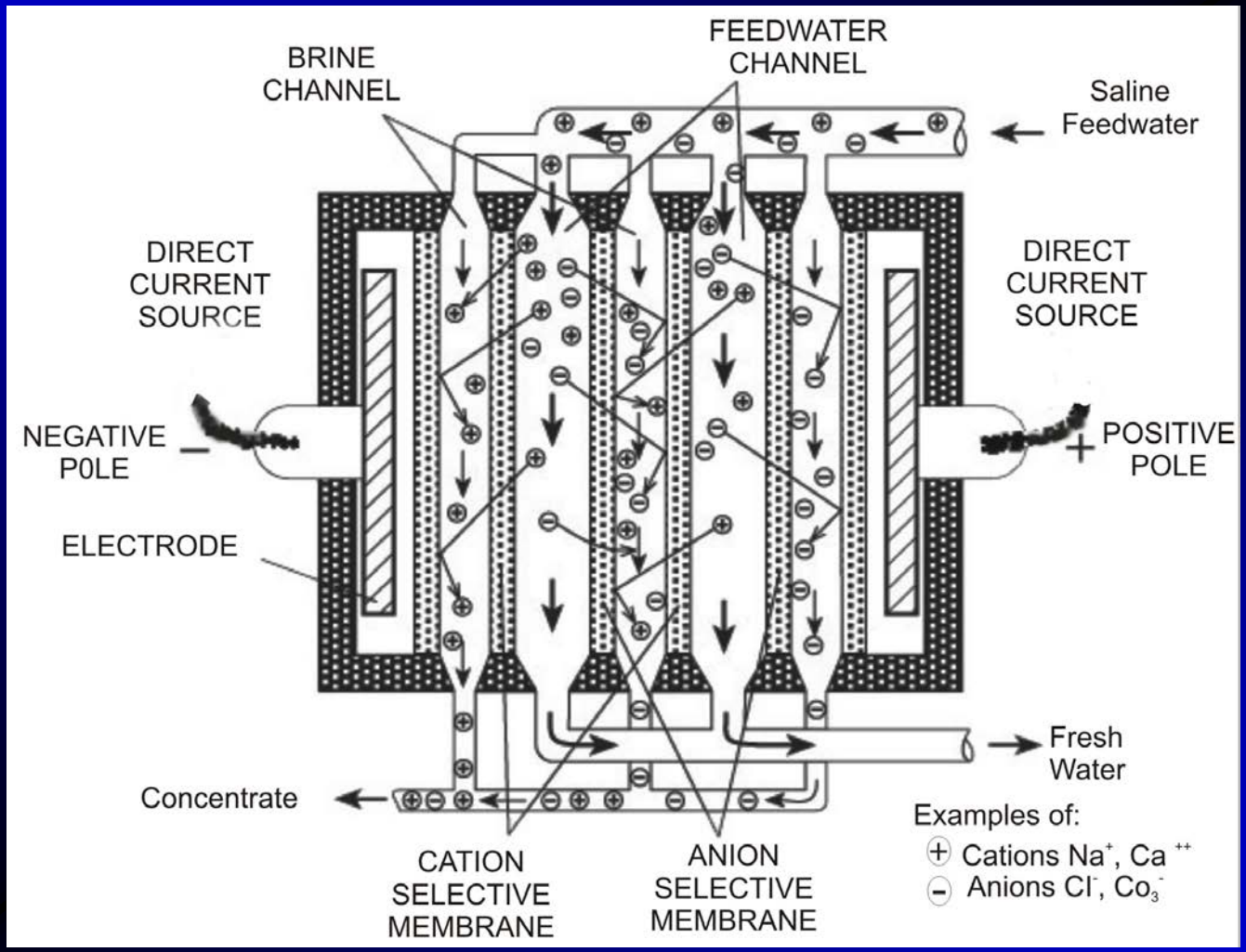


Concept of Seeded R.O.

SPARRO



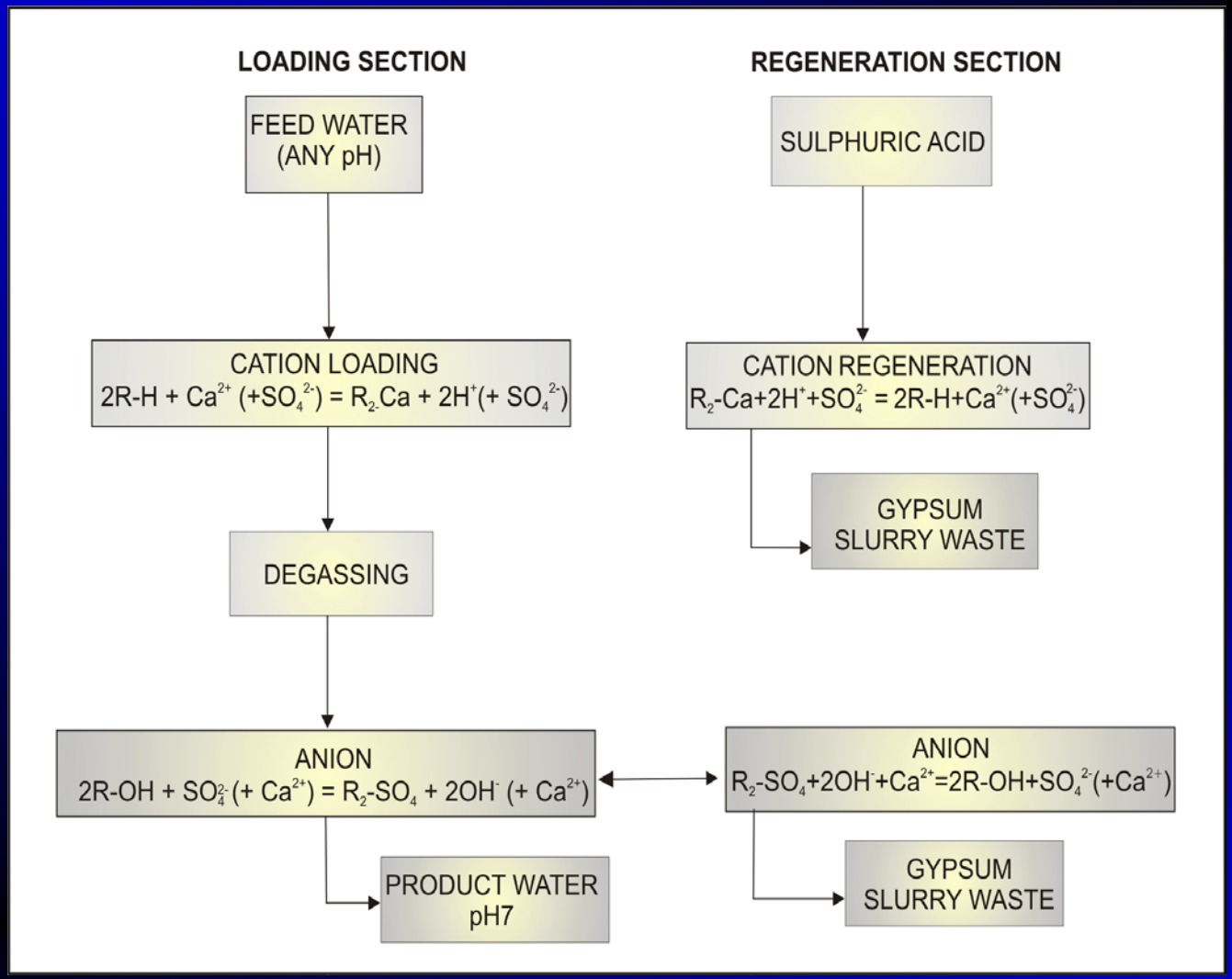
EDR


BRINE CHANNEL
FEEDWATER CHANNEL
Saline Feedwater
DIRECT CURRENT SOURCE
DIRECT CURRENT SOURCE
NEGATIVE P0LE
POSITIVE POLE
ELECTRODE
Fresh Water
Concentrate
CATION SELECTIVE MEMBRANE
ANION SELECTIVE MEMBRANE
Examples of:
Cations Na^+, Ca^{++}
Anions Cl^-, Co_3^-

Ion-Exchange

- GYP-CIX

GYP-CIX


LOADING SECTION
REGENERATION SECTION
FEED WATER (ANY pH)
SULPHURIC ACID
CATION LOADING
2R-H + Ca2+ (+SO4 2-) = R2-Ca + 2H+(+ SO4 2-)
CATION REGENERATION
R2-Ca+2H++SO4 2- = 2R-H+Ca2+(+SO4 2-)
GYPSUM SLURRY WASTE
DEGASSING
ANION
2R-OH + SO4 2- (+ Ca2+) = R2-SO4 + 2OH- (+ Ca2+)
ANION
R2-SO4+2OH-+Ca2+=2R-OH+SO4 2-(+Ca2+)
PRODUCT WATER pH7
GYPSUM SLURRY WASTE

Biological Sulphate Removal

- Bioreactor
- Constructed Wetland
- Alkalinity Producing Systems
- Permeable Reactive Barrier

Biological Sulphate Reduction

- **Dissimilatory sulphate reduction by SRB:**

$$4CH_3OH + 3SO_4^{2-} = 4HCO_3^- + 3HS^- + H^+ + 4H_2O$$

- **Sulphide oxidized to elemental sulphur (S) by:**

  - Chemotrophs: $2HS^- + O_2\,(g) + 2H^+ = 2S\,(s) + 2H_2O$

  - Phototrophs: $2HS^- + CO_2\,(g) + 2H^+ = 1/6C_6H_{12}O_6 + 2S\,(s) + H_2O$

- **Sulphide removal also by:**

  - precipitation as metal sulphides (MeS)
  - H_2S (g) stripping

Anaerobic Pathways