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Water Covers to Wetlands: Opportunities and Constraints

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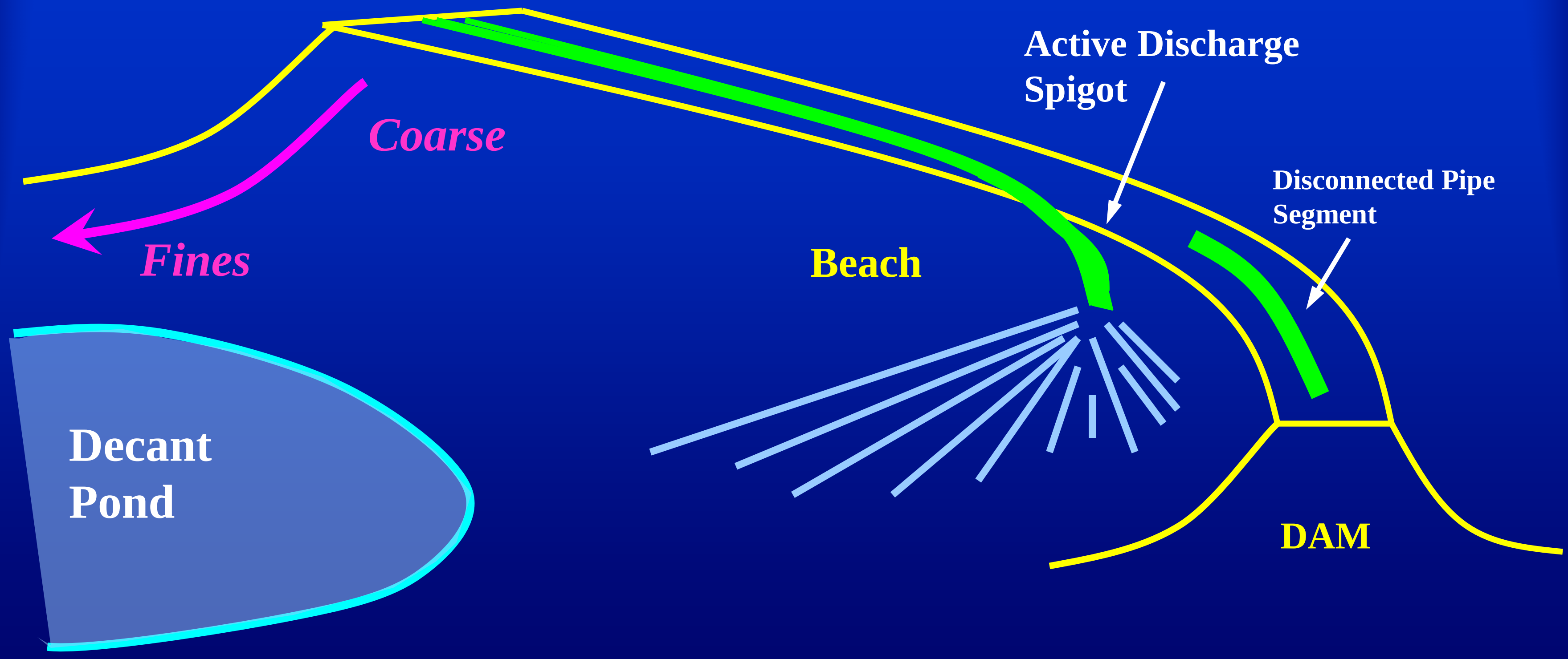
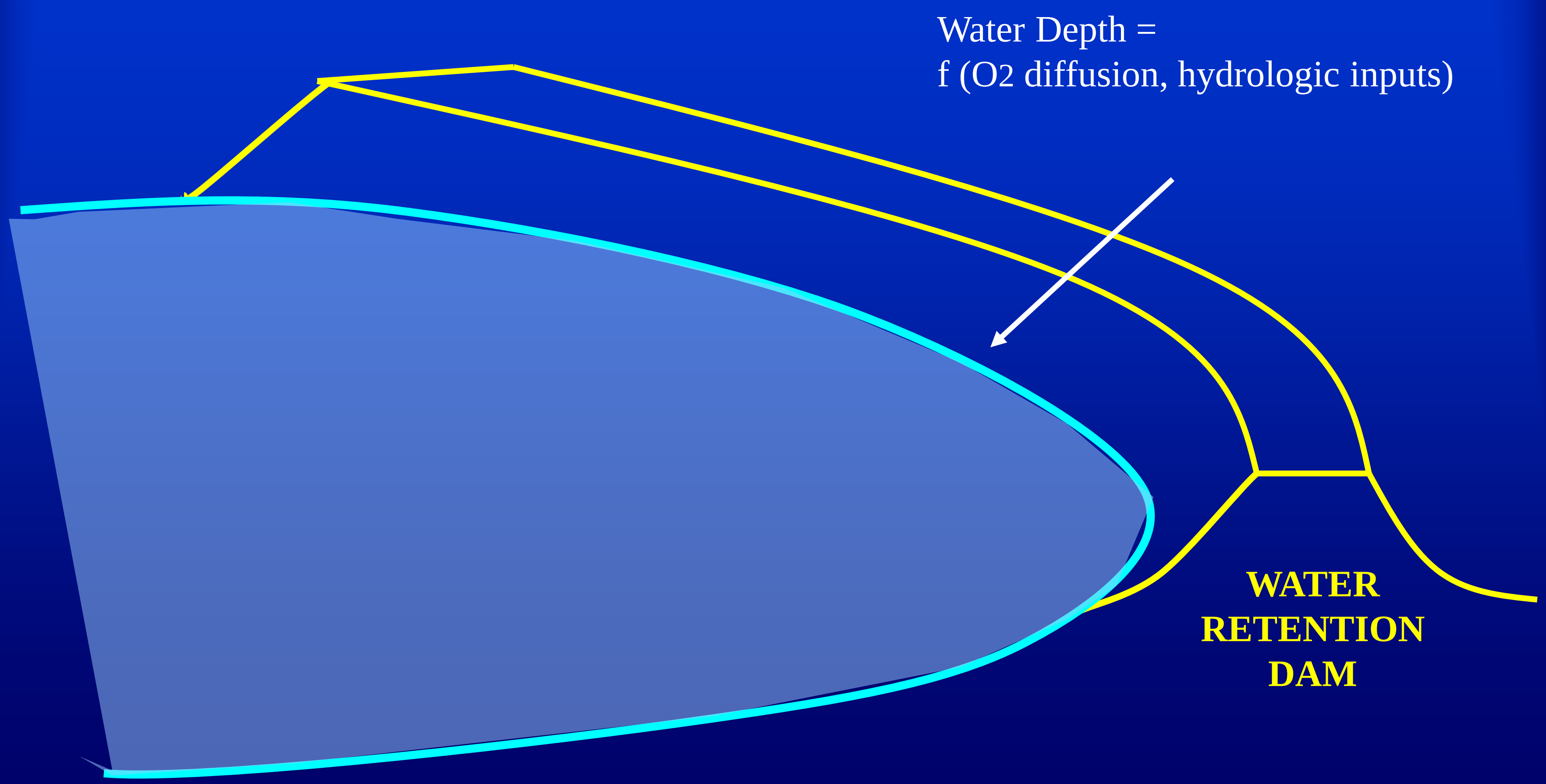
Outline of Discussion

- Tailings Water Covers:
  - Key Mechanisms
  - Current Closure Options
- Natural and Constructed Wetlands
  - Fundamental Principles
- Water Covers to Wetlands
  - Opportunities and Limitations
- Conclusions and Recommendations

Typical Tailings Impoundment



Tailings Water Cover



Tailings Water Covers

- Chemical Stability
  - Low O2 Diffusion ↓ ARD Potential
  - Oxidation Potential: aeration, tailings resuspension, GW, waste composition, etc…
- Water Retention Dams:
  - Typically cross-valley construction
  - Require long-term monitoring and maintenance
  - Water Level Maintenance:
    - Precip/Evap, SW/GW Inflow and Outflow, Seepage
    - Require Spillways for Runoff

Wetlands: A Reclamation Alternative

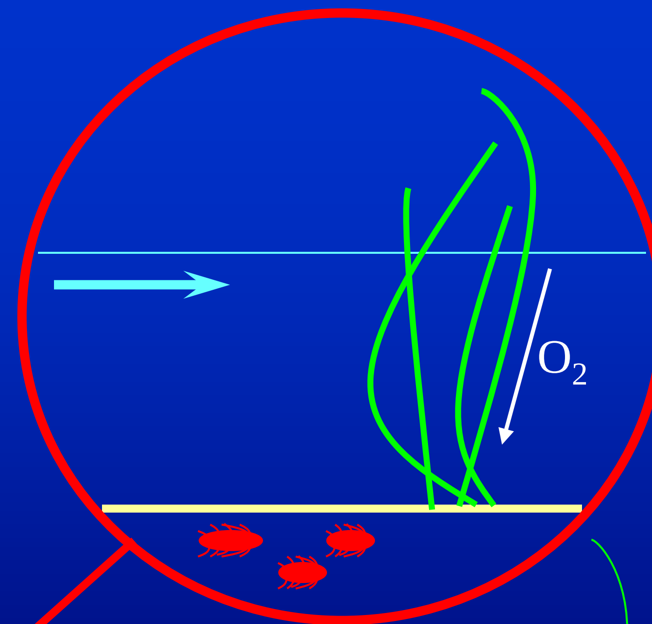
- The Value of Wetlands
  - Habitat Restoration or Replacement
  - Aesthetically Appealing
  - Wave, erosion, and flood control
  - Inexpensive Pollution Treatment or Prevention
- Can be Highly Effective for ARD Treatment

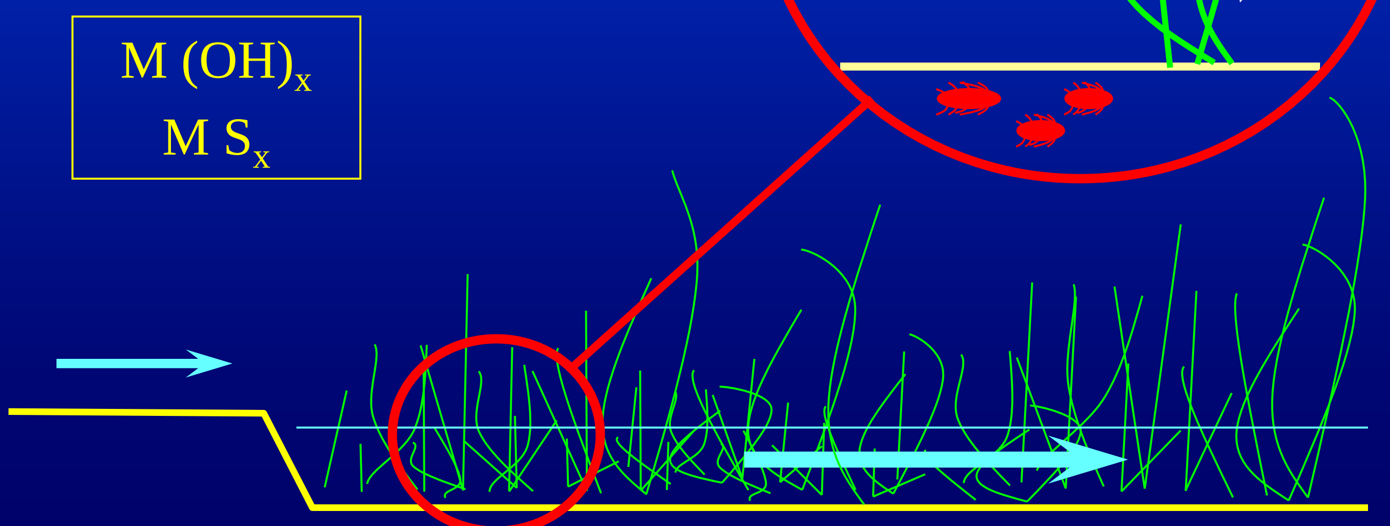
  e.g. West Virginia Coal Mine
  - pH 3.0 $\rightarrow$ 5.5
  - Sulfate 250 mg/L $\rightarrow$ 10 mg/L
  - Iron 50 mg/L $\rightarrow$ 2 mg/L

Metals and Wetlands

<u>Three Pathways for Metal Retention</u>

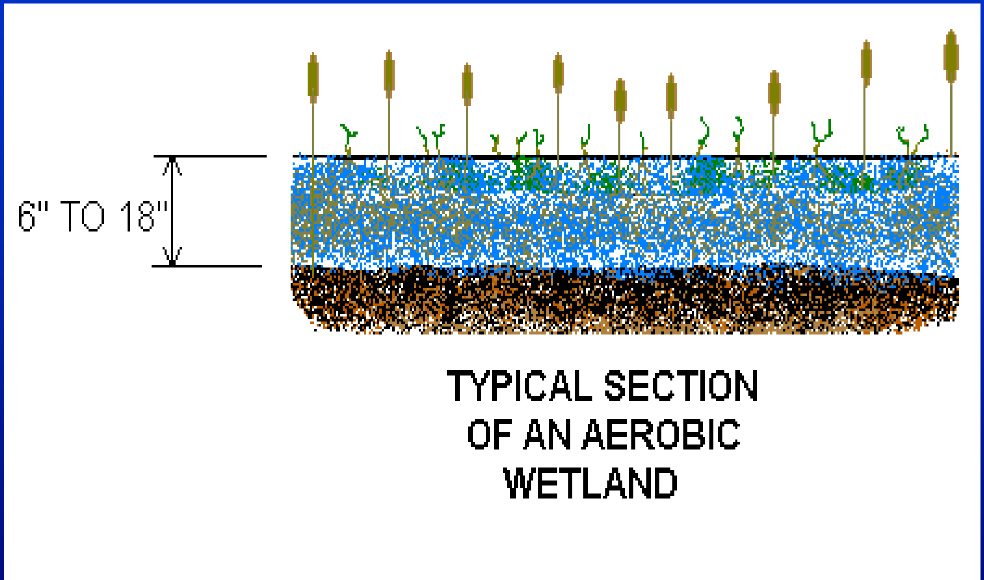
- ***Direct Uptake by Plants.***
- ***Complexation with wetland matrix.***
- ***Chemical/Microbiological Oxidation or Reduction.***





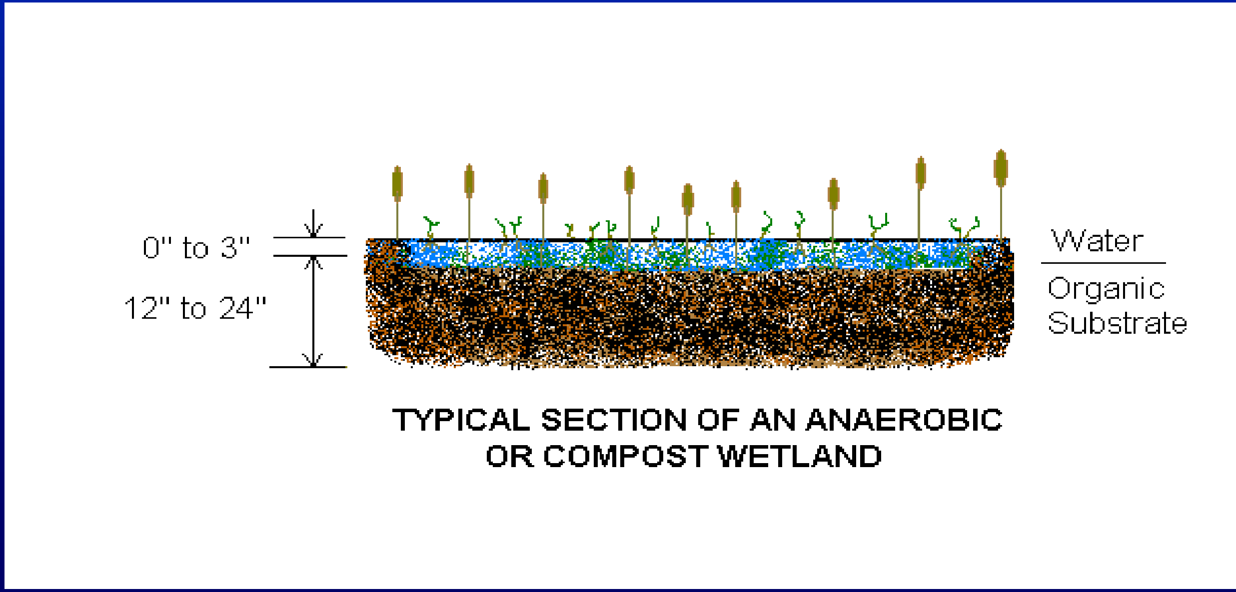
Aerobic Wetlands

- Large SA
- Horizontal flow
- Wetland vegetation
- Best for alkaline drainage
- Efficient when pH >5.5
- Typical water depth: 6 to 18 inches



Anaerobic Wetlands

- Large pond
- Organic substrate (12-24 inches)
- Horizontal Flow within substrate
- Planted with emergent vegetation



Constructed Wetland Design

Some Design Principles…

- Do not overengineer – mimic natural systems
- Utilize natural energies (e.g. streams)
- Design for minimum maintenance
- Design to Fulfill Multiple Goals
  - Water treatment
  - Wildlife habitat
  - Replacement of similar habitat
  - etc..

Key Variables

- Hydrology
  - Hydraulic Loading, Basin Depth and Geometry, Residence Time
- Metal Loading Rate
- Substrate/Soils

Constructed Wetland Design

Performance Evaluation…

- Design Objectives
- Survival Potential

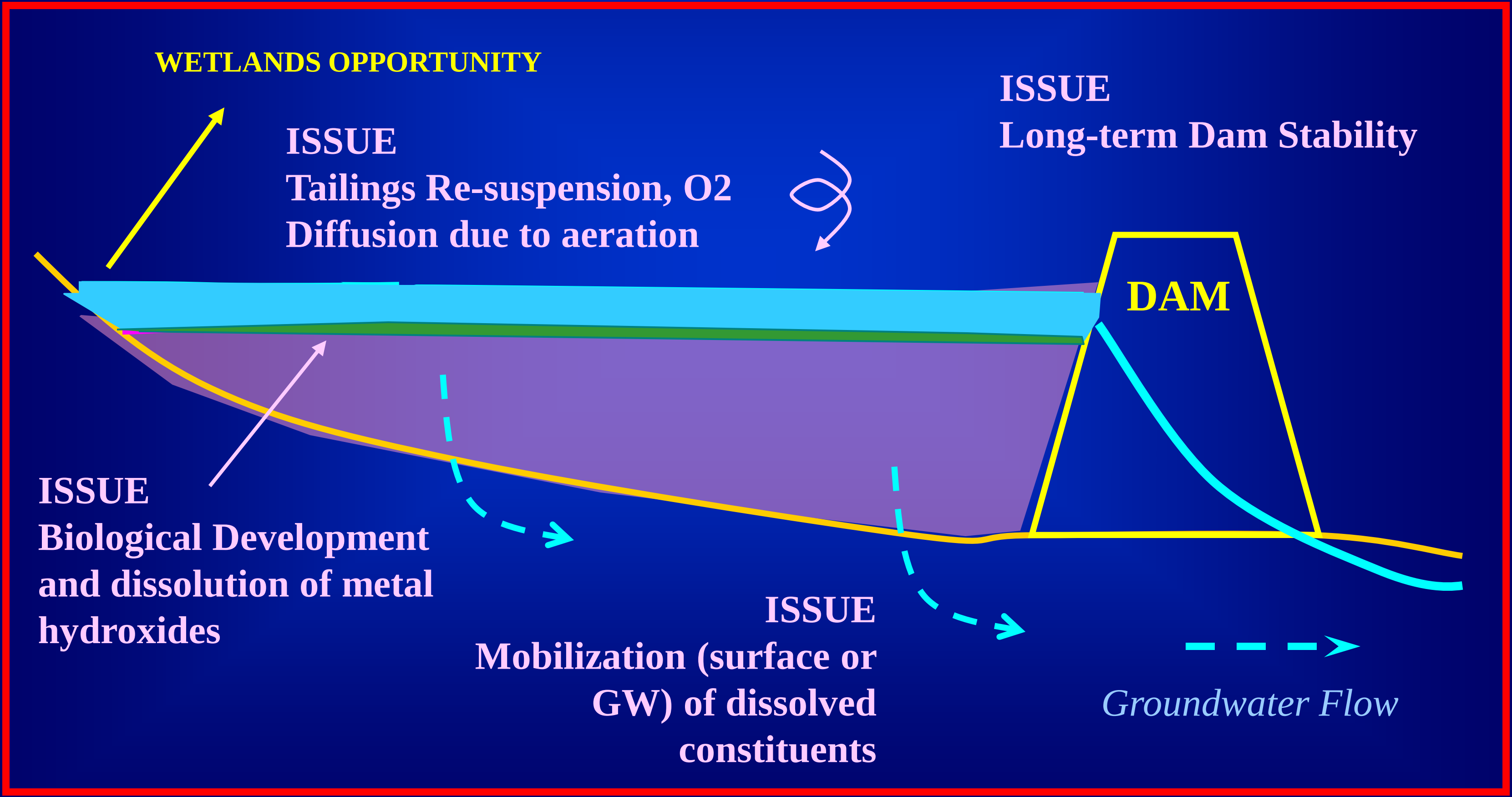
Consider system changes in:

- temperature
- water chemistry
- nutrient and trace metal conc
- water levels and flow rates
- metals and sediment loadings
- micro-organisms

Short term water treatment promising - but little long-term data

Tailings Water Covers

During or Post Operation

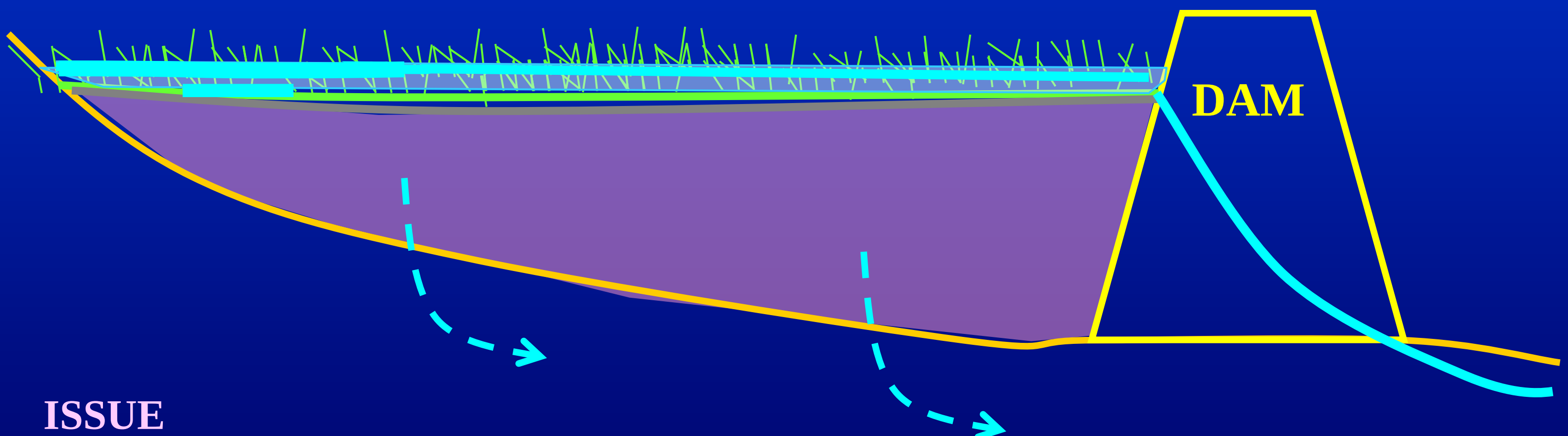


A Water Cover to a Wetland

Post Operation

ISSUE
Metals uptake and transmission to wildlife

ISSUE
Long-term Dam Stability



ISSUE
Mobilization (surface or GW) of dissolved or organic acid associated metals

Groundwater Flow

Wetland Issues (cont…)

- **Hydroxides:**
  - *Fe, Mn Hydroxide - limited by volume of material produced*
  - *May dissolve in presence of organic acids (release coprecipitated metals)*
- **Uptake of Metals by Biota**
  - *Wetlands – biodiversity desirable, favoured habitat for birds*
  - *Organic-acid associated metals may be transported downstream*
  - *How to limit interaction with tailings?*

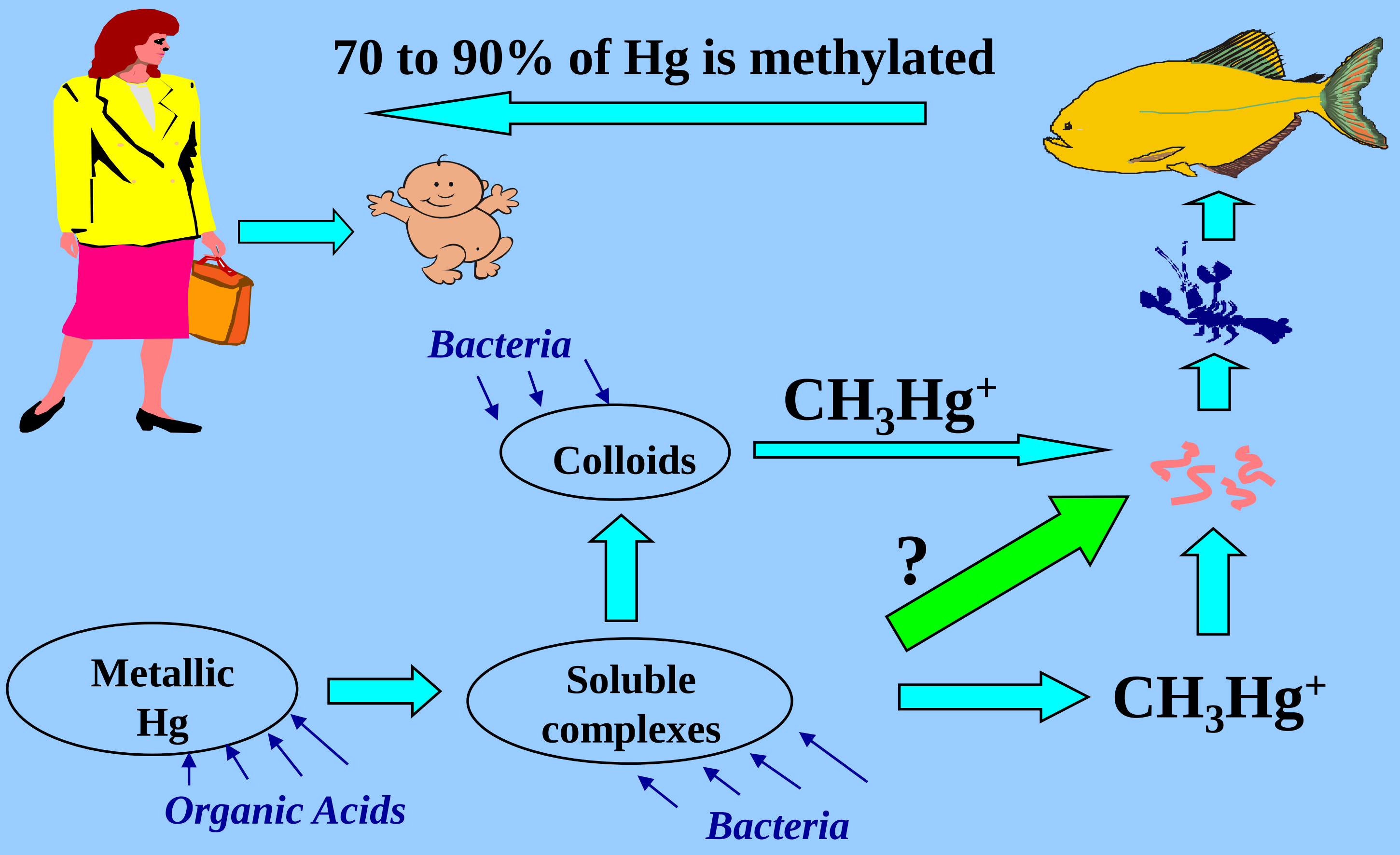
Wetland Plants

- **First Plants:**
  - *Select based on Local Conditions and Tolerance*
  - *Polycultures may be more effective than Monocultures*
  - *Typha latfolia - common cattails*

    - readily available
    - easily transplanted
    - tolerant
    - low accumulation

- **Field Study on High S Tailings** (Griffiths, 1988)**:**
  - *Cattails transplanted onto tailings demonstrated 200% population density increase after one year*
  - *Some planted seed germination (comparatively little success)*
  - *decreased sulfate, Fe, Cu, Ni; increased pH*

Other Issues – Mercury



Bioaccumulation and Biomagnification

After Veiga *et al.* (1999)

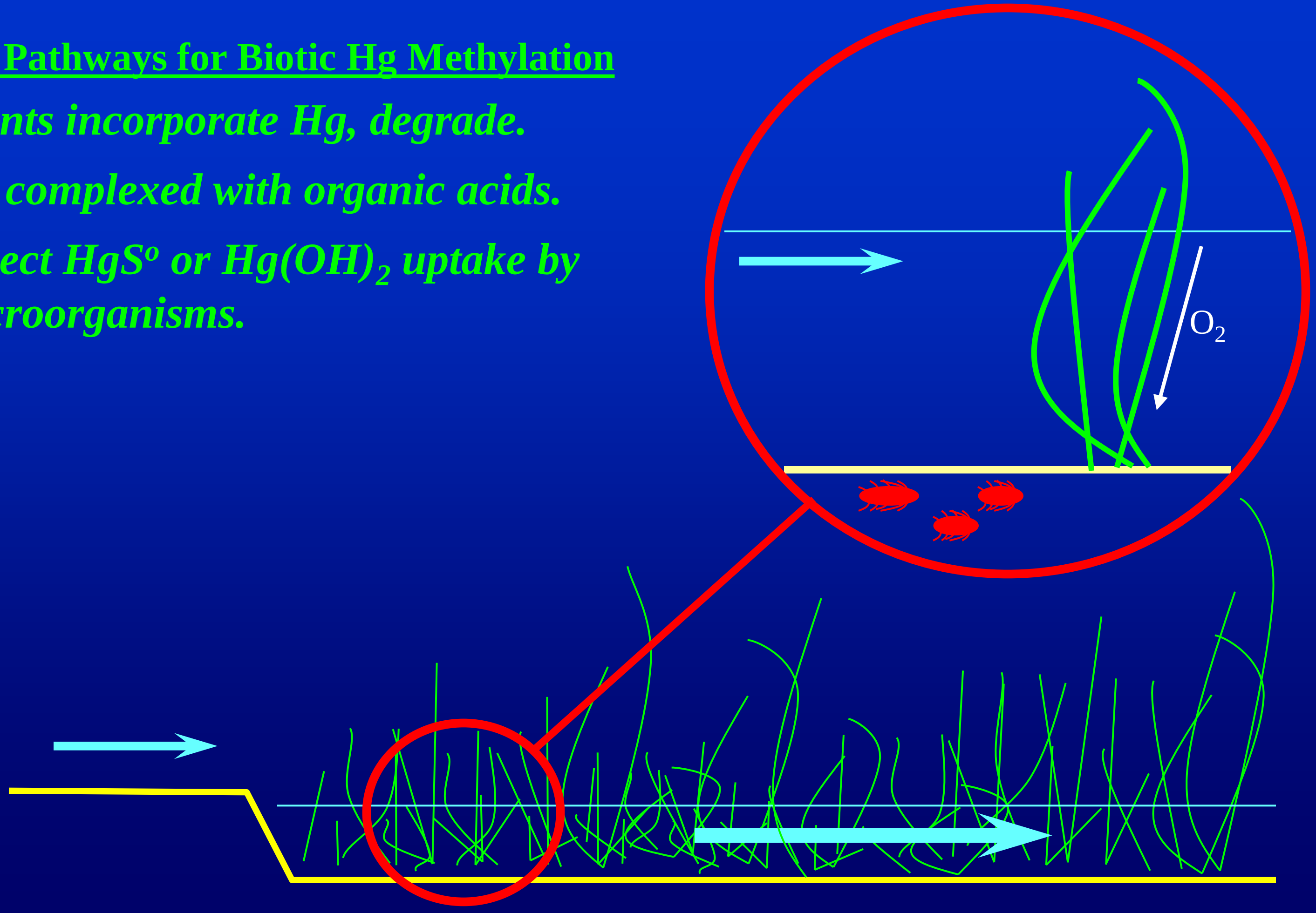
Mercury Methylation

- **Methylation Sites:**
  - *Sediments*
  - *Particle surfaces*
  - *Root systems of certain plants*
  - *Within organism intestines*
- **Numerous Methylating Bacteria: SRBs important**
- **Natural Organic Acids (humic and fulvic acids)**
  - *Hg-organic complexes important to bioavailability, mobility*
  - *Methyl-group donors (abiotic and biotic methylation possible)*
  - *Potential for intestinal methylation of Hg-organic complexes?*

Mercury and Wetlands

<u>Three Pathways for Biotic Hg Methylation</u>

- *Plants incorporate Hg, degrade.*
- *Hg complexed with organic acids.*
- *Direct HgS° or Hg(OH)$_2$ uptake by microorganisms.*



Other Issues - Selenium

- **Biomagnifies up trophic levels**
- **Selenate (SeO_4^{2-})or Selenite (SeO_3^{2-}) bioavailable:**
  - *Dissolved or adsorbed to clay/HFMO*
  - *Uptake by aquatic organisms or rooted plants*
  - *Selenate, selenite predominant forms in wetlands*
- **Why a concern for wetlands?**
  - *Significant potential to enter food chain:*
    - Long residence time
    - Weakly adsorbed in sediments, easily taken up by plants
  - *A fine line between micro-nutrient and toxicant*

Conclusions

Opportunities

- An alternative reclamation option
- Wave and erosion control
- ARD Prevention - maintained anaerobic conditions

Constraints

- Impoundment characteristics (substrate, water depth, etc..)
- Potential mobility, bioavailability of metals associated with organic acids
- Metal uptake by biota
- Long-term viability of wetlands

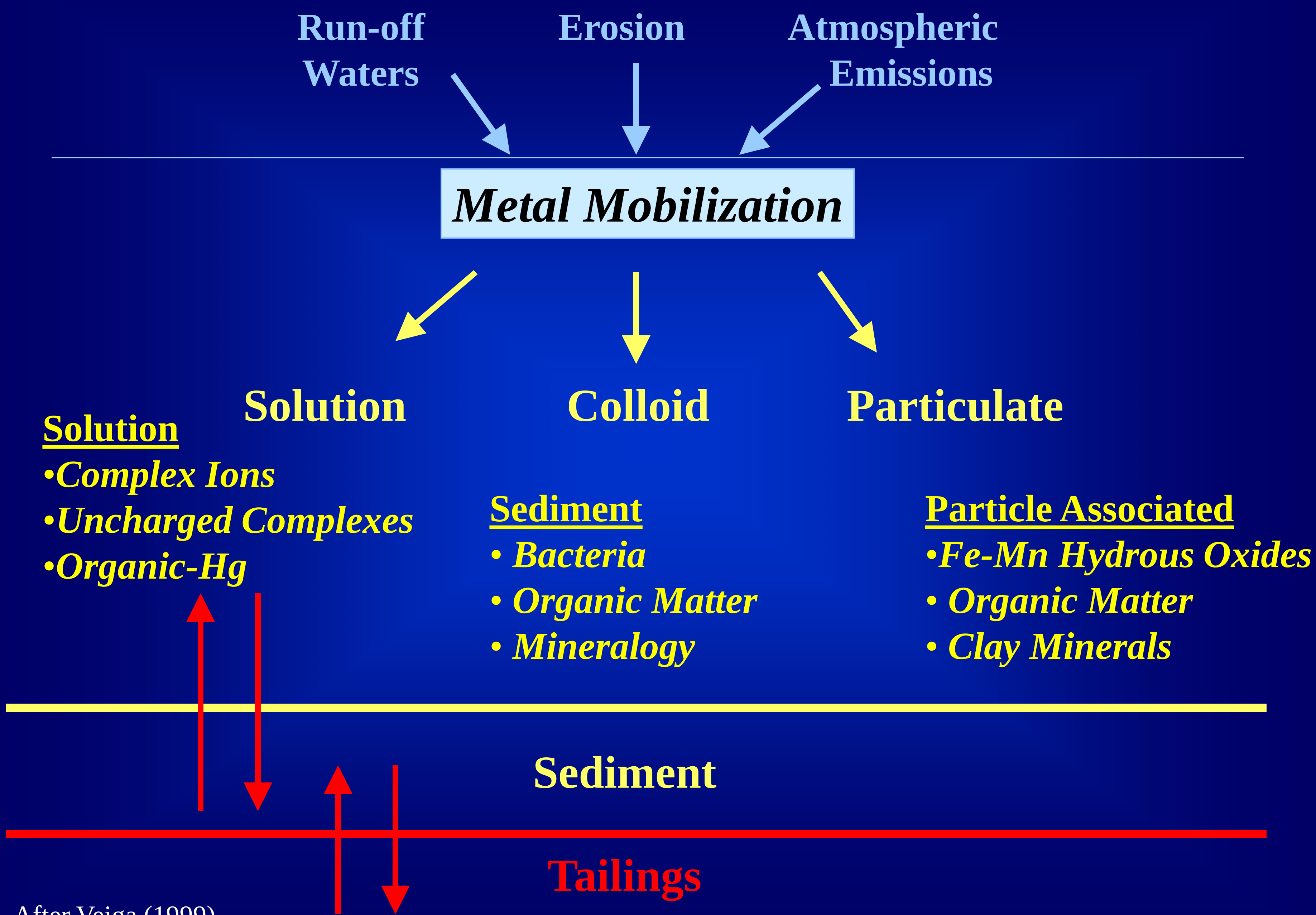
Tools to Evaluate this Option must be developed

Recommendations

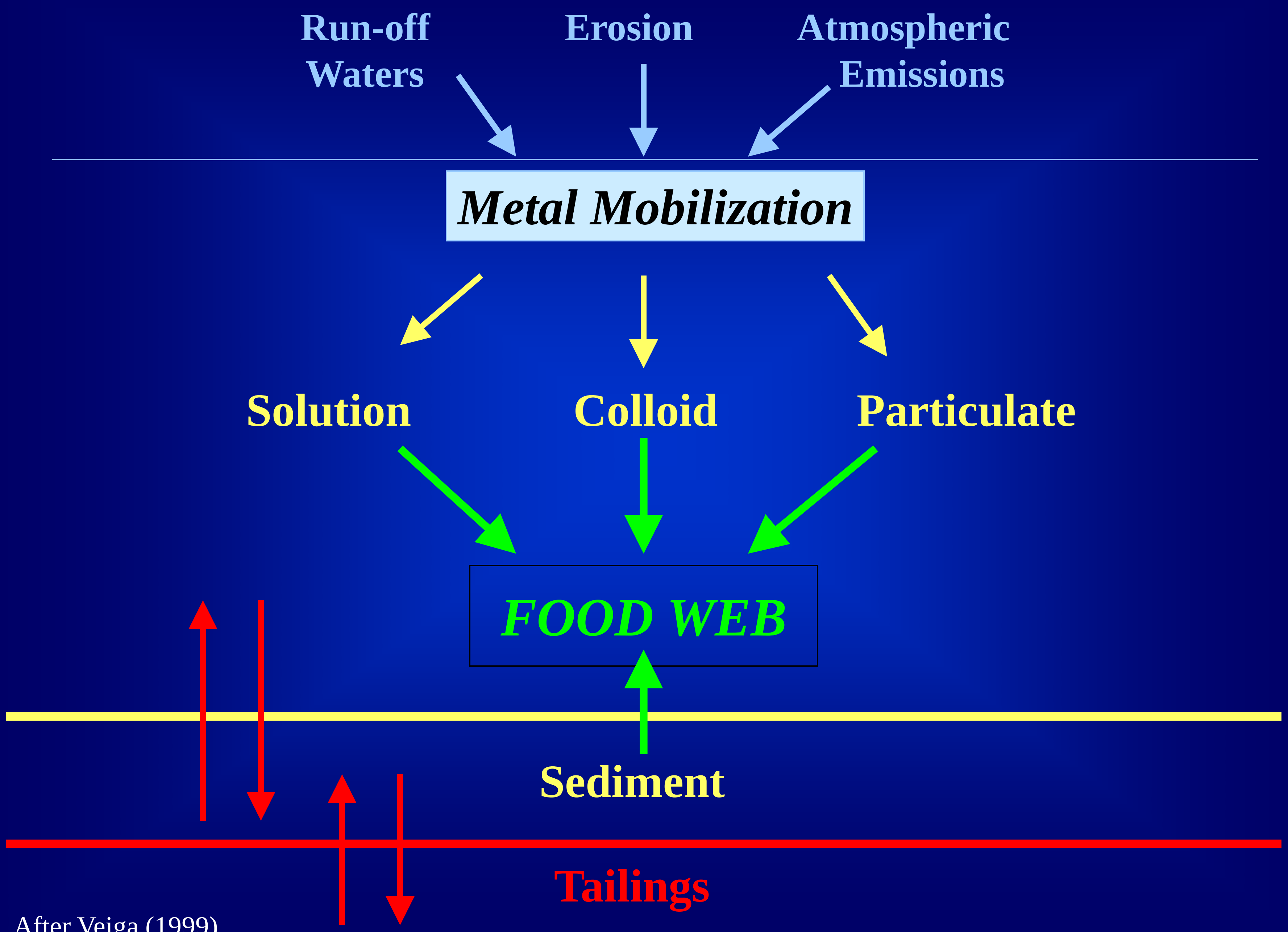
Further Study…

- Effects of various amendments (e.g. gypsum) on metals partitioning
- Potential for anaerobic wetlands to exacerbate dissolution of metals co-precipitated with hydroxides
- Bioavailability of metals associated with organics
- Uptake of metals from tailings by wetland plants

Thank-you…



After Veiga (1999)



After Veiga (1999)