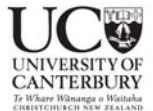


# Predicting ecological impacts

Jon Harding  
Olivier Champeau  
Dev Niyogi

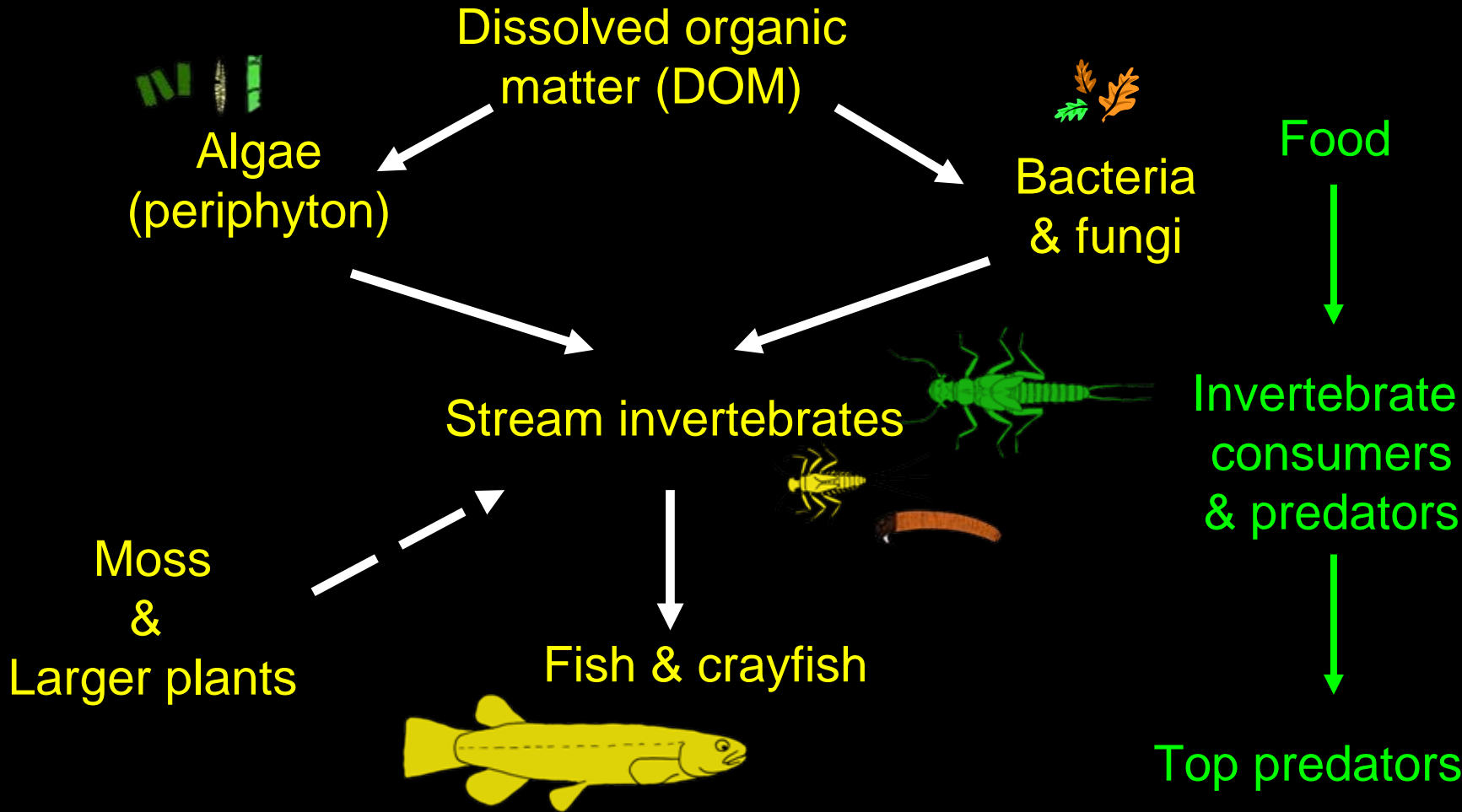
**Mine drainage framework**



# Roadmap

- What is the ecology of a natural stream?
- How do we measure ecological impacts?
- Mechanisms of mine impacts
  - Acid & metal toxicity
- Predicted ecology of systems in PAF & NAF
- What effects might alluvial gold mining have?
- Effects of hard rock gold mining
- Summary

# What is the ecology of a natural stream?





# How do we measure ecological impacts?



1. Field surveys
2. Ecotoxicological trials
3. Literature reviews

# Benthic macroinvertebrates

Mayflies



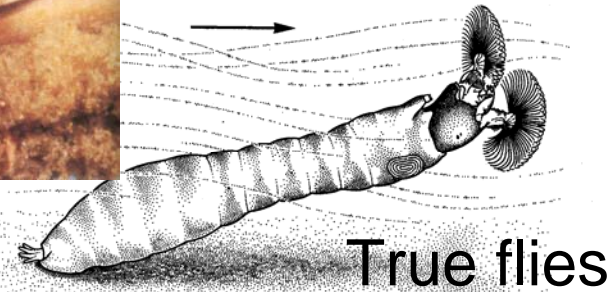
Stoneflies



Snails



Caddisflies







## Confounding factors in measuring stream health on West Coast

Flood disturbance  
+  
Naturally acidic streams

# Confounding factors in measuring stream health in Southland





# Mine outputs which effect stream communities

pH

Metals e.g. Fe, Al, Ni, Zn, As

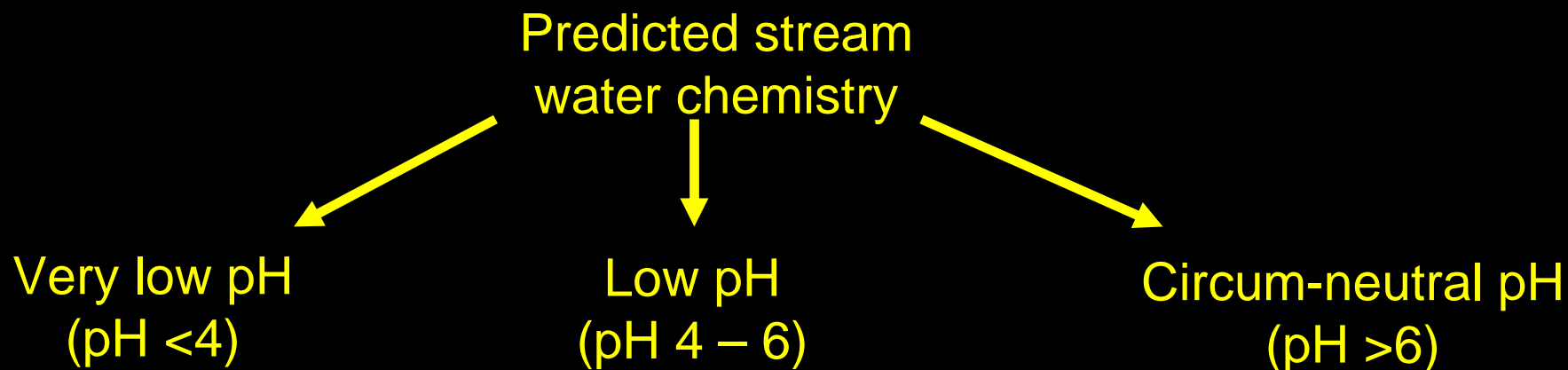
Precipitates



Turbidity?



# Potential acid-forming coal (PAF)



Impact of pH : first major driver

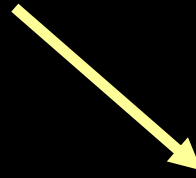
# Impact of water acidification – on plants



Photosynthesis



Productivity



➤ Abundance of filamentous algae



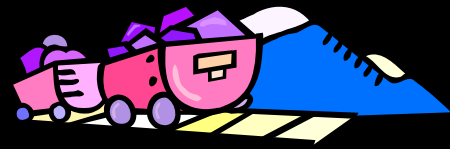
➤ Species diversity



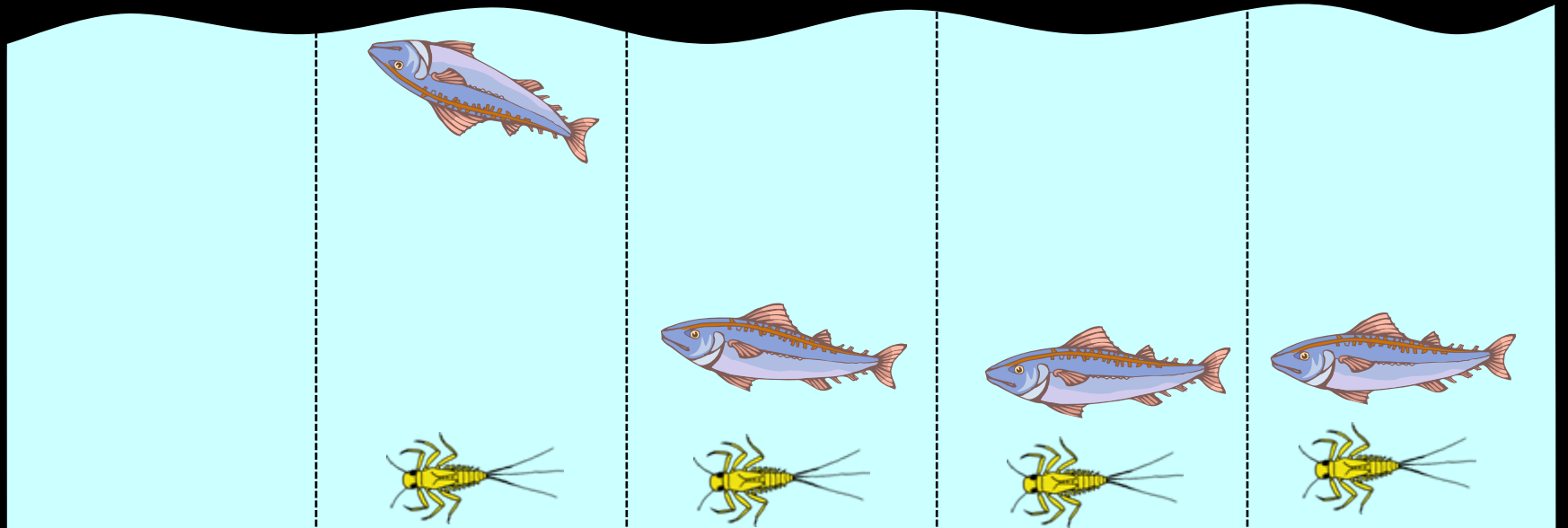
Bioaccumulation of metals







# Impact of pH



H<sup>+</sup> inhibits  
respiratory  
function

Levels of H<sup>+</sup>  
disrupt ionic  
equilibrium

# Impact of water acidification on animals

## Physiology

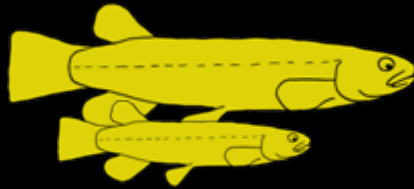
Disruption of ionic regulation  $\text{Na}^+$ ,  $\text{Ca}^{2+}$

Hatching delays



Arrested development of embryos

Growth reduction



Deformities



Increased bioaccumulation and toxicity of aluminium and other trace metals

## Behaviour

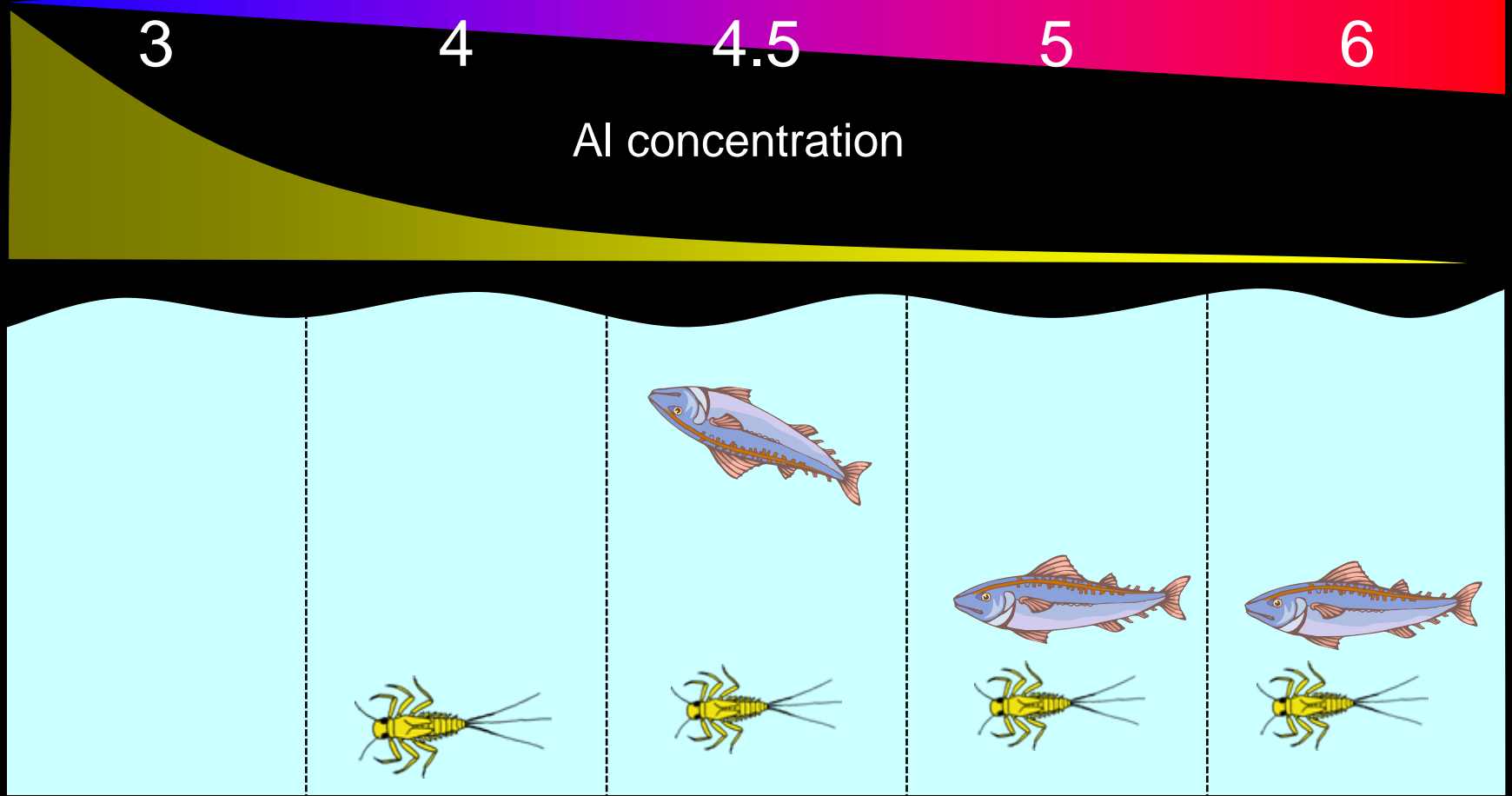


Drift, avoidance, migration

Modified prey/predator relationship



# Impact of metals e.g aluminium + pH



pH toxicity affected by competition between Al and H<sup>+</sup> ligand

Impaired ion regulation  
➔ toxicity of pH

Al adsorption onto gills and asphyxiation

## Impact of precipitates



### Physiology

General abrasiveness  
Breathing disruption  
(gills surface clogging)

### Behaviour

Disruption of movement  
Disruption in feeding  
Reductions in vision



# Potential Acid Forming (PAF)

## Predicted stream chemistry

Very low pH  
(pH <4)

Low pH  
(pH 4 – 6)

Circum-neutral pH  
(pH >6)

High metals  
(>2 mg/l  
any metal)

Low metals  
(<2 mg/l  
each metal)

Metals  
present  
(>1mg/l)

Minimal  
metals  
(<1mg/l)

Metals  
present  
(>0.2 mg/l)

Very low  
metals  
(<0.2 mg/l)

Severe  
impact

High  
impact

Moderate  
impact

Minor or  
no impact

Variable  
impact

No detectable  
impact

Outcome  
1

Outcome  
2

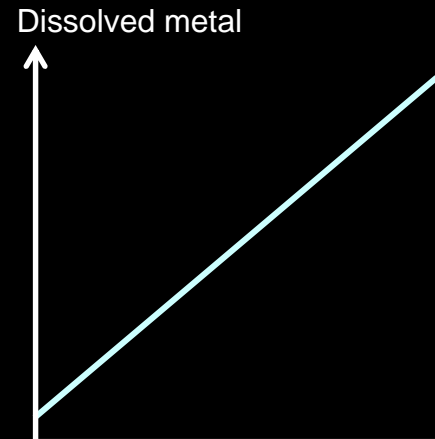
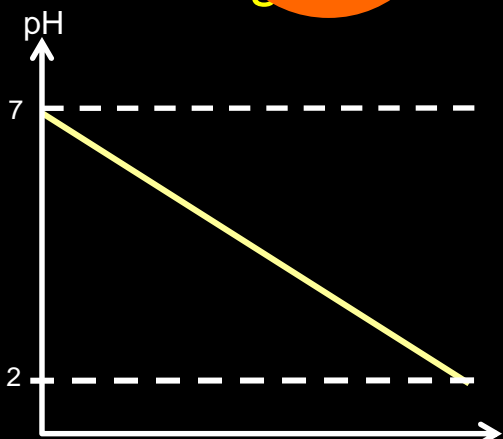
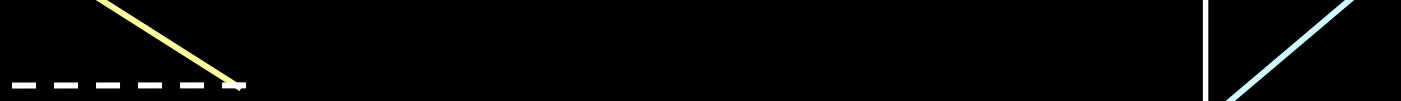
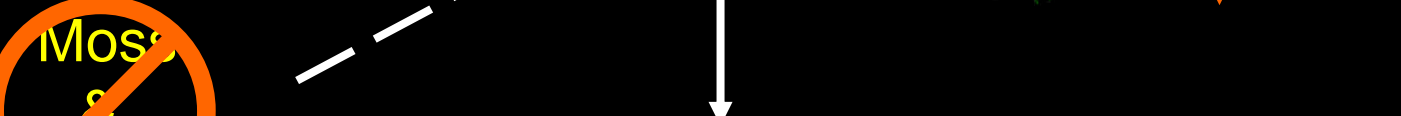
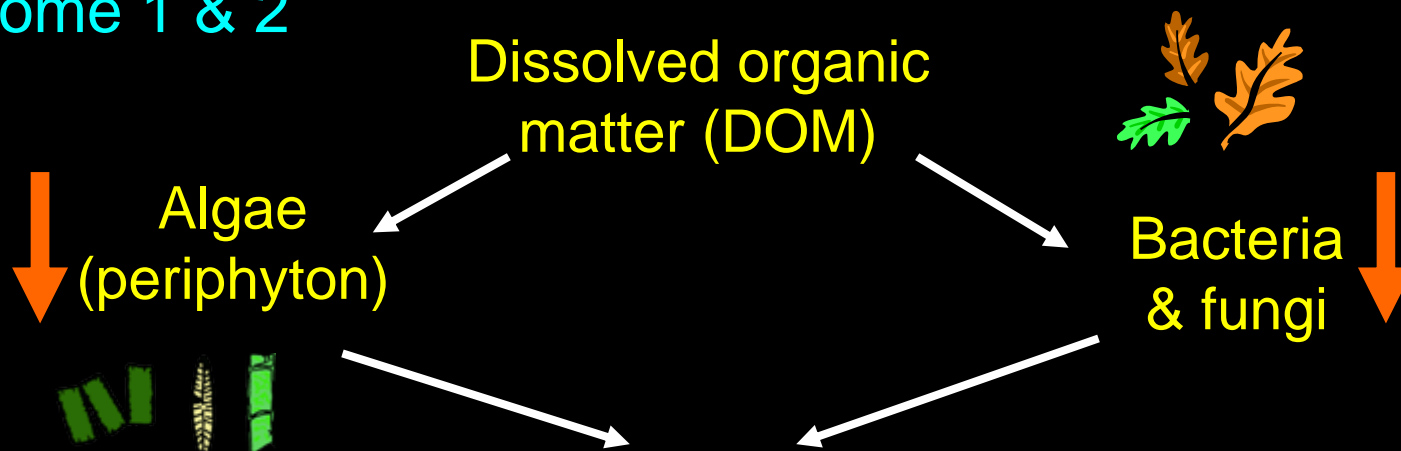
Outcome  
3

Outcome  
4

Outcome  
5

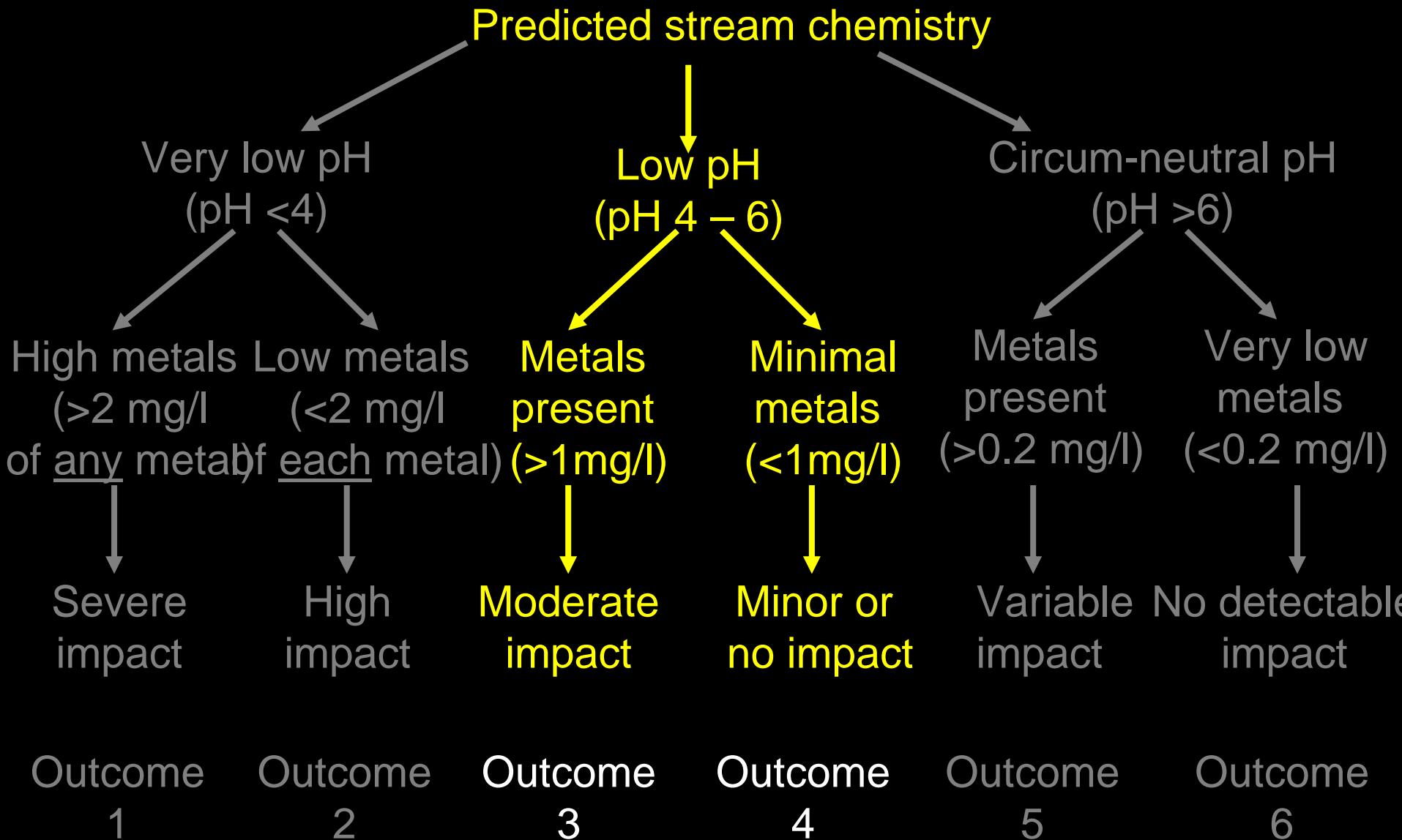
Outcome  
6

# Outcome 1 & 2

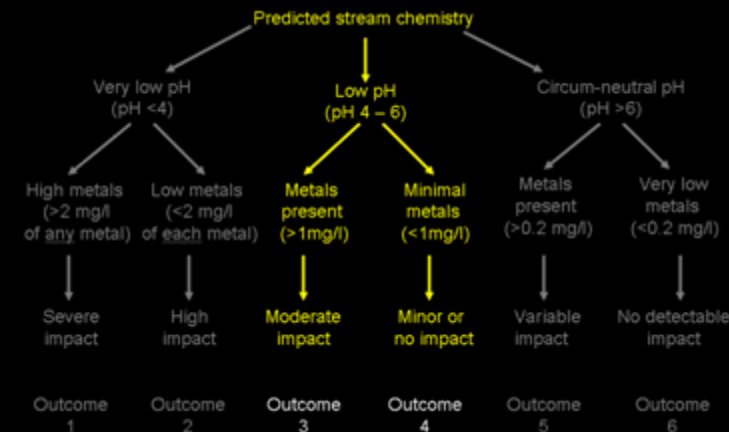
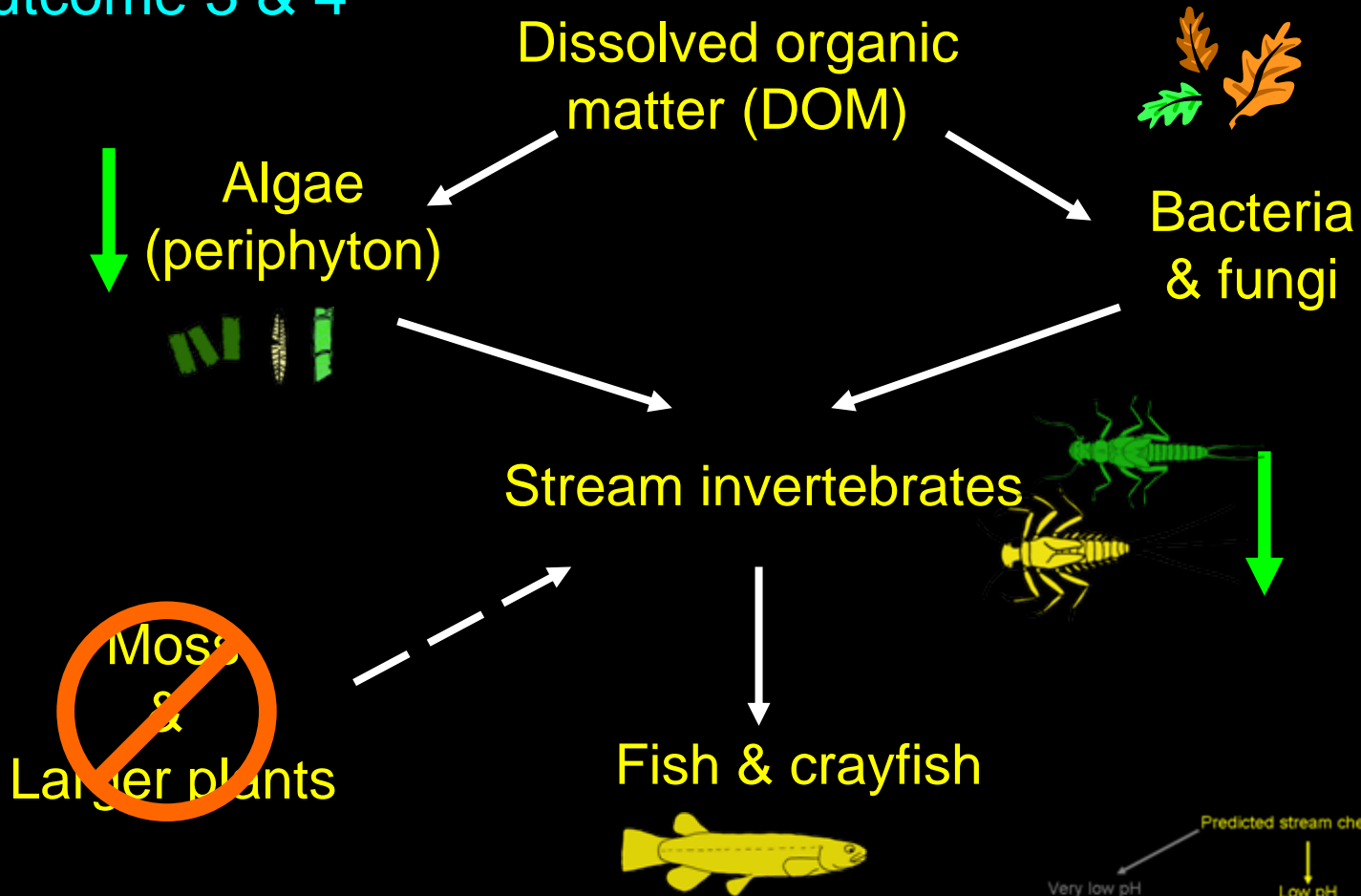




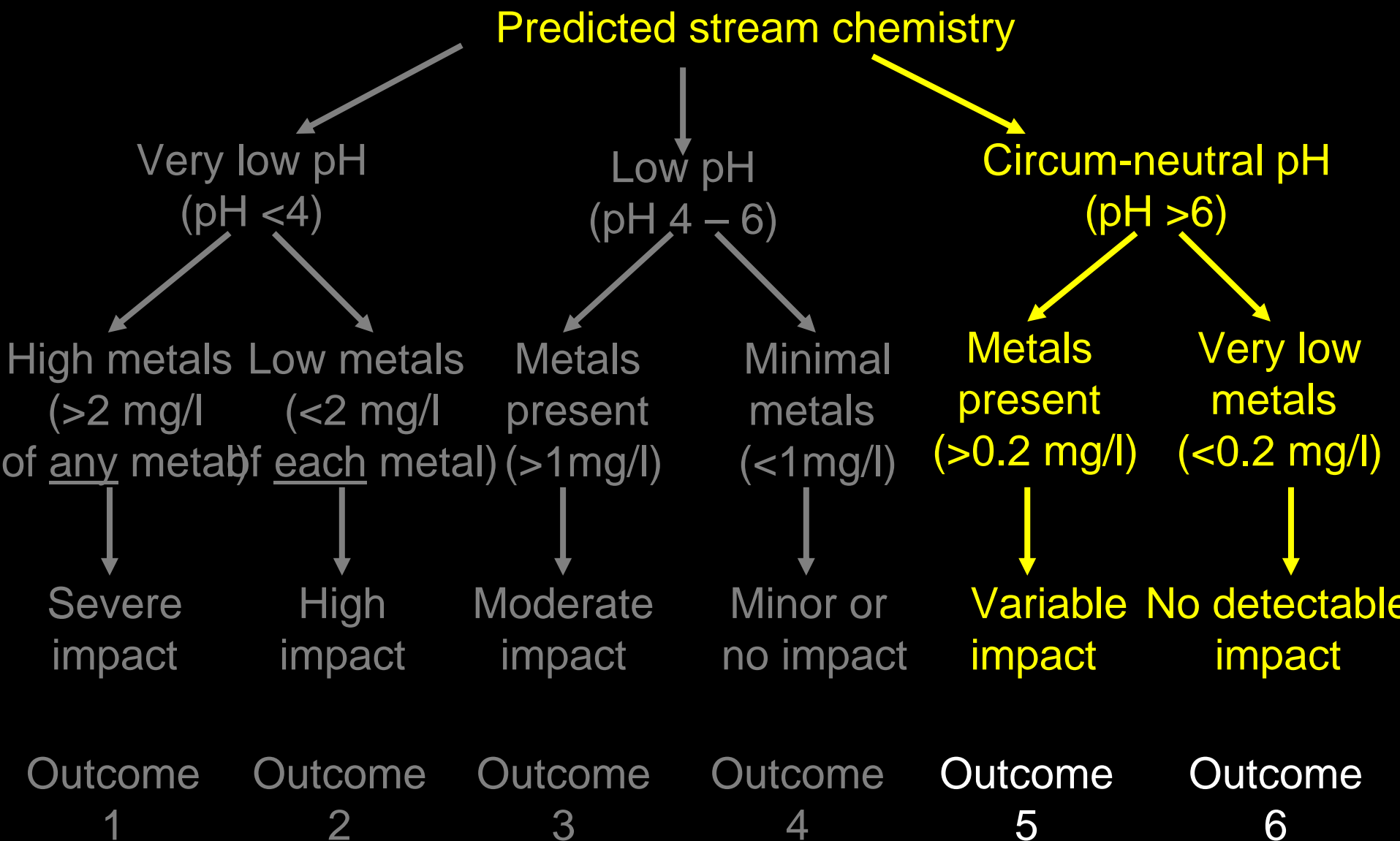
# Potential Acid Forming (PAF)



# Outcome 3 & 4

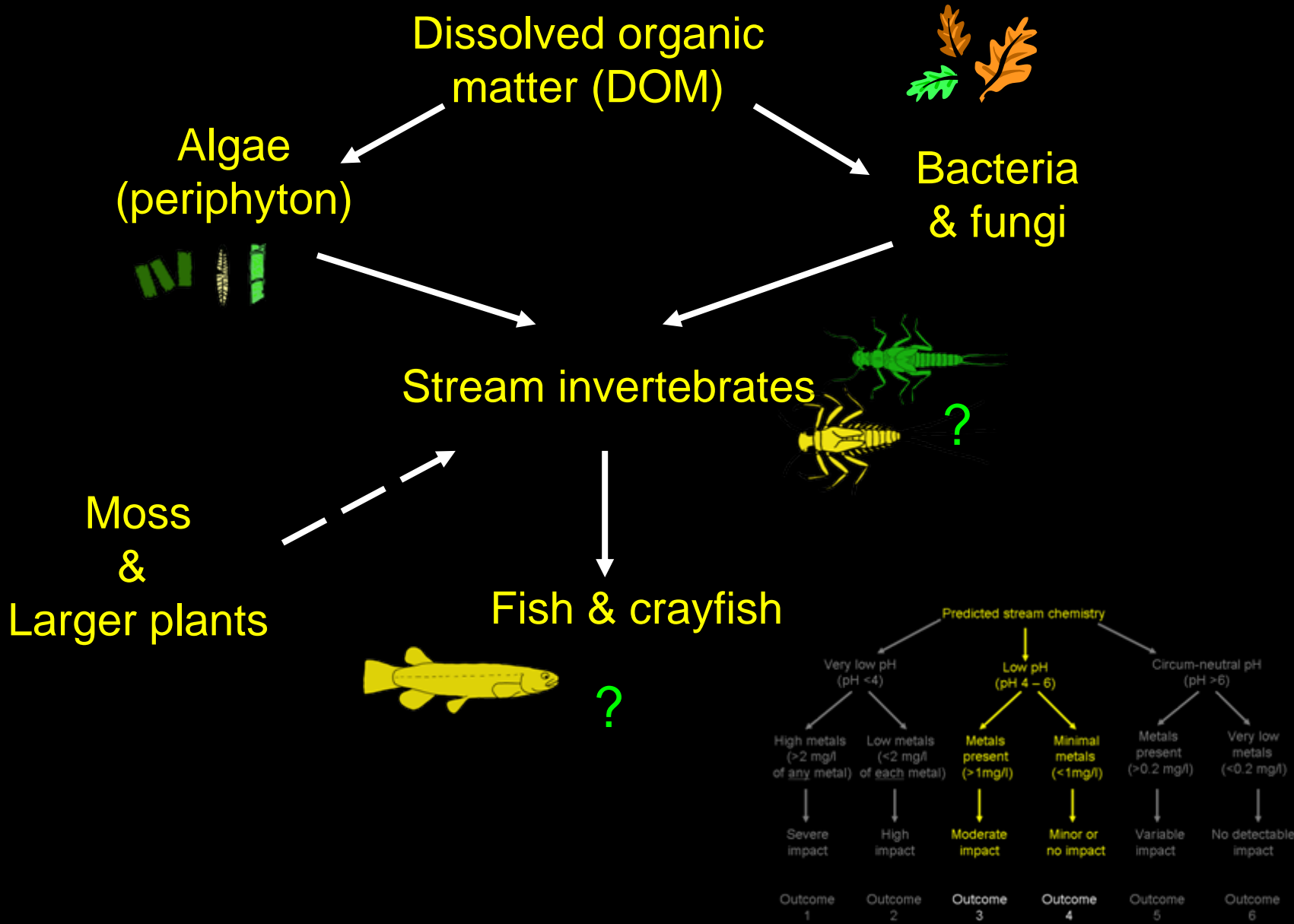


# Non Acid Forming (NAF)





# Outcome 5 & 6 (NAF)



# Gold hard rock

## Predicted stream chemistry

No oxidation processing at mine site

Oxidation processing at site

Very low metals  
Minor dissolution  
As, Sb = 0.01 to  
0.1 mg/L

Minimal Metals  
Moderate  
dissolution  
As, Sb = 0.1 to  
1mg/L

Metals present  
Rapid  
dissolution  
As,  
Sb > 1mg/L

As is pH-  
dependant  
20 mg/L at pH 7  
0.2 mg/L at pH 5  
Sb up to 50 mg/L

Minor  
impact

Moderate  
impact

High  
impact

High to  
severe impact

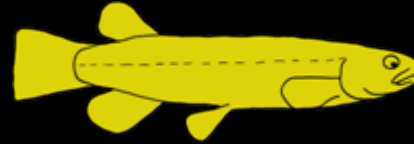
# Impact of metals - Arsenic



Photosynthesis



Productivity



Survival of juveniles



Reproduction



Hatching



Blood haemoglobin





What effects  
might **alluvial gold**  
mining have ?

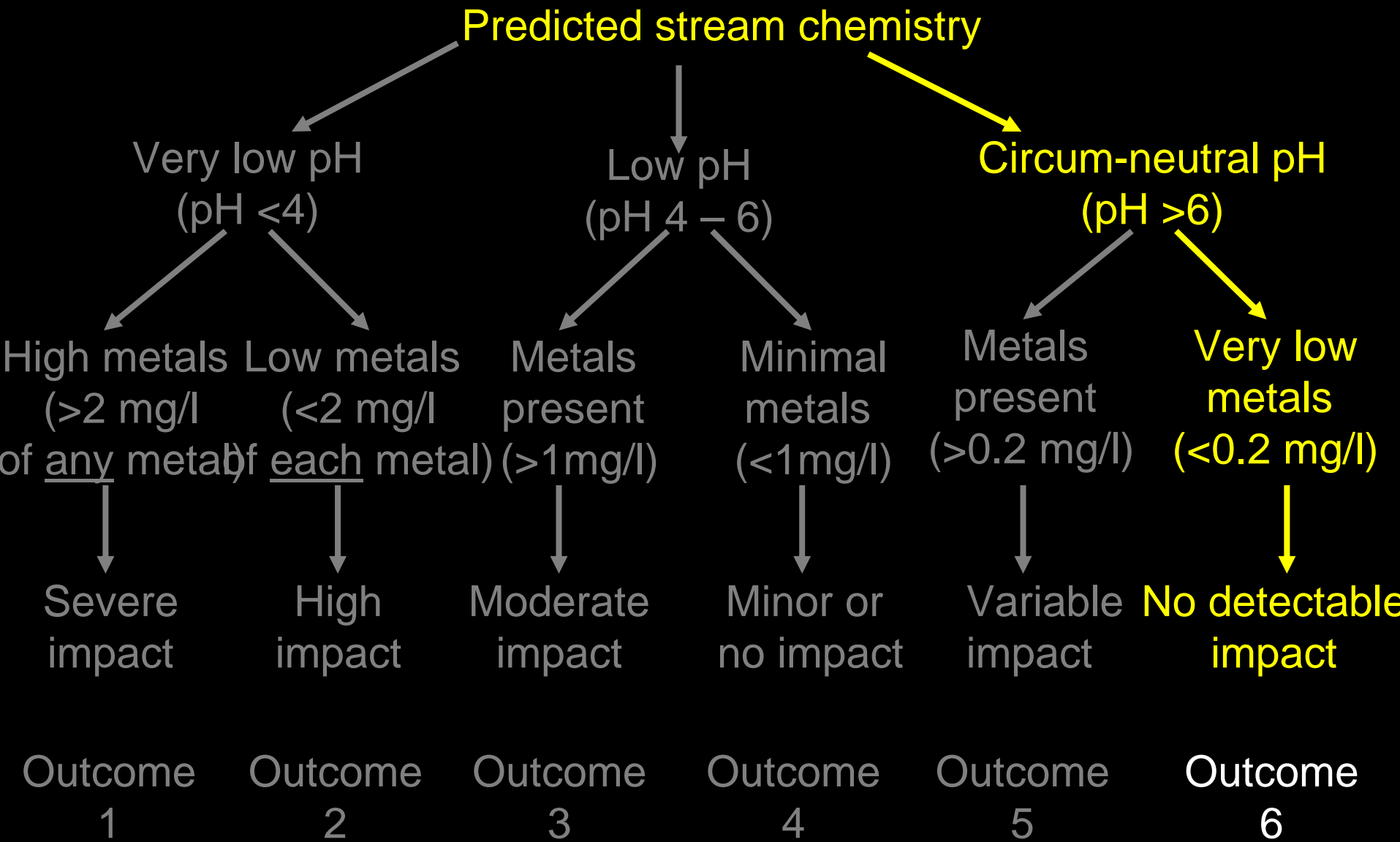


Turbidity



Before mining

During mining





# Impact of turbidity



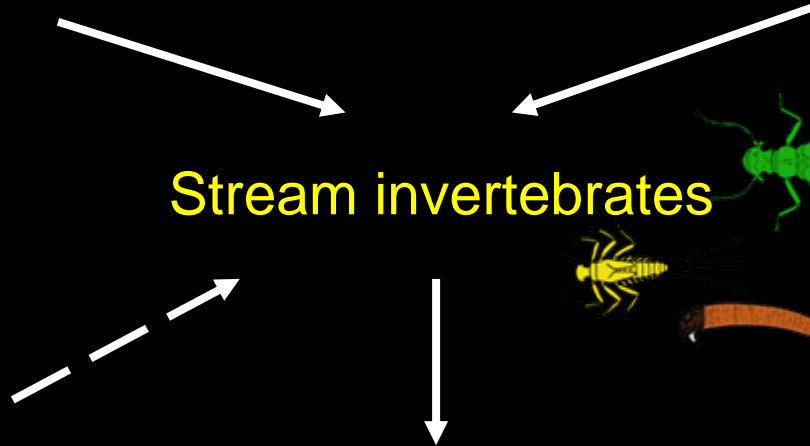
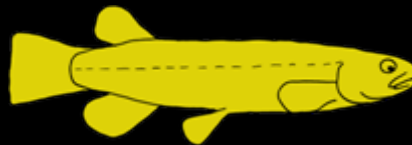
  
Algae  
(periphyton)

  
Bacteria  
& fungi

Stream invertebrates

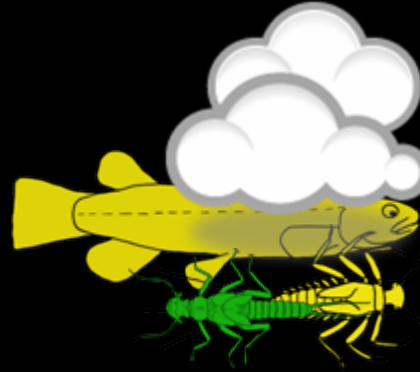
Moss  
&  
Larger plants

Fish & crayfish





# Impact of turbidity



↘ Photosynthesis

↘ Schooling ability

Gills irritation

↘ Productivity

↘ Predator/prey relationship

Stress

↘ Feeding efficiency

Smothering of non-mobile organisms and eggs

↘ Growth

Prolonged hatching time





## Summary

- ❑ Healthy streams include communities of algae, invertebrates and fish
- ❑ PAF mining has the potential to severely degrade stream communities; limiting algae and invertebrates and killing fish
- ❑ pH < 4 and metals (depends on metal) > 2 mg/l
- ❑ NAF mining likely to have much less effects depending on presence of any metals and sediment
- ❑ Gold mining is likely to cause turbidity, possible problems with a limited number of metals