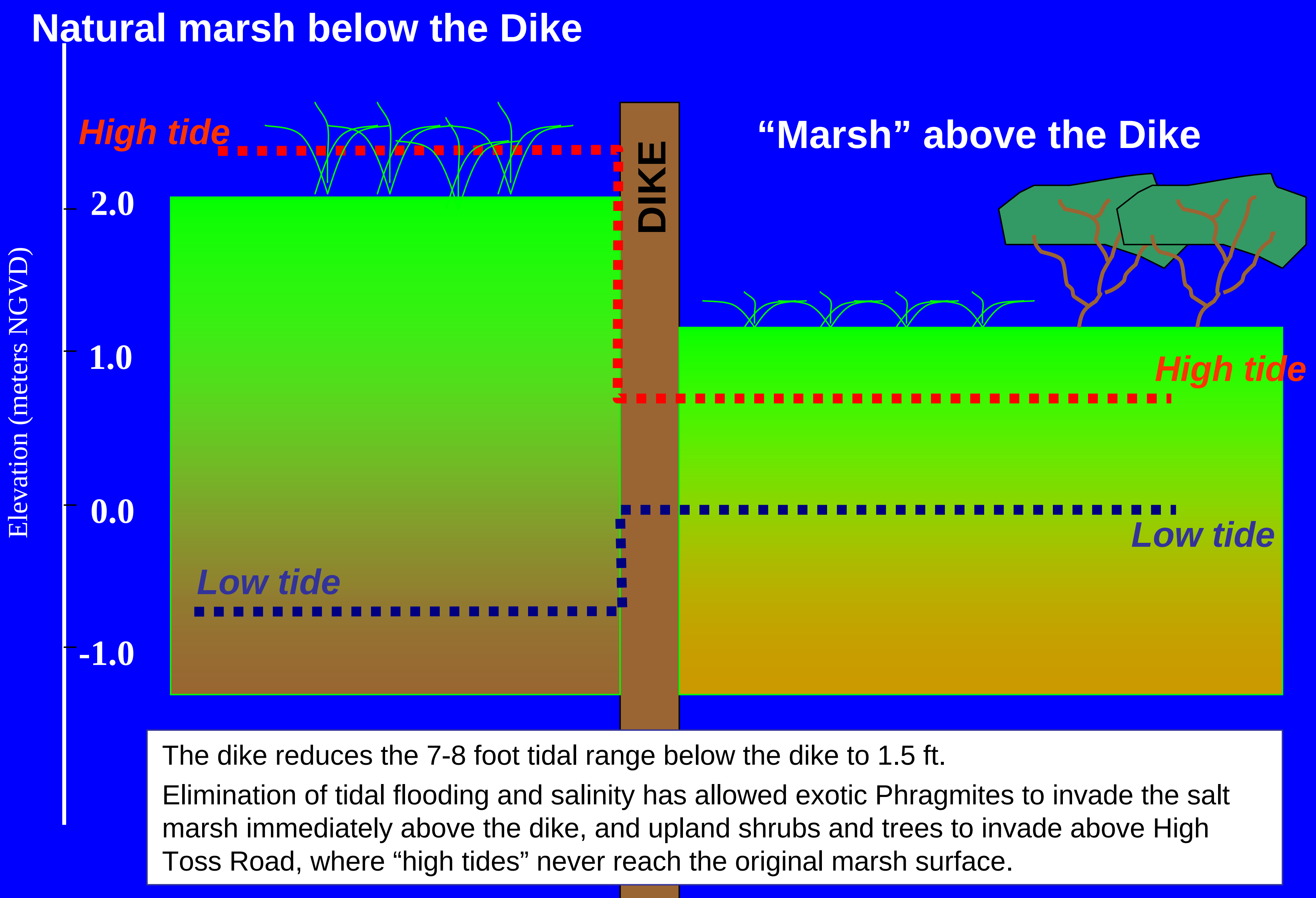
Herring River Dike Effects on Tidal Range, Sediment and Vegetation

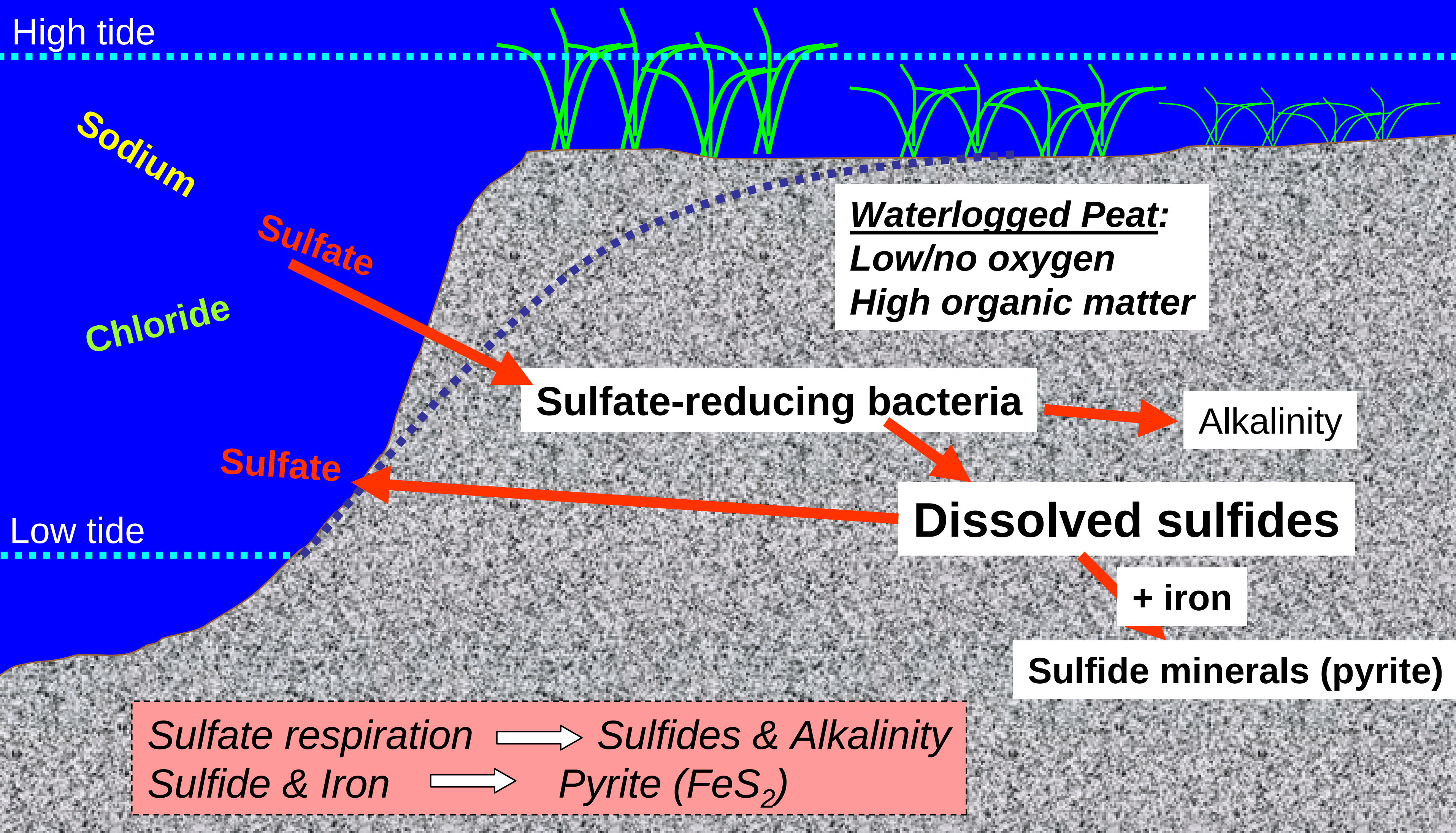


The dike reduces the 7-8 foot tidal range below the dike to 1.5 ft.

Elimination of tidal flooding and salinity has allowed exotic Phragmites to invade the salt marsh immediately above the dike, and upland shrubs and trees to invade above High Toss Road, where "high tides" never reach the original marsh surface.

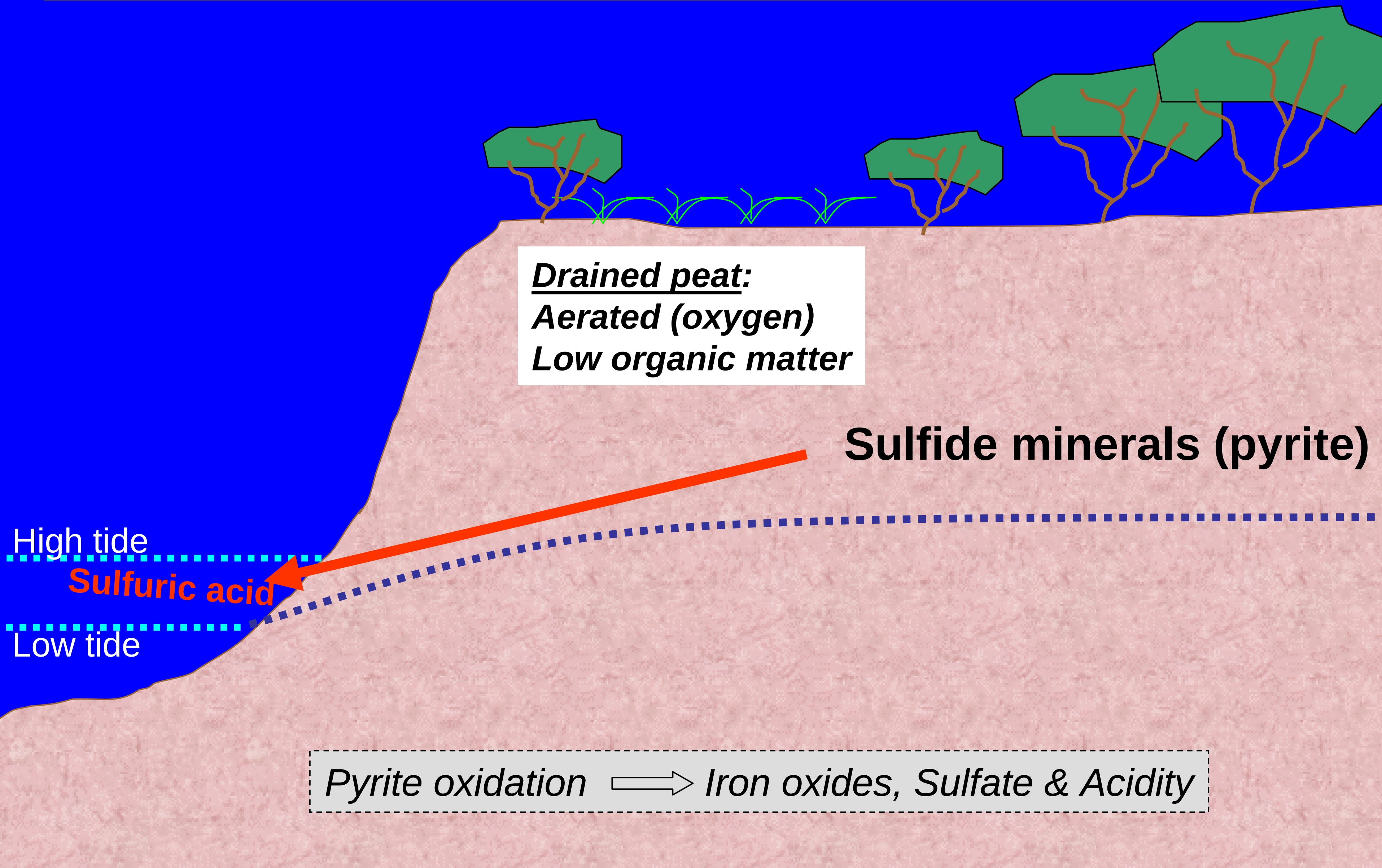
Sulfur cycling in natural salt marshes

Sulfide minerals accumulate in salt marshes because decomposing bacteria “breath” (respire) sulfate in place of oxygen in oxygen-poor peat. Sulfate respiration yields sulfides which precipitate with iron to form sulfide minerals which are stable under anaerobic, i.e. oxygen-free, conditions.



Sulfur cycling in the diked Herring River

Diking and drainage not only eliminates seawater flooding, but also lowers the water level in marsh peat, exposing accumulated sulfide minerals to atmospheric oxygen. Sulfides then oxidize to sulfate, which forms sulfuric acid in poorly buffered Cape Cod freshwater.



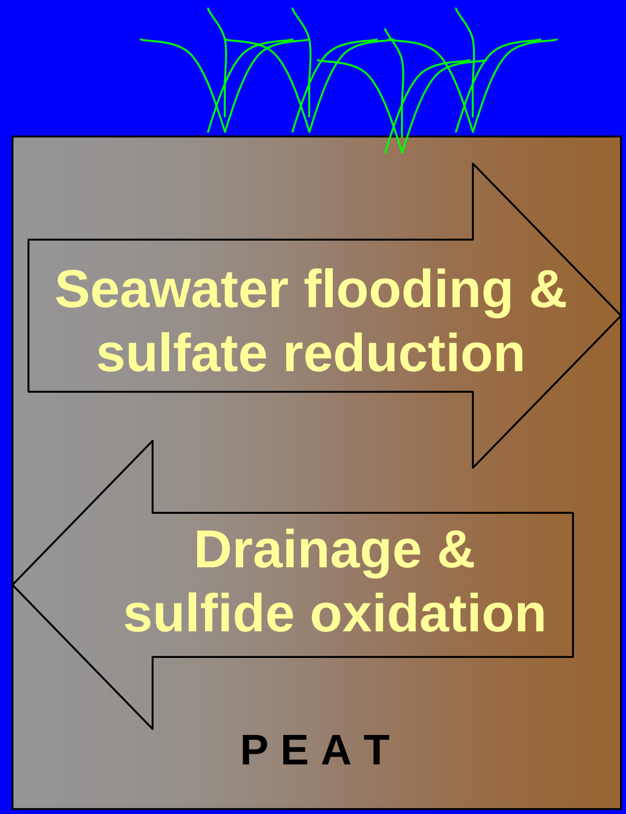
Sulfur cycling & water quality in Herring River

High acidity

Low pH

High aluminum

Fish kills



High alkalinity

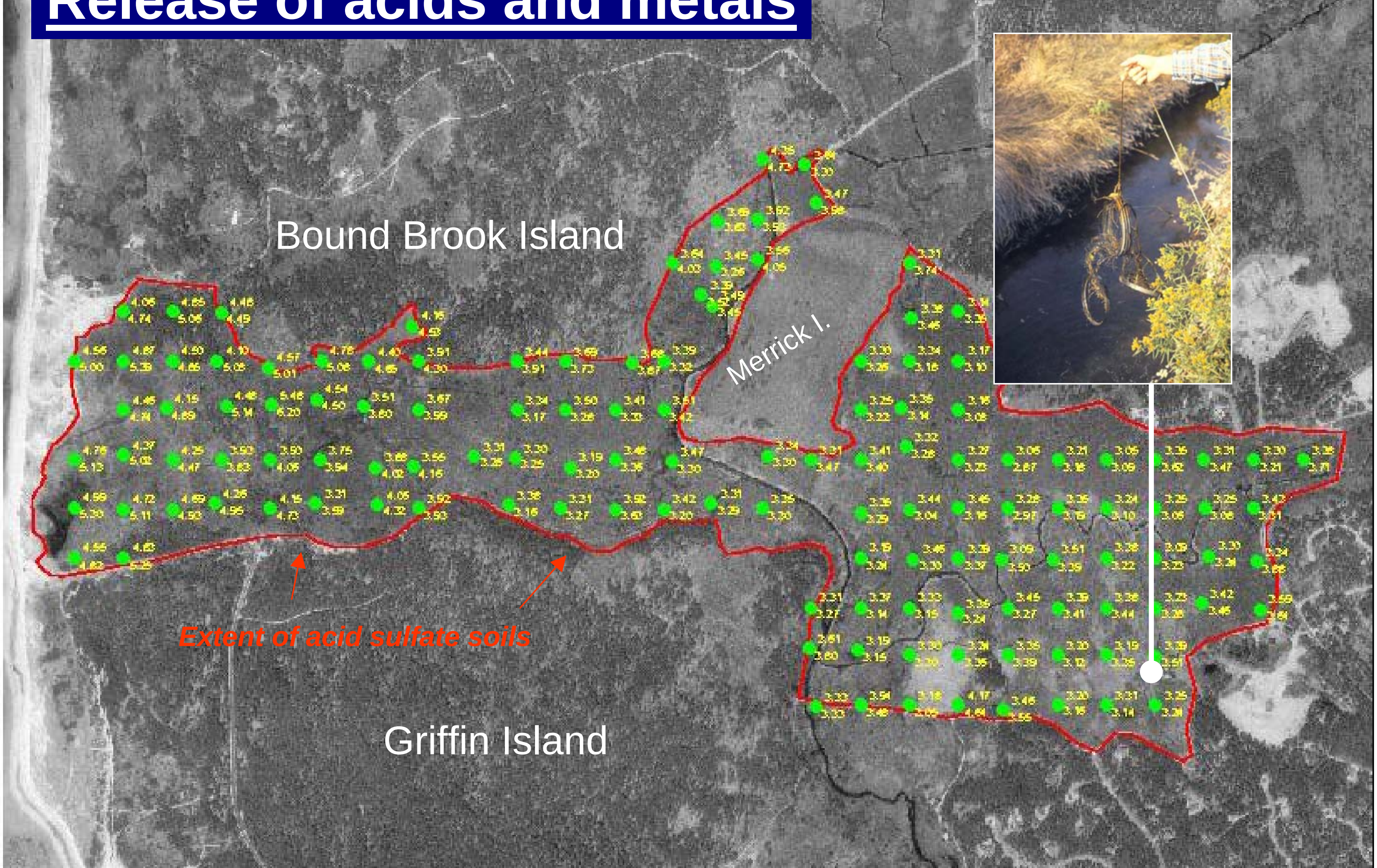
High pH

Low metals

Healthy fauna

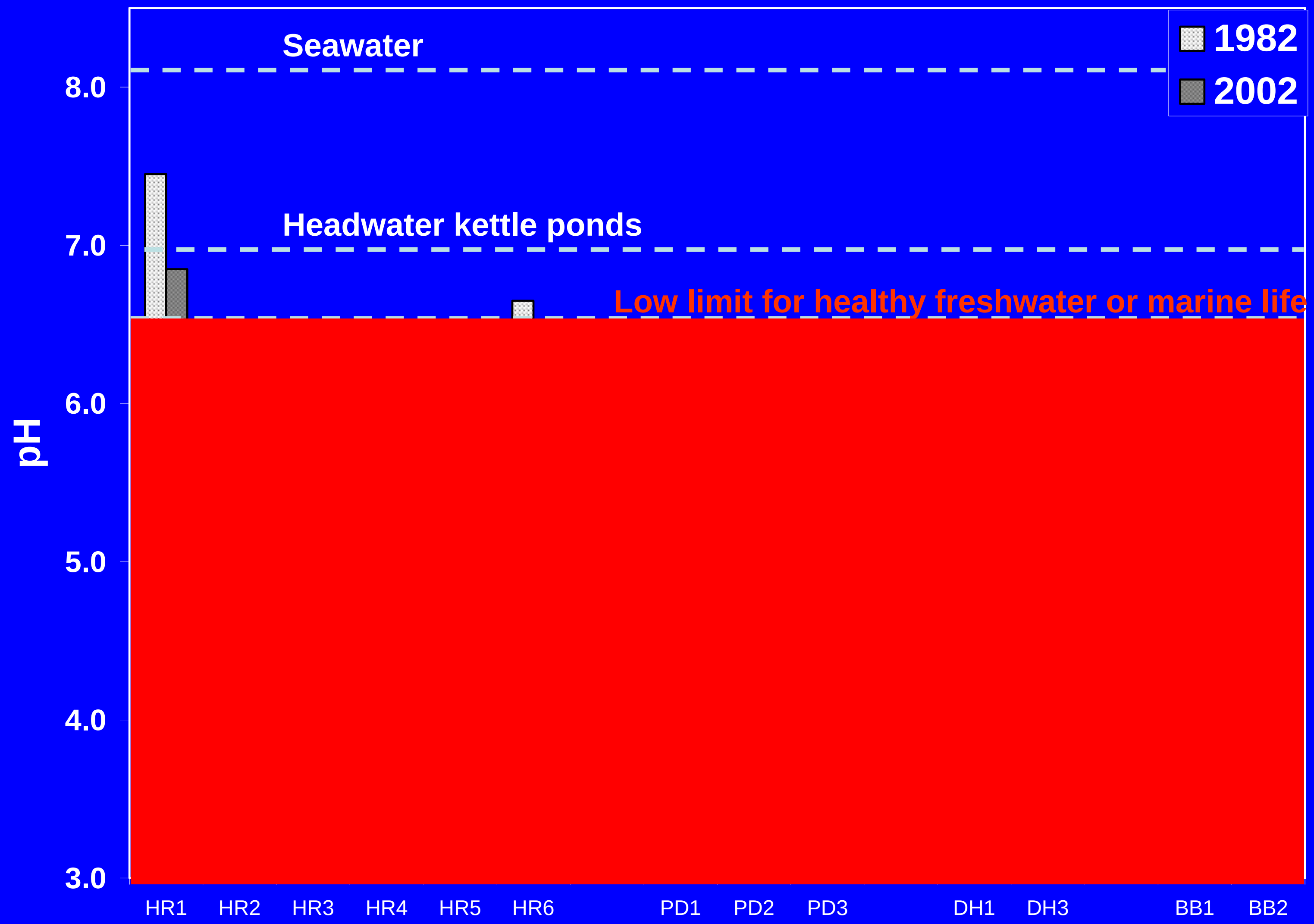
A summary of the relationships among water management, sulfur cycling, surface water quality and the health of aquatic fauna.

Release of acids and metals

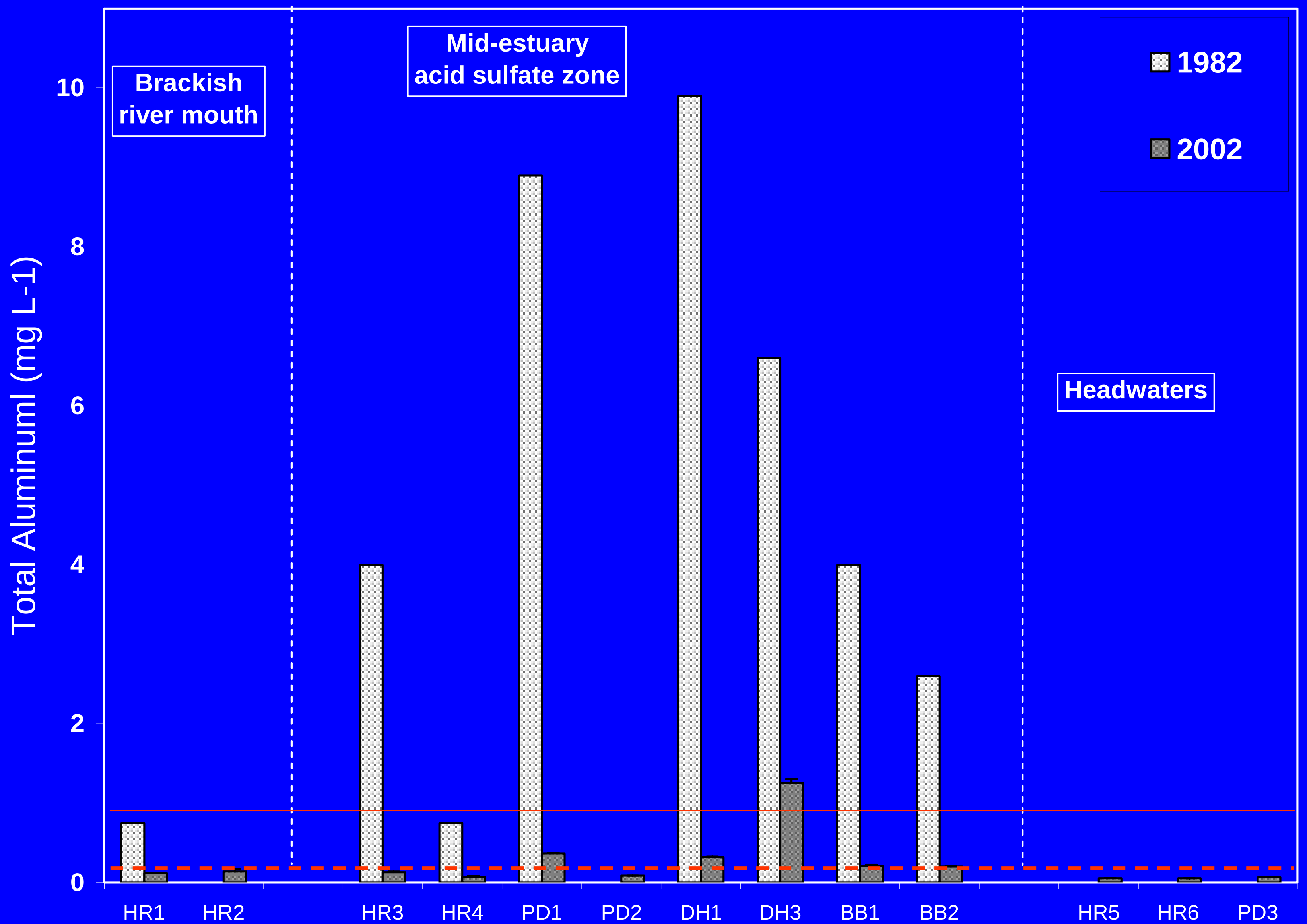


The Herring River sub-watersheds of Duck Harbor and lower Pole Dike marsh comprise about 300 acres of acid sulfate soils with pH less than 4.0 due to 100 years of drainage. These soils leach acidity and toxic aluminum into surface waters. Galvanized wire fish traps dissolve in acidic ditches in 30 days (inset image).

Plot date: July 26, 2001 d:\projectfiles\vegmapplots.apr

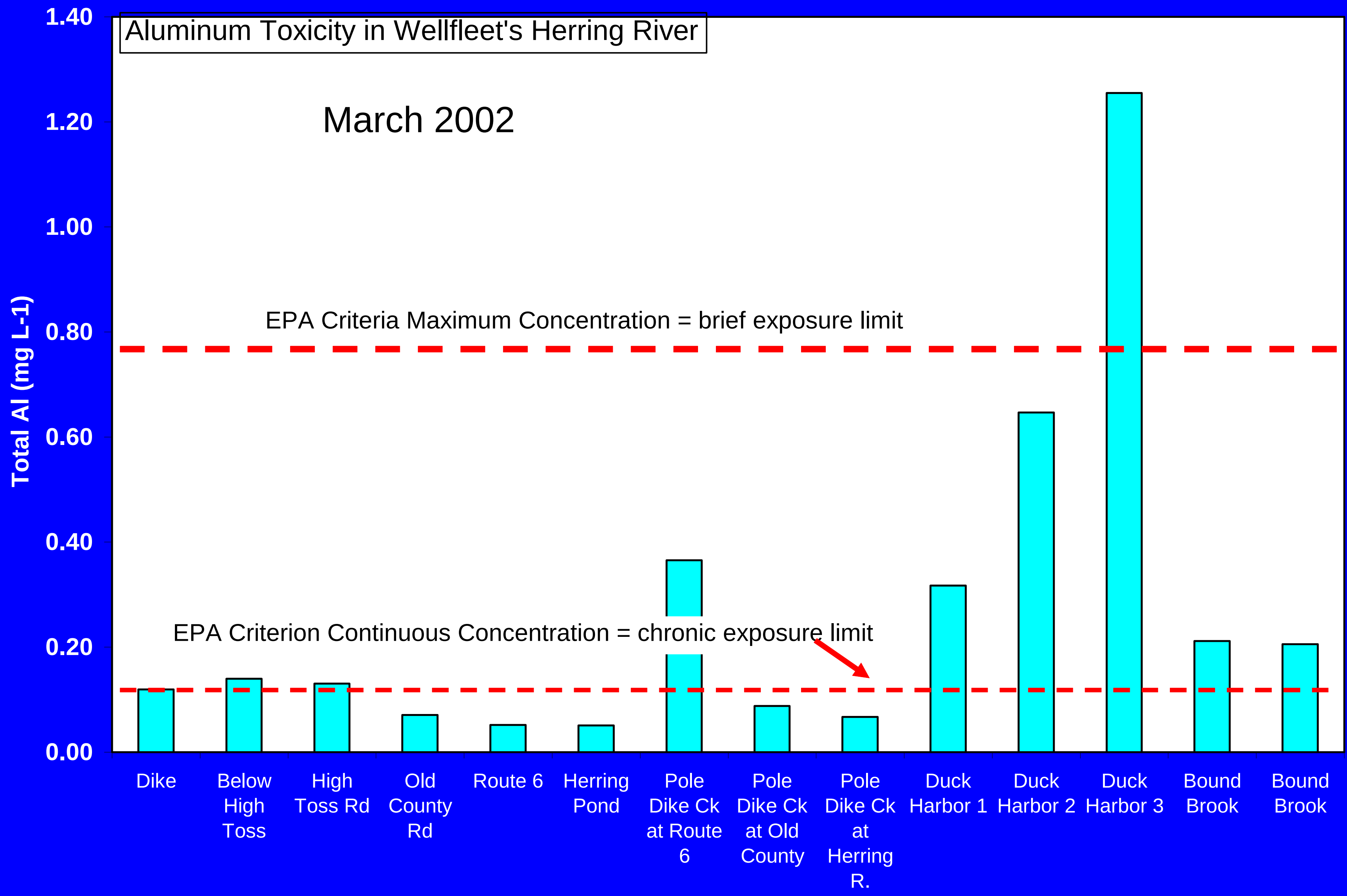


Surface water pH in 1982 and 2002. Most surface waters in the diked Herring River have pH below the EPA limit for healthy aquatic life. There has been some improvement since 1982, probably due to the elimination of regular stream channelization, which exposed stored sulfide minerals to oxidation and acid release.



Toxic aluminum in surface water in 1982 and 2002. Conditions have improved, probably due to the elimination of routine stream channelization; however, concentrations still reach EPA's chronic exposure limit (dashed red line) in several streams, and the brief exposure limit (solid red line) in Duck Harbor.

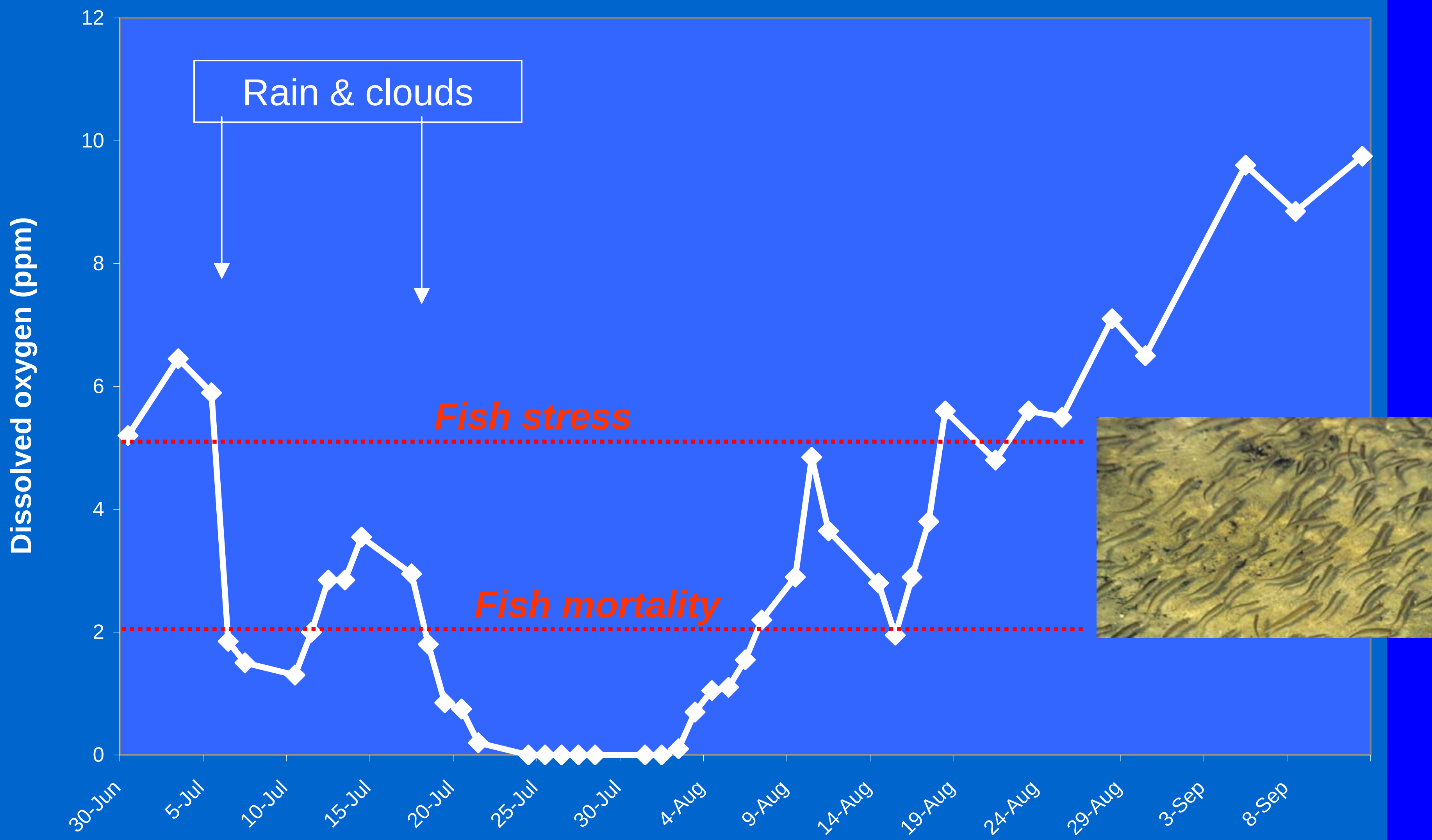
High acidity (low pH) mobilizes toxic aluminum

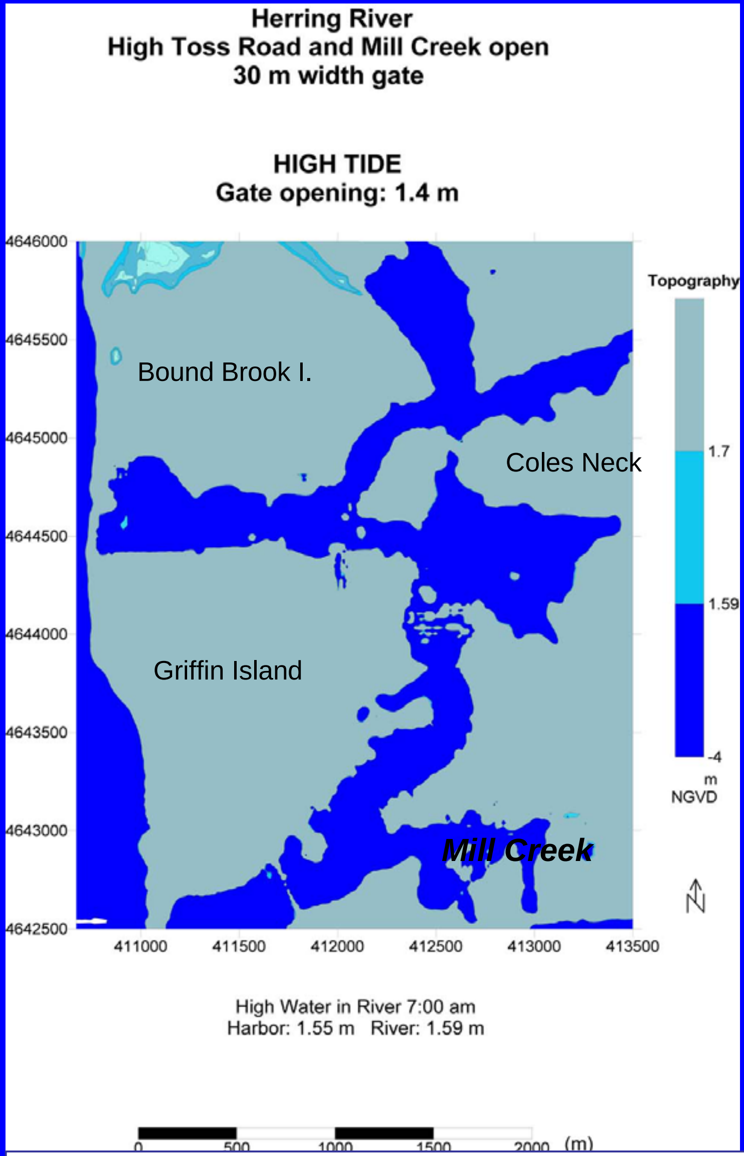


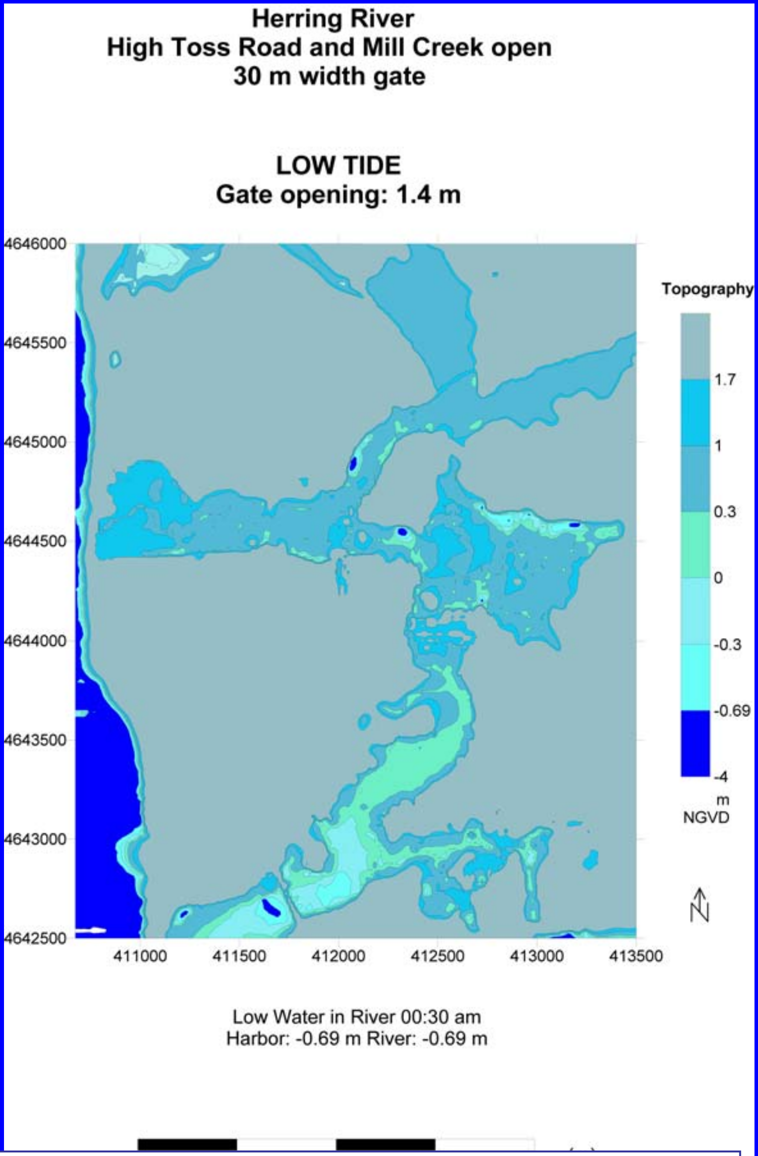
Low pH and high aluminum in Herring River stress and kill fish by damaging gill surfaces, affecting gaseous and ion exchange, and skin, causing lesions.

Summertime oxygen depletion in Herring River

Dissolved oxygen depletion is conditioned by low tidal flushing and high organic loading from the extensive wetlands in the watershed. Most serious events occur in summer with high water temperature, rainfall and wetland runoff, and cloudy weather.







Effects of tidal restoration on tide heights and flushing. Figures show the extent of tidal flooding at high and low tide with the wide-culvert option in the Herring River Dike. This shows an average harbor tide, with 30-meter wide gate open 1.4 m. Note how the system fills at high tide and drains almost completely at low tide, providing both good peat saturation and excellent surface water flushing, i.e. simulating a natural marsh.

In greenhouse experiments, adding seawater to Herring River's acidified soil eliminated the acidity, and thereby eliminated aluminum toxicity, within two months. Salt marsh grasses grew vigorously in the re-salinated peat.

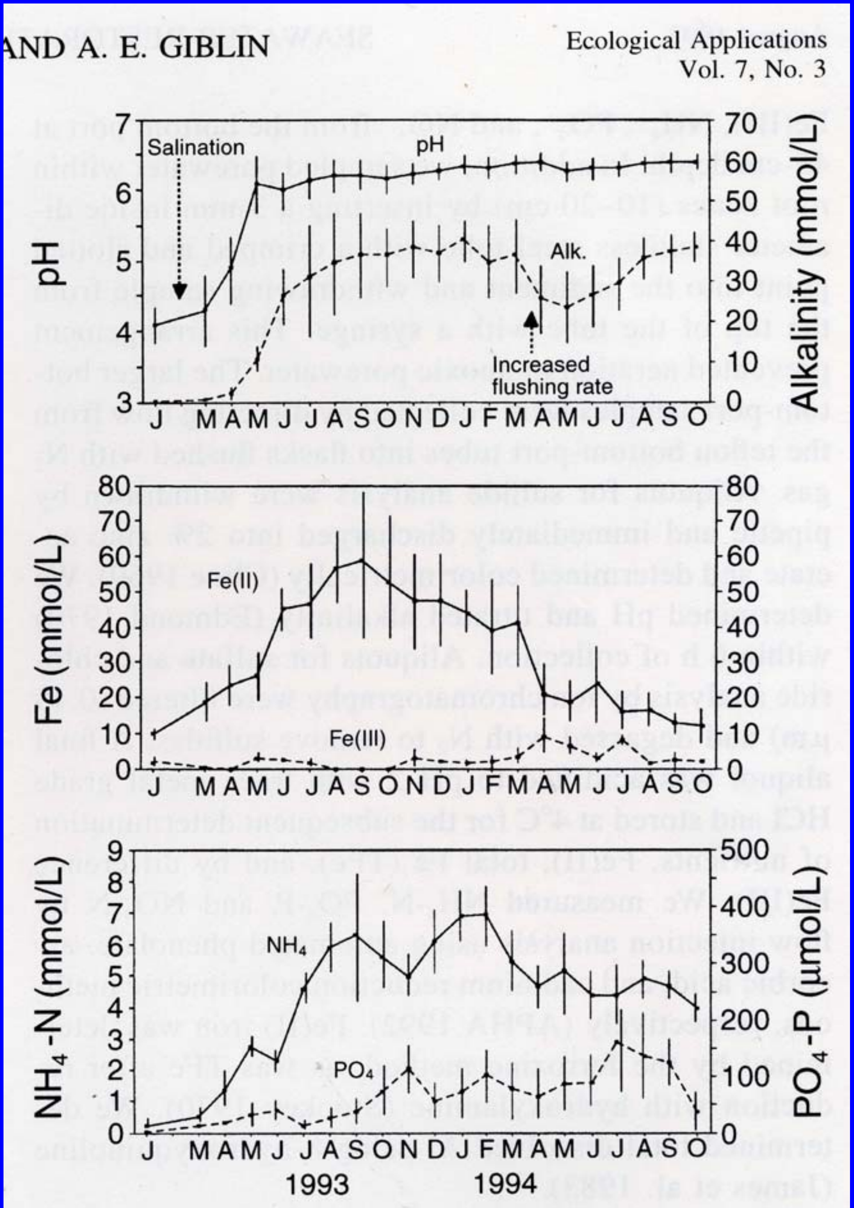
Results of microcosm experiments:

Seawater added to Herring River acid sulfate soils

pH recovery in 2-3 months

Ferrous iron increase, decline

Ammonium-nitrogen increase



When seawater was added experimentally to Herring River acid sulfate soils for 22 months, pH recovered in 2-3 months, ferrous iron increased and then declined, and ammonium-nitrogen increased in sediment pore water. Cordgrass planted in these microcosm grew very well.

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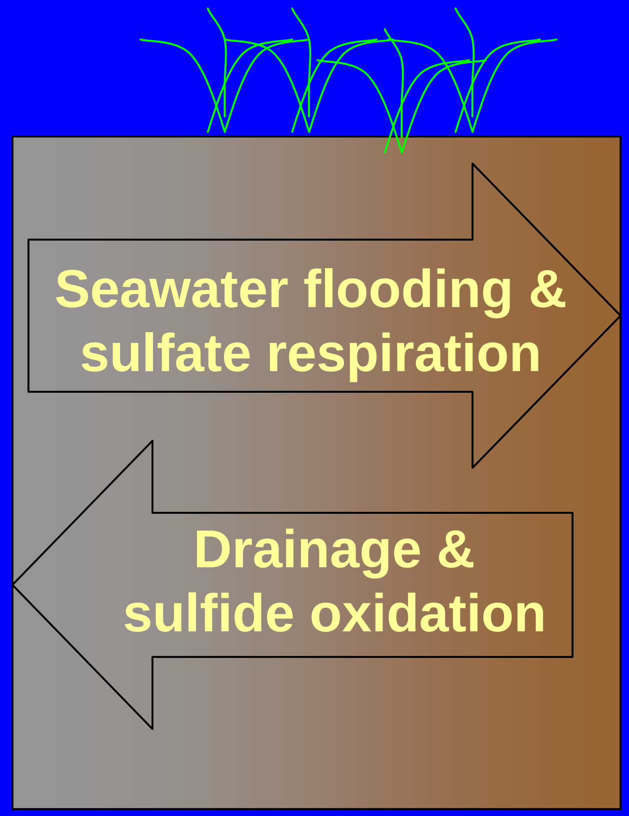

High alkalinity

High pH

Low metals

Healthy fauna

Restored seawater flooding should shift the balance in favor of sulfate respiration (reduction), and improve receiving-water quality and aquatic life.

Conclusions –Water Chemistry

- *Diking and drainage*:
  - Surface water acidification;
  - Release of toxic metals;
  - Reduced flushing, oxygen depletions and fish kills.

- *Restored salinity and tidal range*:
  - Restored normal sulfur cycling, peat saturation and low acidity.
  - Release of ammonium-nitrogen.
  - Restored tidal flushing and aeration.
  - Increased survival of salt-marsh plants, estuarine fish, shellfish, etc.