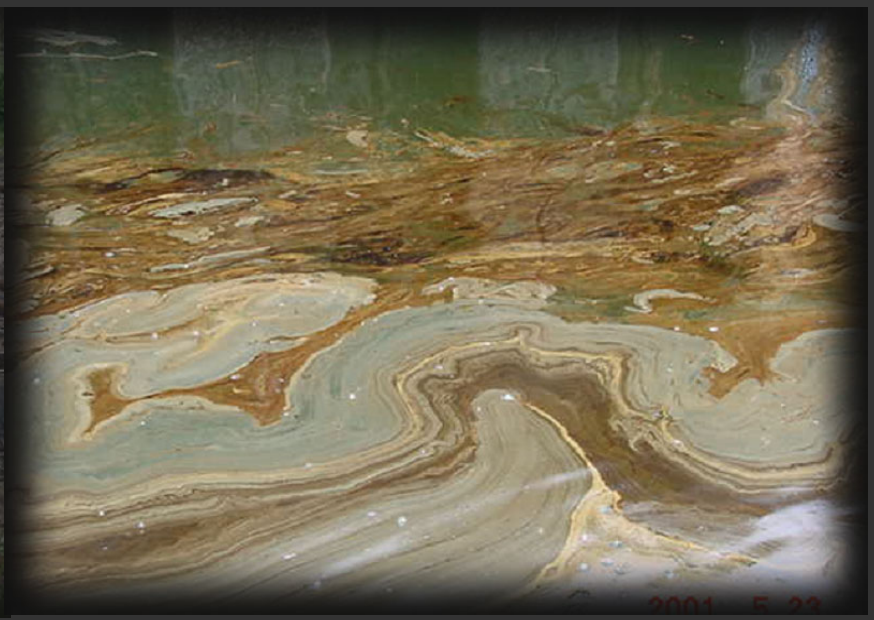
Phytoremediation of Petroleum Spills in Riparian Areas: An Overview



Sand Creek Consultants, Inc.

Rhinelander, WI Roswell, NM

Mark Nega, Phytoremediation Forestry Scientist

& Christopher J. Rog, P.G.

PHYTO = PLANT

REMEDIATE = TO FIX or CURE

Definition of Phytoremediation:

Use of Vegetation to Contain, Sequester, Remove, or Degrade Organic and Inorganic Contaminants in Soils, Sediments, Surface Water, and Groundwater

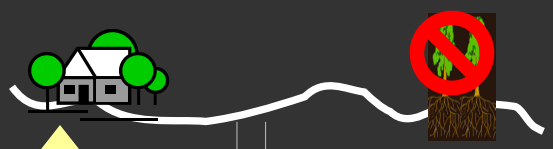
- Complex system with many plant processes involved
- Applicable to a broad range of contaminants

It's one of the very few technologies that can address all media and contaminants simultaneously

Petroleum Spills:

Upland vs. Riparian

UPLAND



300 feet to water & LNAPL

L

AQUIFER

New Mexico:

Pump and Treat

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RIPARIAN

Indiana

0 - 5 feet to water

BTEX and other aromatics

- Rapid volatilization
- Rapid Degradation in Near Surface Environment

Relatively Easy To Bio- / Phyto -remediate

PAH and other Recalcitrants

- Slow aerobic biodegredation;
- Relatively insoluble / less bioavailable;

Riparian Spills

- PAHs persist

Much Current Phyto Research involves PAHs

Typical Riparian Spill

Sheen on surface water

PAHs in Soil

PAH & BTEX in GW

GW FLOW

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Surface Water Clean-up

Resort to Conventional Methods

Are Phytotechnologies Feasible?

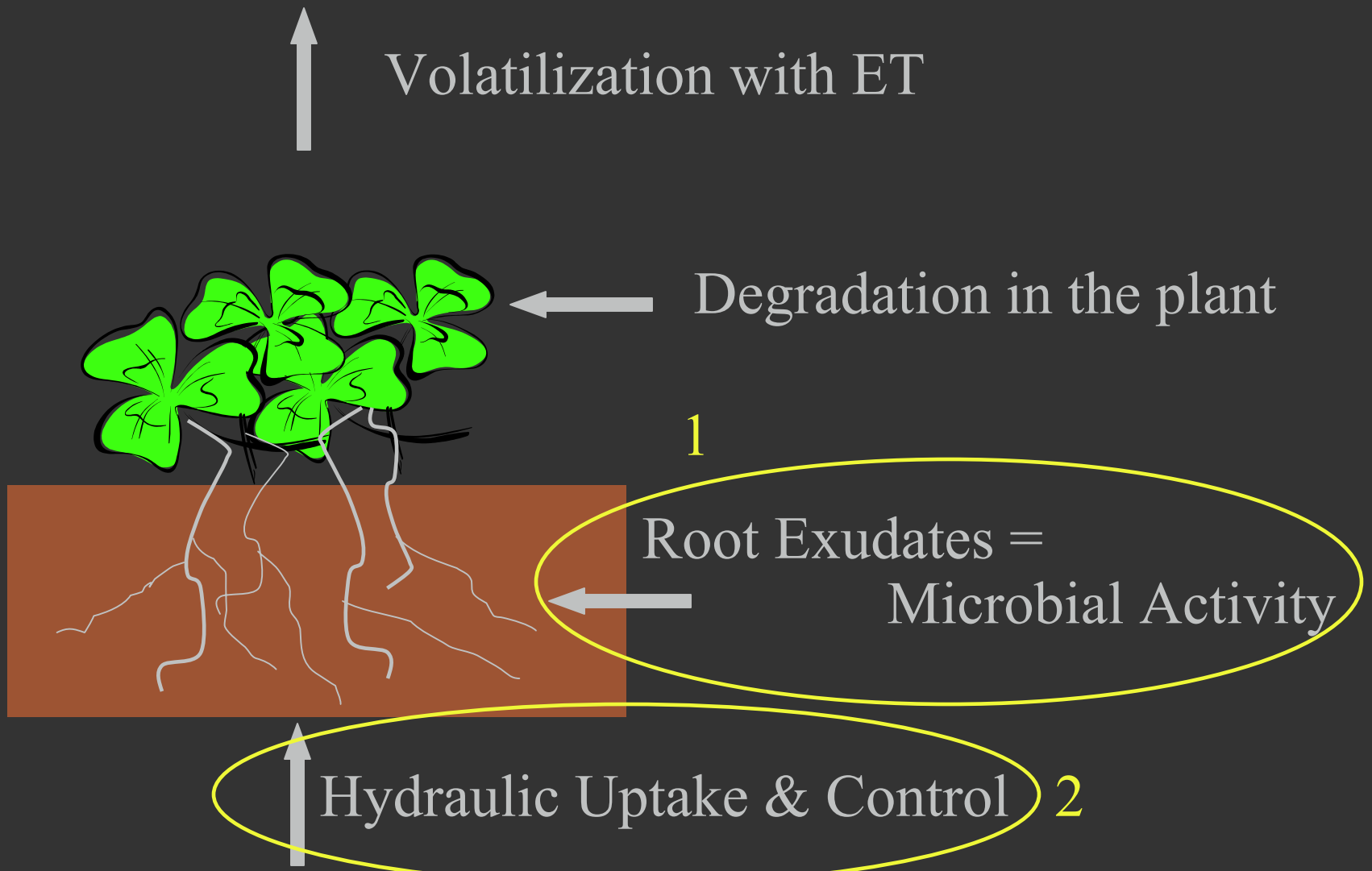
Riparian Zone Clean-up

- Surface and Shallow Soils and GW Only
- GW Discharge Zones

No 'Diving' GW Plumes

Are Phytotechnologies Feasible?

Phytoremediation Processes



Phytoremediation Processes

1) Rhizodegradation

Increase Soil Oxygen Content, Microbial Activity, Organic Matter & Porosity

- Soil microbial counts 5 to 10,000 times higher
- Translocation of carbon from the atmosphere into soil
- Adds up to much increased biodegredation rates

One of the Most Active Areas of Current Research

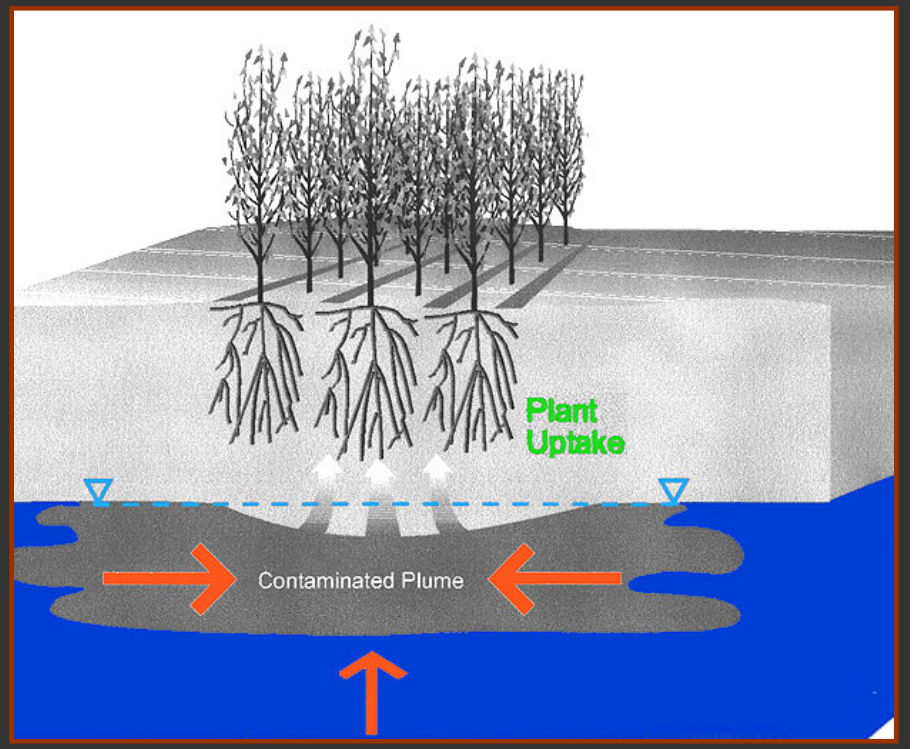
Phytoremediation Processes

2) Hydraulic Uptake & Control

Phreatophytes (hybrid poplar and willow) can transpire 20 to 500 gallons of water per tree per day

- Offers long term ground water benefit, plume control
- ~ passive process for BTEX

Nature's "Pump and Treat"



CH2M Hill, 1999

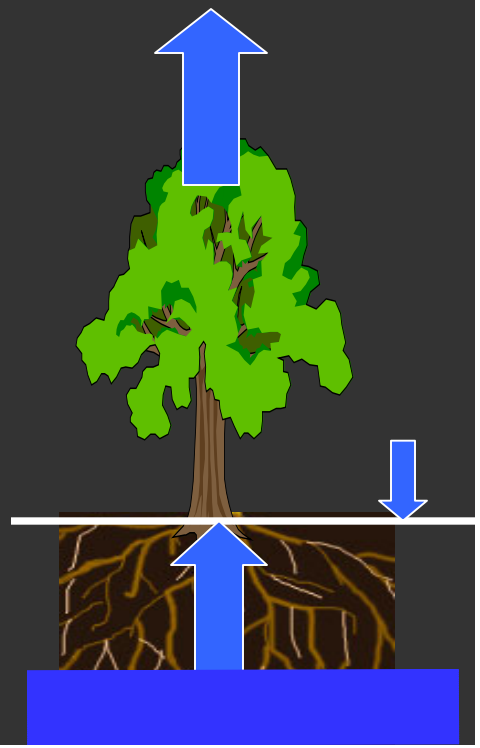
Phytoremediation Processes

2) Hydraulic Uptake & Control

Phreatophytes (hybrid poplar and willow) can transpire 20 to 500 gallons of water per tree per day.

- Offers long term ground water benefit
- Prevents dissolved plume migration

ET >> Great Lakes Rainfall…..
…….by 6- to 50-fold



Federal Phytoremediation Research Support

Nov-2001

$6 Million to Purdue from EPA

Dr. Kathy Banks, Purdue University

Christie Whitman, EPA

Example Project Design

Step 1) Basic Site Assessment

Soil and GW sampling, VOCs, PAHs, nutrients salts, metals

Example Project Design

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Soil and GW sampling, VOCs, PAHs, nutrients
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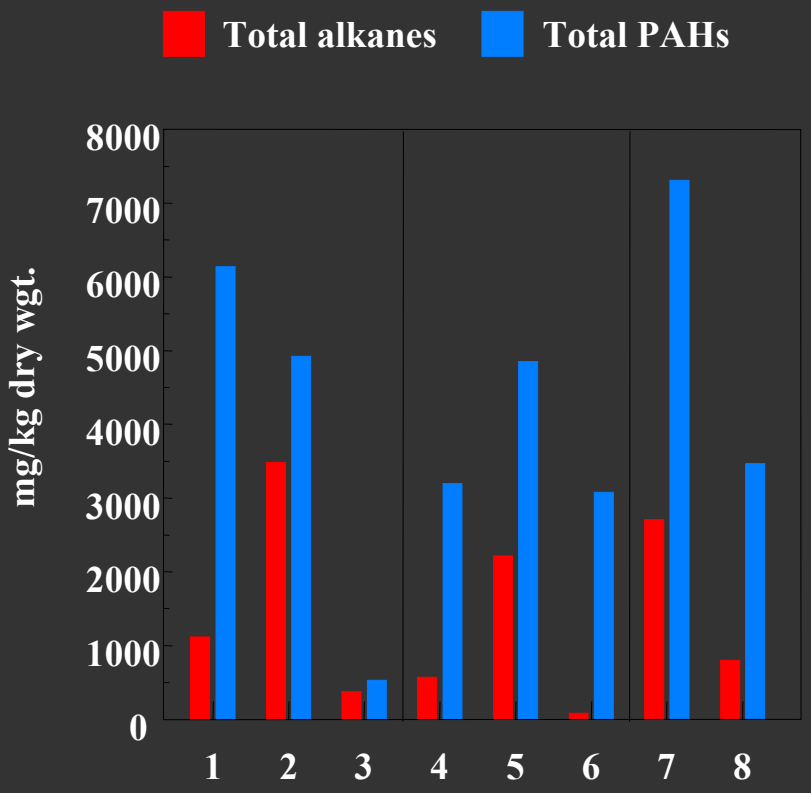

Example Project Design

Step 2) Survey of Existing Plant Community (if any)

Do they *Phytoremediate,* or merely tolerate?

Example Project Design

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Arrowhead
(Sagittaria latifolia)

Example Project Design

Step 2) Survey of Existing Plant Community (if any)

Do they *Phytoremediate,* or merely tolerate?

Example Project Design

Step 3) Literature:

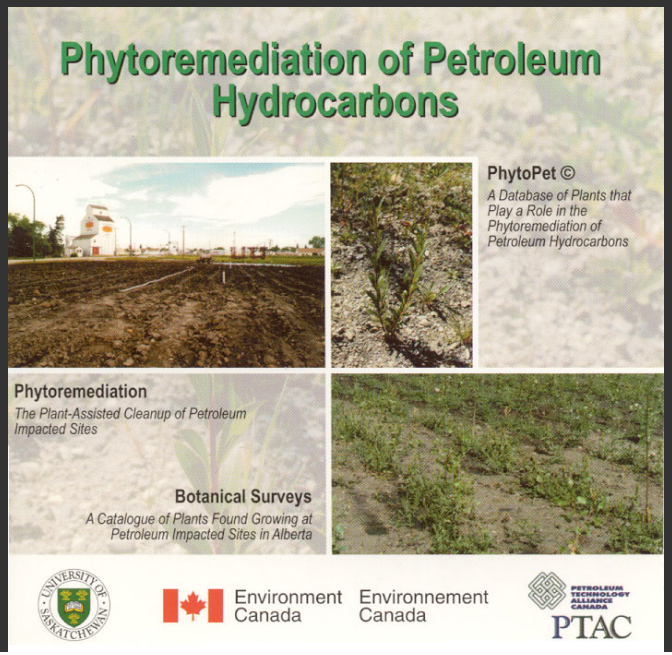
a) Known Effective Phytoremediation Plants
Can we add any 'new' plants to the list?

b) "Ballpark" Phytotoxicity Limits

PhytoPet©

Environment Canada

October, 2000



Common Plant Choices

Poplar trees *(Populus deltoides x nigra)*
big bluestem *(Andropogon gerardi)*
side oats grama *(Bouteloua curtipendula)*
blue grama *(Bouteloua gracilis)*
carrot *(Daucus carota)*
Canada wild-rye *(Elymus canadensis)*
soybean *(Glycine max)*
duckweed *(Lemna gibba)*
alfalfa *(Medicago sativa L.)*
bush bean *(Phaseolus vulgaris L.)*
winter rye *(Secale cereale L.)*
little bluestem *(Schizachyrium scoparius)*
sorghum *(Sorghum bicolor)*

western wheatgrass *(Agropyron smithii)*
annual ryegrass *(Lolium multiflorum)*
perennial ryegrass *(Lolium perenne L.)*
Verde kleingrass *(Panicum coloratum)*
switchgrass *(Panicum virgatum)*
common buffalograss *(Buchloe dactyloides)*
prairie buffalograss *(Buchloe dactyloides)*
bell rhodesgrass *(Chloris gayana)*
Bermuda grass *(Cynodon dactylon L.)*
tall fescue *(Festuca arundinacea Schreb.)*
Arctared red fescue *(Festuca rubra)*
sudangrass *(Sorghum vulgare L.)*
Meyer zoysiagrass *(Zoysia japonica)*

Example Project Design

Step 4) Treatability / Feasibility Studies

a) Confirm remediate vs. tolerate

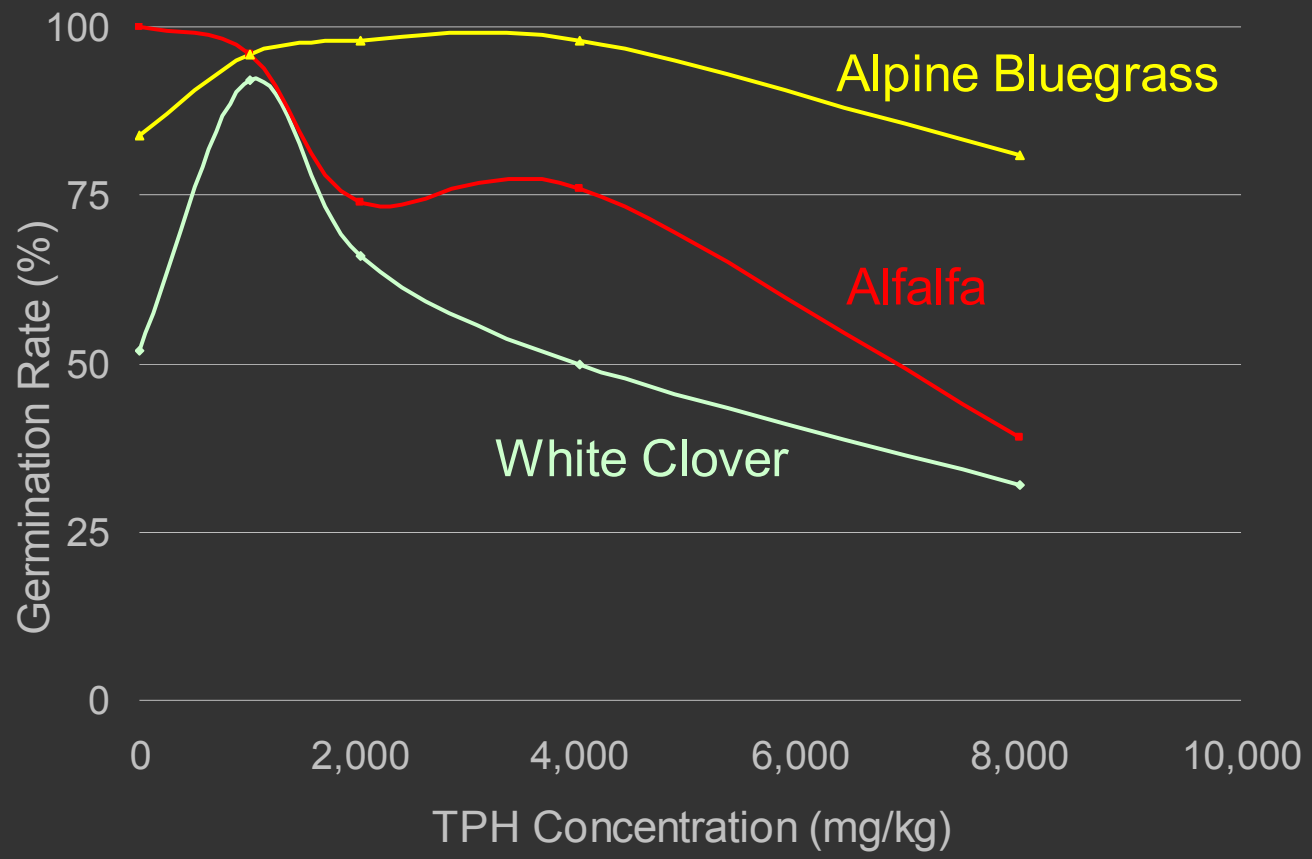
b) Establish Efficacy for Client / Regulators

In-field and/or **Greenhouse**

Germination Rates

are not always the same as

Survival Rates



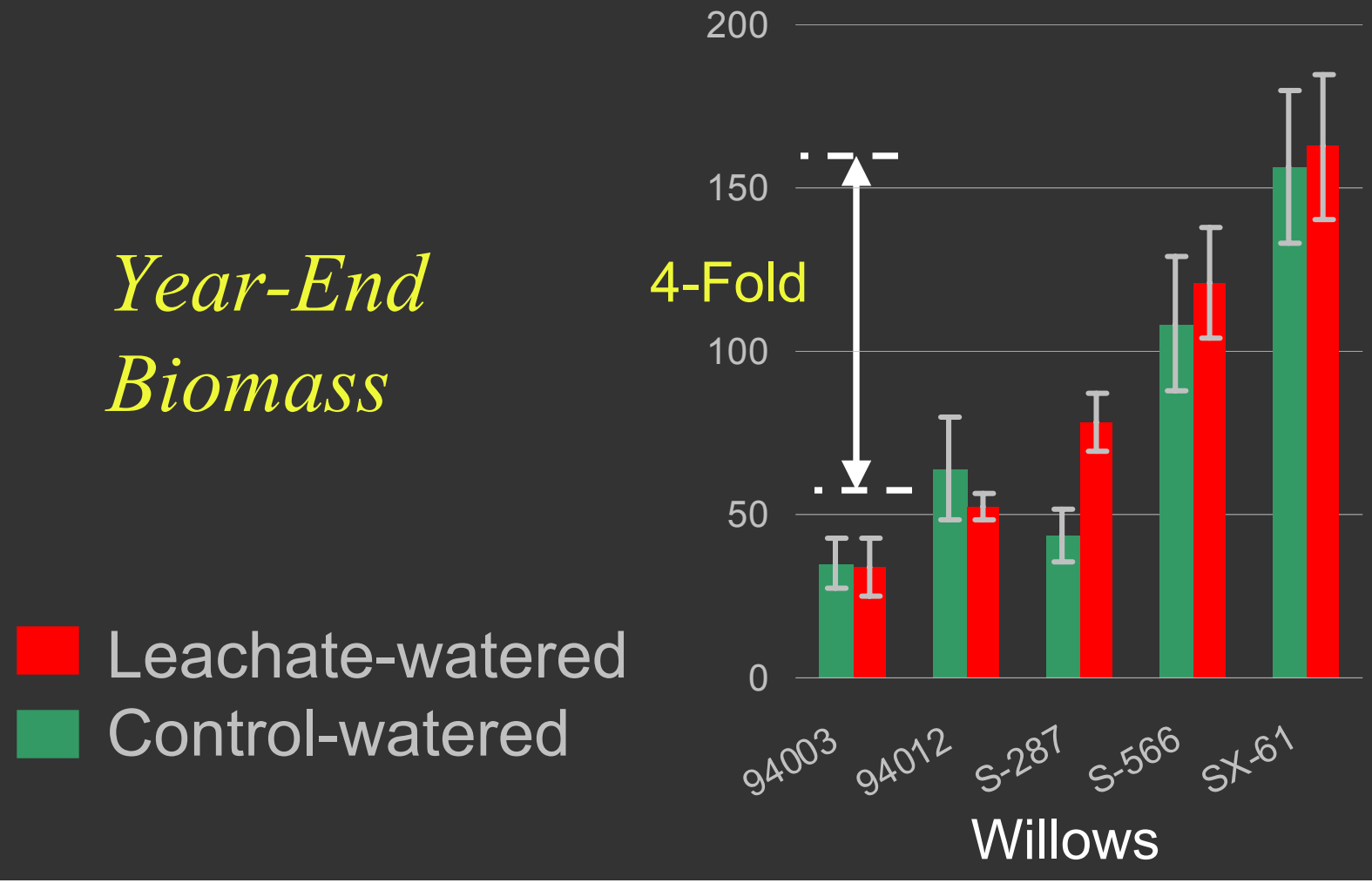
After Rodgers et al, 1996

Survival Rates

are not always the same as

Remediation Rates

Year-End Biomass



Example Project Design

Treatability / Feasibility Studies
Are Not Optional !!

Example Project Design

Step 5) Final Design

Sheen on surface water

PAHs in Soil

PAH & BTEX in GW

GW FLOW

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Example Project Design

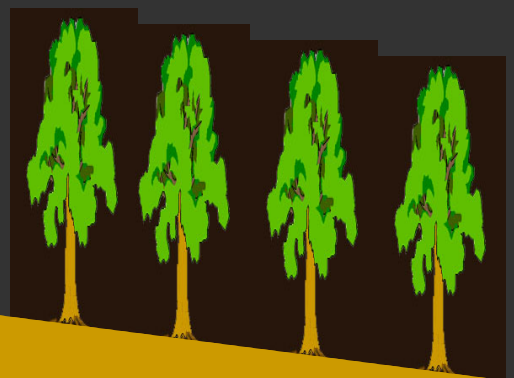
Step 5) Final Design

Hybrid Poplar (*populus, spp.)*
Willow *(salix, spp.)*

Plume control and stabilization

Tall Fescue *(Festuca arundinacea)*
Arrowhead *(Sagittaria latifolia)*

Rhizosphere Degradation



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Managing & Maintaining Phytoremediation Systems

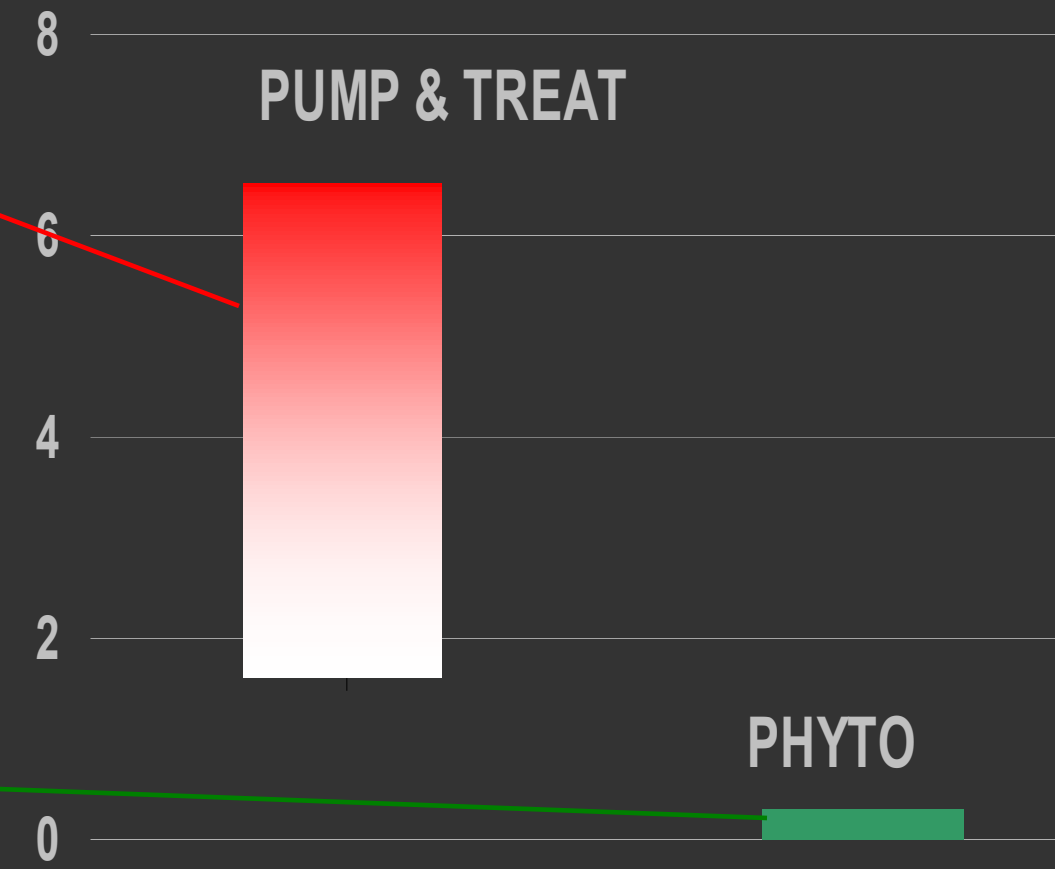
- Maintain Healthy Plants
  - Proper Nutrients
  - Weed/ Pest Control
  - Irrigation
  - Monitor Contaminant Levels

GROUND WATER:

Riparian
Phytoremediation

REMEDIATION COSTS

Annual O&M
$ per 10,000 Gallons



- 6 acres , Great Lakes area

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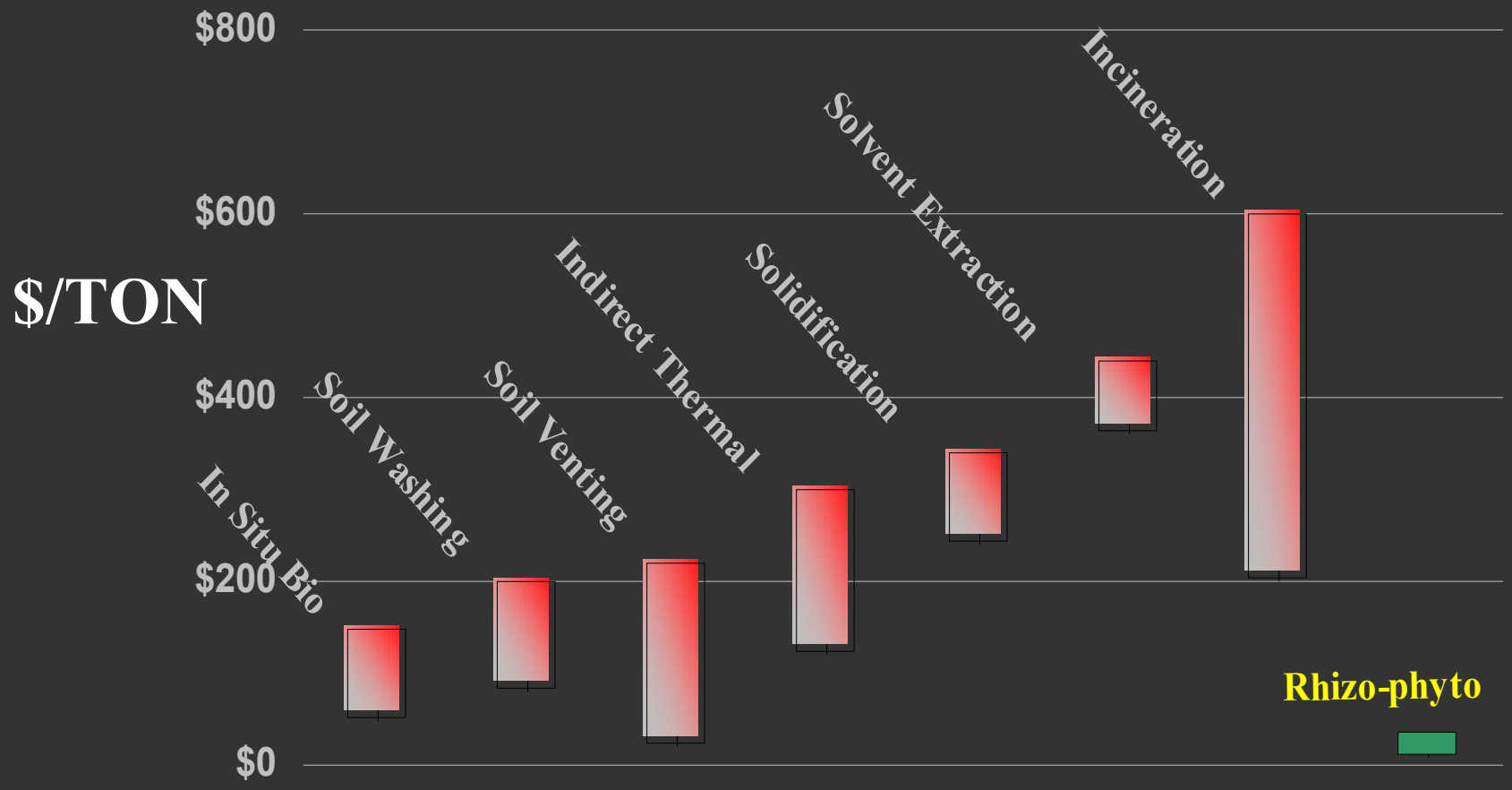
SOIL:
REMEDIATION COSTS

Riparian
Phytoremediation



Source: ITRC 5/01

REGULATORY ISSUES
NATIONAL CONTINGENCY PLAN

Phytoremediation does not require any 'special exemptions' from existing rules

LEADERS

Research, Guidance, and Case Histories

Experience: BP Amoco
CH2M Hill
U.S. EPA / Env. Canada /
Purdue Univ. / U of Wash.
Many others……

Closing

- Phytotechnologies are well-established as effective
- Plant selection & treatability studies are key
- No longer considered ‘innovative’ for petroleum
- Riparian areas are ideal for phytotechnologies