Remediation of petroleum-contaminated soil using in-situ flushing with lignin derivatives

K. Volchek, D. Velicogna, A. Somers, A. Obenauf,
M. Punt, B. Wong, *SAIC Canada*
C.E. Brown, *Environment Canada*

2004 Soils Issues Forum & Poster Session
for the Upstream Oil and Gas Industry

Calgary, March 23-24, 2004

Environment Canada Environnement Canada

SAIC An Employee-Owned Company

Acknowledgements

Financial support provided by

- The Program on Energy Research and Development (PERD)
- Environment Canada

Collaborators

- The City of Calgary
- Tembec Inc (samples of industrial lignosulfonates)
- PWGSC (contaminated soil samples for in-house pilot studies)

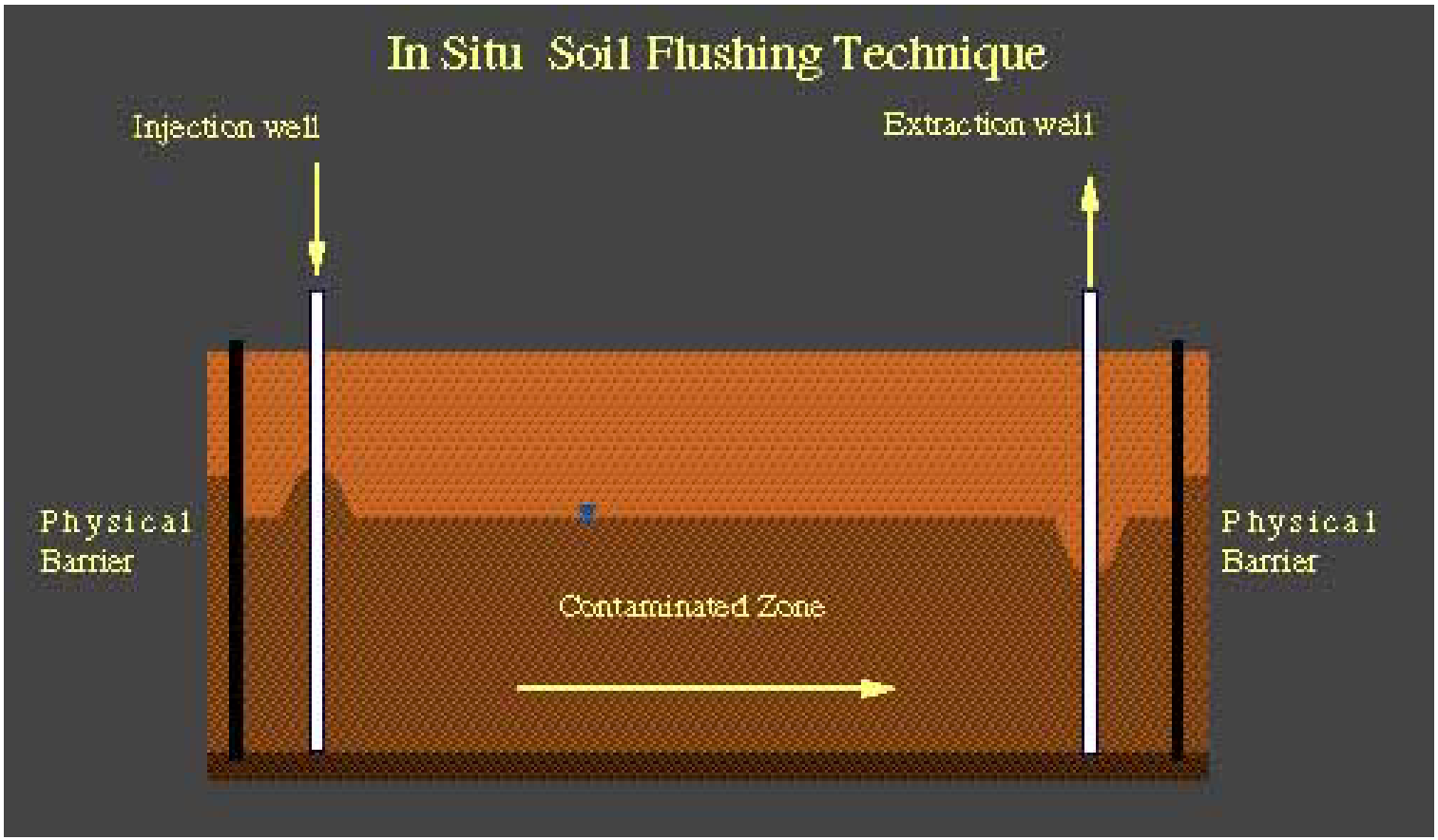
Environment Canada Environnement Canada

SAIC An Employee-Owned Company

Scope of the presentation

- ✓ Principle of the process
- ✓ Work objectives
- ✓ Progress to date
- ✓ Recent work
- ✓ Key findings
- ✓ Outputs and outcomes
- ✓ Project budget and funding leverage

Principle of the process



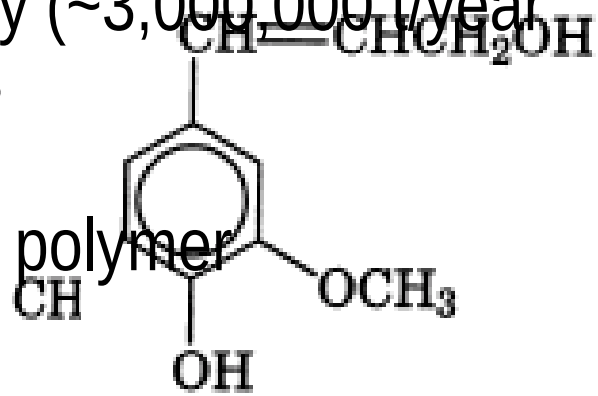
Source: P.Benchimol, M.Pandit "Remediation of Contaminated Soils…" Civil Eng. Dept., Virginia Tech, 1998

Main features of in-situ flushing

- ✓ Lower costs associated with in-situ treatment (no soil excavation/ building demolition required)
- ✓ Minimal interruption of commercial/industrial activities at the site
- ✓ Treatment rates are generally slower than for ex-situ treatment
- ✓ “Open” treatment system

Lignosulfonates as prospective flushing agents

- ✓ By-product of pulp and paper industry (~3,000,000 t/year worldwide).
- ✓ Uses: vanillin, industrial surfactants, polymer fillers, etc.
- ✓ Chemical properties: phenolic, carboxylic, aldehyde groups.
- ✓ Act as mild surfactants
- ✓ Bind metal ions.



Work objectives

- ✓ Evaluate the in-situ flushing of the petroleum-contaminated soil;
- ✓ Evaluate the effect of lignosulfonates on the removal of PHC;
- ✓ Optimize process parameters;
- ✓ Design and build a prototype pilot test system;
- ✓ Demonstrate the technology;

Progress to date

- ✓ Bench-scale tests completed and showed promising results;
- ✓ Tests carried out on both spiked soil and actual contaminated soil samples;
- ✓ A number of commercial lignosulfonates tested and the best performing product selected;
- ✓ Process parameters optimized;
- ✓ Pilot-scale system designed and manufactured
- ✓ Pilot-scale tests to be completed soon

Experimental setup

- ✓ Phase I – aqueous solubility tests
- ✓ Phase II – slurry leaching

Environment Canada Environnement Canada

SAIC An Employee-Owned Company

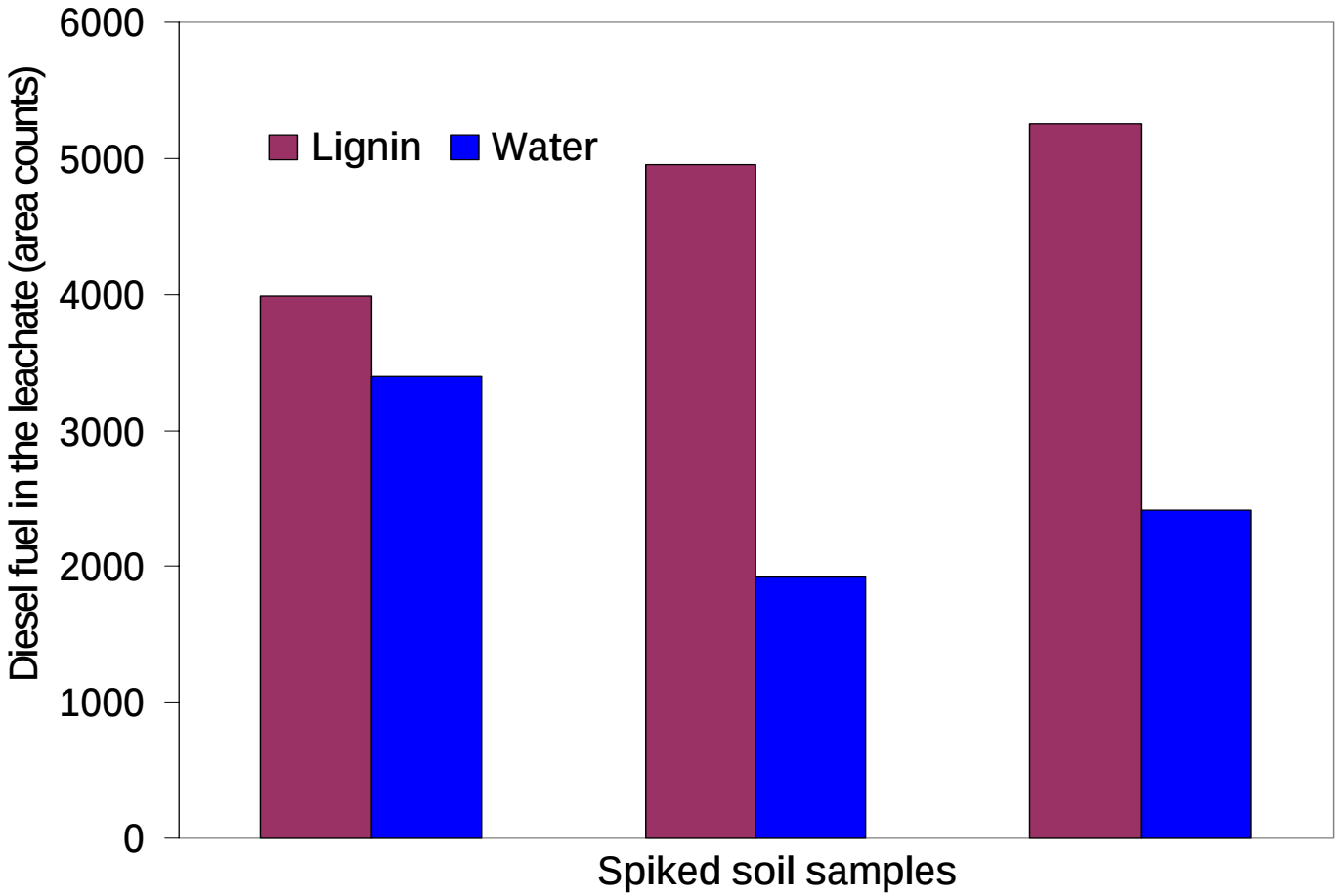
Experimental setup

- ✓ Phase III – column leaching
- ✓ Phase IV – leachate treatment

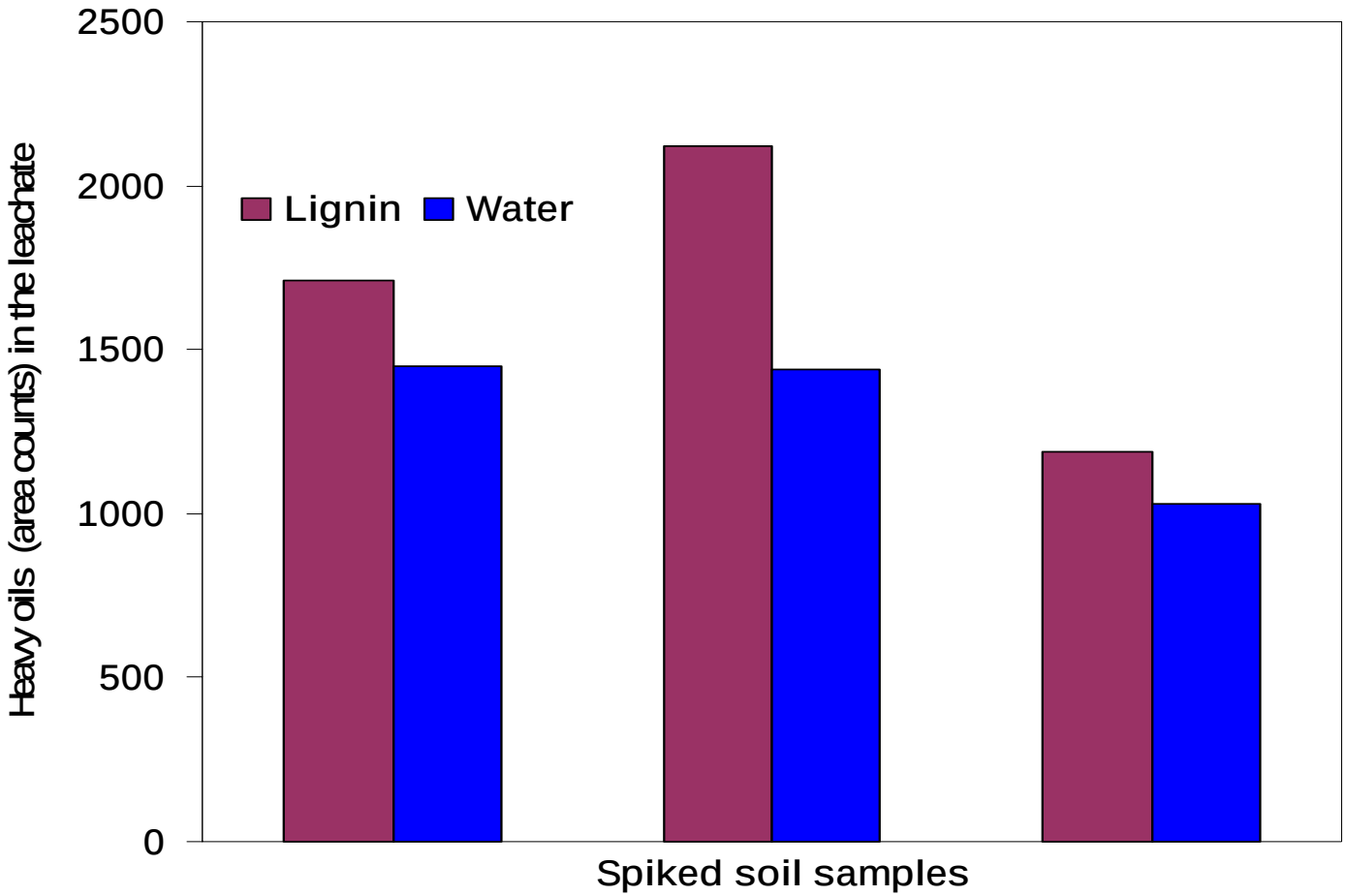
Environment Canada Environnement Canada

SAIC An Employee-Owned Company

Results of slurry leaching: Diesel fuel



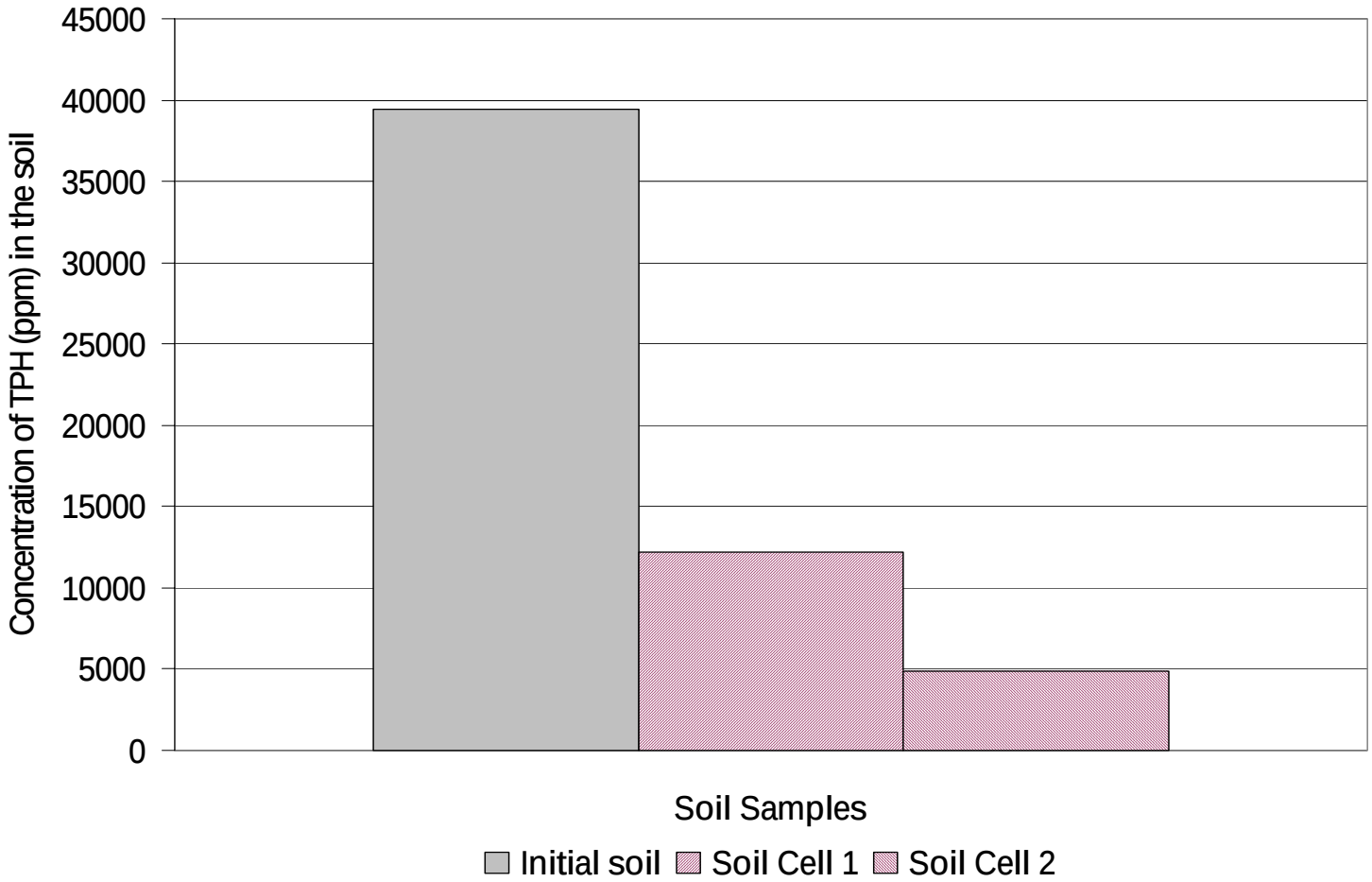
Results of slurry leaching: Heavy oils



Environment Canada Environnement Canada

SAIC
An Employee-Owned Company

Results of column leaching: Total petroleum hydrocarbons



Environment Canada Environnement Canada

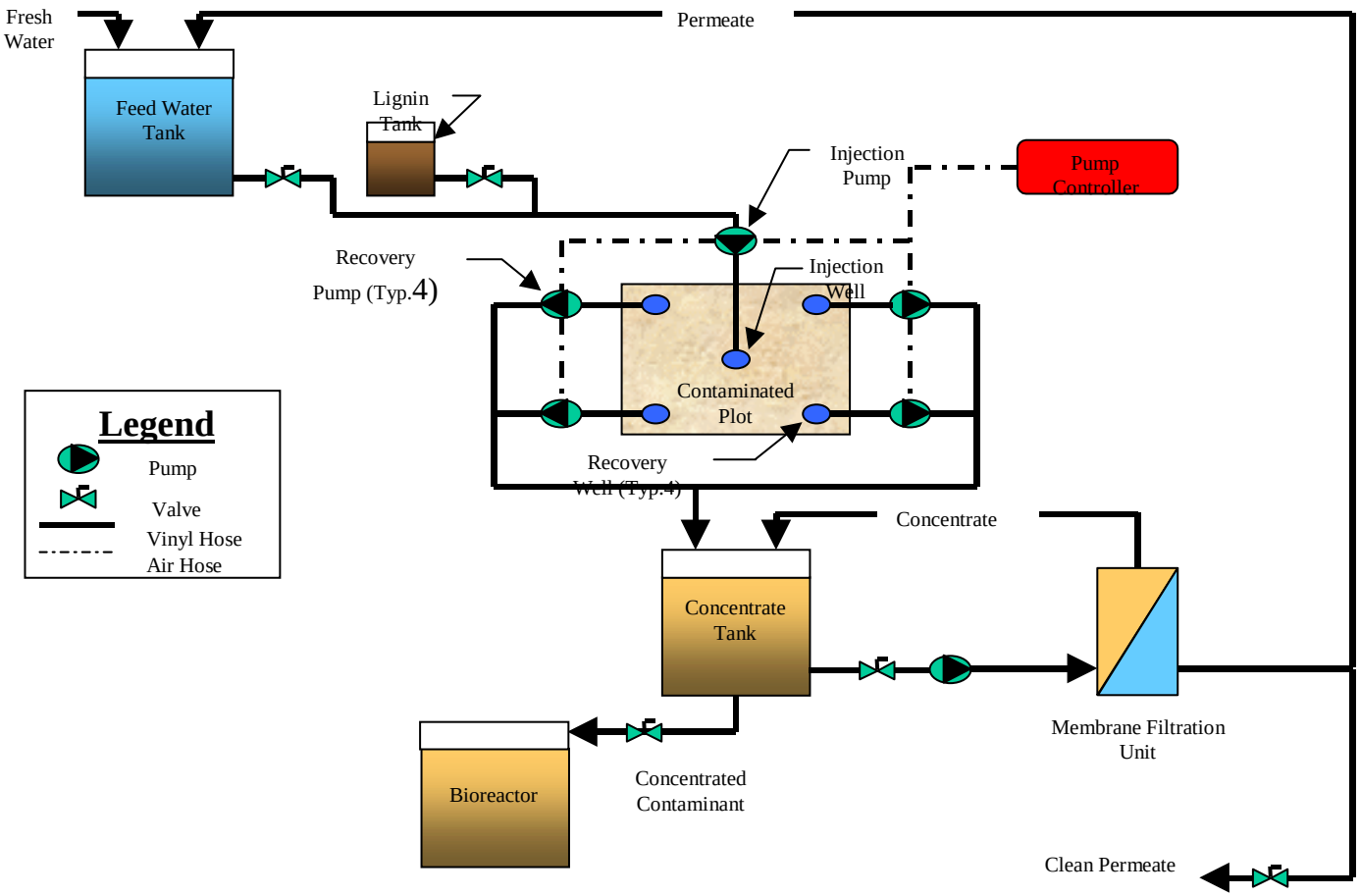
SAIC An Employee-Owned Company

Removal of heavy metals

Contaminants*	Percentage removal	
	"conventional"process	with lignin derivatives
Hg	0%	15%
U	0%	42%
Cd	26%	70%
Cr (III)	0%	24%
Pb	29%	75%

* Initial concentrations: 500 mg/L

Flow chart of the pilot test system



Pilot-scale tests

- ✓ Were originally scheduled for the summer of 2003, to be done in Calgary as field trials
- ✓ Delayed due to a slow permitting process
- ✓ In-house pilot study was conducted instead
- ✓ Local (Ottawa) petroleum-contaminated soil was used instead

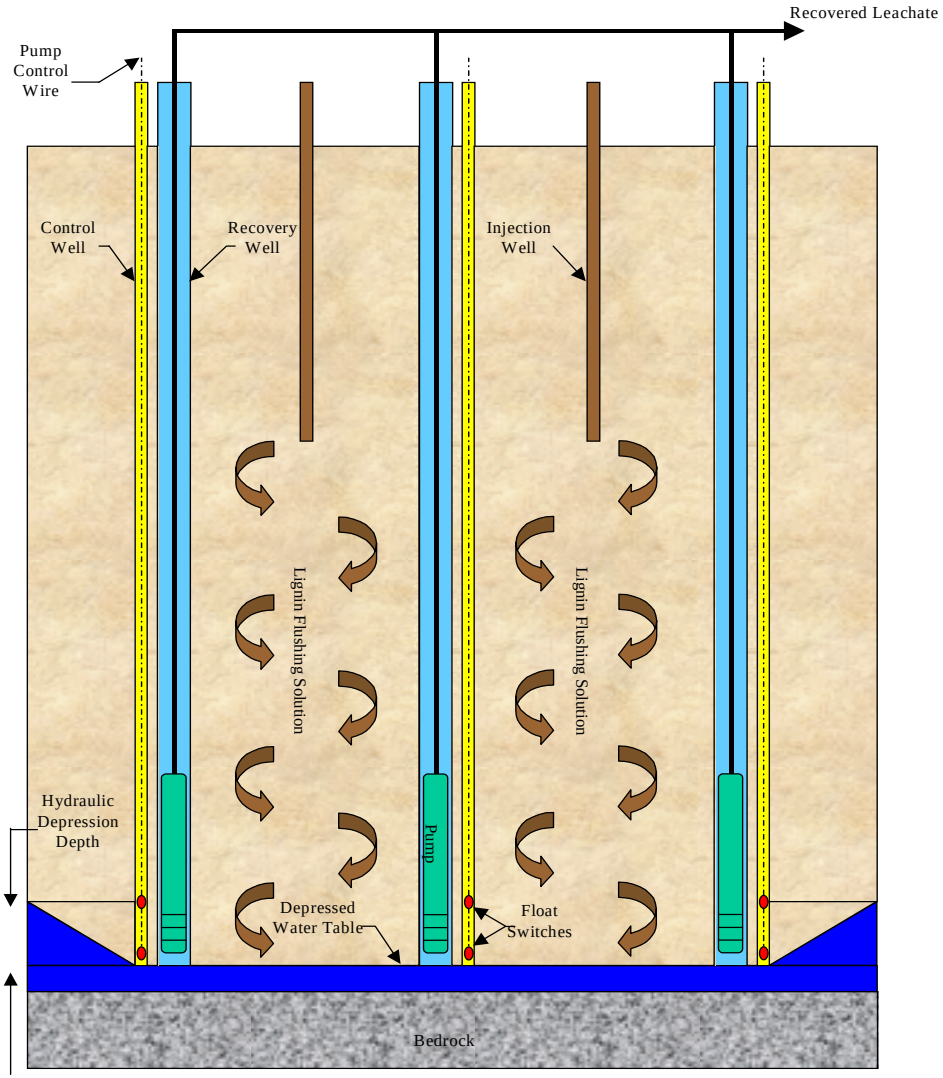
Excavation of contaminated soil

Placing the soil in the test cell

Environment Canada Environnement Canada

SAIC An Employee-Owned Company

Cross section of the treatment zone



Environment Canada Environnement Canada

SAIC An Employee-Owned Company

Test system in operation

Bioreactor for the concentrated leachate

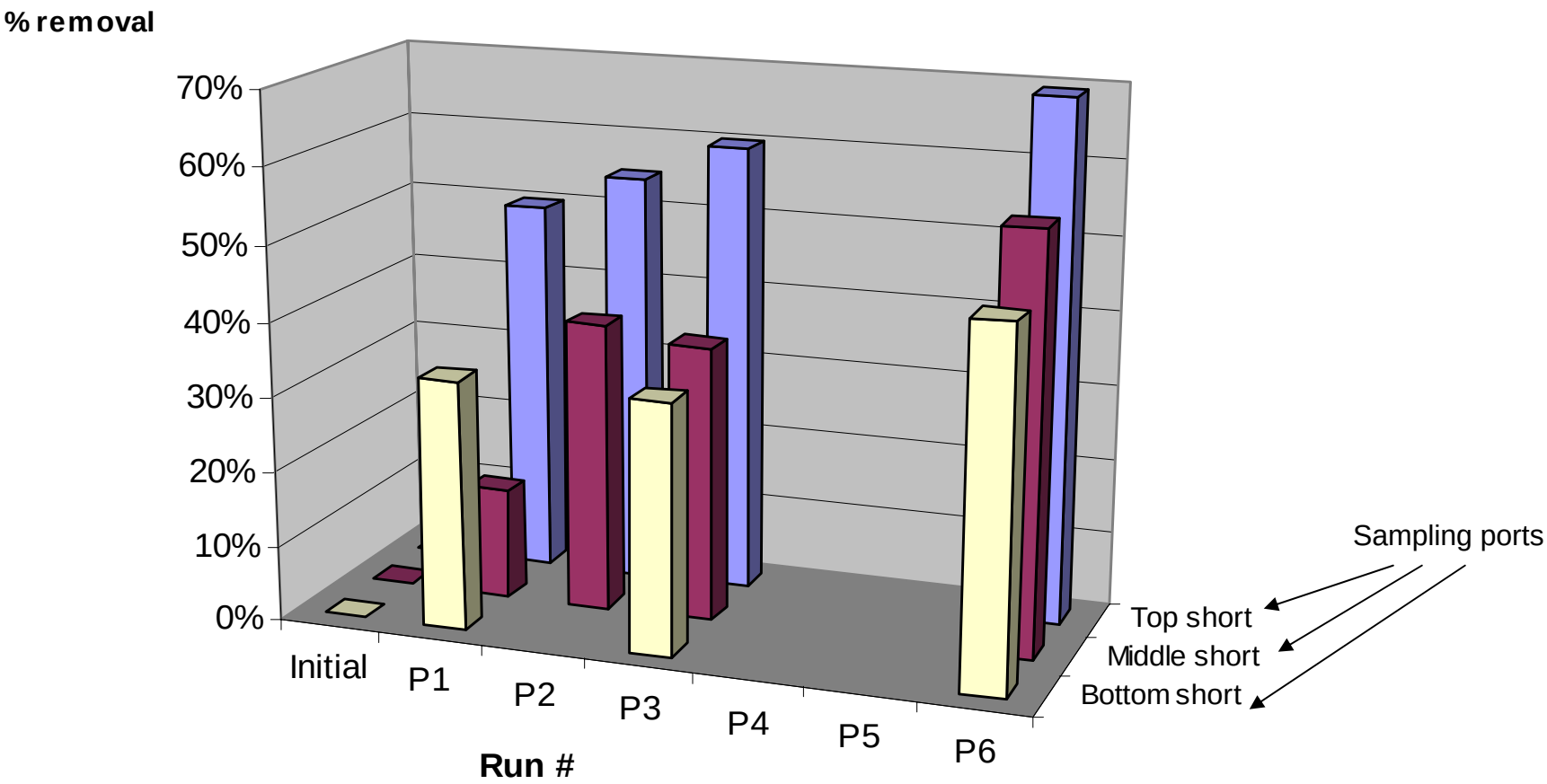
Environment Canada Environnement Canada

SAIC An Employee-Owned Company

Pilot study
Preliminary test results

- ✓ Within the first week of treatment, the concentration of PHC in soil was reduced by 50%
- ✓ Leachate was concentrated using membrane filtration, with more than 95% of water recovered and reused
- ✓ Biological treatment of the concentrated leachate in progress

Preliminary pilot test results: Removal of PHC



Key findings

- ✓ Both bench and the pilot-scale tests to date have been successful
- ✓ Lignosulfonates enhanced the removal of petroleum hydrocarbons from soil
- ✓ Heavy metal removal observed. Possibility for the treatment of mixed contaminated soil
- ✓ Leachate could be concentrated using membrane filtration
- ✓ Bioremediation of the concentrated leachate in progress

Outcomes

- ✓ Both bench and the pilot-scale tests to date have been successful;
- ✓ New in-situ remediation technology has been developed and demonstrated on a pilot scale (in-house);
- ✓ New utilization was found for by-products of the pulp and paper industry