

**SURFACTANT ENHANCED SOIL WASHING OF
DRILLING CUTTINGS & MUDS. THREE APPLIED
CASE STUDIES
ARGENTINA, COLUMBIA, & CANADIAN
BENCH TO FIELD SCALE**

**REMTECH 2013
OCTOBER 16-18, 2013
FAIRMONT BANFF SPRINGS
BANFF, AB CANADA**



PRESENTATION OVERVIEW

- 1) What are drill cuttings and muds;
- 2) Why are they an environmental issue globally;
- 3) What limits treating drill cuttings and muds;
- 4) Surfactant Enhances Soil Washing (SESW)
Opportunity For Treatment (With related considerations);
- 5) Case Studies (Argentina, Canada & Columbia);
- 6) Conclusions & Opportunities...



SOIL WASHING OF DRILLING CUTTINGS

Between 2008 through Spring of 2012 Ivey International Inc. was approached by a companies in North and South America seeking an innovative way to treat drilling cuttings that were associated with oil and gas exploration drilling activities.

These companies sent samples of their drill cuttings to our office for testing.

The samples were taken to our laboratory for bench scale treatability testing with modified blends of our proprietary Ivey-sol non-ionic surfactant products.



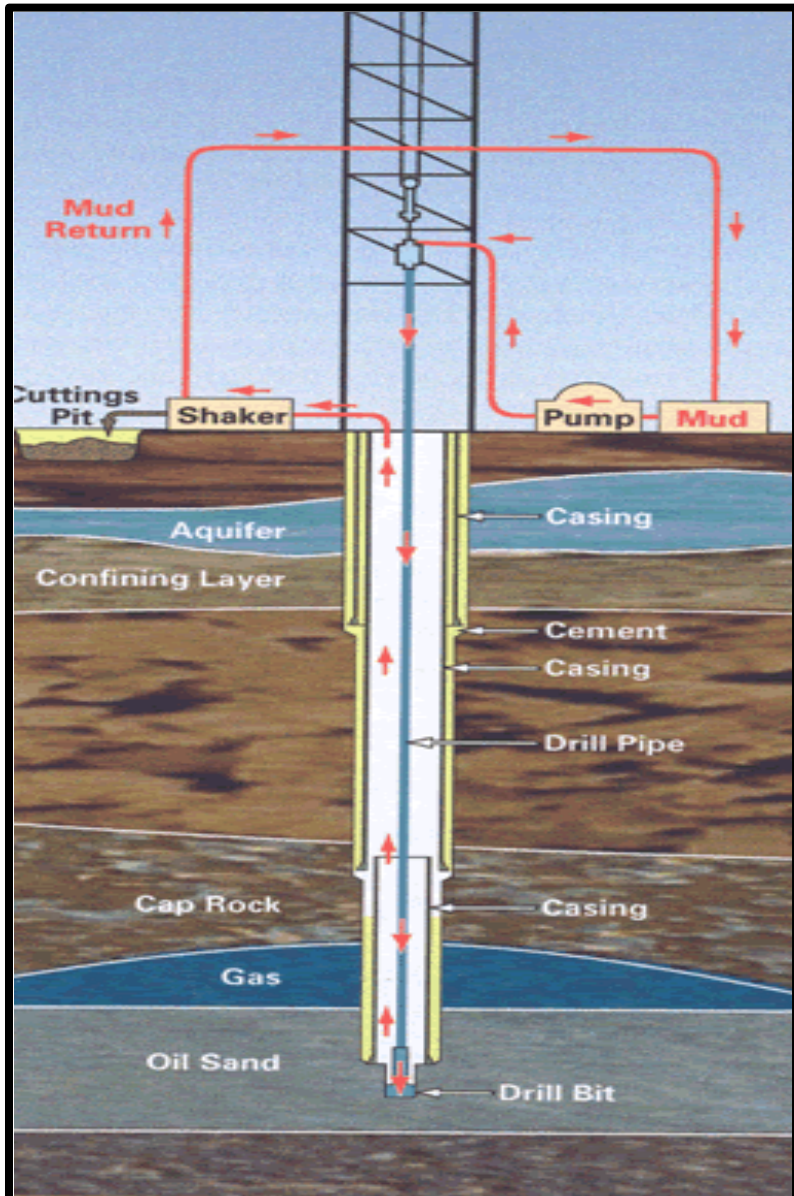
Drill Cuttings

Drill cuttings are the broken bits of solid material removed from a borehole drilled by rotary, percussion, or auger methods. Boreholes drilled in this way include oil or gas wells, water wells, and holes drilled for geotechnical investigations or mineral exploration.

The drill cuttings are commonly examined to make a record (a well log) of the subsurface materials penetrated at various depths. In the oil industry, this is often called a mud log.

Drill cuttings are produced as the rock is broken by the drill bit advancing through the rock or soil; the cuttings are usually carried to the surface by drilling fluid circulating up from the drill bit. Drill cuttings are separated from the drilling fluid by shale shaker (for liquid drilling fluid), or by cyclone separators (for air drilling). In cable-tool drilling, the drill cuttings are periodically bailed out of the bottom of the hole. In auger drilling, cuttings are carried to the surface on the auger flights.

Oil Based drill cuttings, originating from oil and gas drilling, are often impacted with a broad range of petroleum hydrocarbons.



ARKANSAS
OIL AND GAS
COMMISSION

RECEIVED
ARK OIL & GAS COMM
2009 SEP 9 AM 9 49

Submit Form To
El Dorado Regional Office
P O Box 1472
El Dorado, Arkansas 71731

11974

Permit No 42776

API No.: 03- 141-10895

FORM 2
NOTICE OF INTENTION TO DRILL FOR OIL OR GAS

(This application to drill must be accompanied by a remittance of \$300 00)

Date Issued 9-10-09

Expiration Date 3-8-10

Date September 8, 2009

Name of Operator CHESAPEAKE OPERATING, INC

Send Permit to Street 6100 N. Western ATTN ALETHA DEWBRE-KING (P O Box 18496, Oklahoma City, OK 73154-0496)

City Oklahoma City State OK Zip 73118

E-Mail adewbre-king@chkenenergy.com Phone 405-935-4775 Fax 405-849-4775

Well Name Carey Beavers 11-12 Well No 1-19H

Is proposed well Vertical Directional Horizontal Acres In Lease 640 Acres in Drilling Unit 640

Will oil-based drilling mud be used in the drilling of this well YES NO

Description of Drilling Unit or Lease (if uncontrolled or wildcat) Section 19-11N-12W

Location of proposed well from nearest drilling unit or lease (if applicable) boundaries - Must agree with Surveyor's Plat

(SHL) 722' FSL & 2314' FEL (PBHL) 560' FNL & 965' FWL

Location of proposed well from nearest section lines - Must agree with Surveyor's Plat

(SHL) 722' FSL & 2314' FEL (PBHL) 560' FNL & 965' FWL

Lat & Lon (dd dddd) Lat 35 569722262, Long 92 304457295 Sec 19 Twp 11N Rge 12W

County Van Buren Field B-43

Distance and direction from nearest town 8.9 miles east of Clinton, Arkansas

Distance and direction from proposed location to nearest drilling, completed or applied for well

Approximately 1 mile southeast of Chesapeake Operating Inc's Bradford 11-13 1-13H well in Sec 13-11N-13W

Date work will start 9/11/09 Depth to be drilled 1,782' TVD 6,326' MD

Name of drilling or workover contractor Normac Drilling Company

Formation you propose to complete in Fayetteville Shale

If exceptional location, include copy of exceptional location permit or submit application with this form

Purpose of Form 2 Original Amendment Renewal Re-entry

Remarks Covered by Rule B-43 Directional Surveying Agreement

Handwritten note: No. 1000 wire 9/10/09

CERTIFICATE

I declare under the penalties of perjury that this report has been examined by me and to the best of my knowledge is true, correct and complete, and that the above named operator has a valid lease, farmout or other agreement that establishes the right to receive a permit and drill the above described well

Handwritten: 500' PZ
4-4-09
MN

Signature of Debbie C. Fritsche

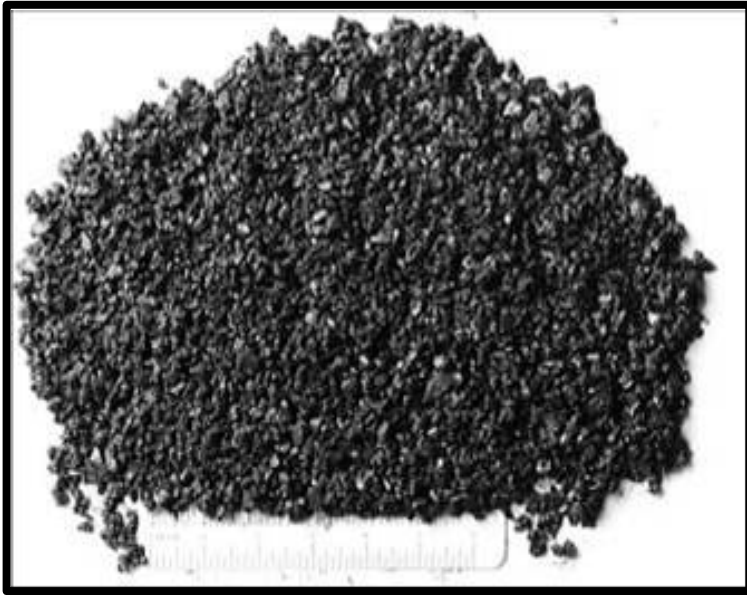
Consulting Geologist
Title
9/8/2009
Date

Debbie C Fritsche
Typed or Clearly Printed Name

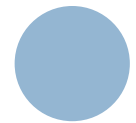
See Instructions on Reverse Side

Revised 02/09

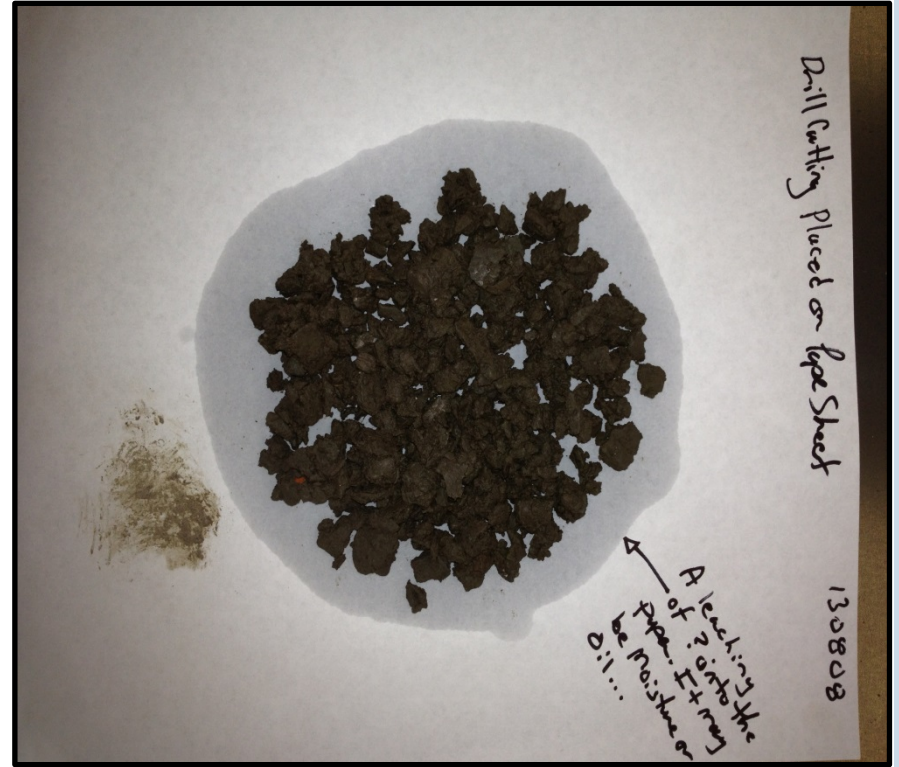
Drill Cuttings and Mixture Drill Cuttings, Muds and Fluids



CUTTINGS & MUDS SHAKER



DRILL CUTTINGS & MUDS (CANADIAN SITE)



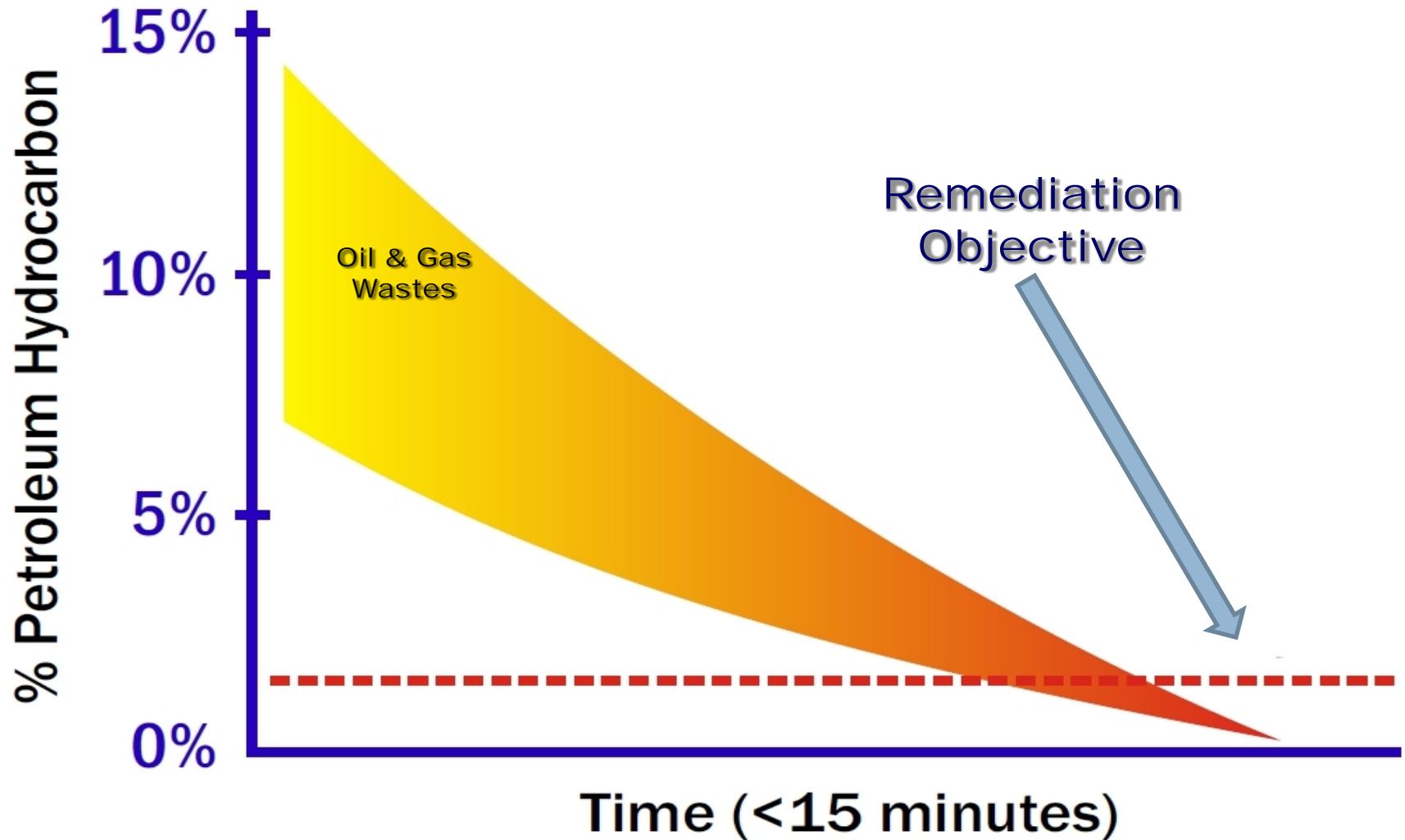
Global Environmental Impacts From Drill Cutting and Muds

Source - Pathway – Receptor Model



We need an innovate, cost effective, sustainable way to treat drilling cuttings & muds!

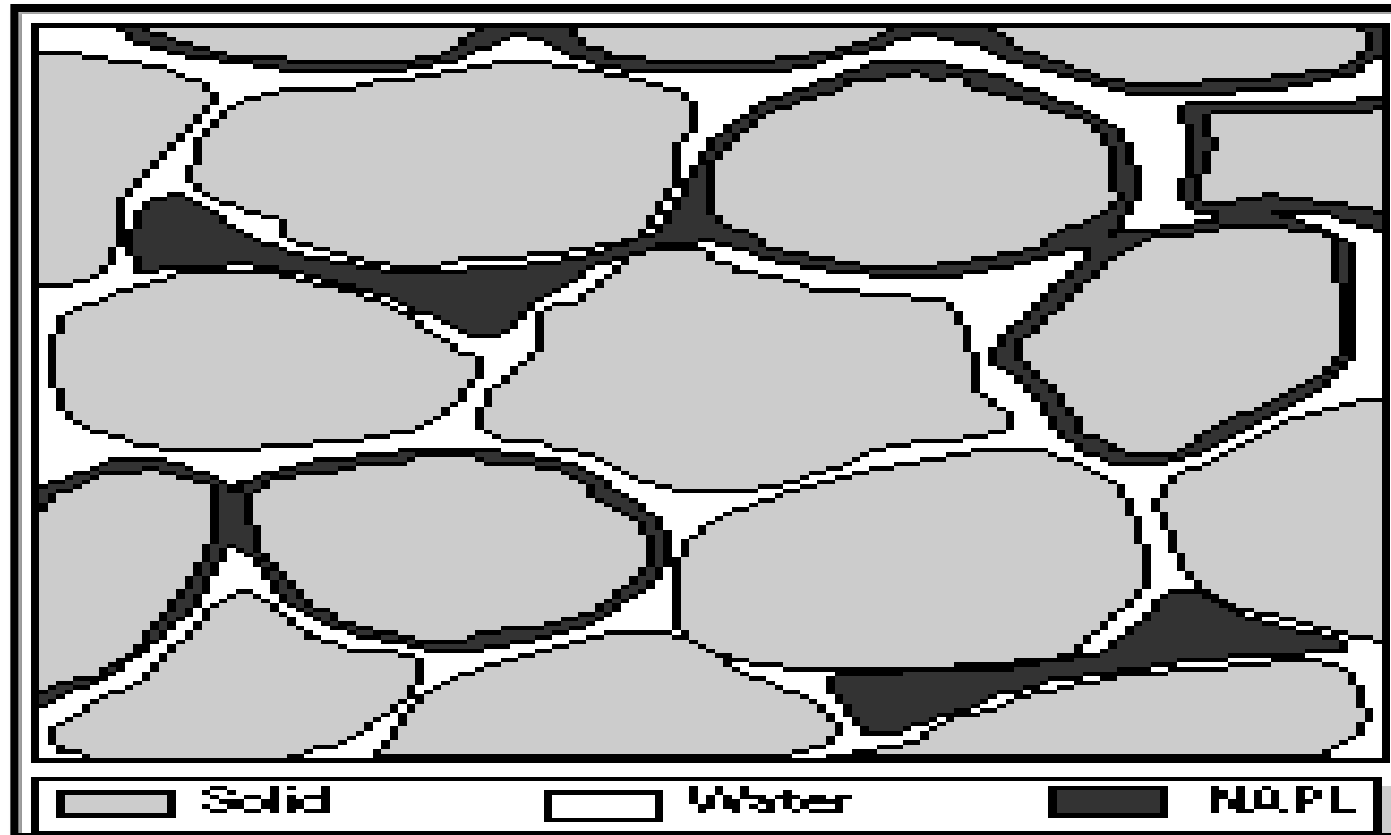
Surfactant Enhanced Soil Washing (SESW)



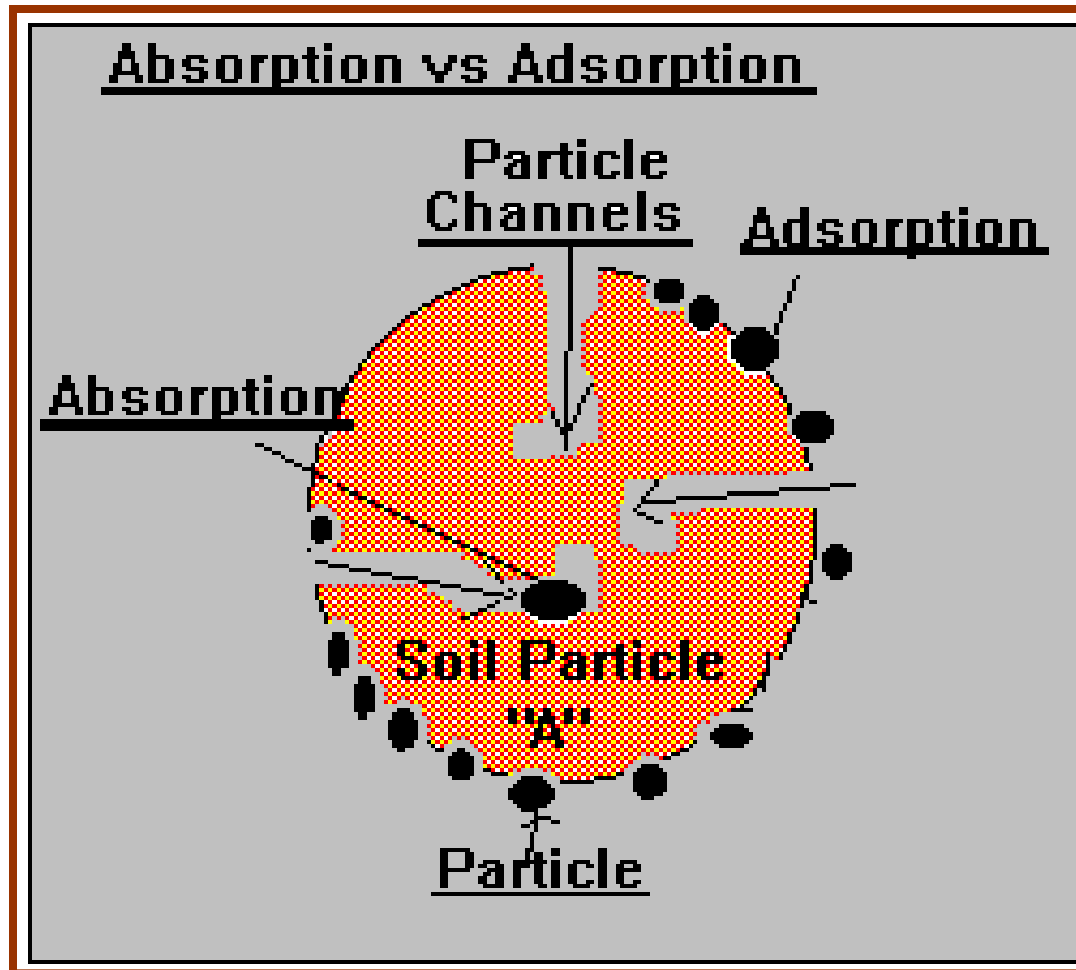
SORPTION

Adsorption and Absorption
Properties and Characteristics

Soil & Solids Remediation Must Address
This Factor to be Successful!

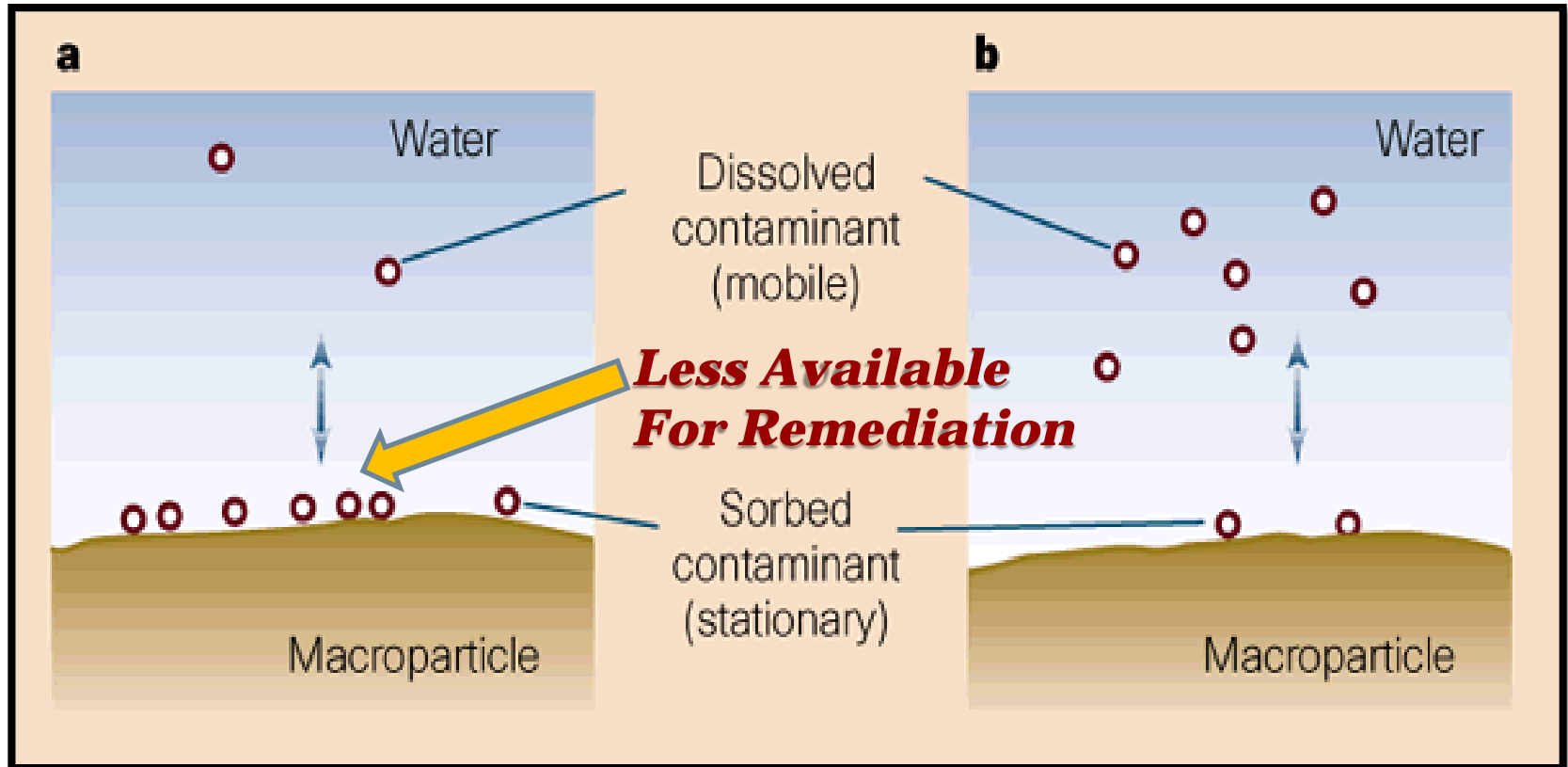


Adsorption vs. Absorption



Adsorption is fast while Absorption is slower

SORPTION A FUNCTION OF SOLUBILITY



The lower the Solubility the Greater the Sorption of the Contaminant! This affects soil and groundwater contaminant Availability for Remediation



FACT

>90 % of All Organic Contaminants Are
Absorbed or Adsorbed (Sorbed) To Particles In
Soil, Sediments, Drill Cuttings, Bedrock, Sludge, Etc...

Contaminant Sorption

Limits The 'Availability' of Contaminants For All Forms of:

Physical, Chemical & Biological Remediation!

Sorption Is The #1 Reason Why Many
Remediation Project Are Slow, Very Costly and/or Fail To
Achieve Their Objectives!



Sorption Affects Contaminant Availability

‘During the past decade, much discussion has centered on the unavailability of absorbed compounds to soil microorganisms; it is generally now assumed that desorption and diffusion of bound contaminants to the aqueous phase is required for microbial degradation’

(W.P. Inskeep, J.M. Wraith, C.G. Johnston, Hazardous Substance Research Center, 2005).



FACT

***90 to 95 % of All Contaminants Are
Sorbed To Soil Particles In
Soil, Sediment and Groundwater***

Absorption Limits Availability of Contamination For





INTRODUCTION TO SURFACTANT TECHNOLOGY





Hydrophobe

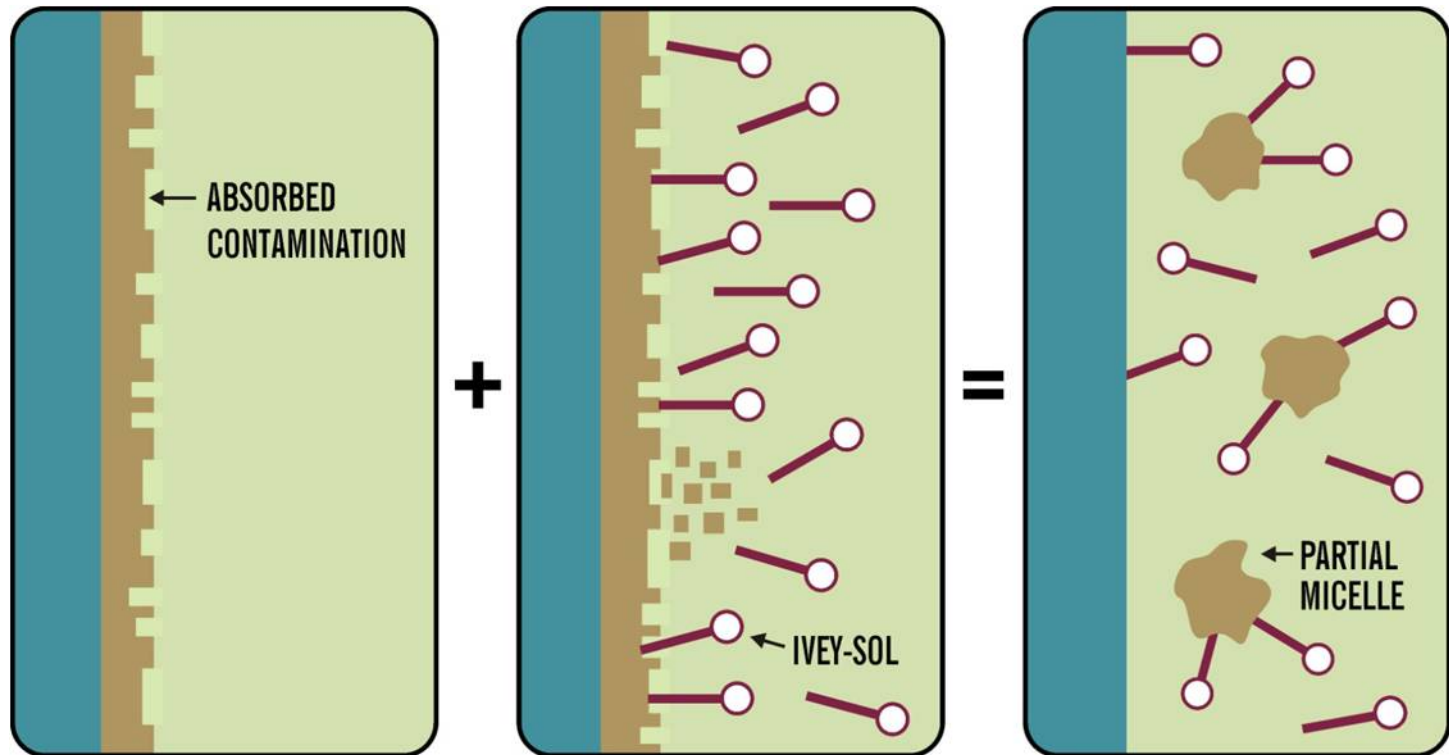
Hydrophile

Surface Active Agent (SAA)

- **Hydrophilic (water loving) and**
- **Hydrophobic (oil-liking)**
- **Groupings Shown.**



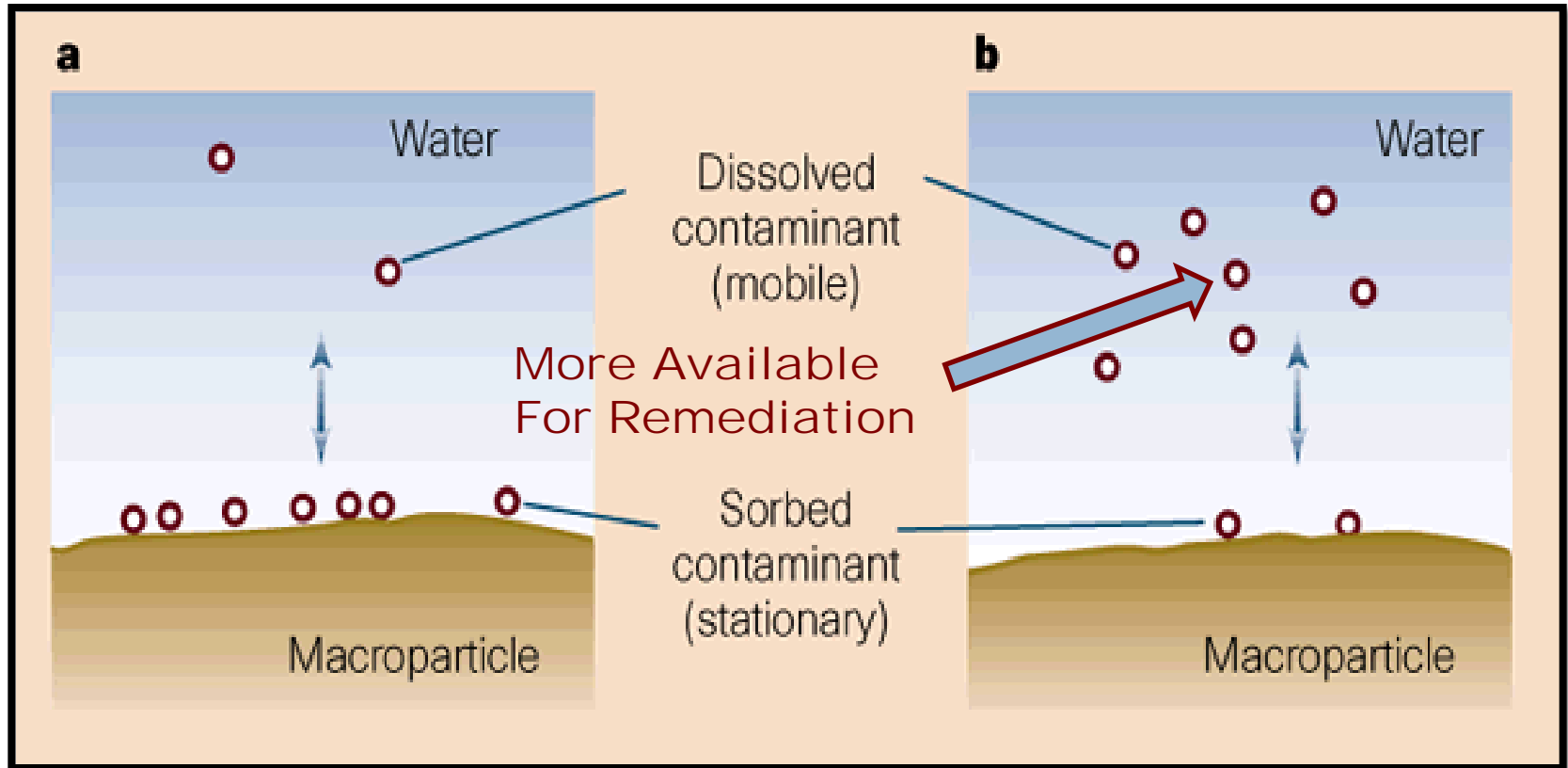
MECHANISM



**Ivey-sol Interaction With Oil On A Surface
With Partial Micelle Encapsulated of Oil Droplet
(Ivey-sol is Effective Below The CMC)**



SORPTION A FUNCTION OF SOLUBILITY



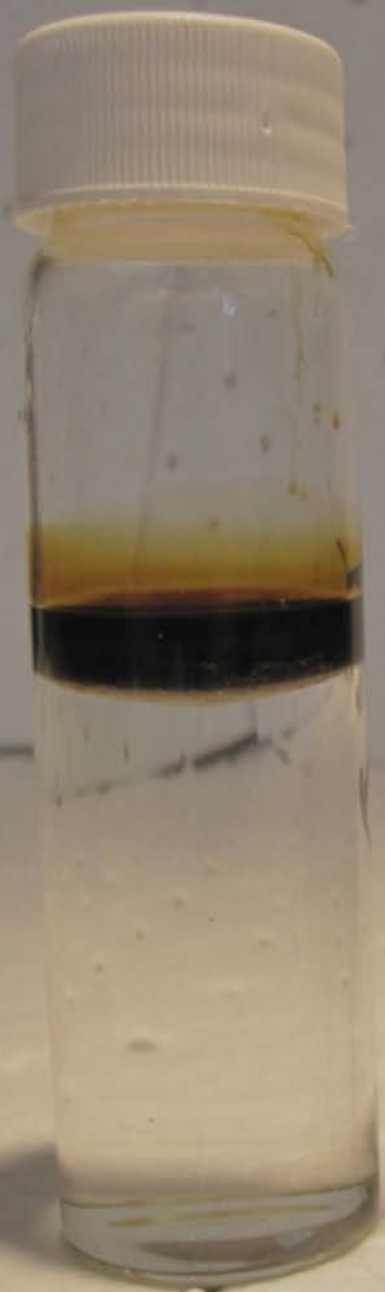
Ivey-sol can overcome the limitation of sorption and make the contaminants more **"Available"** Remediation!





Pre and post Ivey-sol Surfactant washed solids impacted with heavy-end petroleum hydrocarbons

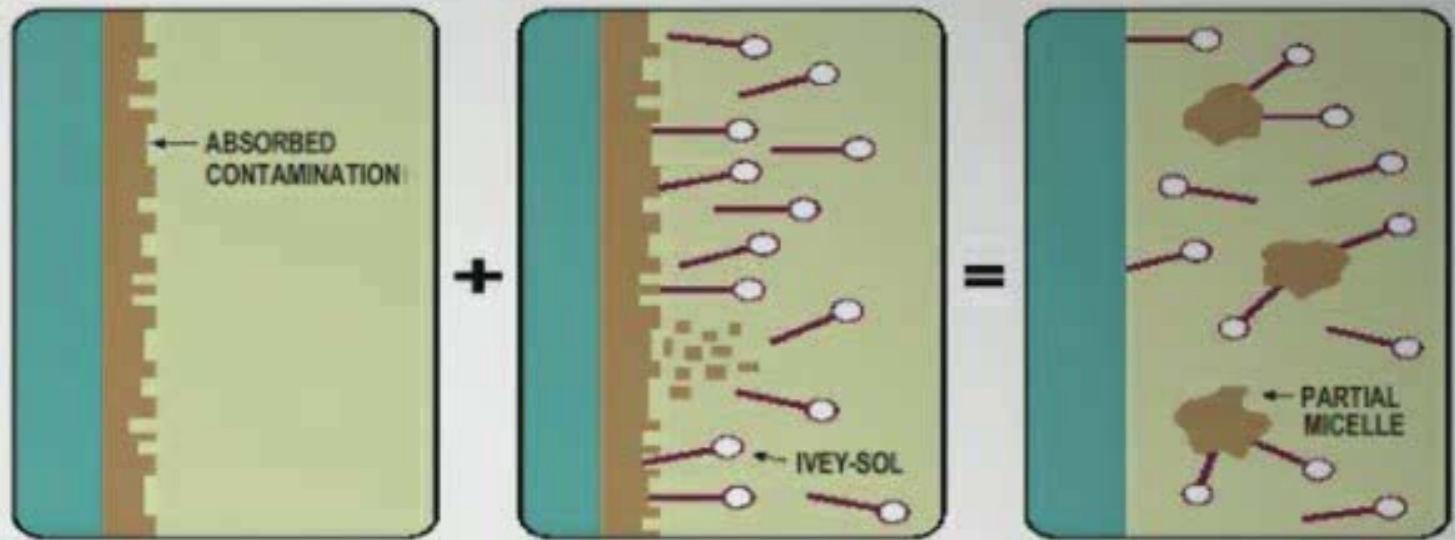




IVEY-SOL MECHANISM ANIMATION



Mechanism



Ivey-sol[®] shown desorbing contamination off a surface. Once liberated the desorbed contaminants have increased 'Availability' for improving the associated in-situ or ex-situ remediation method being employed.



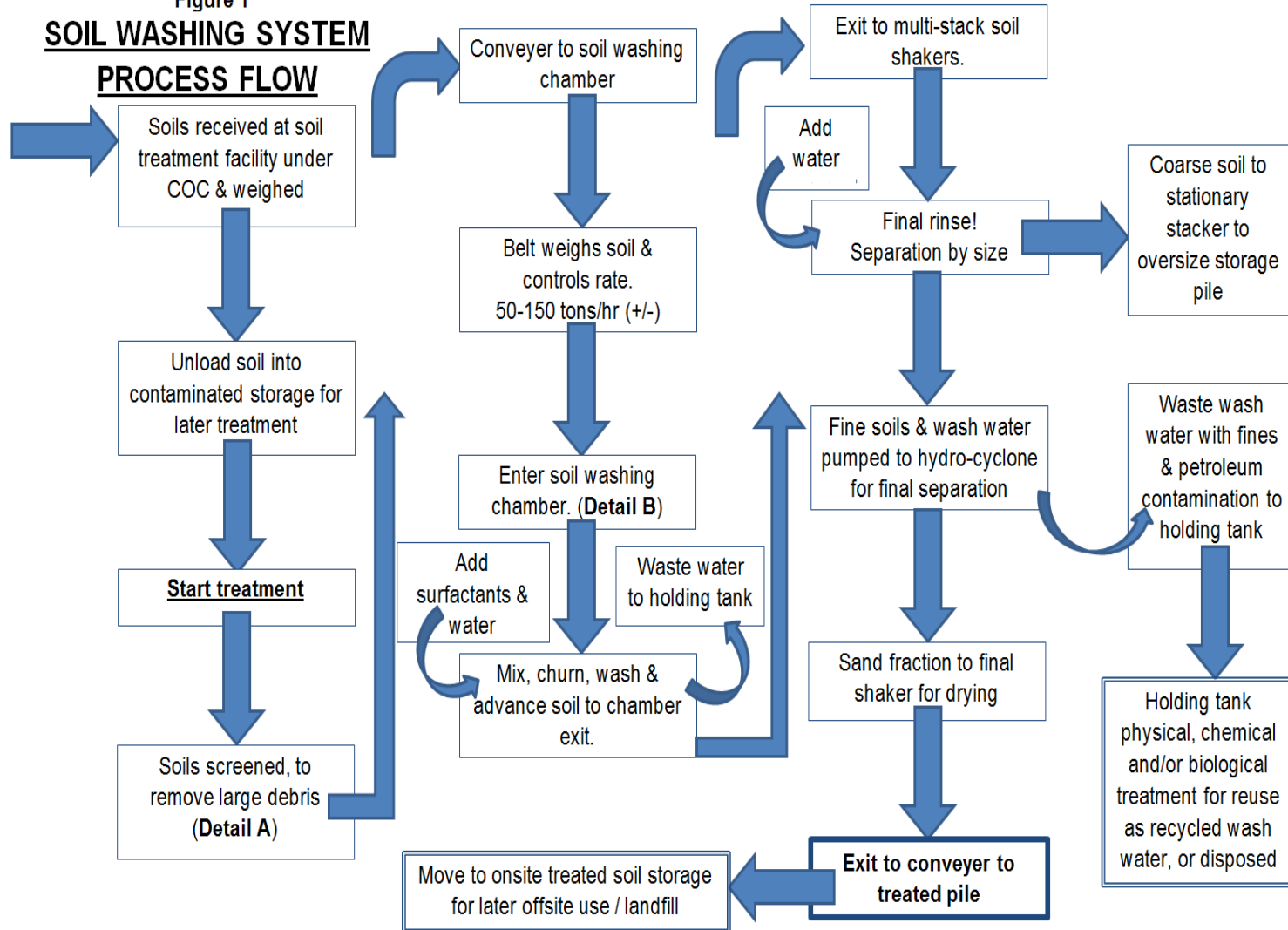
CONTINUOUS SOIL WASHING SYSTEM
50 TO 150 TONS/HOUR



BATCH SOIL WASHING SYSTEM
25 TO 35 TONS/HOUR

GENERAL SOIL WASHING SYSTEM APPROACH

Figure 1
**SOIL WASHING SYSTEM
PROCESS FLOW**



APPLICATION RANGE

LNAPL

Full LNAPL Range, Includes Compounds Like: BTEX, Gasoline, Diesel, Motor-Oil, Bunker-C MTBE, PAH's, etc.

DNAPL

25 Fold (+) Increase In Solubility & Recovery Rate. This includes Compounds Like: PCE, PCB, TCE, TCA, CTC, TCM, PCP, & Various other Cl / Br Solvents

Heavy Metals

Transition metals, including organo-metallic complexes, and radio-active metals associated with NORMS.

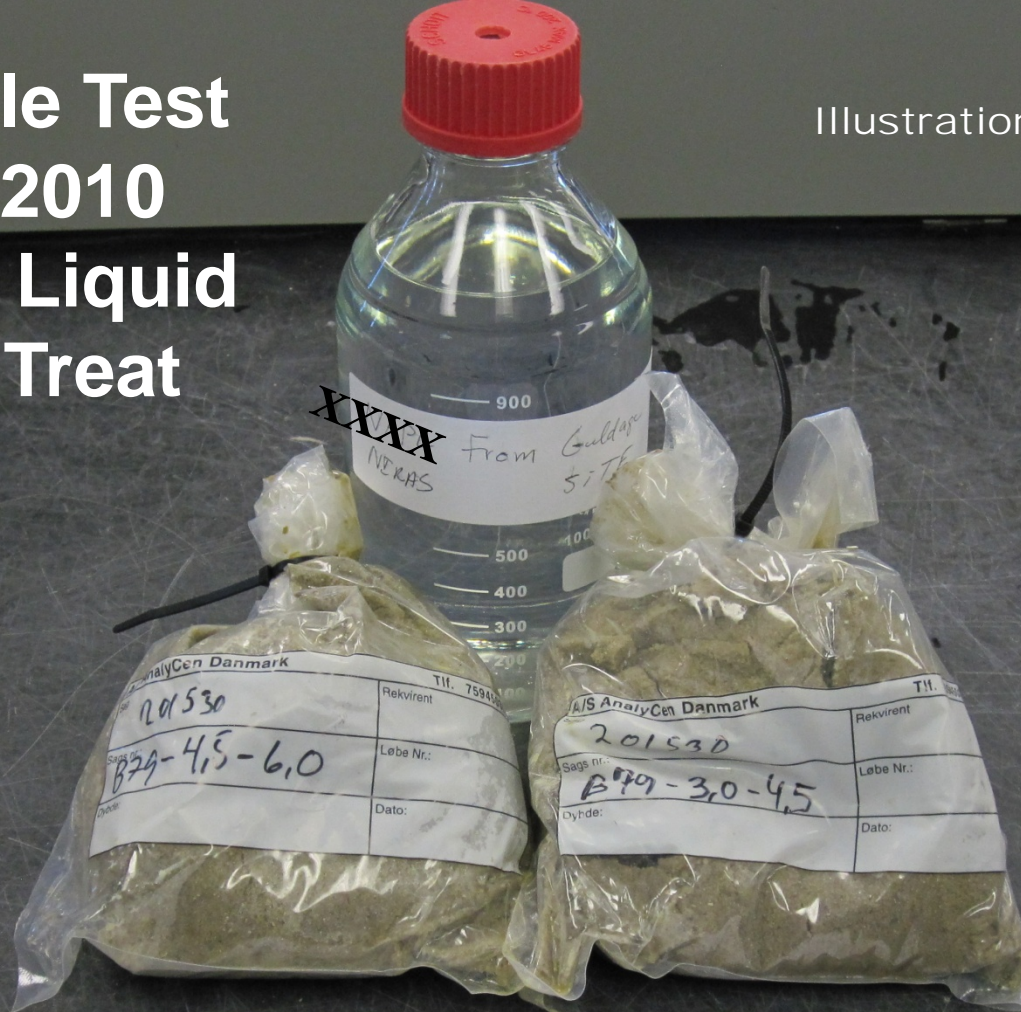


BENCH TO FULL SCALE SOIL WASHING CASE STUDIES



Bench Scale Test December 2010 Solids and Liquid Wastes To Treat

Illustration Purposes only



XXXXXXXXXX

Maxxam Analytics
4606 Canada Way

Burnaby, British Columbia
V5G4K5
CANADA

3. december 2010

TO MAXXAM ANALYTICS

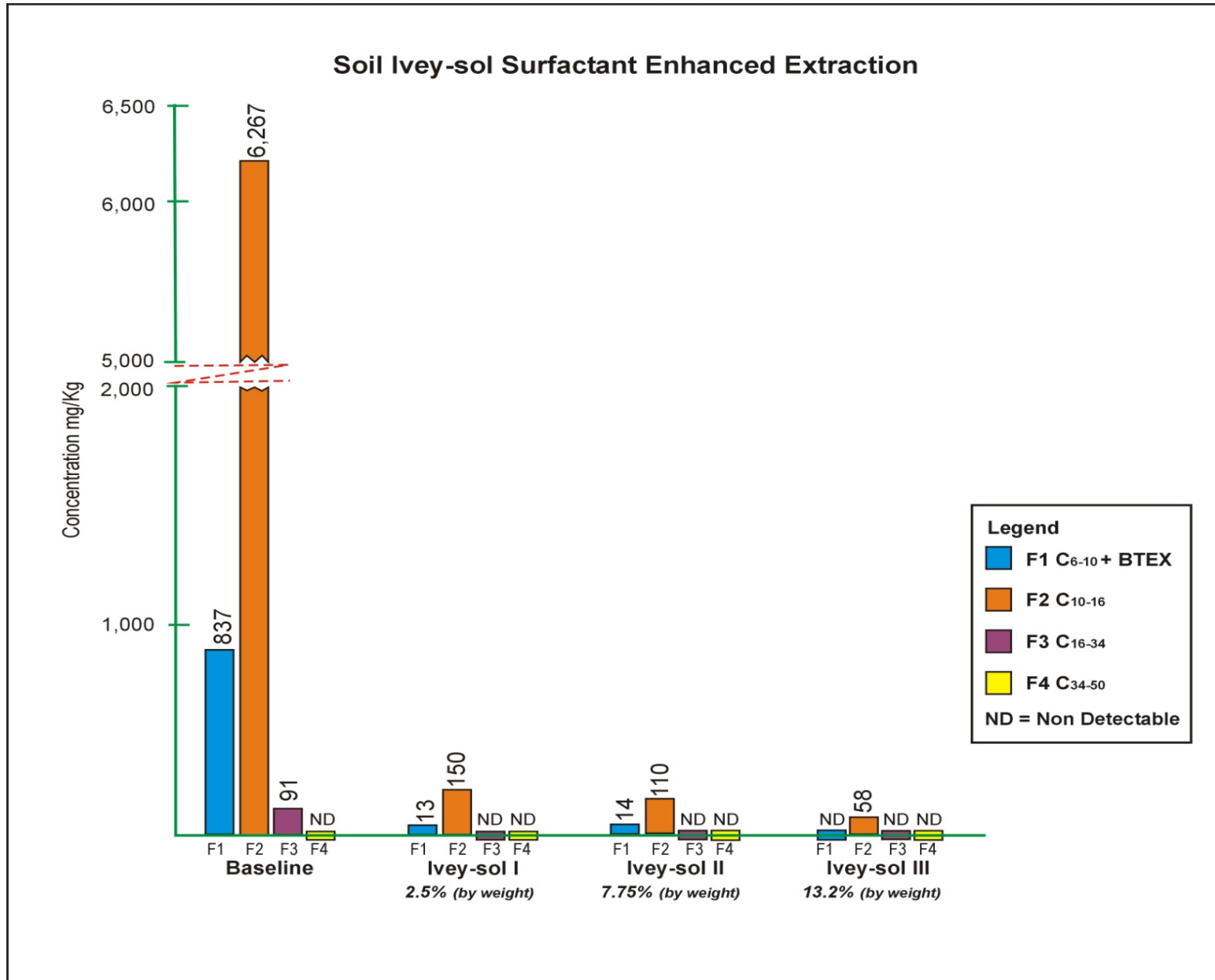
I agreement with Ivey-International Inc, George A. Ivey transmittes hereby geological material for bench scale study for In-situ remediation.

Søren Rygaard Lenschow, NIRAS

Telephone: +45 23215487



BENCH SCALE SER[®] SOIL WASHING RESULTS



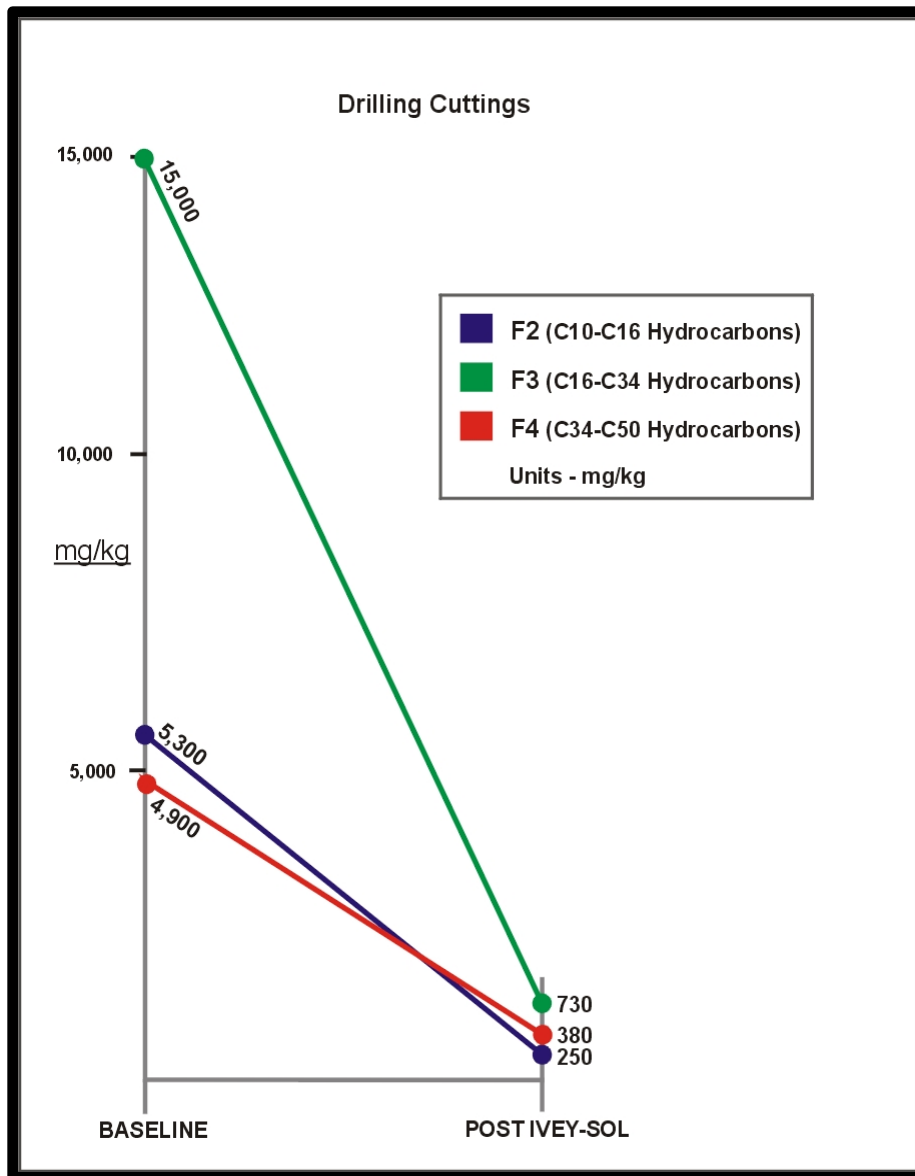
Summary Of Results

2.50% Ivey-sol [®]	F1 98.5%	F2 97.6%	F3 100%
7.75% Ivey-sol [®]	F1 98.3%	F2 98.2%	F3 100%
13.2% Ivey-sol [®]	F1 100 %	F2 99.1%	F3 100%

Hence Ivey-sol Was Very Effective



Drill Cuttings (25,200 ppm) - Alberta, Canada



Reduced the F2 to F4 concentrations significantly.

% Reductions were as follows:

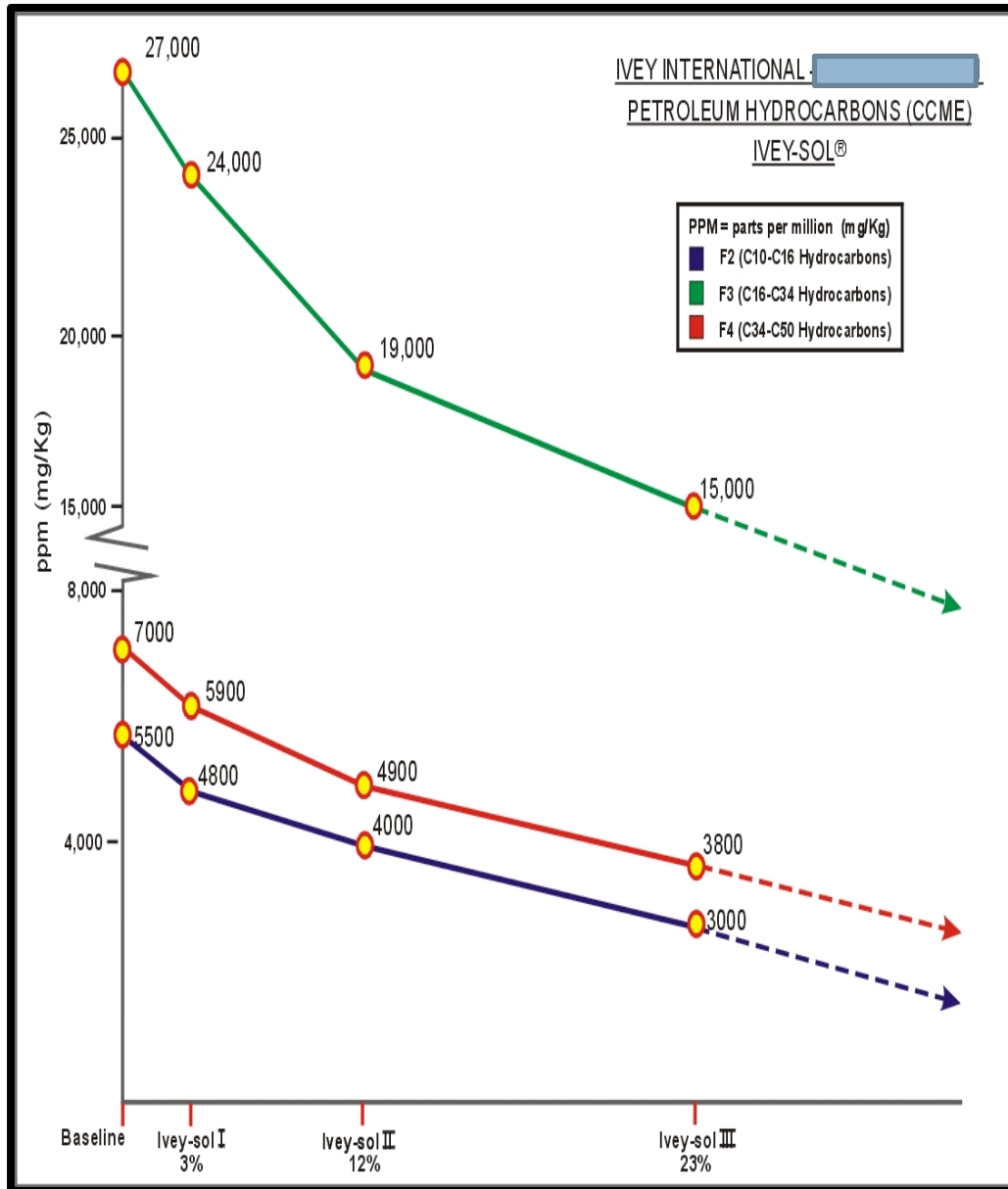
- F2 >95% (5300 to 250 ppm)
- F3 >95% (15,000 to 730)
- F4 >92% (4,900 to 380)

SOIL WASHING OF DRILLING CUTTINGS PRE - DURING - POST



Ca. August 2013 R&D

Drill Cuttings (39,500 ppm) - Columbia



Case Study Patagonia Argentina

Soil Washing
Pilot

Helping Local
Company In
Trouble...



Tank Bottom Sludge, Oil Field Spills,
Pipeline Spills, Crude Oil, Drill
Cutting, Drill Sludge etc...

RANGE 25,000 TO >100,000 ppm





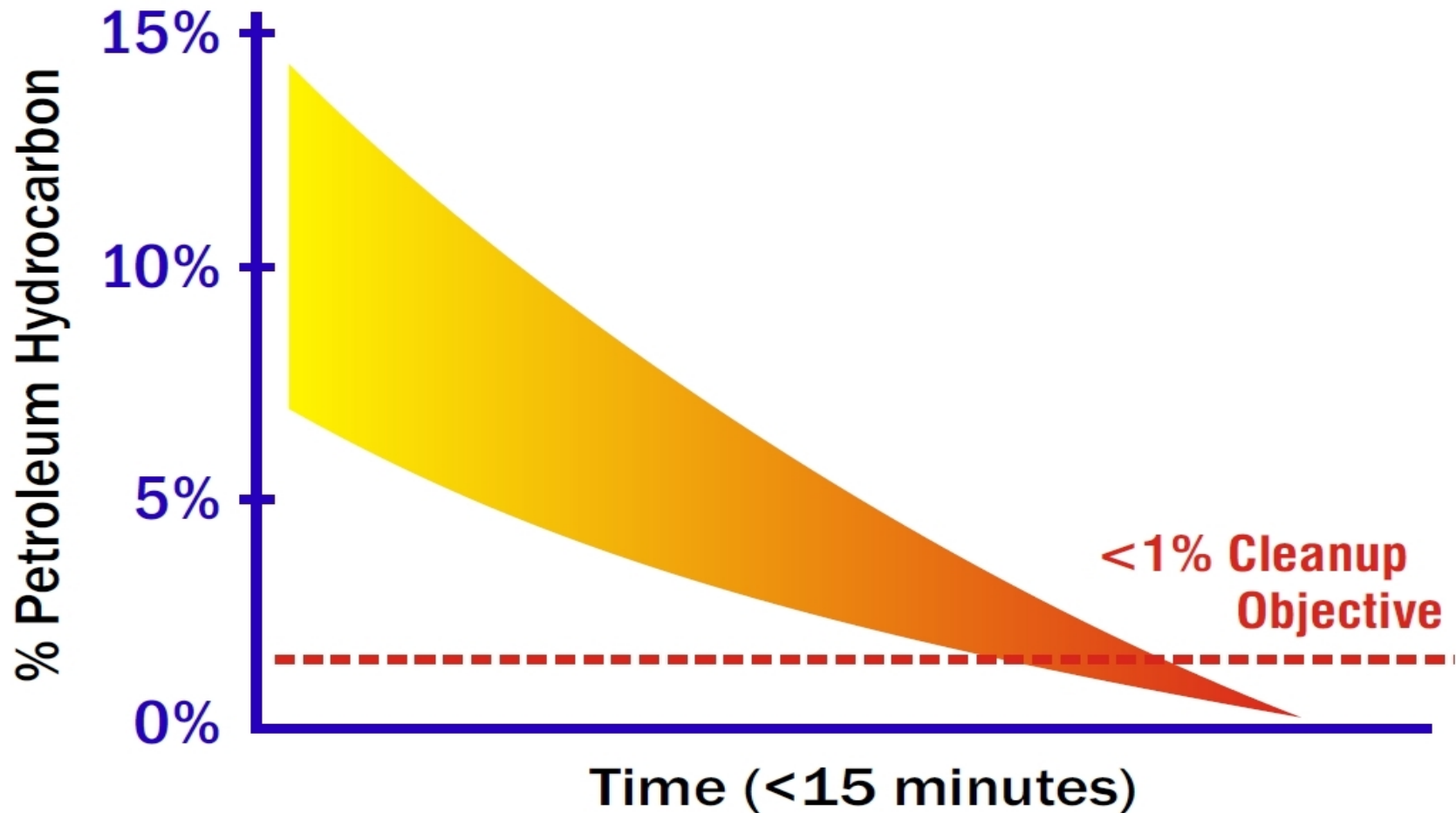


← **After Optimization
(No Water Rinse)**



**After Optimization
With Water Rinse →**

Ivey-sol Surfactants Can Achieved (<1%) National Oil & Gas Clean-up Objective



Note: 1% = 10,000 ppm



CONCLUSIONS

Surfactant Enhances Soil Washing (SESW) using Ivey-sol is an effective tool for remediation of high molecular weight petroleum contaminated soils;

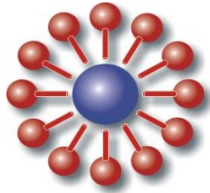
SESW is effective for treating drill cuttings;

SESW can potentially allow for oil recovery from waste water;

SESW is rapid and can achieve stringent regulatory standards domestically and internationally;

SESW is cost effective





Ivey International Inc.

“Today’s Environmental Solutions For A Better Tomorrow”

**George (Bud) Ivey, B.Sc., CES, CESA, P.Chem., EP
President and Senior Remediation Specialist
Ivey International Inc.**

BOOTH #3

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Time Permitting

Applied Case Studies

Soil Washing



600 TONS OF MGP SITE IMPACTED ROCK AUSTRALIA



Ex-Situ Soil Washing Treatment (600 Ton) From Class A (Hazardous) to Fill Criteria (Non Hazardous)



Western Canada Refinery Site



**Refinery Site Soil Contamination
30,000 to 45,000 ppm**





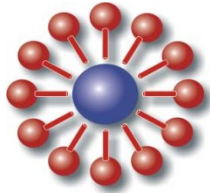
Western Canada Refinery Site

Contaminated soil with a baseline concentration of 40,000 ppm (4%). Ex-situ Ivey-sol Soil Washing SER Process achieved applicable soil remediation site objectives. Project data set provided below showing pre and post soil washing remediation results with time based sample analysis.

<u>Soil Parameter</u>	<u>Base Line</u>	<u>5 Minutes</u>	<u>7 minutes</u>	<u>Reductions</u>
F1 C6-10	72 ppm	< 1 ppm	< 1ppm	100%
F1 BTEX	71 ppm	< 1 ppm	< 1ppm	100%
F2 C10-16	417 ppm	35 ppm	21 ppm	95%
F3 C16-34	13, 600 ppm	1,600 ppm	826 ppm	94%
F4 C34-50	5,060 ppm	512 ppm	259 ppm	95%
F4 C34-50+	13,000 ppm	571 ppm	290 ppm	98%

Soil washing using Ivey-sol Surfactants achieved F1 to F4 and F4G clean-up objectives.





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