

# Ivey-sol Surfactant Enhanced '*Push-Pull*' Method For In-situ Remediation of Petroleum Hydrocarbons and Chlorinated Solvent Vapor, Soil, and Groundwater Contaminated Sites

Ivey-sol Remediation Presentation  
TerraCorrect bvba  
BELGIUM  
September 16-17, 2019M

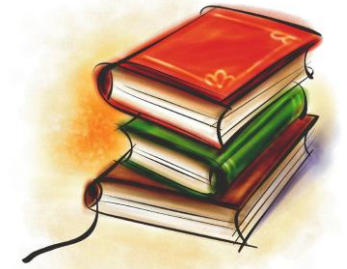
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**No Unwanted By-products or Impurities**  
**PFOA & PFOS (PFAS) FREE**  
**1,4 Dioxane Free**  
**Dioxins & Furan Free**  
**Non Detectable for all USEPA**  
**Regulated Compounds**

# Sorption Literature Reference



The growing concern regarding contaminant sorption, and its reduced availability for remediation, has been well cited in literature as demonstrated by the following quotation:

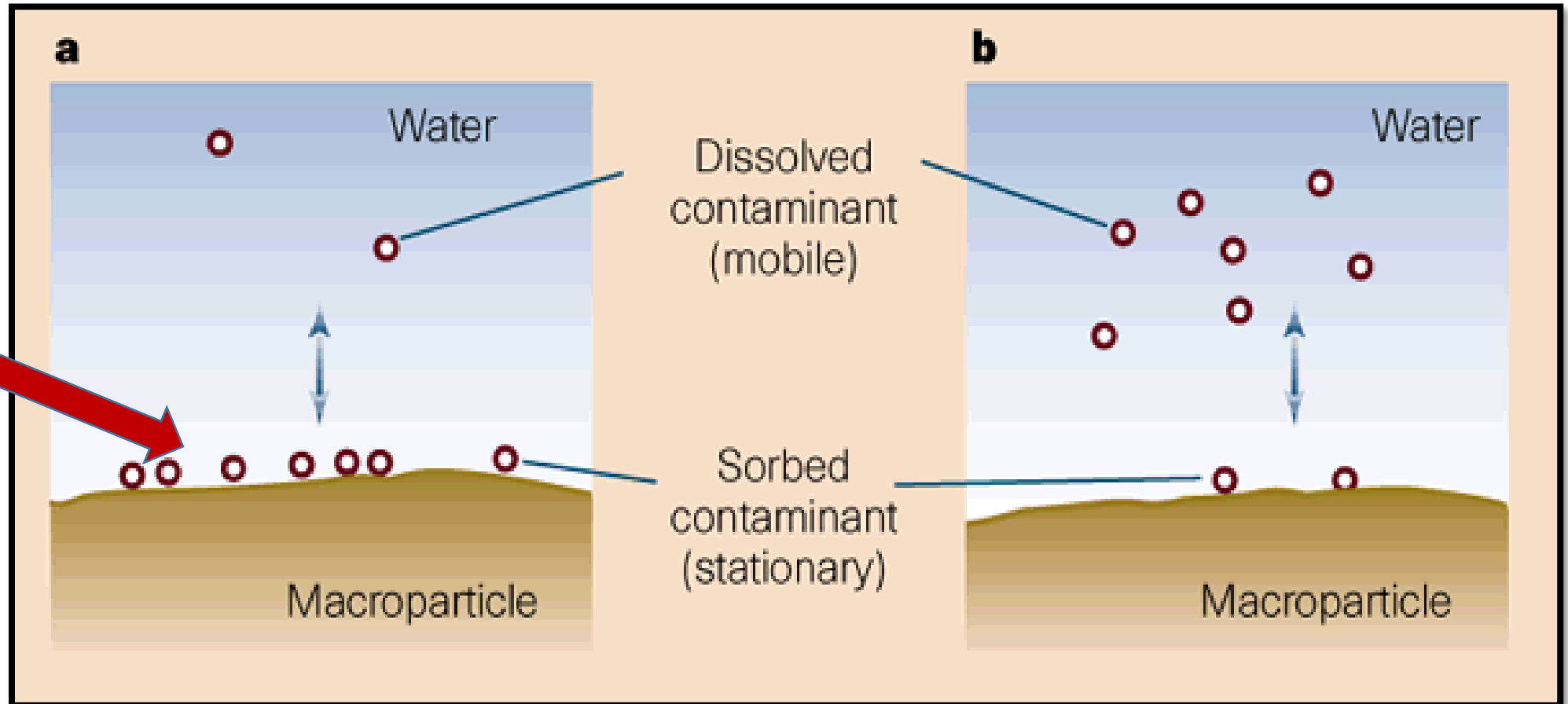
***“During the past decade, much discussion has centered on the unavailability of absorbed compounds to soil microorganisms; it is generally now assumed that desorption and diffusion of bound contaminants to the aqueous phase is required for microbial degradation.”***

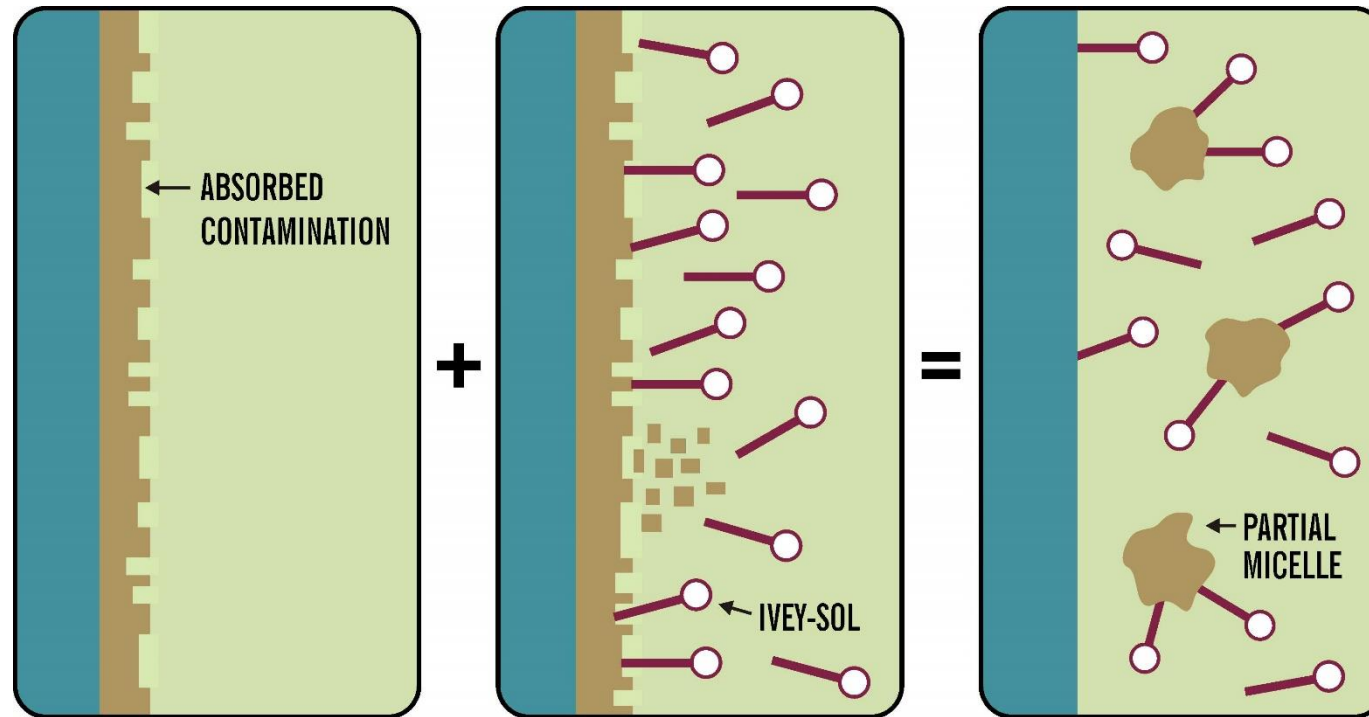
***(W.P. Inskeep, J.M. Wraith, C.G. Johnston, Hazardous Substance Research Center, 2005).***

# SORPTION

Hydrophobic organic chemicals exhibit limited solubility in groundwater. As a result the contaminants (Vapors, Dissolved, Sorbed, or NAPL) *Phase Partition* and sorb (i.e., absorb and adsorb) onto the soil or bedrock surfaces. This image shows how contaminant sorption negatively effects their Availability for Remediation.

**Sorbed With Limited Availability**





**Ivey-sol<sup>®</sup> mechanism is selective and works below the CMC**

Increasing Physical, Biological and Chemical Availability For Enhanced Remediation  
Biodegradable, pH Neutral, Non-toxic, Effect To Treat Broad Range of Contamination  
*(Peer Reviewed Journal Paper Available On Request Available)*

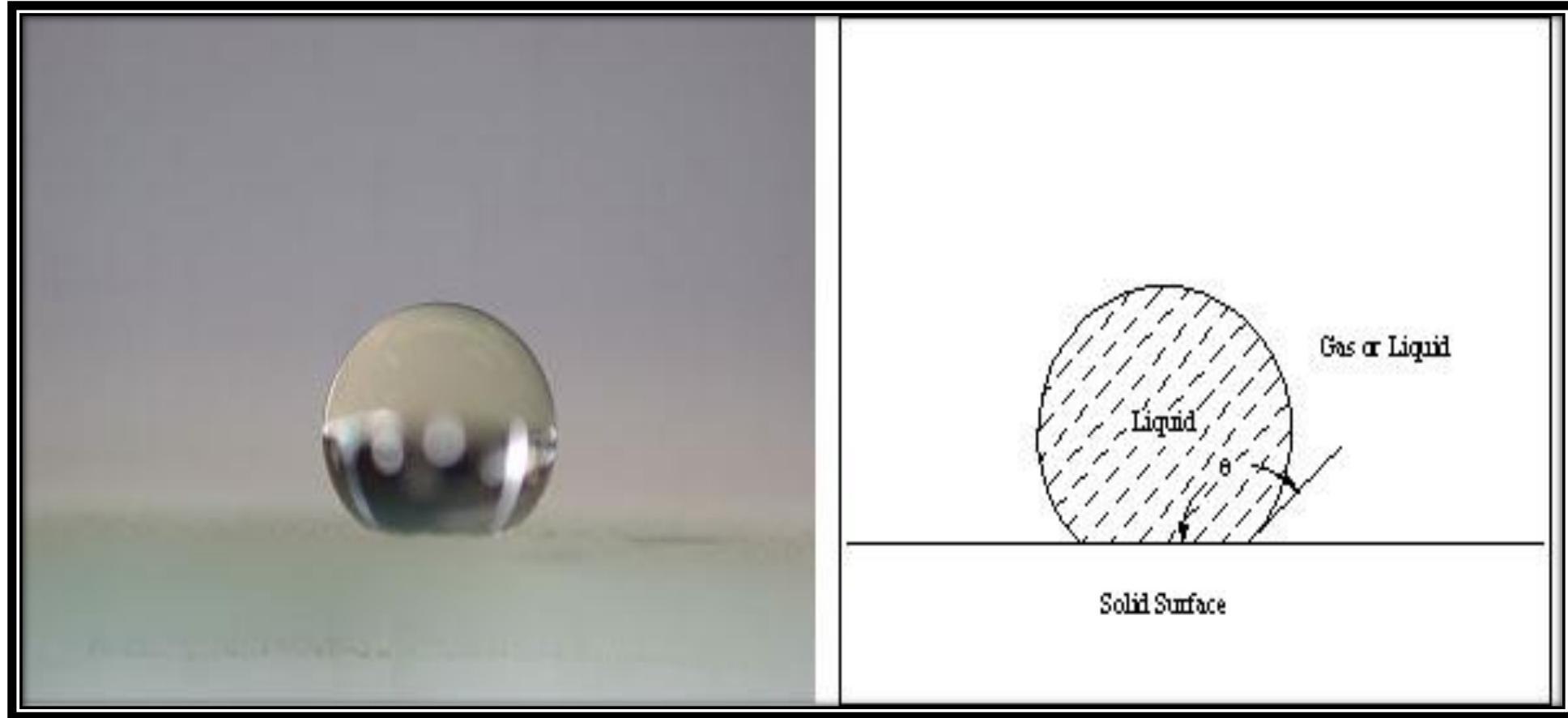


## Selective below the Critical Micelle Concentration (CMC)

- **Ivey-sol<sup>®</sup> 103**                      **BTEX, Jet Fuel, Gasoline**
- **Ivey-sol<sup>®</sup> 106**                      **Diesel (Light-Medium-Heavy), PAH's, Heating Oil**
- **Ivey-sol<sup>®</sup> 106 (CI)**                **Chlorinated Solvents**
- **Ivey-sol<sup>®</sup> 108**                      **Motor Oil, Lubricants, Bunker-C**
- **DECON-IT<sup>®</sup>**                        **Equipment Decontamination Product**

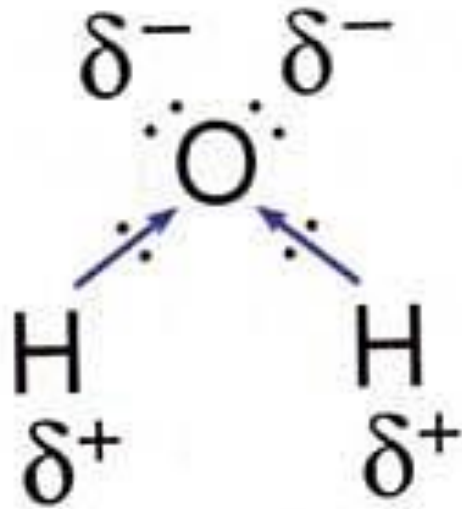
***Can Dilute 1:50+ With Water So A Little Goes A Long Way***

# To Understand 'K' Ask What Is **Water** ?

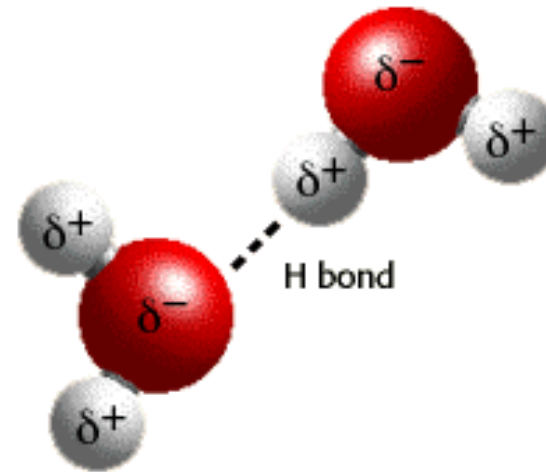


~~It's H<sub>2</sub>O~~

# Hydrogen Bonding

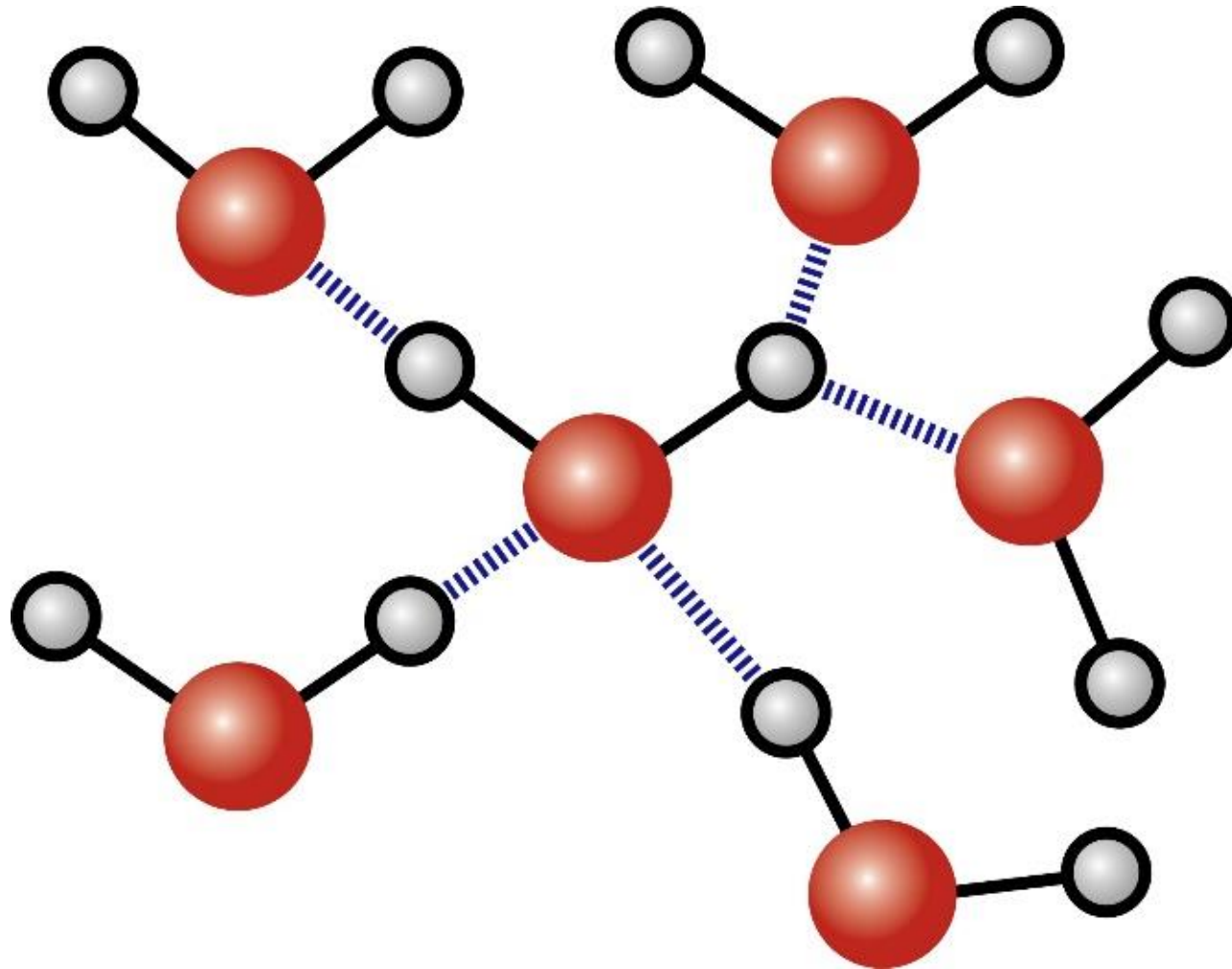


Hydrogen bonding  
between water molecules





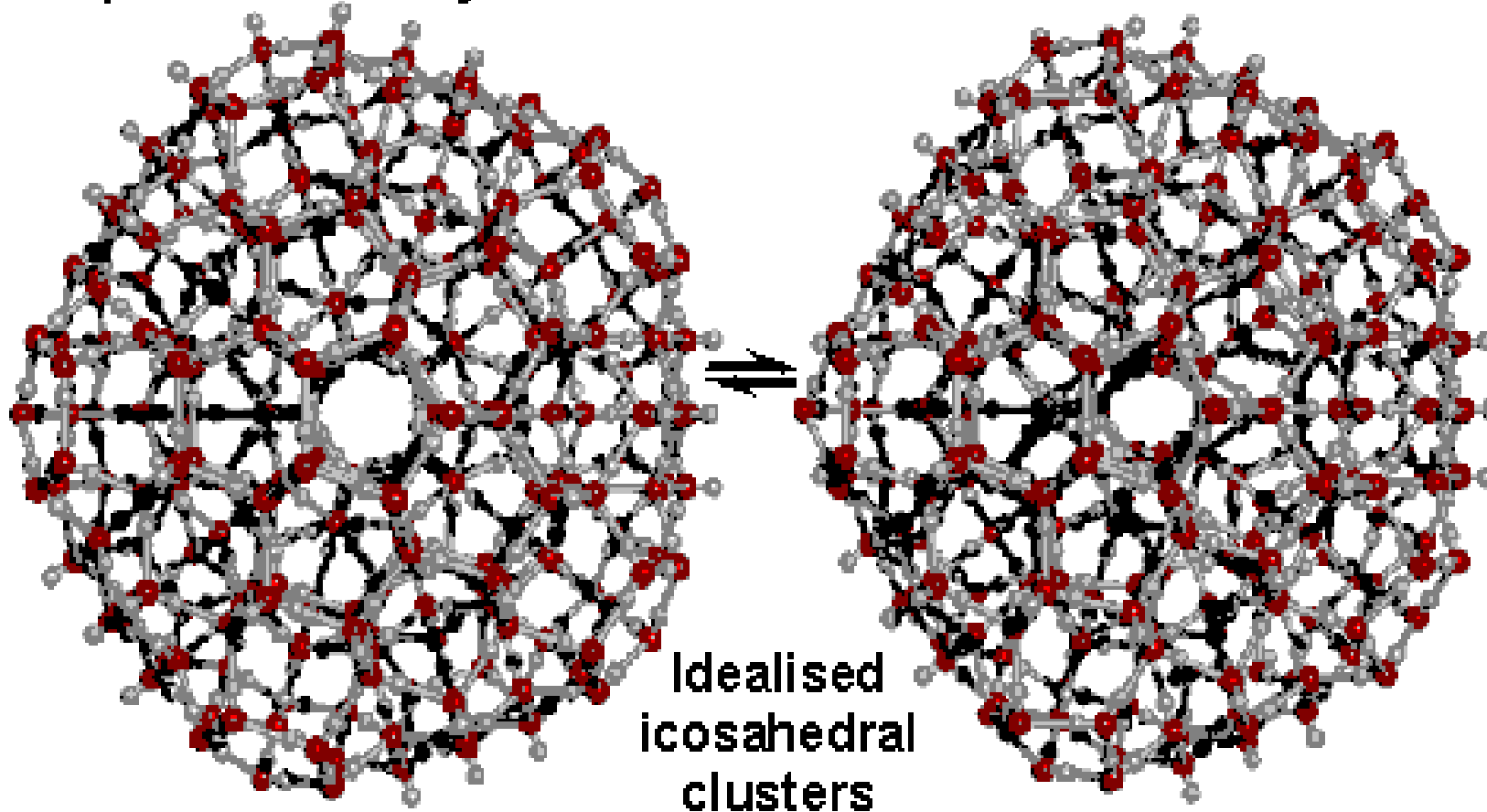
# Hydrogen Bonding Expanded



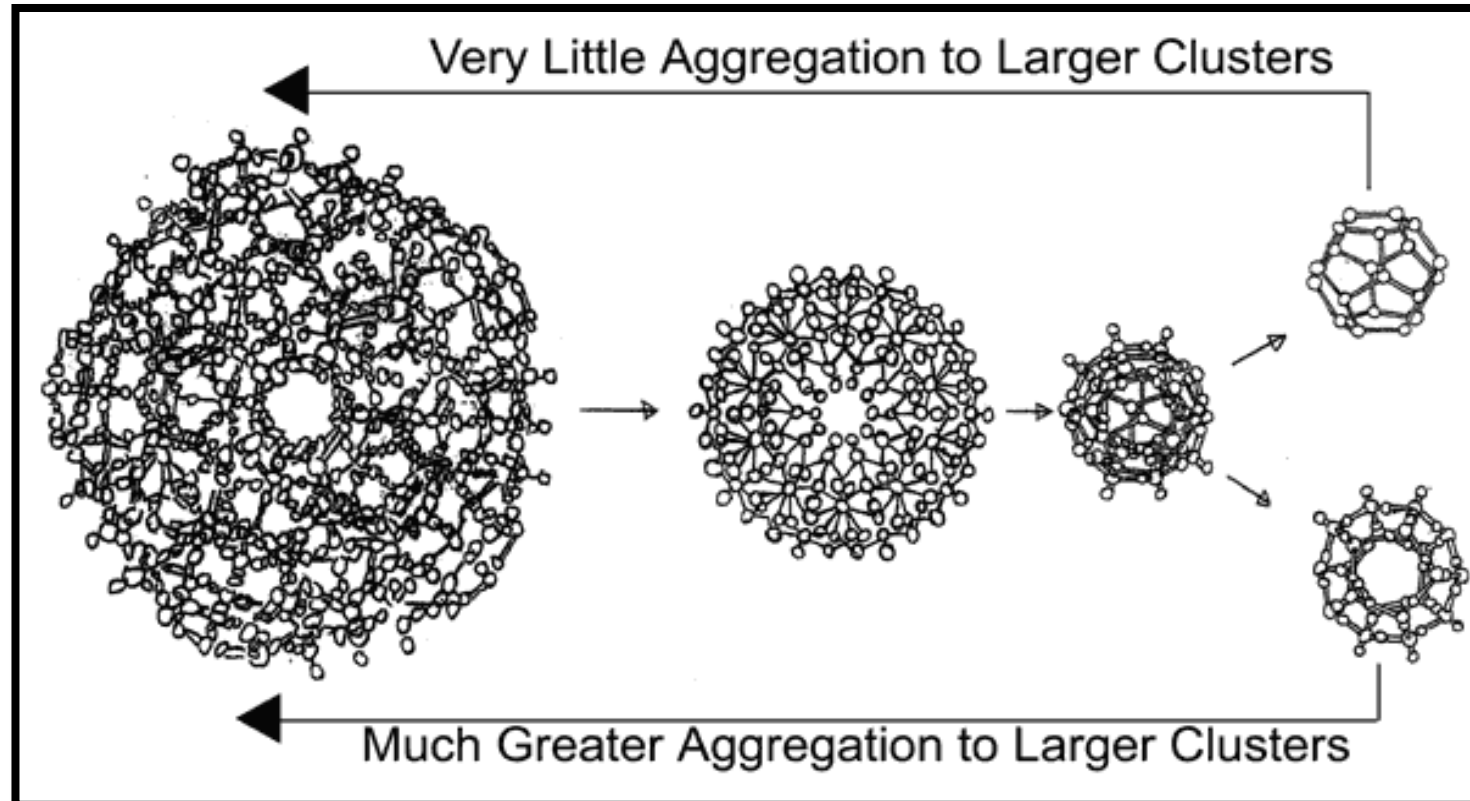
**Water Is Actually A 3-Demensional 'Cluster' - With Surface Tension of 73 Dynes  
The Cluster Size Limits Water's Ability To Mover Through Finer Soil Geology  
Ivey-sol Can Make Clusters Smaller (*Lower Surface Tension < 30 Dynes*) So Moves  
Through Geology More Easily**

Open low density structure

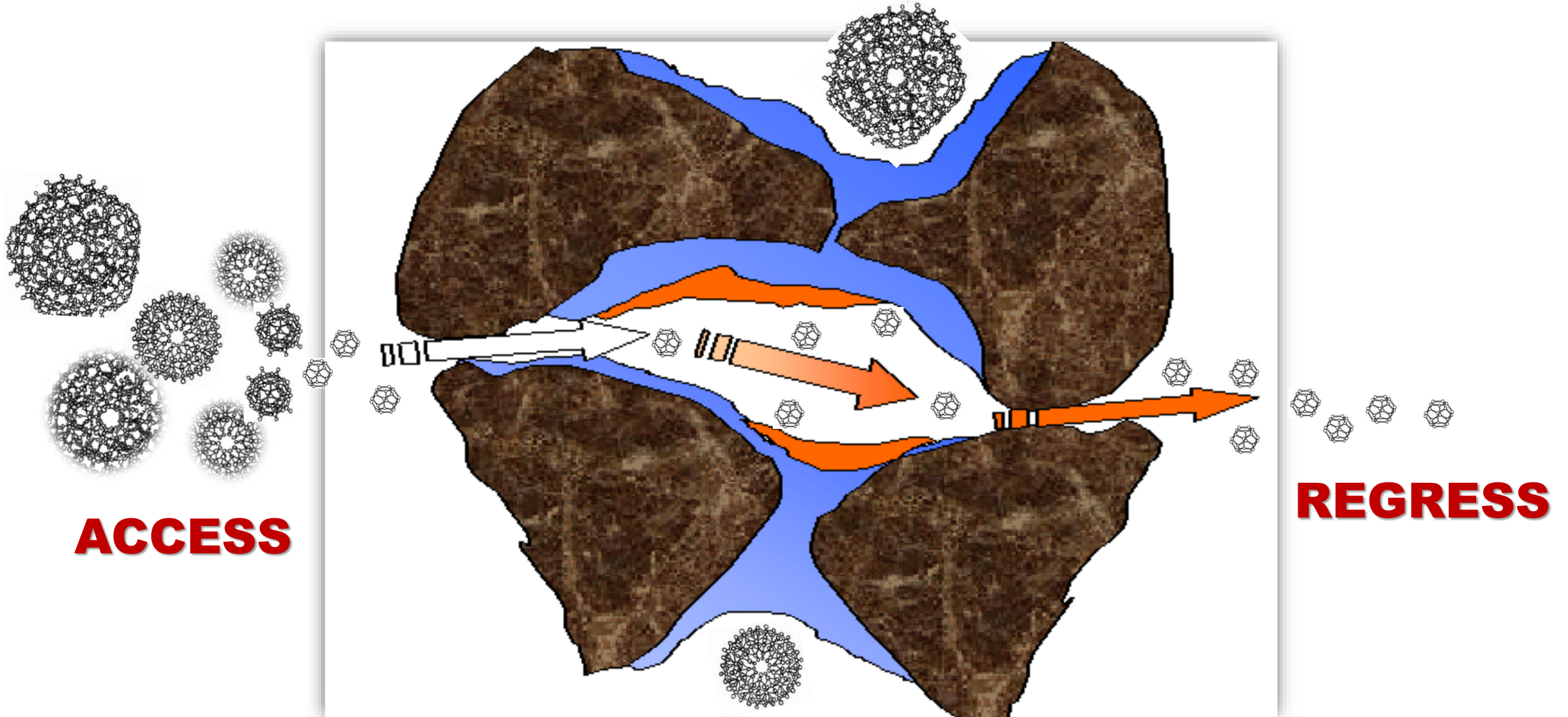
Condensed structure



**Ivey-sol Reduces The Size of Water Cluster  
(Lower Surface Tension from 73 Dynes to < 30 dynes)  
For Fine Grain Soil Textures Applications Improving K**



# Over Coming Low K and Retardation In Fine Grain Geology Allowing Access & Regress



Ivey International, Inc.  
**Ivey-sol<sup>®</sup> Injection and Diffusion Radius**



# Surfactant Enhanced Recovery of Separate-Phase Petroleum Hydrocarbons

Sunnyside Yard, Queens, New York

Presented by:

Richard Mohlenhoff, P.E. (Amtrak)

Charlie McGuckin, P.E. (Roux Associates)

# Site History

- Located in Sunnyside Yard, Queens, New York
- Over 100 years of service
- State Superfund Site
- Six Operable Units (OUs)
- 130 acre Site
- OU-3 LNAPL and PCB Plume



# OU-3 Record of Decision

## Cleanup Standards

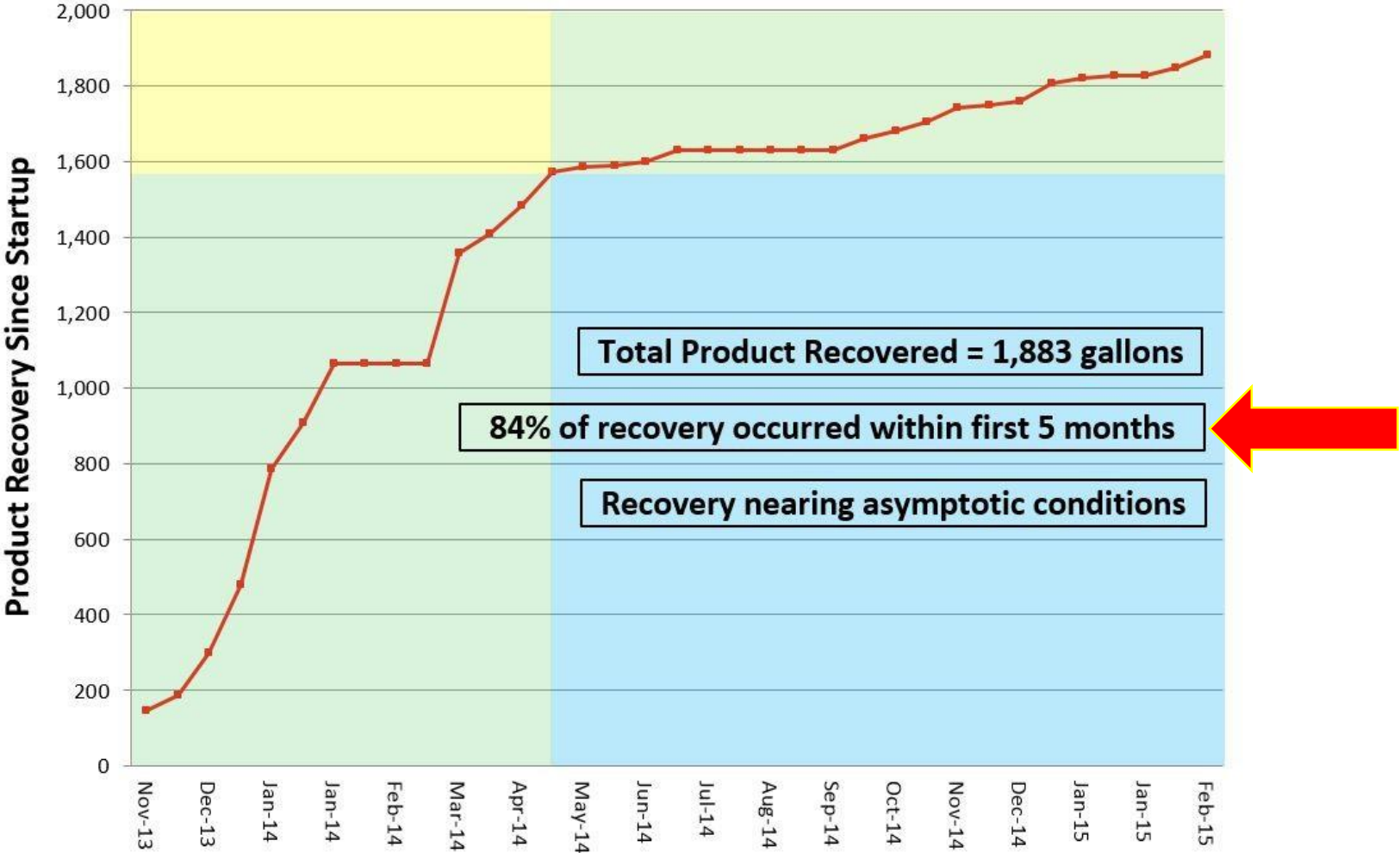
- PCBs < 25ppm
- Lead < 3,900 ppm
- cPAHs < 25 ppm (total of 7 compounds)
- SVOCs < 500 ppm
- LNAPL thickness < 0.1 foot





# DPVE System Performance

## Cumulative Product Recovery Over Time



# Ivey-sol<sup>®</sup> Surfactant Technology

- Composition
  - Several patented non-ionic surfactant formulations
- Applications
  - Desorb and liberate free-phase LNAPL and/or sorbed petroleum hydrocarbons
- Mechanism
  - Makes the contaminants more miscible in the aqueous phase, increasing the “physical availability”
- Additional Uses
  - Enhances bioremediation

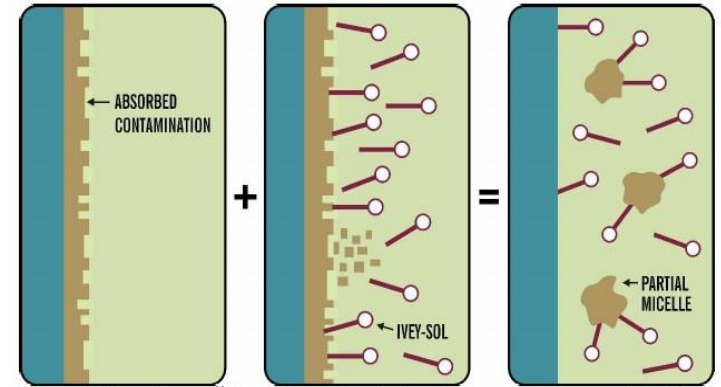
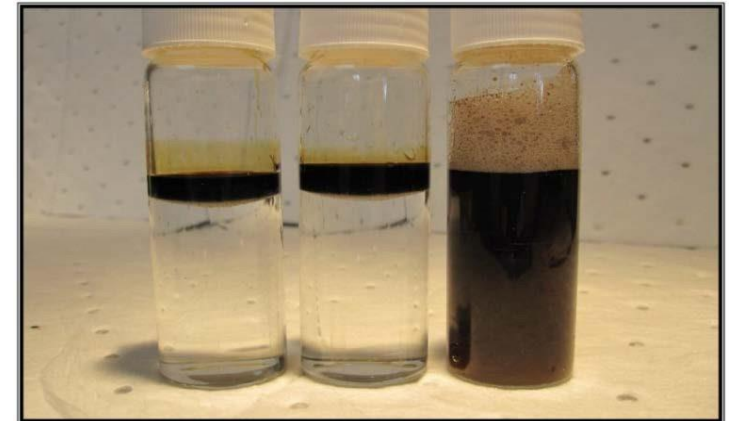
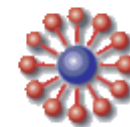


Figure 2-2: Ivey-sol<sup>®</sup> desorbing contamination off the soil surfaces, or NAPL layer making it more ‘Available’ for in-situ or ex-situ remediation.

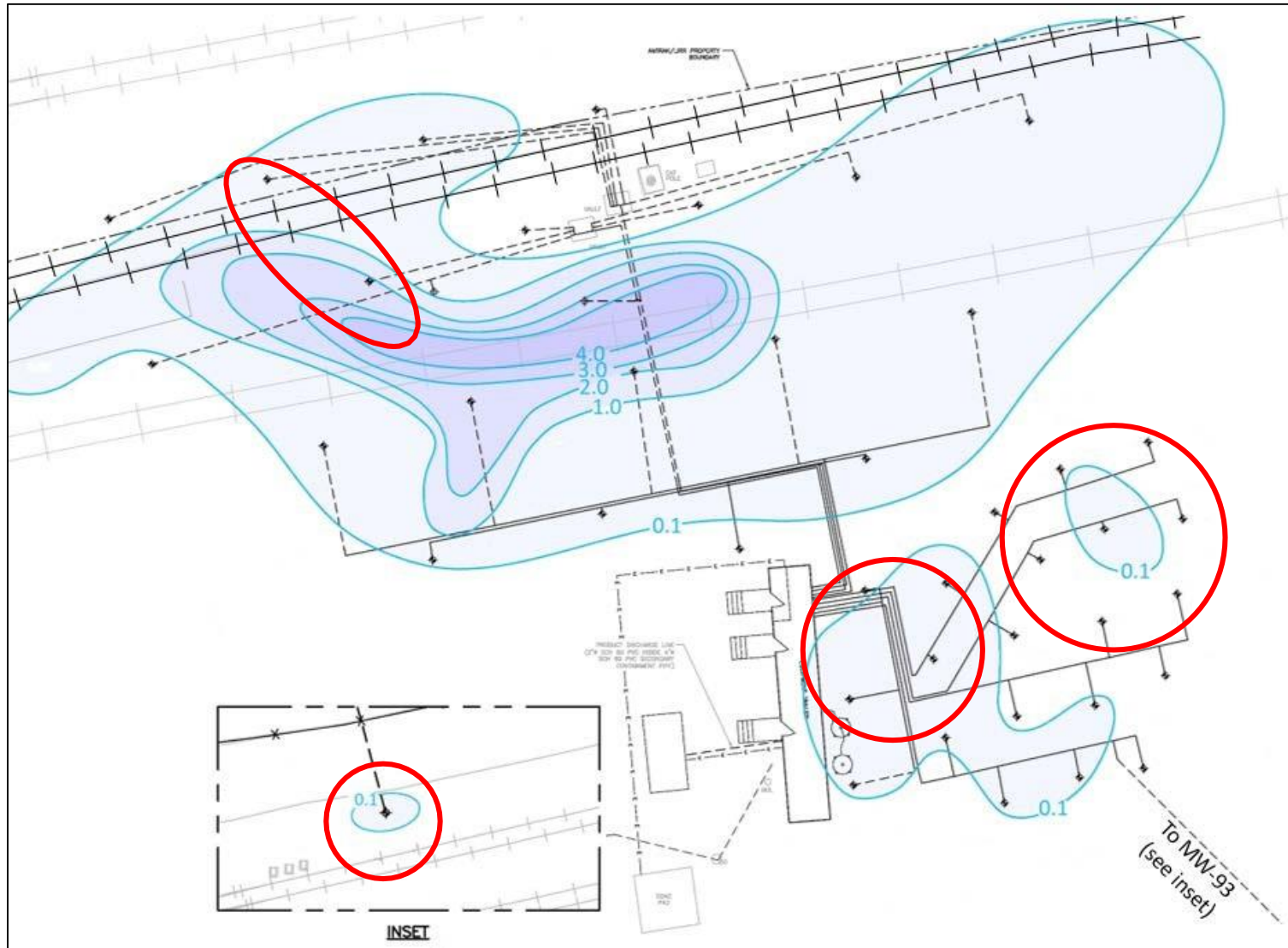


Photograph 2-2: Pre-post Ivey-sol<sup>®</sup> Free NAPL Product Remediation



**Ivey International Inc.**  
“Today’s Environmental Solutions For A Better Tomorrow”™

# Injection Areas 8 Wells



# Pilot Study Methods

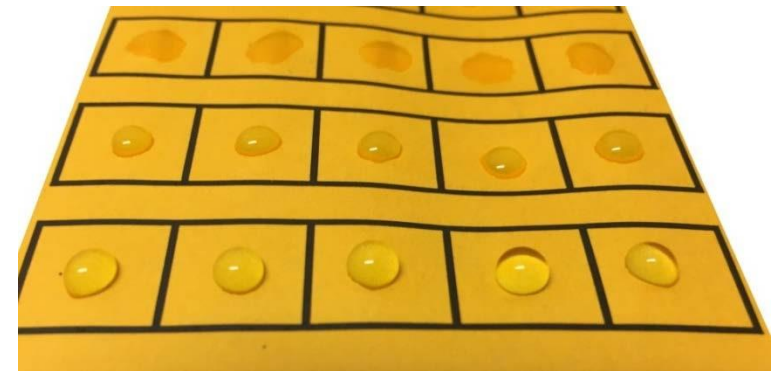
## 1. Injection (gravity fed/geoprobe)

- Experimented with surfactant to water ratios
- Experimented with volumes of total mixture

## 2. Extraction (DPVE system)

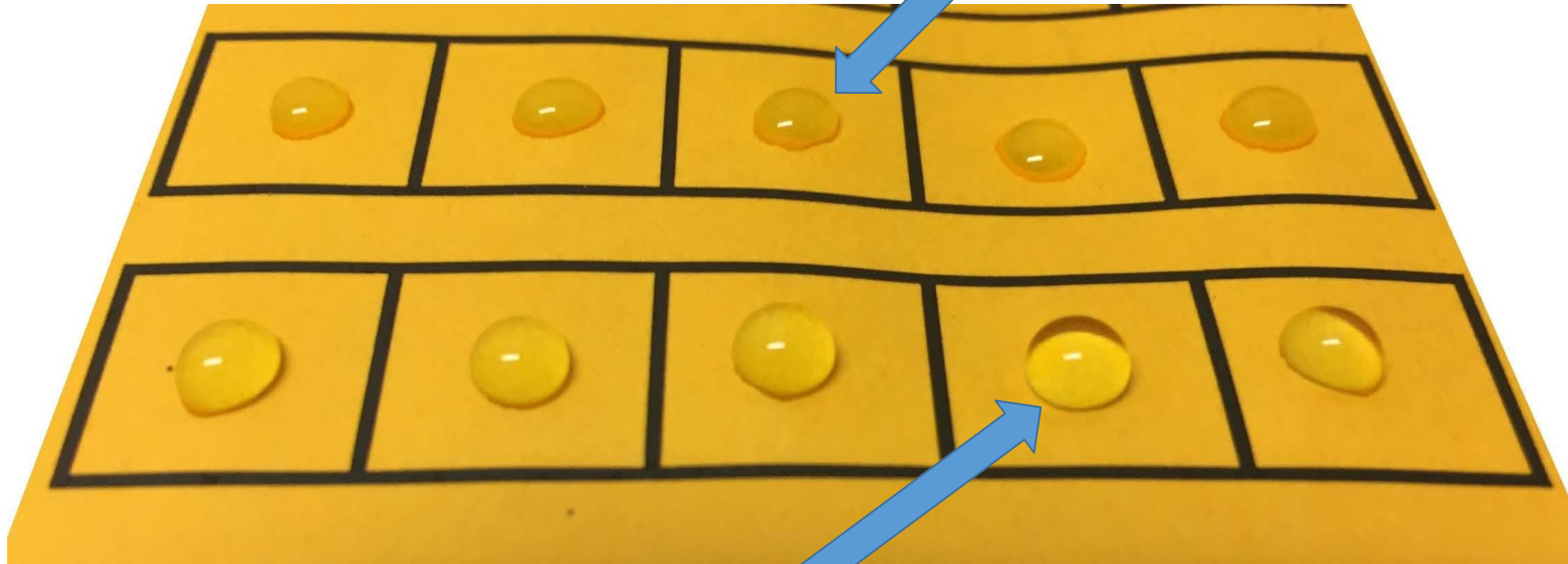
- Removed at least 3x the injection volume
- Continued extraction until no surfactant was present

## 3. Extract from injection point or nearby extraction well



## Water mixed with Surfactant

Irregular edges Loses its beading and Absorbed by the paper

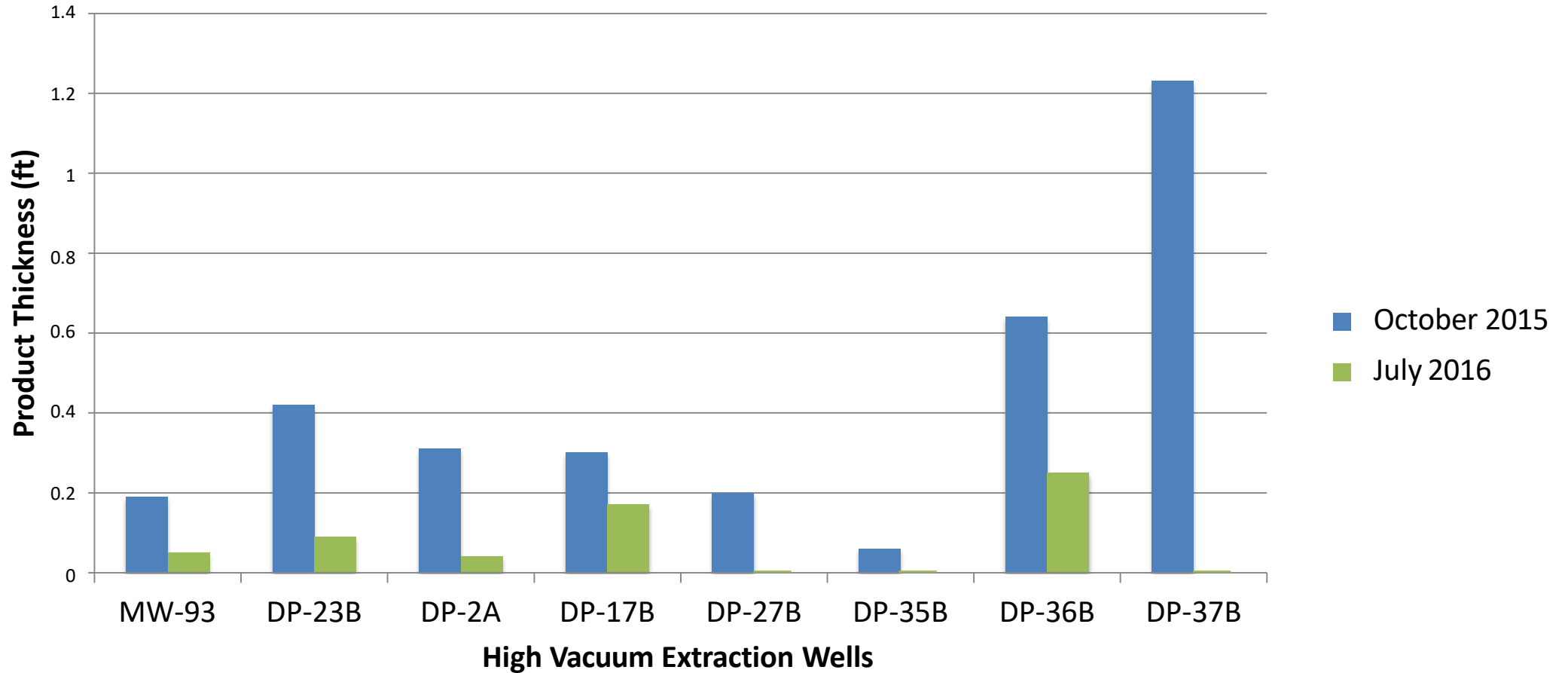


## Water free of Surfactant

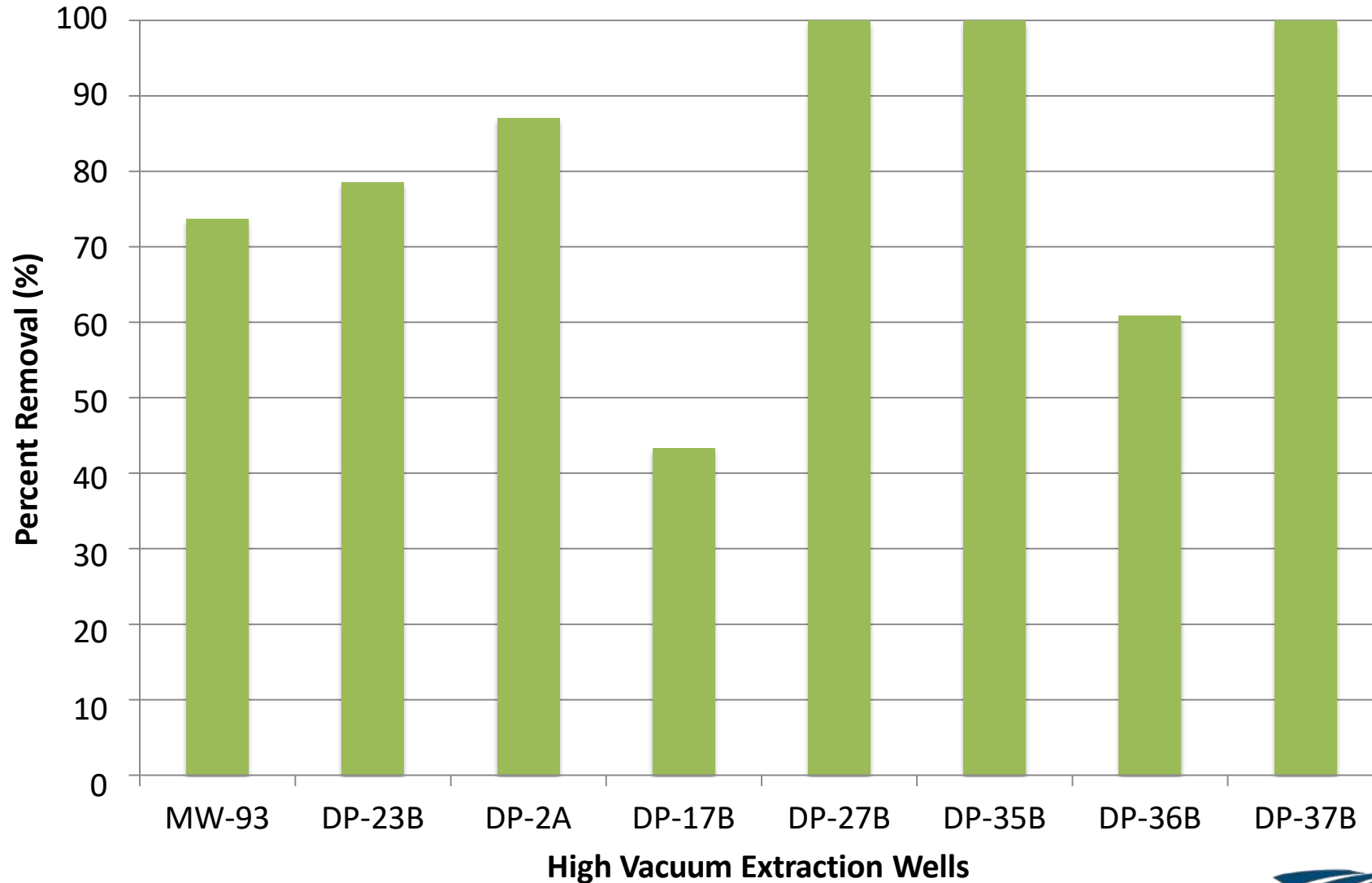
Forms near-perfect circles  
Retains its beading Does  
Not absorb into the paper

# Pilot Study Results

## Product Thickness, Before and After



# Free Product (NAPL) Percent Removal





# Conclusions

- SPH recovery was enhanced by the increase of SPH solubility with 41% to 100% removal and 81% average after 1 week.
- Free product was not observed in the extracted groundwater
- Reduction of SPH thickness was usually observed within 24 hours of surfactant injection and persisted for several weeks or longer
- Low concentration ratios of surfactant (1:25 to 1:50) are effective and higher concentrations do not increase effectiveness
- Low injection volumes or injection rates were generally needed in OU-3 due to the low permeability soil conditions and high groundwater table



# Its Stress-free To For Us To Evaluate Your Site

## 1-Pager Writable Form

**Free Site Evaluation**



Ivey International Inc.  
 Suite 61-2955-156 St,  
 Surrey, BC, Canada V3S 2W8  
 Tel: 1-800-246-2744  
 Fax: 1-888-640-3622  
 Email: budivey@iveyinternational.com

### General Site Information Form

#### Client Information

Date: \_\_\_\_\_ Ivey Contact: \_\_\_\_\_  
 Company name: \_\_\_\_\_ Contact Person: \_\_\_\_\_  
 Email: \_\_\_\_\_ Phone: \_\_\_\_\_  
 Fax: \_\_\_\_\_ Cellular: \_\_\_\_\_  
 Street address: \_\_\_\_\_  
 Shipping address: \_\_\_\_\_

#### Project Information:

Project Name: \_\_\_\_\_  
 Project Location: \_\_\_\_\_  
 Project Number: \_\_\_\_\_  
 Regulatory Agency: \_\_\_\_\_  
 Land Use and Zoning (Circle):  Parkland  Agricultural  Residential  Commercial  Industrial

#### Site Information:

Remediation Objectives: \_\_\_\_\_  
 Contaminant(s) of concern (TPH, BTEX, TCE, PCB, etc.) \_\_\_\_\_  
 Soil Impacted: Yes / No Groundwater Impacted: Yes / No Vapor Impacts: Yes / No  
 Is NAPL Present: \_\_\_\_\_ Time Since Release: \_\_\_\_\_  
 Soil Type(s): \_\_\_\_\_ Soil Porosity: \_\_\_\_\_  
 Depth to Groundwater: \_\_\_\_\_ Hydraulic Conductivity (K): \_\_\_\_\_  
 Hydraulic Gradient: \_\_\_\_\_ Groundwater Flow Direction: \_\_\_\_\_  
 Area of Contamination: \_\_\_\_\_ Maximum Depth of Contamination: \_\_\_\_\_  
 Current Remediation Activities: \_\_\_\_\_

#### Monitoring Well Network Information:

Number of Existing or Proposed Monitoring Wells: \_\_\_\_\_  
 Number of Proposed Injection Wells: \_\_\_\_\_  
 Number of Proposed Extraction Wells: \_\_\_\_\_

#### Please Provide the Following:

- Site location map or drawing
- Site map showing source/treatment area and isoconcentration contours (if available)
- Site map showing monitoring and injection well locations and ROI estimates
- Table summarizing well construction details and GW level history
- Pilot test results (if available)
- Geologic cross section
- Copy of laboratory analytical results or summary table of contaminants of concern
- Site photographs
- Site investigation report

Please complete this site information form and return to: [budivey@iveyinternational.com](mailto:budivey@iveyinternational.com)

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# CONTACT INFORMATION

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