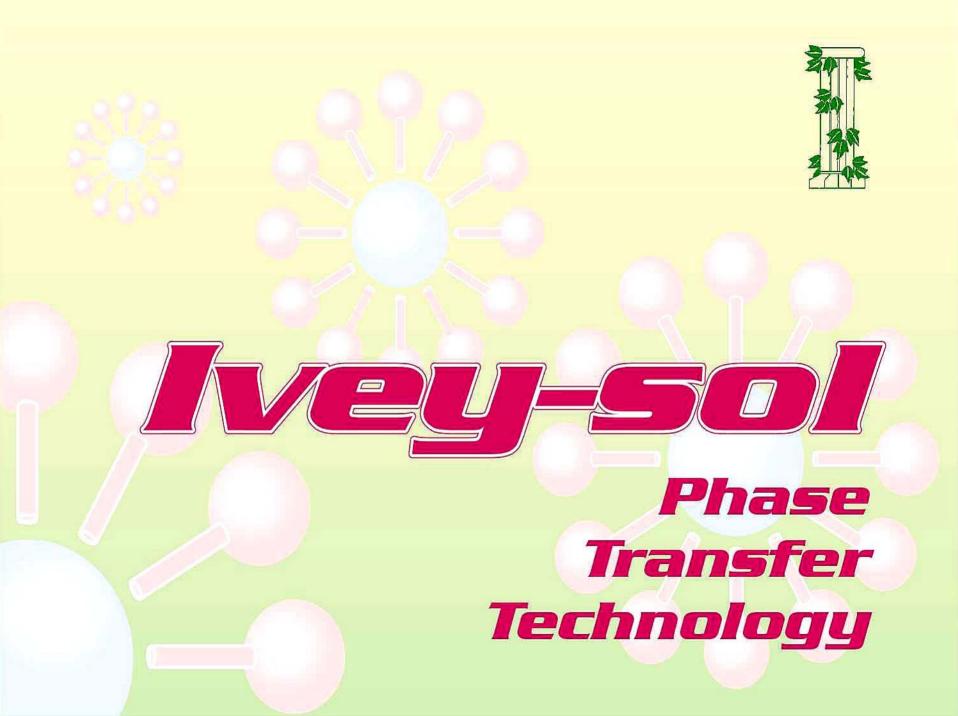


INTERNATIONAL INC.

Today's Environmental Solutions For A Better Tomorrow.





FACT

90 to 95 % of All Contaminants Are Absorbed To Soil Particles In Soil and Groundwater

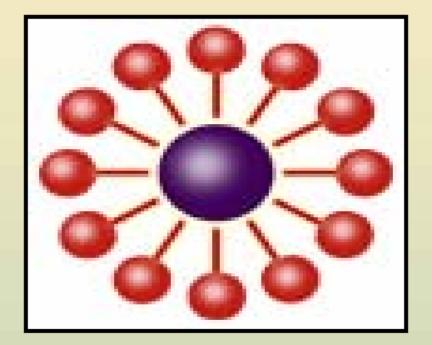
Absorption Limits Availability of Contamination For

- Removal by <u>Pump and Treatment;</u>
- Availability for <u>Bioremediation</u>;
- Availability for <u>Oxidative</u> and or <u>Reductive</u> <u>Chemical Treatment</u>

Ivey-sol Desorbs Contamination Improving The Above Remediation Methods

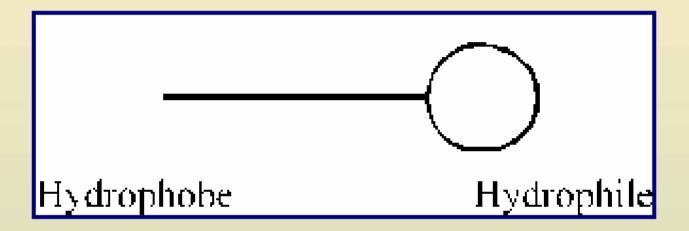
- **Selective Phase Transfer Technology SPTT®**
 - **Overview of Presentation:**
 - i) General Facts
 - ii) How It Works (SAA Selectivity)
 - iii) In-situ & Ex-situ Applications
 - iv) NAPL Range (TPH, MTBE, PCB, PAH, TCE, PCE, Metals)
 - v) Case Studies (In-situ, Ex-situ, and Commercial)
 - vi) Questions & Answer Period
 - vii) How To Contact Us





Micelle Encapsulated Oil Droplet Typical View of Surfactants





Surfactant Chemical Structure

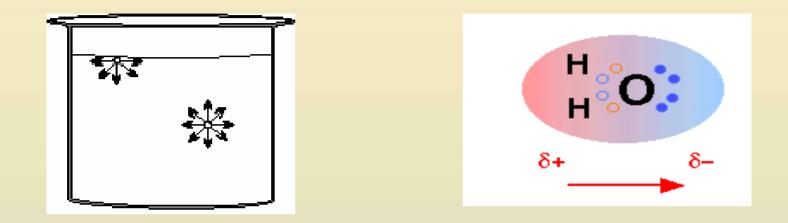
Hydrophilic (water loving) and Hydrophobic (water hating oil-liking) Groupings Allow For Surface Interaction With Many Contaminants



Classes Of Surfactants

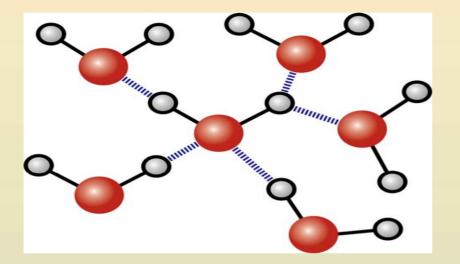
Anionic: They have one or more negatively charged groupings. They have very good detergent ability and are commonly used as **laundry detergent**.

- <u>Cationic</u>: They have one or more positively charged groupings. They typically have poor detergency, but are well suited for use as germicides, fabric softeners, and emulsifiers.
- Non-ionic: As their name implies, they have no ionic constituents or groupings. They are the largest single group of SAA and have a correspondingly wide range of chemical characteristics and application. Ivey-sol surfactant mixtures, are nonionic and have the unique ability to selectively dissolve LNAPL's, DNAPL's, polycyclic aromatic hydrocarbons (PAH's), poly chlorinated byphenols (PCB), dichloroethane (DCE), trichloroethane (TCE), perchloroethylene (PCE), NORM's and metals.
- **Amphoteric**: They contain both anionic and cationic groupings and have the characteristics of both anionic and cationic SAA. They work well at neutral pH and are found in products such as **hair shampoo**, **skin cleaners**, **and carpet shampoo**.



Surface Tension Forces ShownPolar Water MoleculePulling Water Together{Oxygen (ζ-) Hydrogen (ζ+)}

Surface Tension In Water: Is Caused By The Attractive Forces Between Neighbouring H_2O molecules. The oxygen (-) in one water molecule is attracted to the hydrogen (+) atoms in the neighbouring water molecules. Forming "Hydrogen-Bonding"



H = 0 H =

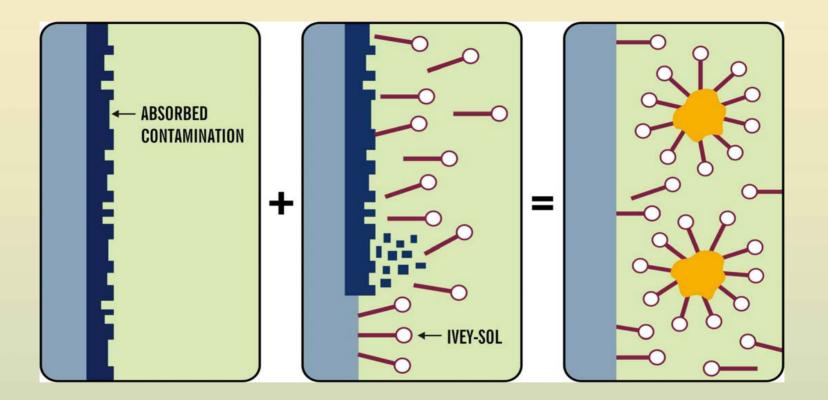
Hydrogen Bonding Between Polar Water Molecules (*in-blue*) Pulling Water Together Between Neighbouring H₂O.

Water Clusters Can Form Form As A Result That Range In Size & Complexity

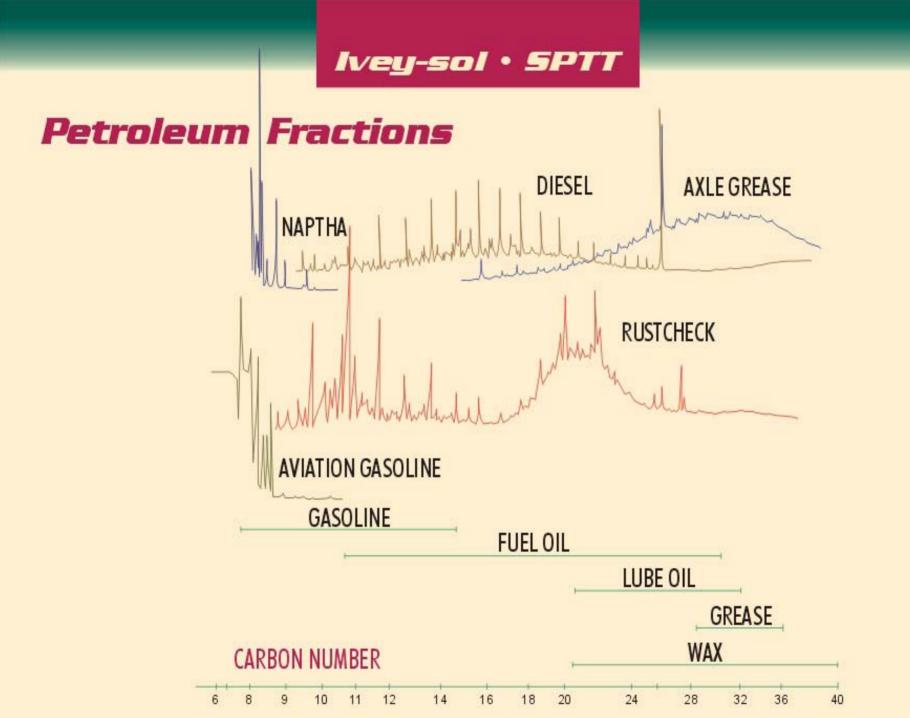
<u>Hydrogen Bonding</u> Is What Gives Rise To The Insolubility Of Non-Polar NAPL Compounds, And Why the Hydrophilic (*Water Liking*) End Of The Ivey-sol Molecules Are So Effective In Rendering The NAPL Compounds Miscible In Water.

Ivey-sol Lowers The Surface Tension of Water From 72 Dynes to <30 dynes

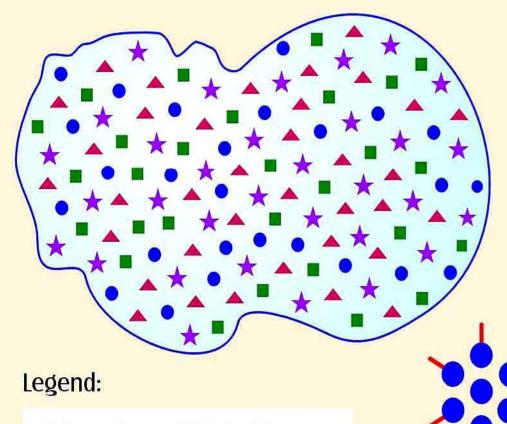
This increases the wetting ability of the water when present, making Ivey-sol[®] application possible in fine grain soils improving apparent permeability (K).



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



Selective Micelle Encapsulation of Contamination



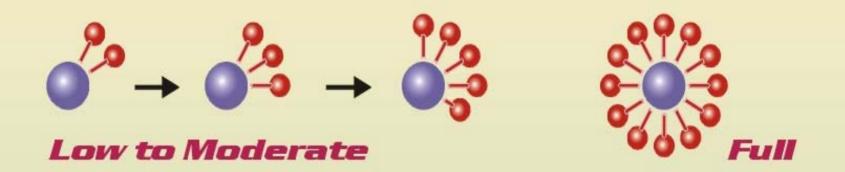
Cyclic Alkanes

A PAHs

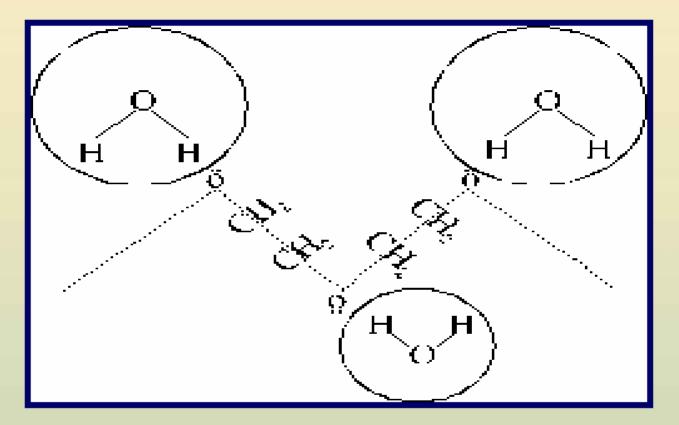
- Selective Micelle Formation
- Encapsulation and increased solubility
- Applicable for full LNAPL and PAH range
- Ivey-sol mixture is taylored to type/range of contamination being treated



Encapsulation Effects



- Liberation of contamination can be effected with low to moderate encapsulation. Hence, low SPTT concentrations are effective.
- Solution As partial encapsulation is predominant due to injection concentrations, no negative effects are realized at the treatment system (e.g., GAC, Air Stripping, Bio-Reactors, Membrane Separation, etc.)



Ivey-sol's Hydrophilic Interaction With Water (H₂O) Utilizing Hydrogen Bonding Effects To Aid Dissolving Contaminants in Water

Remediation By-Products

- USEPA & Environment Canada Are Concerned About By-Products By-Products Produced During Chemical & Biological Remediation.
- Chemical Reactions Are Not 100%! Hence They Giving Rise To The Formation of By-Products During Remediation.

- Chemical Oxidation and Reduction of Organic Contaminants Will Produce By-Products. (Often Unknown and/or Missed During Laboratory Analysis. The Old "Out of sight out of mind" Philosophy!)
- RISKS: Remediation By-Products Can Be More Toxic Than The Target Contamination. <u>Example</u>: The well published Biodegradation of TCE forming Vinyl Chloride, that was 15+ times more toxic than the original TCE contamination.
 - *Ivey-sol does not alter the chemical structure of contaminants. Hence, no by-products formed averting by-product risks.*



APPLICATION RANGE

LNAPL

Full LNAPL (F1,F2, F3, and F4) Range Including: 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-metalic complexes, and radio-active metals associated with NORMS.



Fuel-oil - Bunker-C - Gasoline Dissolved In Water With Ivey-sol



PAH Soil Remediation

Parameters	Baseline	lvey-sol 106	% Reduction
PAH'S	ррт	ррт	ppm
1-Methylnaphthalene	130	5	96.1%
2-Methylnaphthalene	220	6	97.3%
Acenaphthene	46	6.1	86.7%
Acenaphthylene	140	6.4	95.4%
Anthracene	190	19	90.0%
Benzo(a)anthracene	100	14	86.0%
Benzo(a)pyrene	74	9	87.8%
Benzo(b)fluoranthene	54	6.3	88.3%
Benzo(ghi)perylene	21	3.3	84.3%
Benzo(k)fluoranthene	54	6.3	88.3%
Chrysene	100	13	87.0%
Dibenzo(a,h)anthracene	9.6	1.2	87.5%
Fluoranthene	230	26	88.7%
Fluorene	190	12	93.7%
Indeno(1,2,3-cd)pyrene	35	4.5	87.1%
Naphthalene	560	9.7	98.3%
Perylene	20	1.6	92.0%
Phenanthrene	420	37	91.2%
Pyrene	170	19	88.8%

Treatment of Chlorinated Contaminated

Chlorinated Compounds	Baseline Mg/kg	Treatment No. 1	Reduction (%)	Treatment No. 2	Reduction (%)	Total Reduction
1,2-Dichlorobenzene	8,300,000	490,000	94%	56000	89%	99.33%
1,3-Dichlorobenzene	1,100,000	45,000	96%	8100	82%	99.26%
1,4-Dichlorobenzene	2,900,000	110,000	96%	14000	87%	99.52%
Chlorobenzene	170,000	12,000	93%	150	98.80%	99.91%
Styrene	1200	74	94%	ND	100%	100%
TCE	590	41	93%	ND	100%	100%



Recent Research Has Confirmed *Ivey-sol* Increases **The Controlled Solubility and** Rate of *MTBE* Recovery From Soils, Bed Rock, and Groundwater **By >740%**

Reference: Dr. Davis Craft, University of Alberta (2004)



PCB's

Ivey-sol Increases The Solubility of PCB's by > 900%

Based on Research and Development Work Completed in 2005 by Dr. David Craft (NRC) & George Ivey (Ivey International)

Surfactant Enhanced Oxidation (SEO)

- Ivey-sol Surfactants are applied to PCB contaminated soils to desorb PCBs
- Following de-sorption of PCB's a water soluble oxidizing chemical (Agent) is applied.
- PCB levels reduced to clean-up standards with some samples coming back Non-Detectable.
- When oxidizers are used alone, efficiency was < 35%.

Reference: 2005 Project Collaboration Ivey International & National Environmental Contractor



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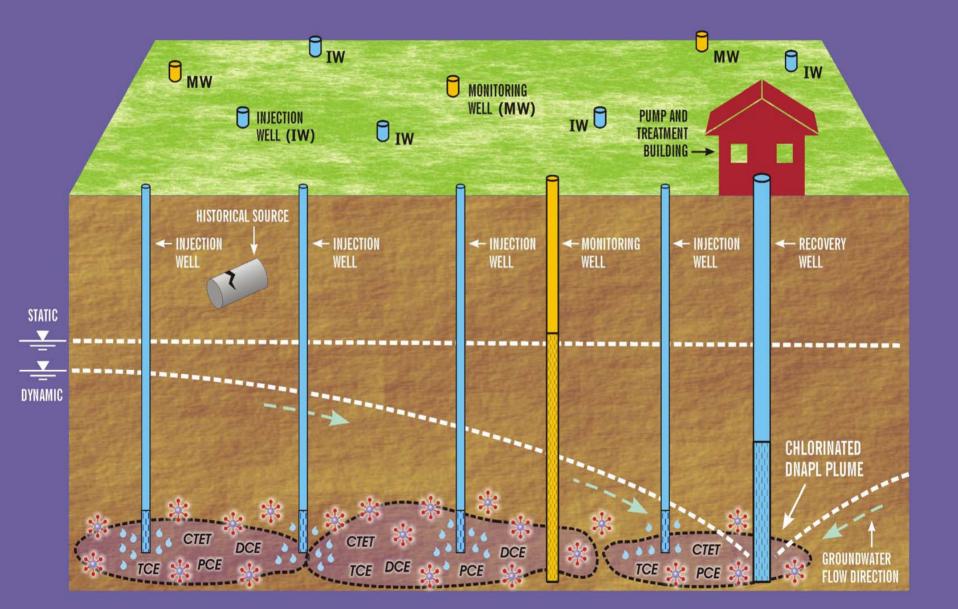
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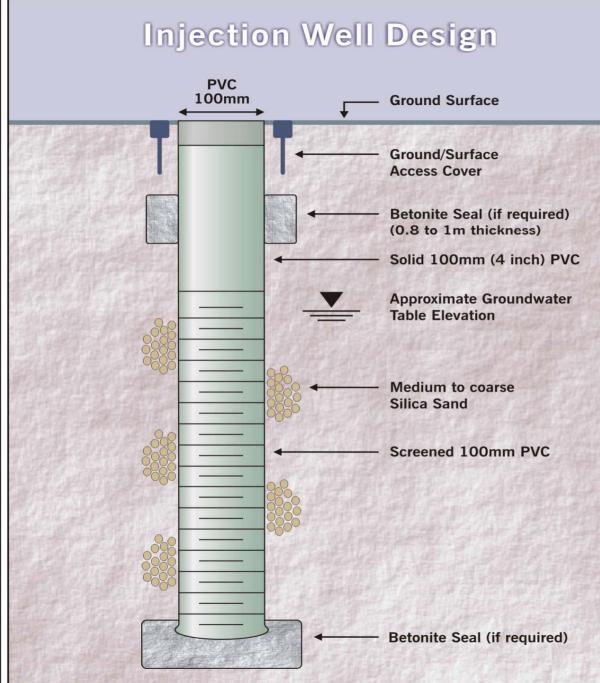
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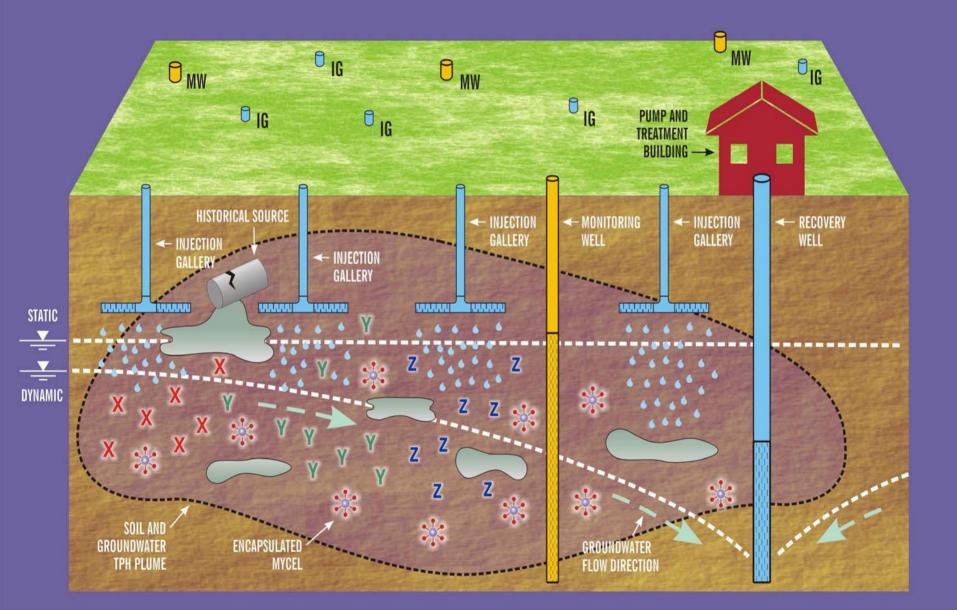
IN-SITU REMEDIATION





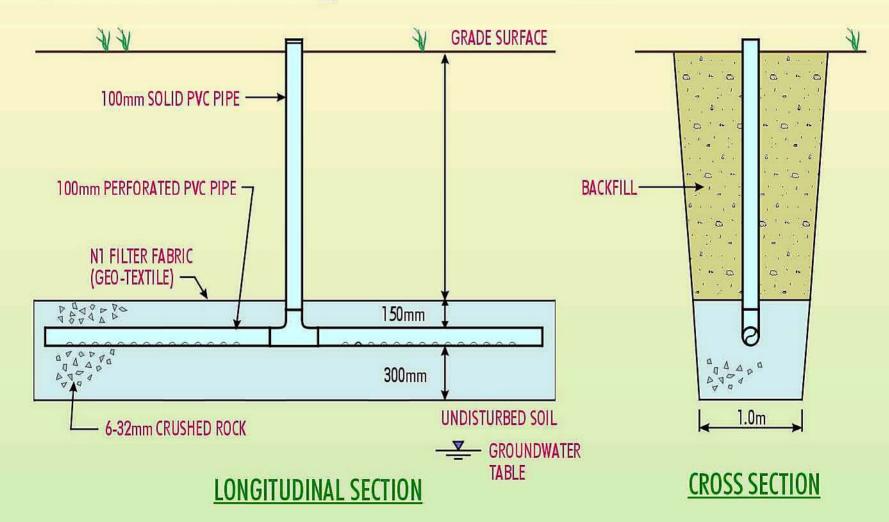
Standard Injection Well (IW) Design

Not To Scale

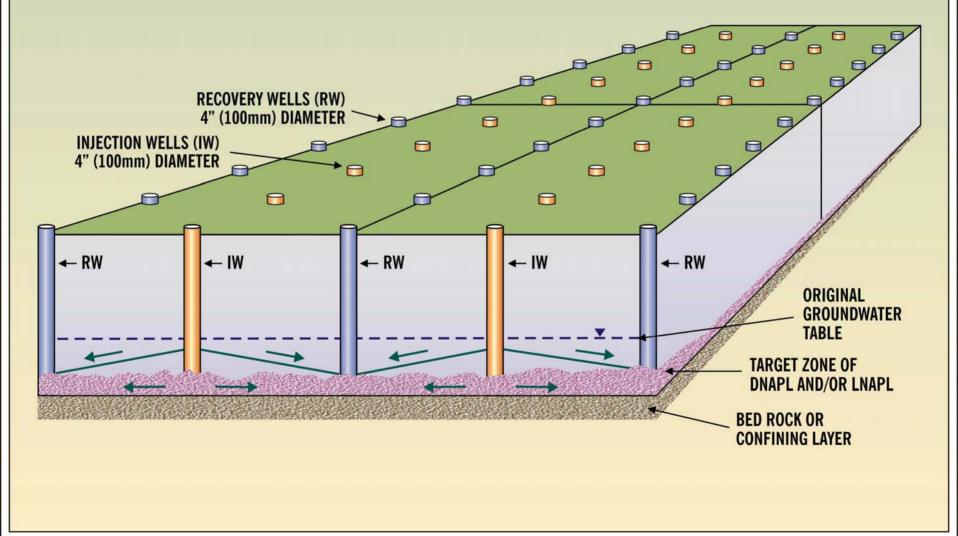




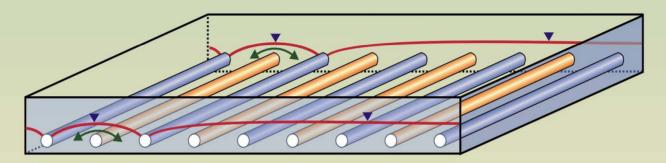
Injection Gallery (Basic Design)

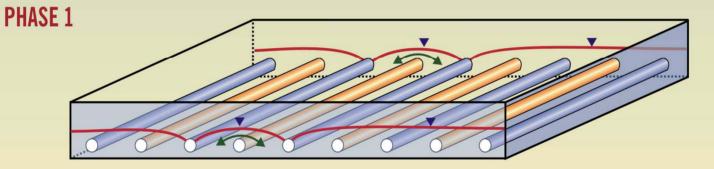


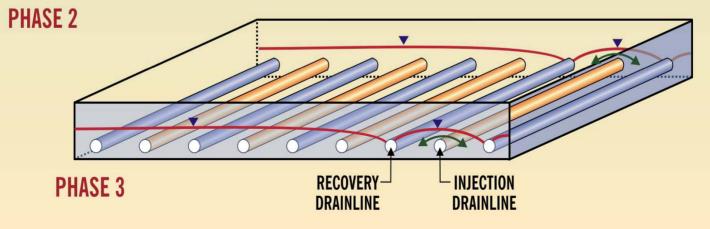
Conceptualization of Iveysol Surfactant Injection/Recovery System

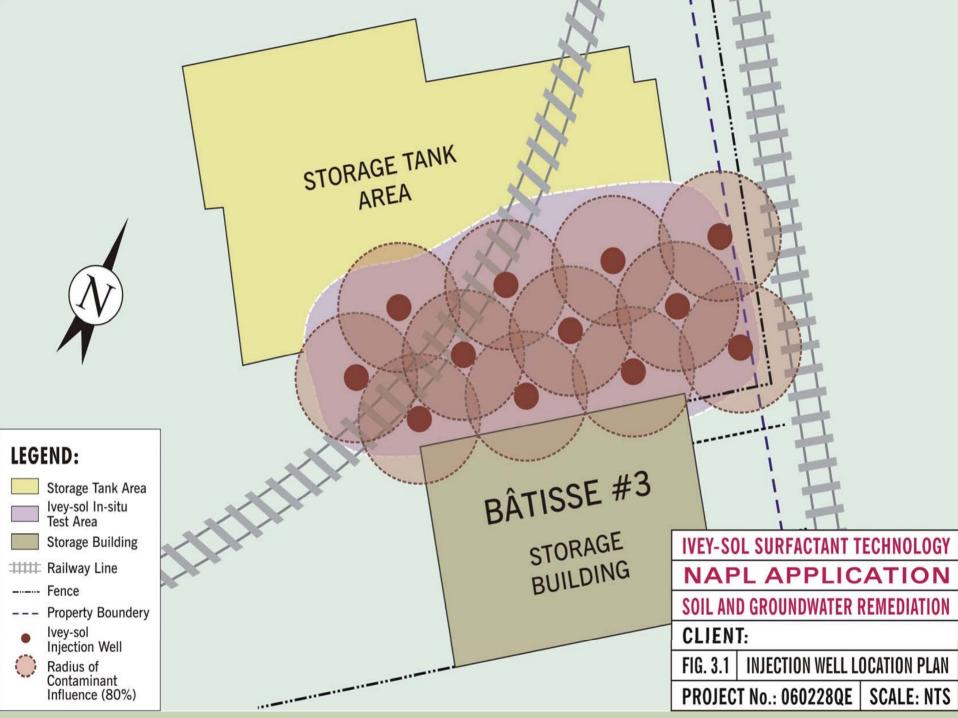


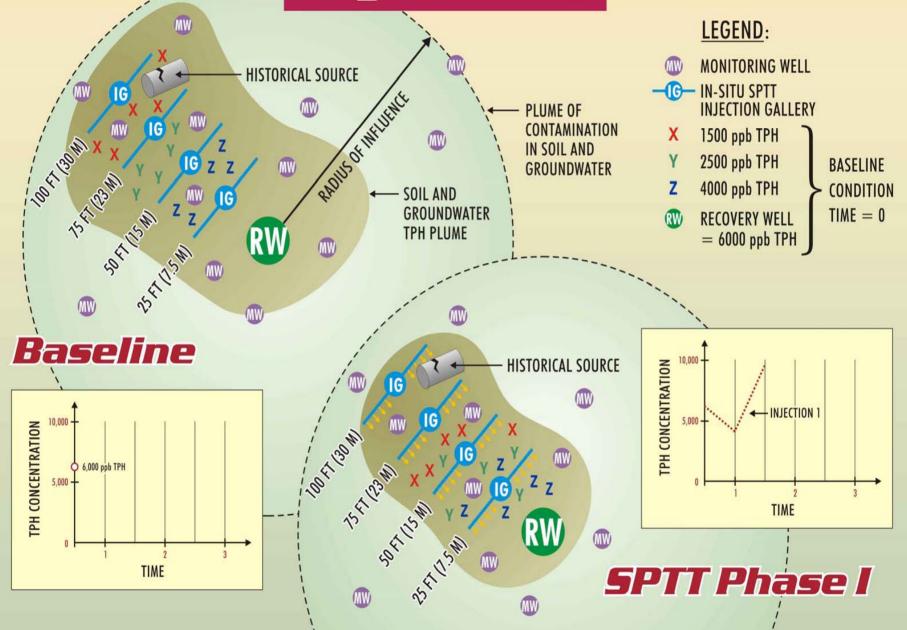
Conceptualization of a Phased Modular Implementation Approach (Ivey-sol)

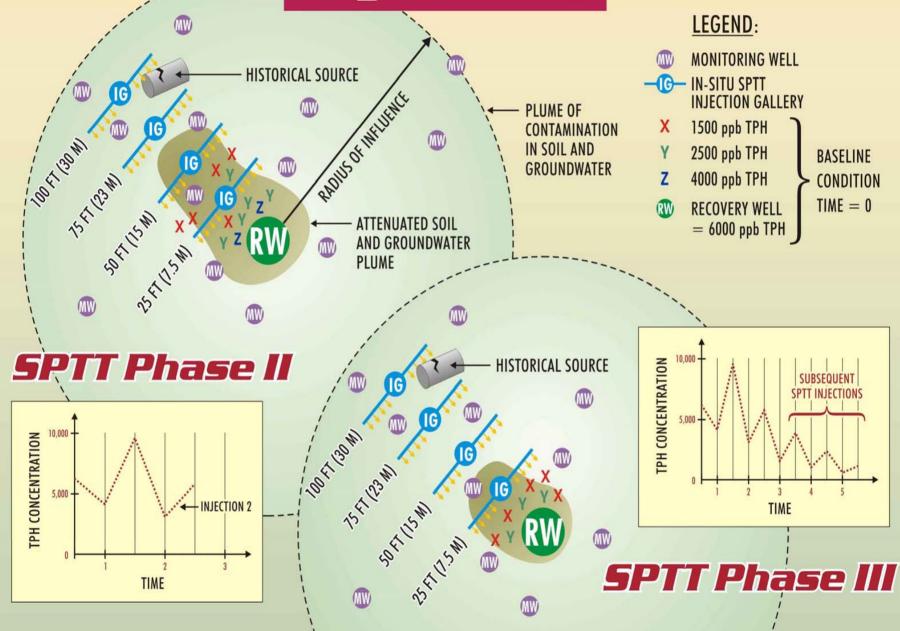










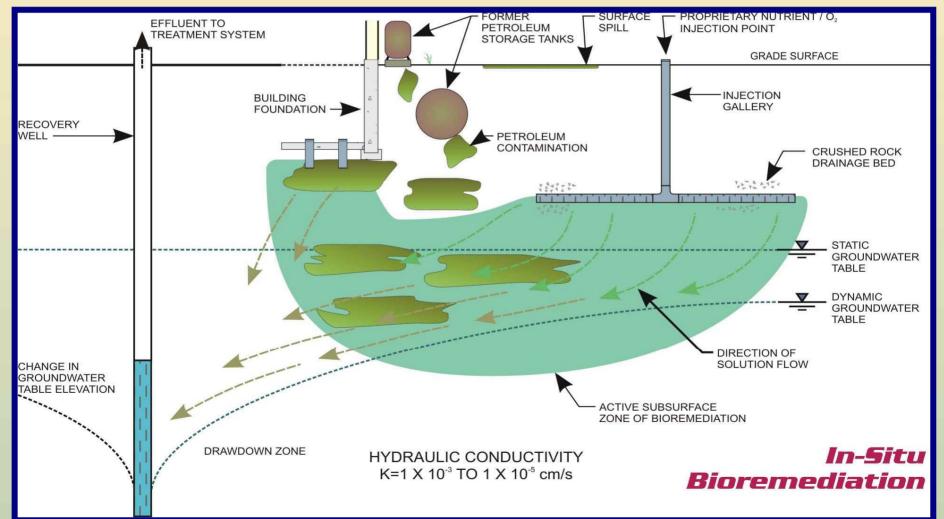


Individual conducting Ivey-sol Injections at an Injection Well (IW).

Introducing Ivey-sol mixture followed by water during injection process.



In-Situ SEB Surfactant Enhanced Bioremediation





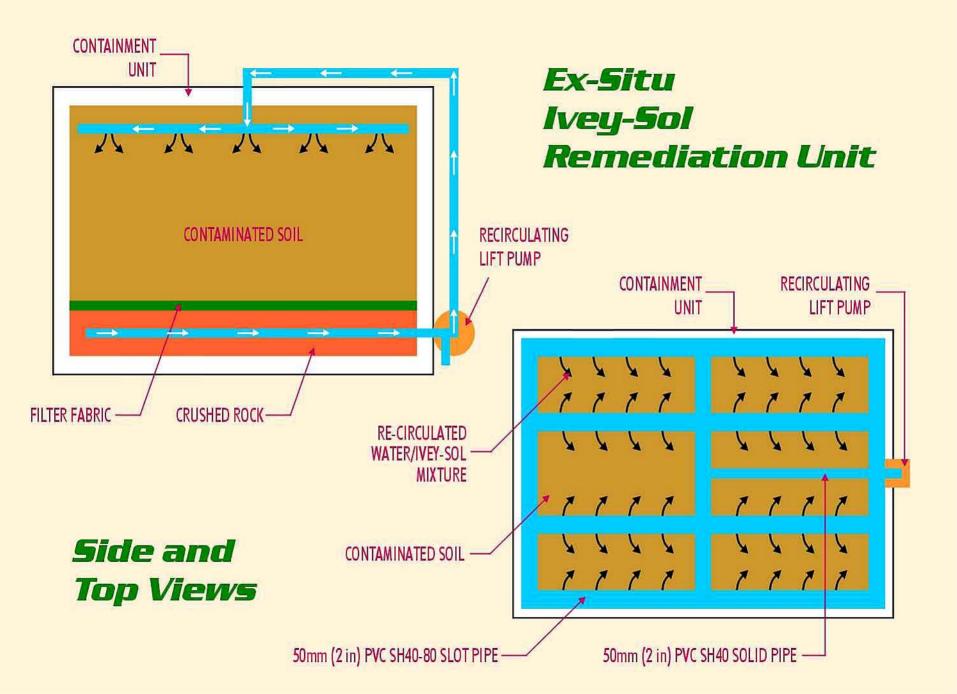
EX-SITU REMEDIATION



Ex-Situ Soil Treatment Unit

Small To Large Scale LNAPL & DNAPL Soil Remediation

(Mobile 3 to 35 cubic yards units)





Ex-situ Soil Treatment SEO & SEB









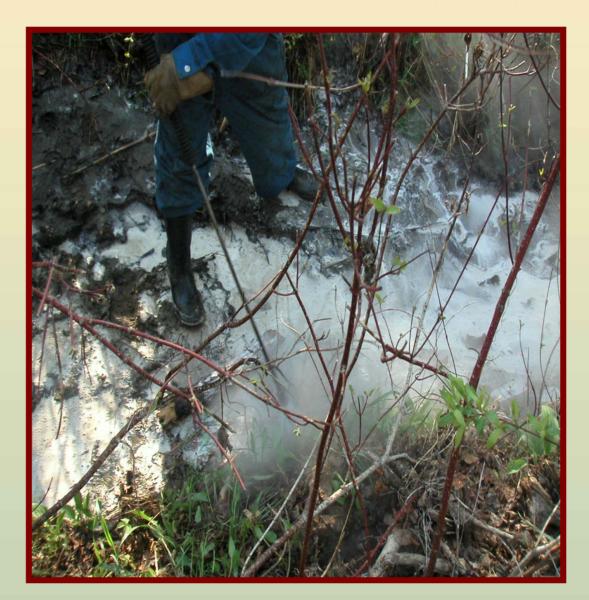


Tank Cleaning Applications Before & After Ivey-sol® Cleaning

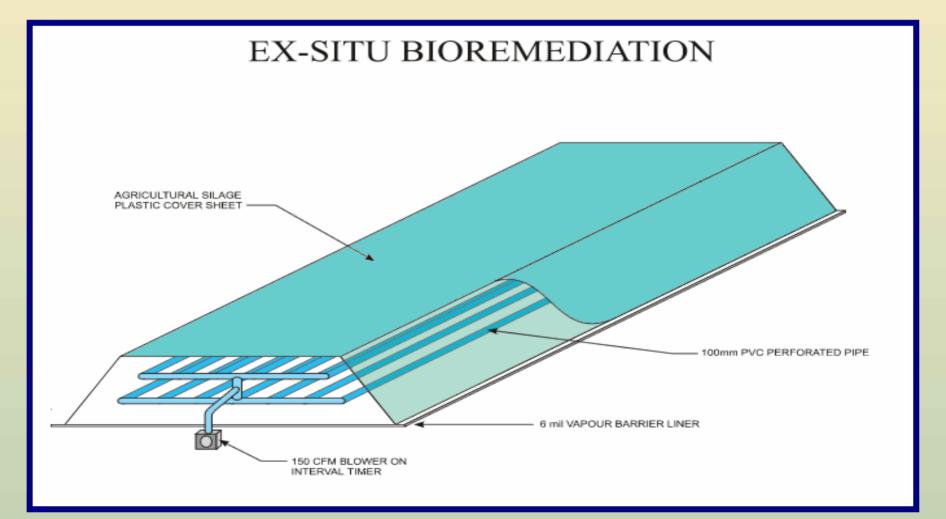
Stream and Shoreline Spill Clean-up With (Ivey-sol ®).

Application via highpressure spray to liberate hydrocarbons from stream-bed sand, rock and vegetation.

Removal of dissolved wastes from localized area via Vacuum suction hose.



Ex-Situ SEB Surfactant Enhanced Bioremediation (F3 &F4)



SEB Fine Grain F3 & F4 Remediation



Range Of Applications

- **Surfactant Enhanced Bioremediation (SEB)**
- Surfactant Enhanced Aquifer Remediation (SEAR)
- Surfactant Enhanced Chemical Oxidation and Reduction Treatment (SEO)
- ► Oil Recovery From Oil-Sands
- **Tank Cleaning**
- **NORM Treatment**
- **Blending Bio-Oil and Diesel**
- **•** Off Shore Oil Dispersant
- **•** Oil Stain Removal (Parking Areas)
- ► Degreaser





PRESENTED BY: George A. Ivey Senior Environmental Scientist, Ivey International Inc.





- Former heating oil terminal from the mid-1950's to the late 1970's
- No. 2 fuel oil was stored at the site



- Multiple releases occurred over time
- Site and surrounding area are wetlands, with the former terminal area elevated with fill material for commercial use



Irregular fill consisting of sand, silt, gravel and boulders with some timbers and metal buried throughout the site



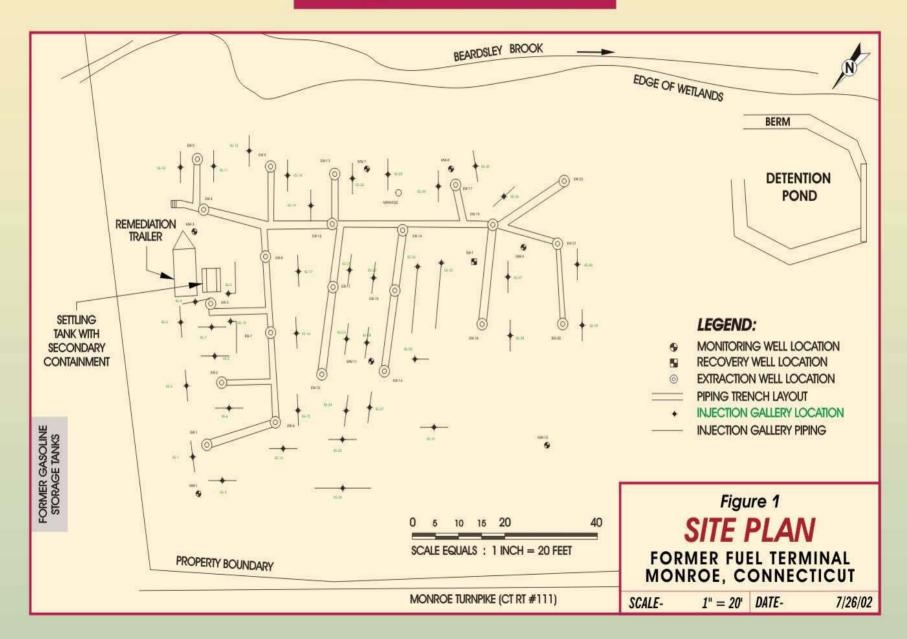
Sensitive receptors are adjacent stream and down-gradient potable wells



High vacuum (dual phase) extraction system in use at the site since late 1999 Selective Phase Transfer Technology (SPTT) system installed in May 2002



Monthly SPTT injections commenced in May 2002



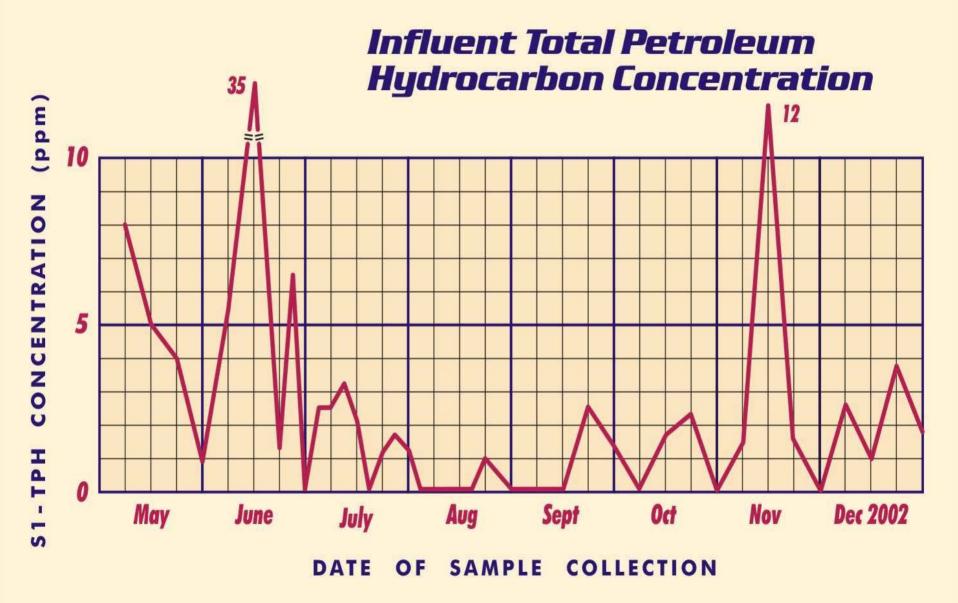
















- **Mass Recovery = Flow Rate x Concentration**
- Mass Recovery (pounds per day) = gallons per minute (gpm) x mg/l X 0.012



- 3.785 l/gal x 1 lb/454,000 mg x 1440 minutes/day = 0.012
- Mass Recovery prior to the injection period is based on an average influent concentration of 0.75 mg/l



8 gpm x .075 mg/l x 0.012 = 0.072 lbs/day = 3.269 x 10⁴ mg/day (prior to SPTT use)



Mass Recovery during the injection period is based on a concentration average calculated using the post injection peak concentrations of 3.07 mg/l



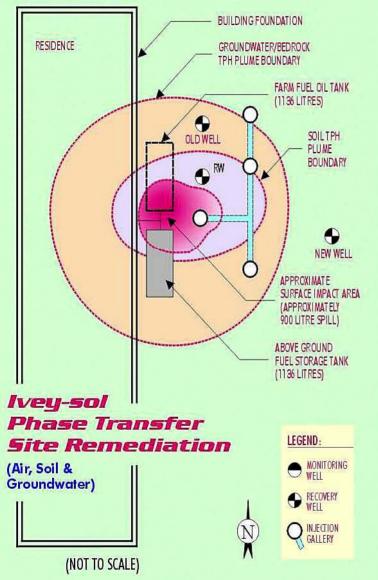
8 gpm x 3.07 mg/l x 0.012 = 0.29472 lbs/day = 13.38 x 10⁴ mg/day (during SPTT use)



Pre vs. post injection mass removal rates show an increase of 409.3%

lvey-sol

PROJECT NO. 93-156



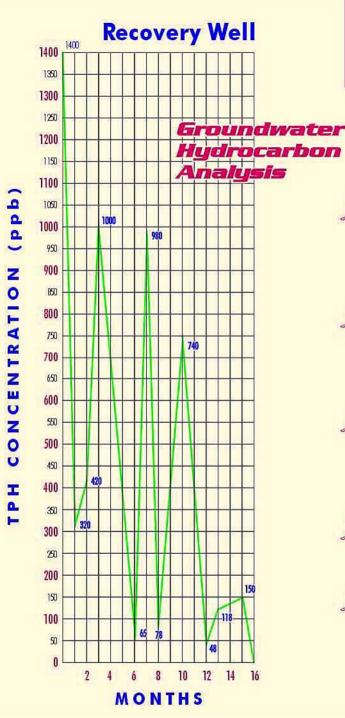
Case Study I

Approximately 900 L (200 gal) fuel oil spill at the above ground storage tank

Drinking water well and bedrock-aquifer were contaminated at 1400 ppb TPH



Classified as a Sensitive Site by the **Department of Environment with** a 10 ppb TPH groundwater clean-up objective



lvey-sol

Ivey Environmental Services installed a pump & treat system at the recovery well

Case Study I



Several Ivey-sol injection galleries were designed and installed



The site was successfully cleaned up to under 10 ppb in less than 18 months



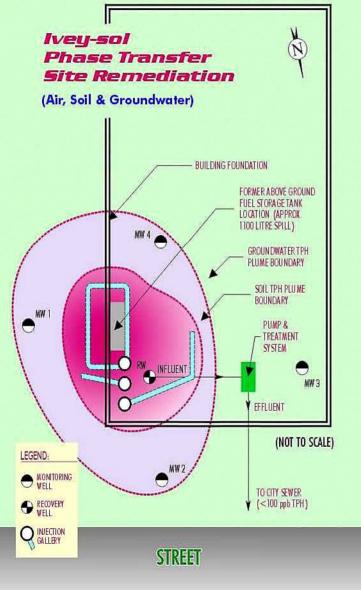
The client estimates the savings at > \$50,000



The Department of the Environment decommissioned the site

lvey-sol

PROJECT NO. 98-271



Case Study II

Approximately 1100 L (240 gal) fuel oil spill from an above ground storage tank

The water table was contaminated at 9500 ppb TPH; the soil under the building was saturated with free product



Classified as a Non-sensitive Site by the Department of Environment, with clean-up objectives of 1000 ppb TPH for groundwater and 100 ppm TPH for soil

Groundwater Hydrocarbon Analysis

lvey-sol

81000 **Recovery Well** 50000 48000 45000 9 40000 0 0 35000 Ζ NCENTRATIO 30000 25000 24700 20000 0 U 15000 I 0 11000 10000 9500 5000 1700 400 2 3 7 0 5

MONTHS

 Ivey Environmental Services designed and installed a recovery well and a pump & treat system within the building basement

Case Study II



Several Ivey-sol injection galleries were designed and installed in the vicinity of structurally sensitive foundation footings



The site was successfully cleaned up to 220 ppb in eight months



The Department of the Environment decommissioned the site



IVEY-SOL FACT: 90-95% of Ivey Environmental Services clients have their site cleaned up in under 18 months on average, and can claim cost savings of at least 20% - 40% compared to alternative technologies.



Ex-situ Case Study Waste Oil Refinery Site Heavy-ends Soil Contamination

Baseline : <u>40,580 ppm</u> Client Objective : <u>< 3 %</u>



Refinery Site Soil Contamination 40,000 ppm Clean-up Objective: < 30,000 ppm





Mineral Oil & Grease 40,580 ppm





Post Treatment: <u>4200 ppm</u>

90% Reduction To < 0.4% Mineral Oil & Grease Exceed Client Industrial Clean-up Goal

Ivey-sol Metal Remediation

Metal	Baseline	Treated
Pb	203 ppm	n.d.
Cu	<i>42 ppm</i>	n.d.
Al	3,950 ppm	n.d.
Ar	1.5 ppm	n.d.
Fe	8,720 ppm	n.d.
Ca	91,400 ppm	n.d.
Cr	<i>11 ppm</i>	n.d.
Mn	<i>42 ppm</i>	n.d.
Hg	0.07 ppm	n.d.
Na	195 ppm	n.d.
Ti	199 ppm	n.d.
Zn	366 ppm	n.d.
· · ·	parts per million n.d. = non ble not extractable metals in si	



Pre and Post Ivey-sol Treatment

Effective Removal of Heavy-end Hydrocarbons.

Other Applications (Slide Examples)

- Tank Cleaning
- Shore Line Clean-up
- Frac-Sand Treatment (Oil & Gas Well Waste)
- Oil Recovery

Oil & Gas Well Frac-Sand Waste Treatment (Ivey-sol®)

Sample From Alberta, Western Canada



Oil Recovery Potential

- Coagulants & Flocculants were used to precipitate the petroleum from the post treated water
- Upper water layer is clarified and available for re-use.
- Hence water use is less a limiting an issue as a result.
- Passing the precipitate through a Filter-press would allow for the recovery of the target hydrocarbons. These may be of economic value.

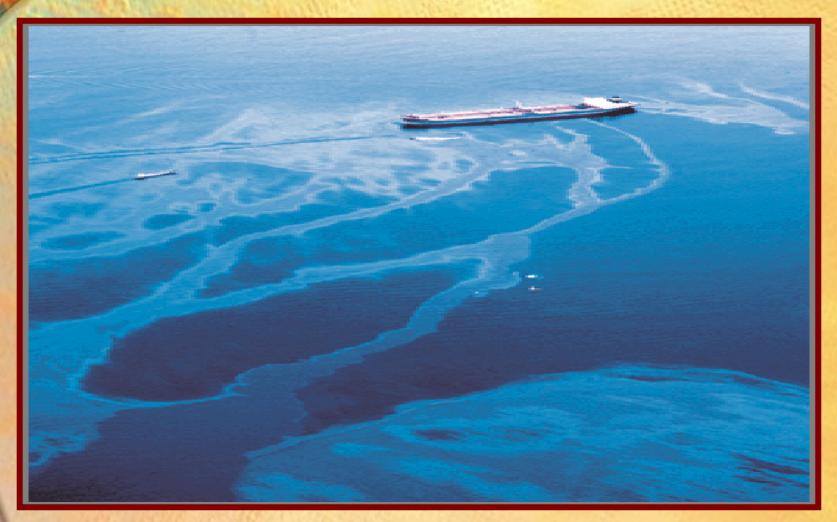


Dispersants tend to reduce the long term impacts of an Oil Spills.

By dispersing and lessening the concentration of oil in the water column can make the oil more available for natural biodegradation

Surfactant Enhanced Biodegradation

Oil Spill As Viewed From The Air



Dispersant Applications

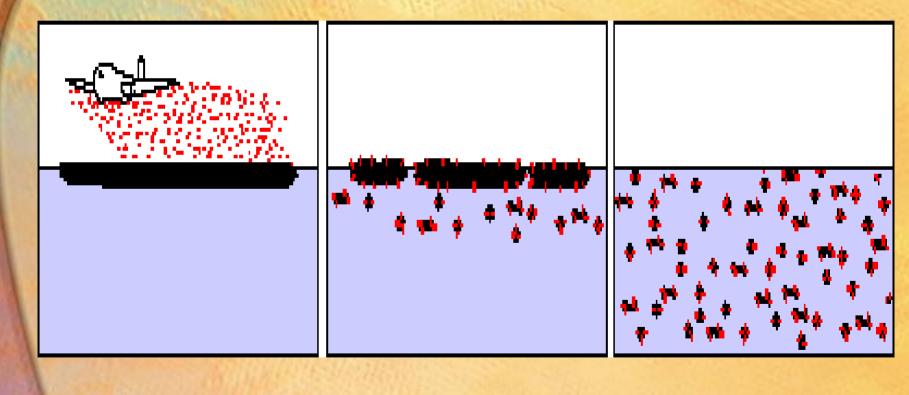








Mechanism Aerial Dispersion



To Be Effective, dispersants must be applied within a short 'Window of Opportunity' following a spill.



Taken From Plane 1- Day After Dispersant Application (Very Effective) Taken From Plane Just After Dispersant Application (*Time Zero*)



Before and After Dispersant Shore Line Clean-up



1989 - Exxon Valdez 40,000 tons of oil spilled





Copy of Technical Paper Available At Our Booth Following Presentation

lvey International Inc.

Contact Information



UNITED STATES: 26 Berkeley Place, Newington, CT 06111

Tel. 506-363-4494 Fax 506-363-4606 Toll-Free 1-800-246-2744 E-mail: cupw@nbnet.nb.ca



CANADA EAST: P.O. Box 1103 Fredericton, NB E3B 5C2

CANADA WEST: P.O. Box 706 Campbell River, BC V9W 6J3

Tel. 250-923-6326 Fax 250-923-0718 Toll-Free 1-800-246-2744 E-mail: budivey@island.net

www.iveyinternational.com