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## 5 Lessons Learned From Surfactant-Enhanced Aquifer Remediation of Light and Dense NAPLs

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#### **Does SEAR work for DNAPL?**



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# I. It works for DNAPL



#### **Goals?**

- MCL's
- Reduce Mass Discharge
- Mass Removal
- Reduce O&M Costs







- Composition
- GTP ratio

#### **Hydraulic Control**

- Trapping Number
- Flow Scheme



Composition

 $HLD = \ln(S) - k \cdot EACN + C_c - a_T (T - 25^{\circ}C) + f(A)$ 





### • Composition







### • Composition





#### Are there succesfull Source Zone DNAPL remediation techniques?

NO: Application of existing technologies may not substantially reduce risk and could potentially worsen site conditions (e.g., through redistribution of DNAPL, metal release, sterilization, or increased aqueous-phase contaminants)

YES: A number of innovative technologies have been developed for substantial mass removal under favorable conditions.

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• GTP ratio





#### **Hydraulic Control**



Fig. 1. Schematic diagram of vertical circulation well.

$$Ca = rac{\mu v}{\sigma}$$
  $Bo = rac{\Delta 
ho \cdot g \cdot r^2}{\gamma}$ 

TN (trapping number) =  $(Ca^2 + 2Ca \cdot Bo \cdot \sin \theta + Bo^2)^{0.5}$ 



# **2.** Push-pull $\neq$ line-drive



#### **Push-Pull**

- Pilot
- "One well at a time"
- Limited water
- High K
- Biosurfactants

### **Line Drive**

• All other scenarios





# 3. Project budgets vary significantly



**tersus** environmental



Love's Stores, Oklahoma City, OK





LA LNAPL Working Group



## 4. Prepare for non-technical challenges



## 5a. Pilot tests are decision points





# **5b. Include performance monitoring**



#### Can you name NAPL characterization methods?

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Large pockets of whitish-brownish foam can be seen on the St. Joseph River



# **Bonus: bring defoamer!**



# Summary

- I. Lot's of research on SEAR for DNAPLs
- 2. <u>Hydraulic control</u> is imperative
- 3. \$100/CY
- 4. This technique is not yet "mainstream"
- 5. Use the 6-step approach and include performance monitoring





# Conclusions

### **Small-scale heterogeneities are problematic**

**Removal is from high K zones** 

## The answer lies in combining techniques

### Less is more



# Thank you!

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