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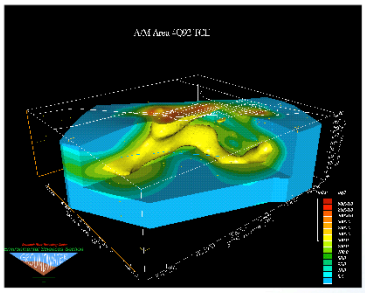
Large and Dilute Plumes of Chlorinated Solvents – Challenges and Opportunities

Brian Looney

Environmental Stewardship Directorate

Savannah River National Laboratory



Clu-In Webinar

May 2013

Informal Definition…

Large and Dilute (L&D) Plume:

A plume of relatively low concentration that extends over a large area – many L&D plume lengths measured in "km" or "miles"

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2

A Key Perspective on L&D Plumes: SERDP Research Program

What conditions create L&D plumes for chlorinated solvents?

Permeable aquifers, with relatively high flow

Low organic carbon contents and low biomass

Aerobic systems where influx of electron acceptors makes it difficult to establish and maintain reducing conditions

Attenuation processes are generally slow
(e.g., degradation half-lives more than 2.5 years) *

Often deep

Often affected by mass transfer in/out of less-transmissive compartments (clay/silt layers)

See for example -- Water Research (2006, 40:3131–3140)

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3

L&D Plumes: SERDP Research Program (cont.)

So What's the Problem?

There is a desire to actively remediate

High costs and technical difficulties involved in treating large volumes of water and large areal footprint

Sometimes plumes are too deep for cost-effective interdiction or containment (hard to implement PRBs…)

Concentrations will exceed standards for a long time with or without treatment

Significant contaminant mass often present relatively inaccessible ("immobile") zones, resulting in "secondary sources" and persistent concentrations after primary source mass is removed

Large scale manipulation of the geochemical environment over an entire plume can be very difficult, expensive and undesirable

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4

DOE Examples

M-Area – DOE Savannah River Site

TCE, approximately 2 square miles and extending to 200 feet deep, initial source concentration → DNAPL

200 Area – DOE Hanford Site

Carbon tetrachloride, approximately 3 square miles and extending to 350 feet deep, initial source concentration → DNAPL

Northwest Plume – DOE Paducah Gaseous Diffusion Plant

TCE, approximately 1 square mile extending 75 feet deep, initial source concentration → DNAPL

Test Area North – DOE Idaho National Laboratory

TCE, approximately 1 square mile and extending to 350 feet deep, initial source concentration → DNAPL

Many DOD examples (Hill AFB, Tinker AFB, MMR, Tooele, etc.) and industrial facilities

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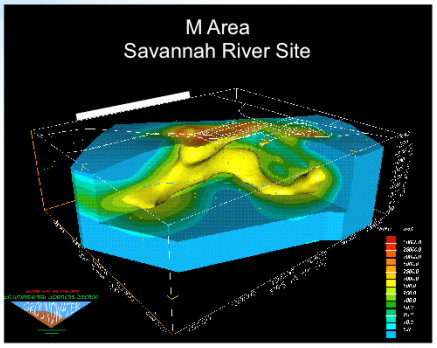
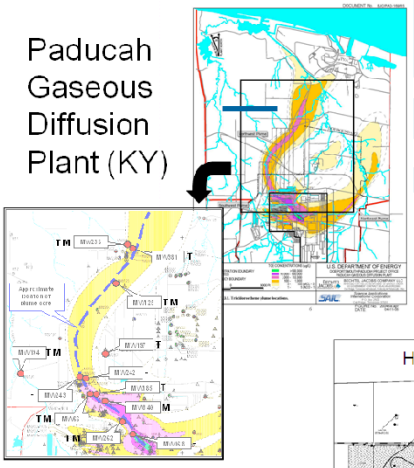
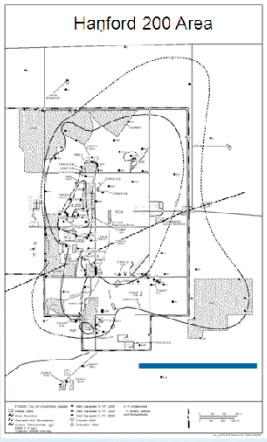
5

A few example plume maps from DOE sites



Paducah Gaseous Diffusion Plant (KY)





bold bar = 1.60934 km

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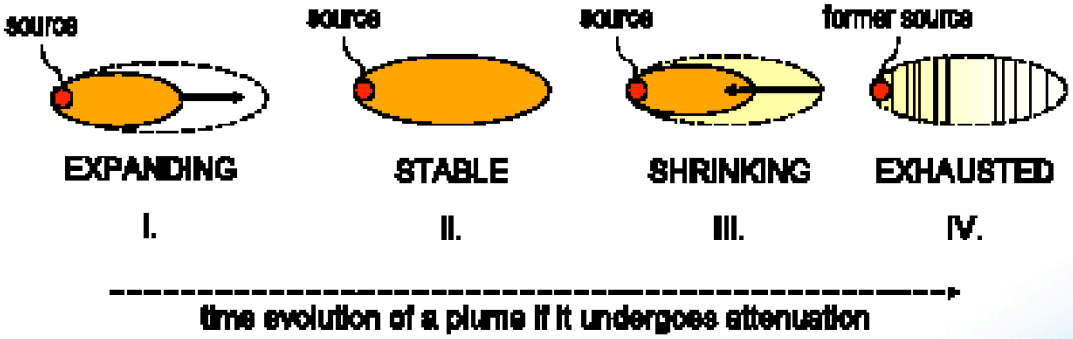
Lifecycle of a Contaminant Plume

Contaminants released into the soil and groundwater will form a "plume".

As contaminants are attenuated by natural processes the plume will stabilize and then shrink – a "mass balance"



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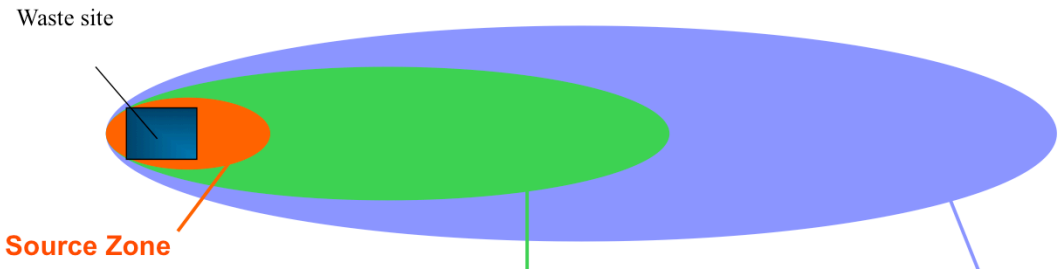
7

Anatomy of a Contaminated Site



Source Zone

Characteristics:
DNAPL and high Concentrations

Need:
Aggressive technologies to limit long term damage

Examples:
destruction or stabilization in place; heat/steam; chemical oxidation or reduction; immobilization.

Primary Groundwater / Vadose Zone Plume

Characteristics:
Moderate to high aqueous/vapor phase concentrations

Need: Baseline methods or moderately aggressive alternatives

Examples: pump (gas or water) and treat; recirculation wells; enhanced bioremediation

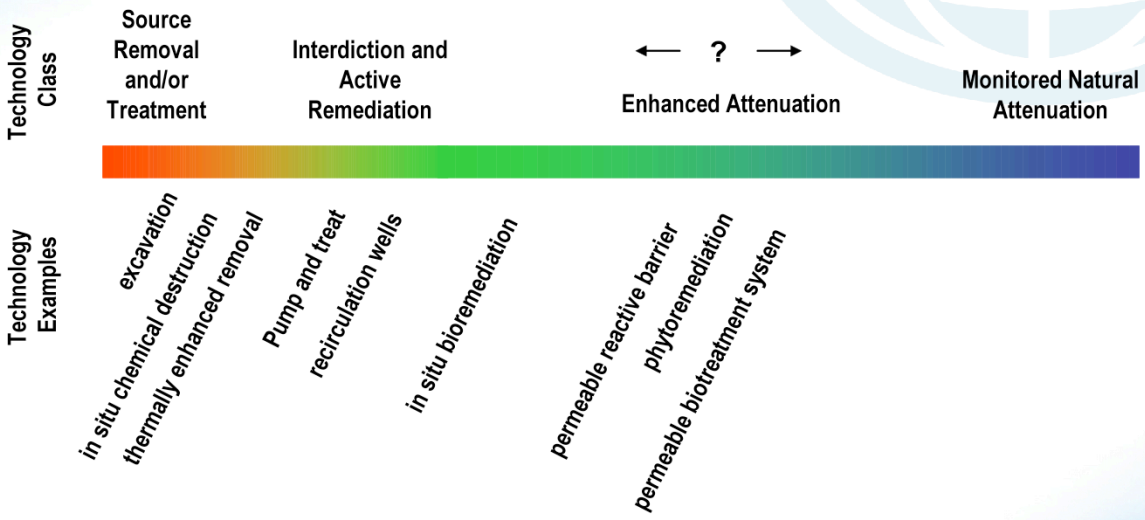
Dilute Plume / Fringe

Characteristics:
Low aqueous/vapor phase concentrations; Large water volume.

Need: innovative technologies - sustainable low energy concepts

Examples: MNA, Passive pumping (siphon, barometric, etc.); enhanced attenuation

Continuum of Treatment Technologies for DNAPL sources and resulting plumes



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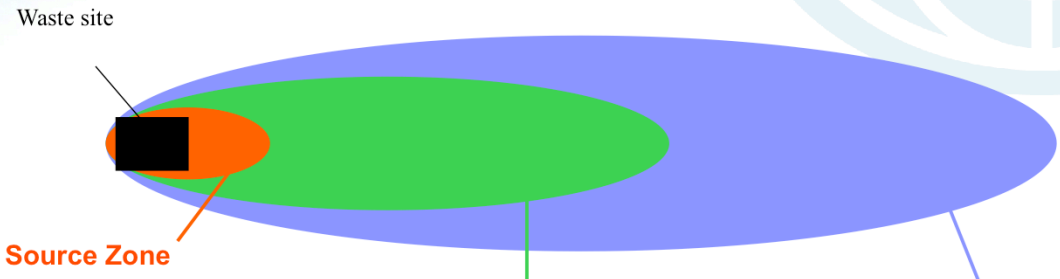
9

Treating a Contaminated Site



Source Zone

Costs:
$/lb contaminant or $/cu yd. Removal examples:
< $50-$100/cu yd or
< $100/lb for chlorinated solvents

hot spot characterization reduces cleanup volume

Primary Groundwater/Vadose Zone Plume

Costs:
$/treatment volume (gallon/cu ft) example:
<$0.5-$10 / 1000 gallons

zone of capture characterization needed, optimize extraction to reduce treatment volume

Dilute Plume/Fringe

Costs:
Operation and maintenance costs $/time

mass transfer and flux characterization needed

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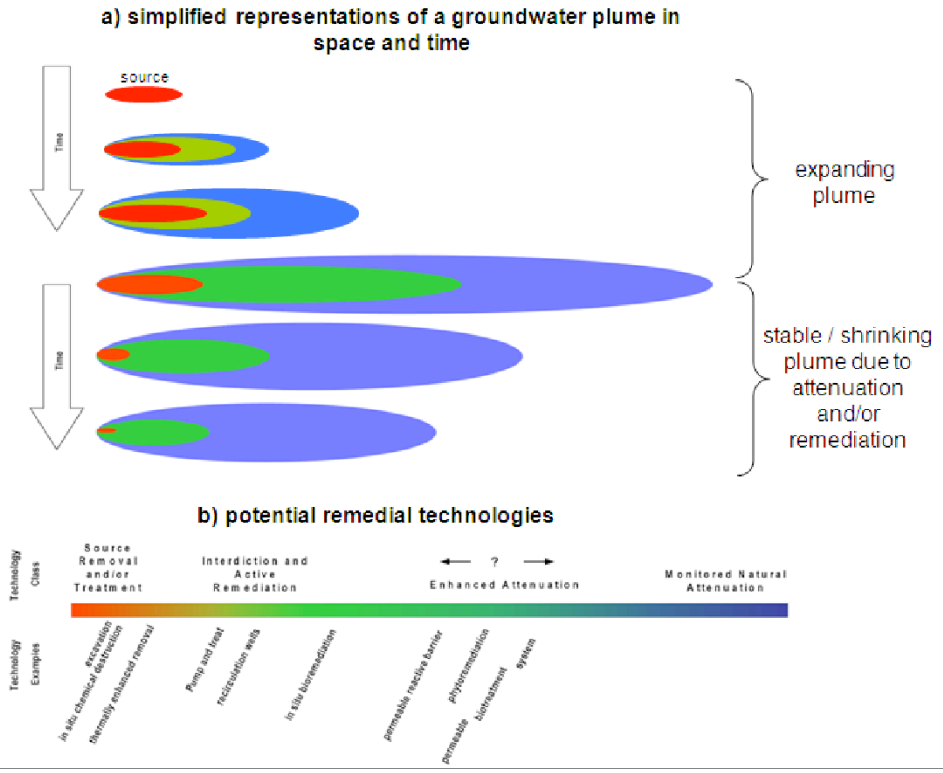
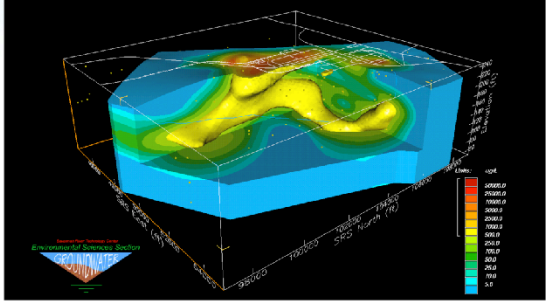
10

Updated Lifecycle of a Contaminant Plume



Real world plumes

Plume Scale
(TCE in groundwater beneath the A/M Area of SRS)



"Dime" Scale

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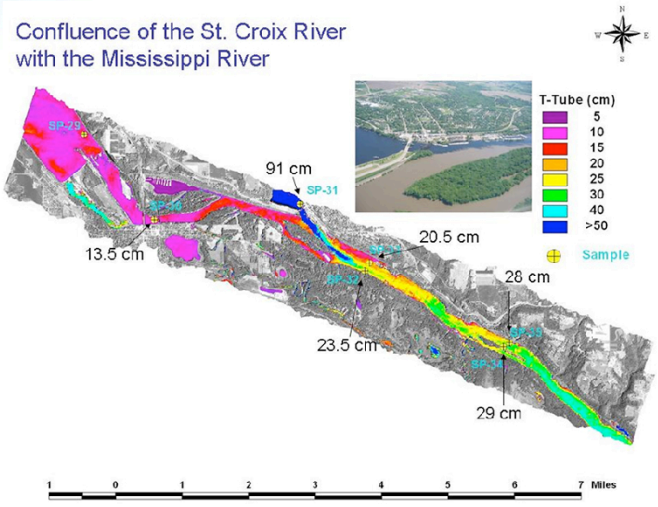
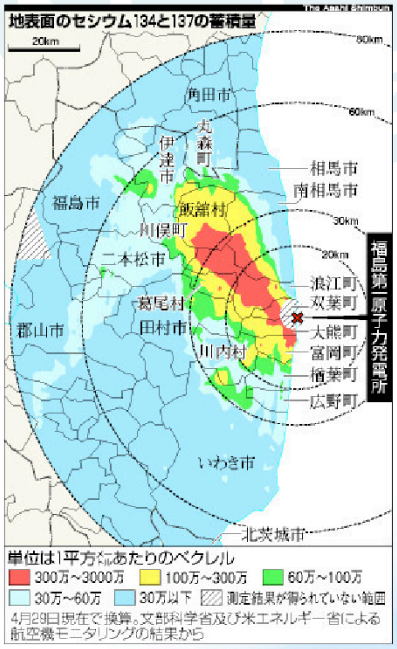
Surface Water and Air



"River" Scale



Fukushima

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