SUBSURFACE TRANSPORT OF OILFIELD WASTES

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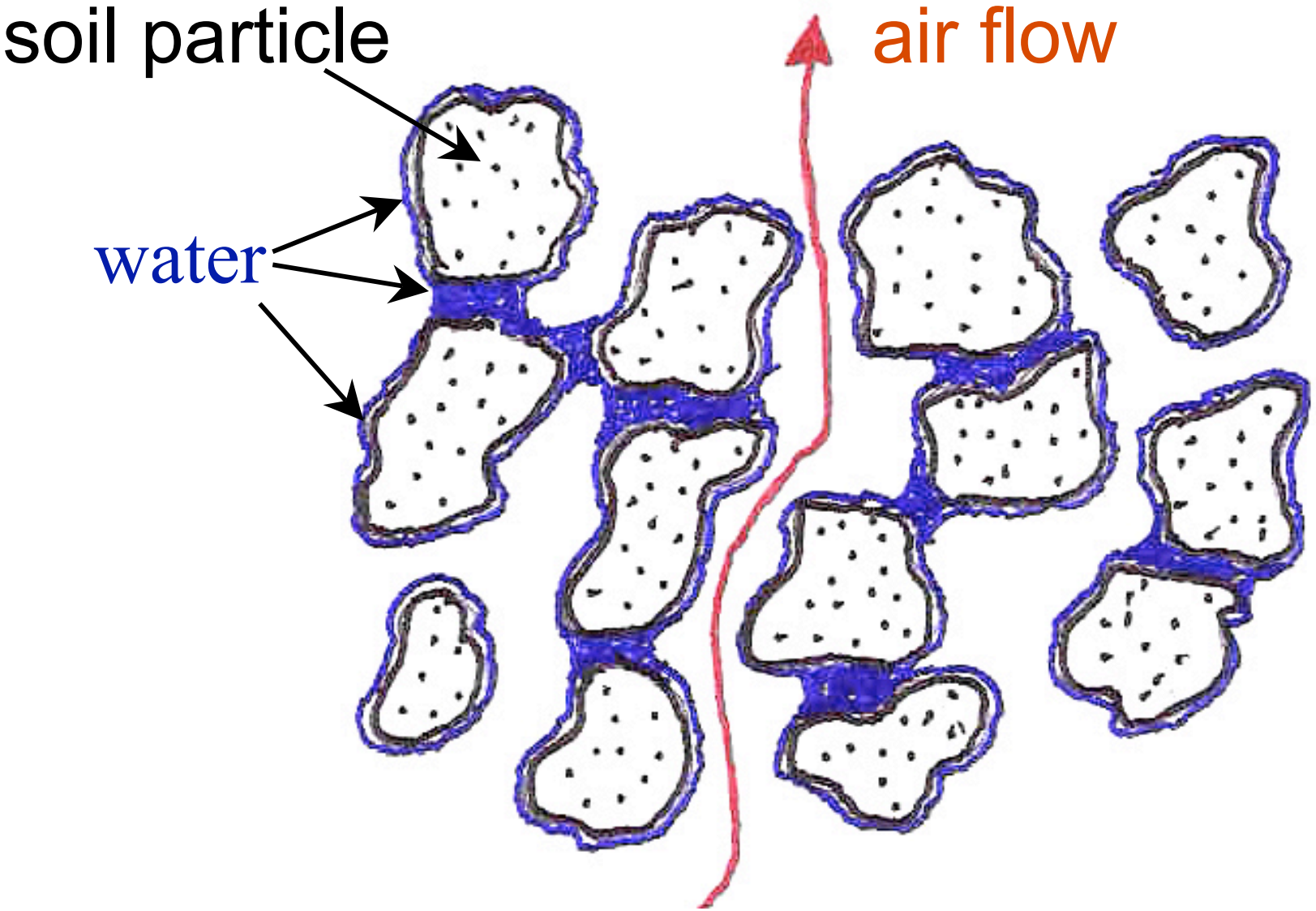
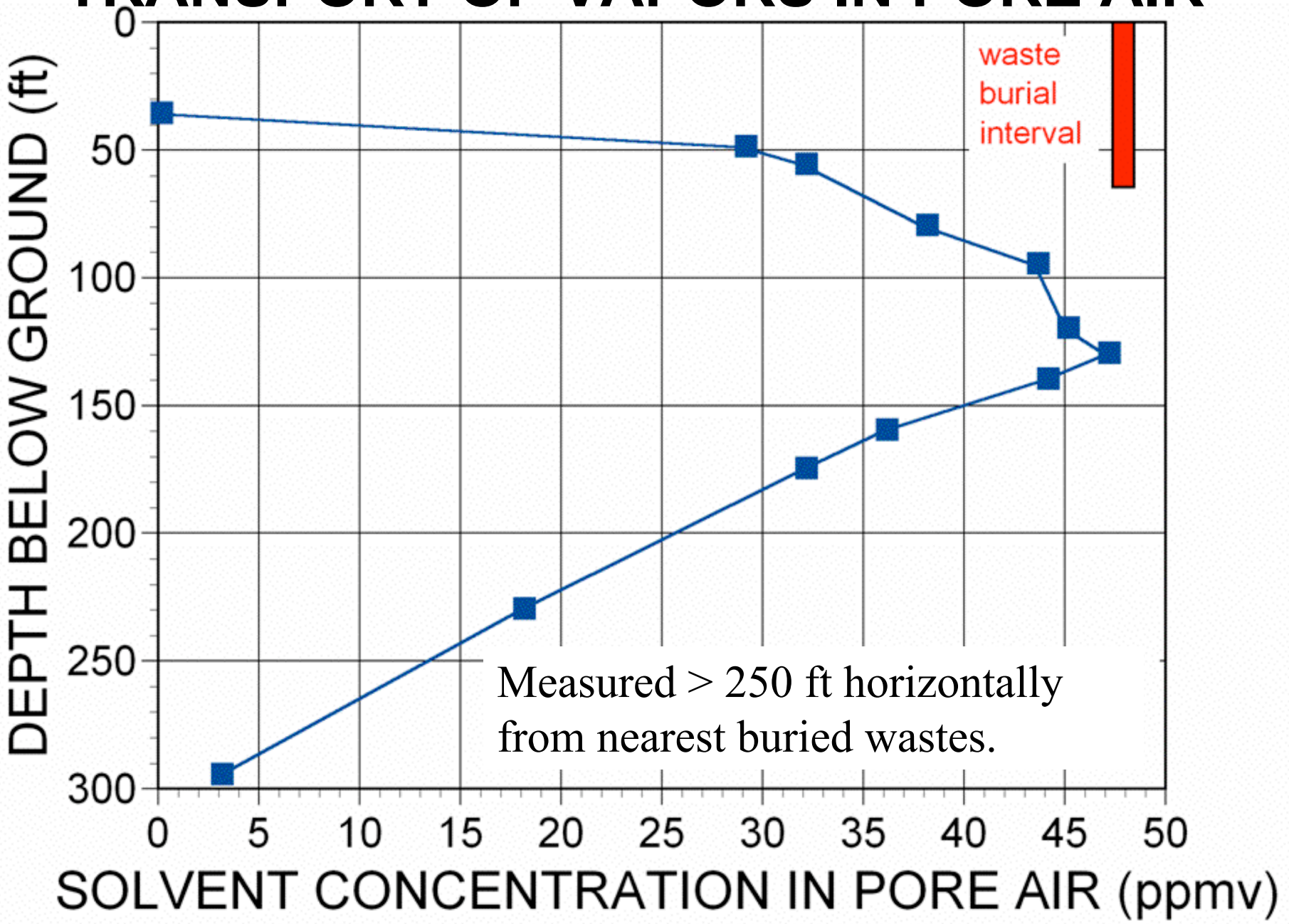
This presentation is at
http://home.earthlink.net/~dneeper/OGAP6.htm

New Mexico Citizens for
Clean Air & Water, Inc.

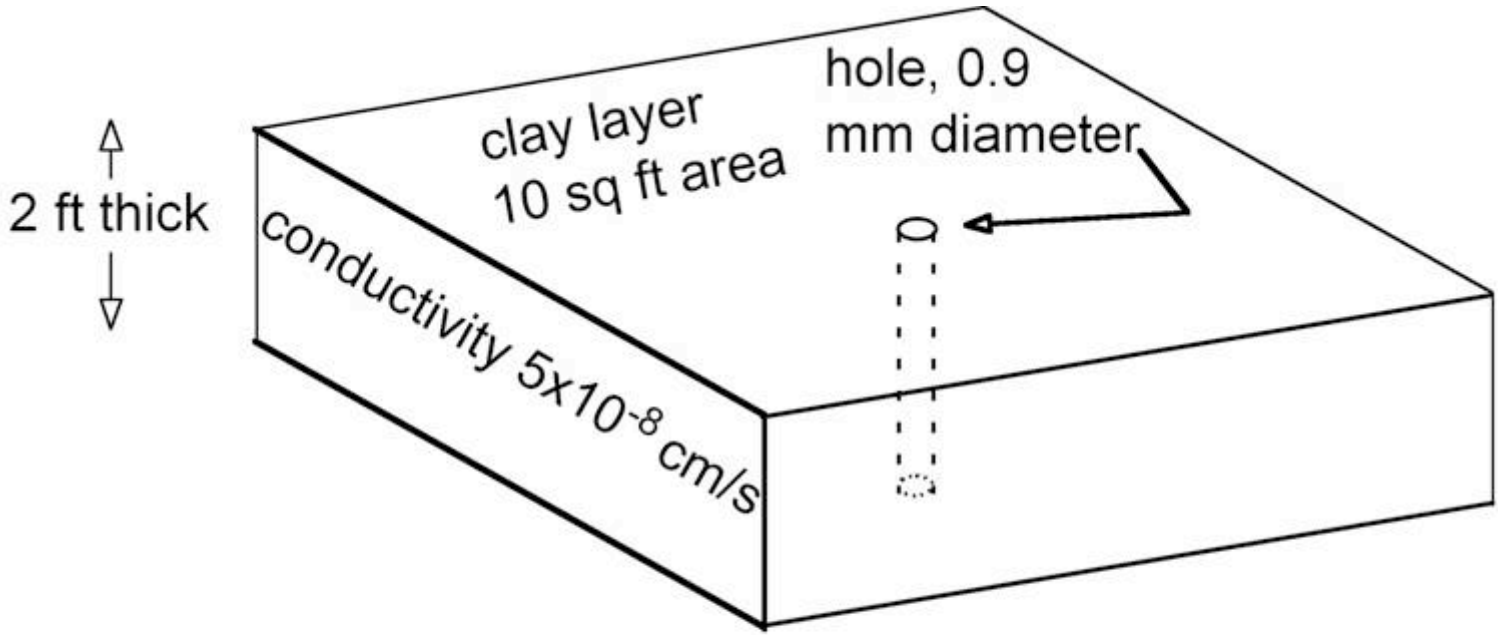
POROUS STRUCTURE OF THE SOIL



TRANSPORT OF VAPORS IN PORE AIR



FLOW OF WATER THROUGH TIGHT SOIL

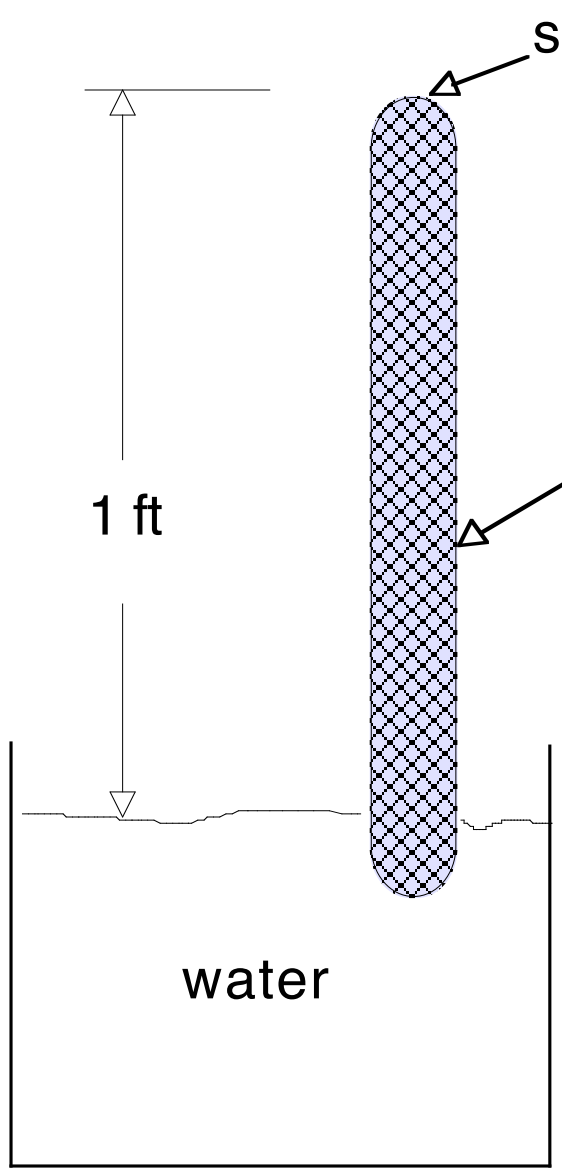


One hole per square meter, the size of a pencil lead, will increase the seepage rate by 300x.

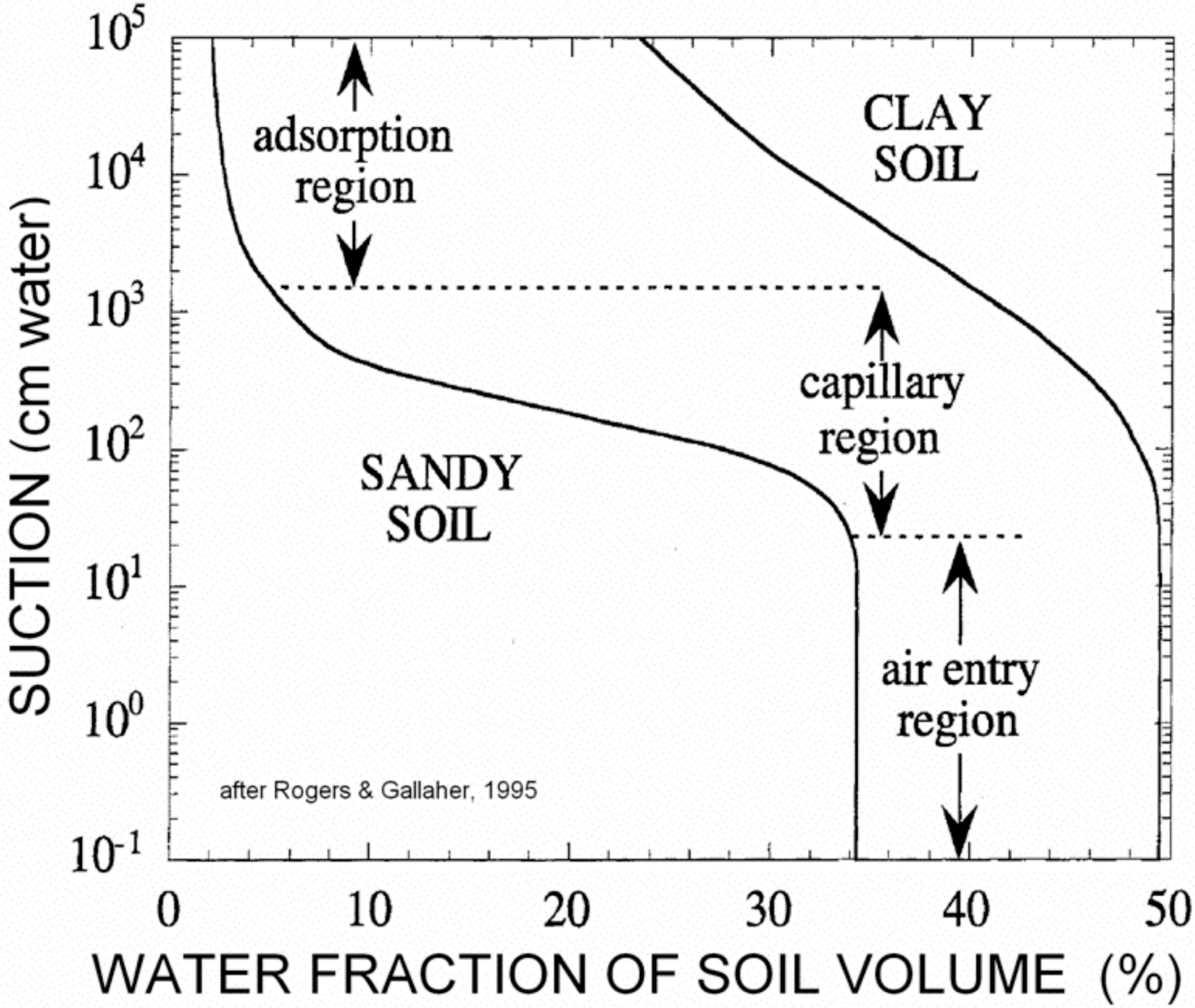
This illustrates the effect of preferential channels.

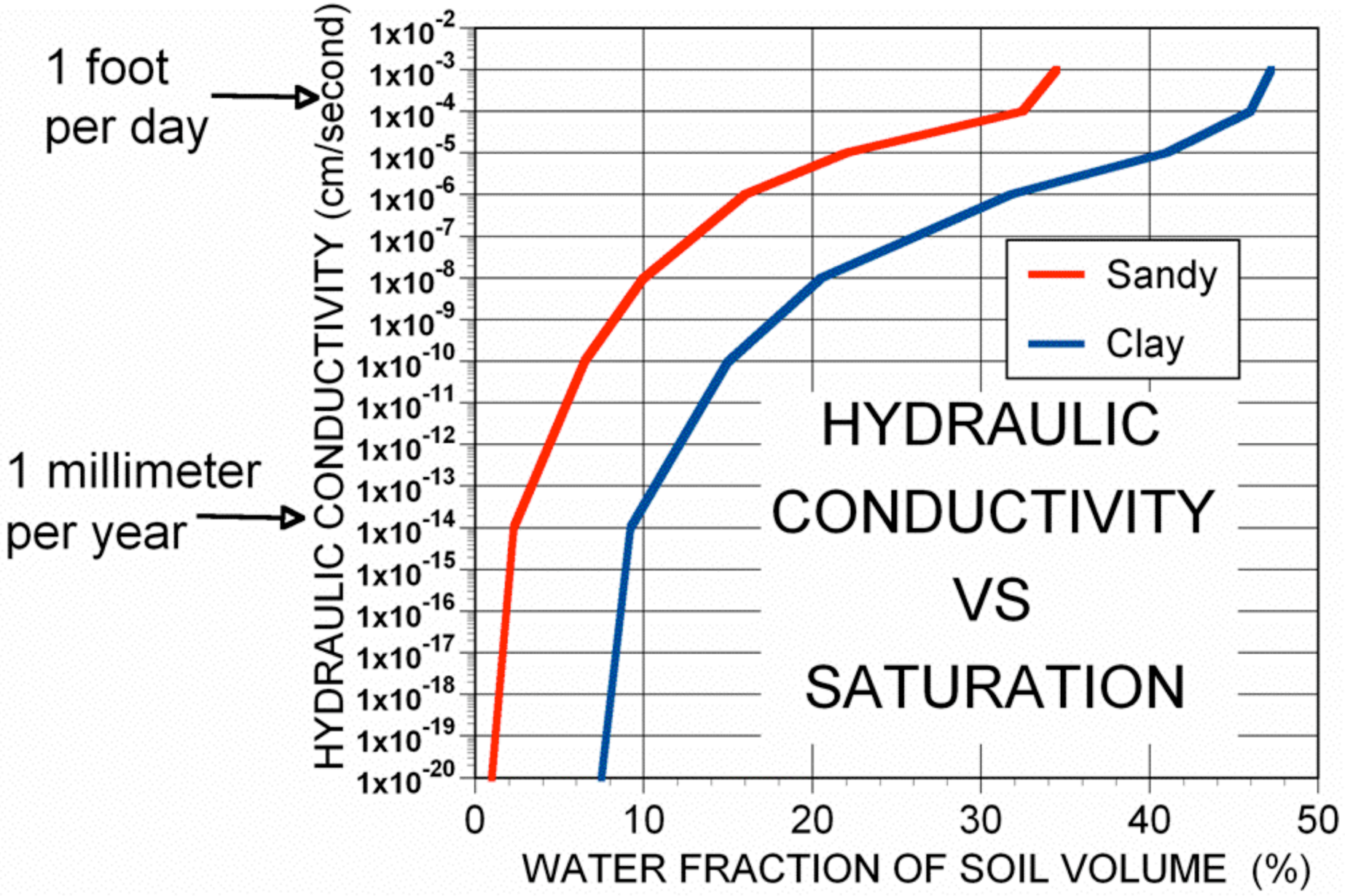
SUCTION

unsaturated soil



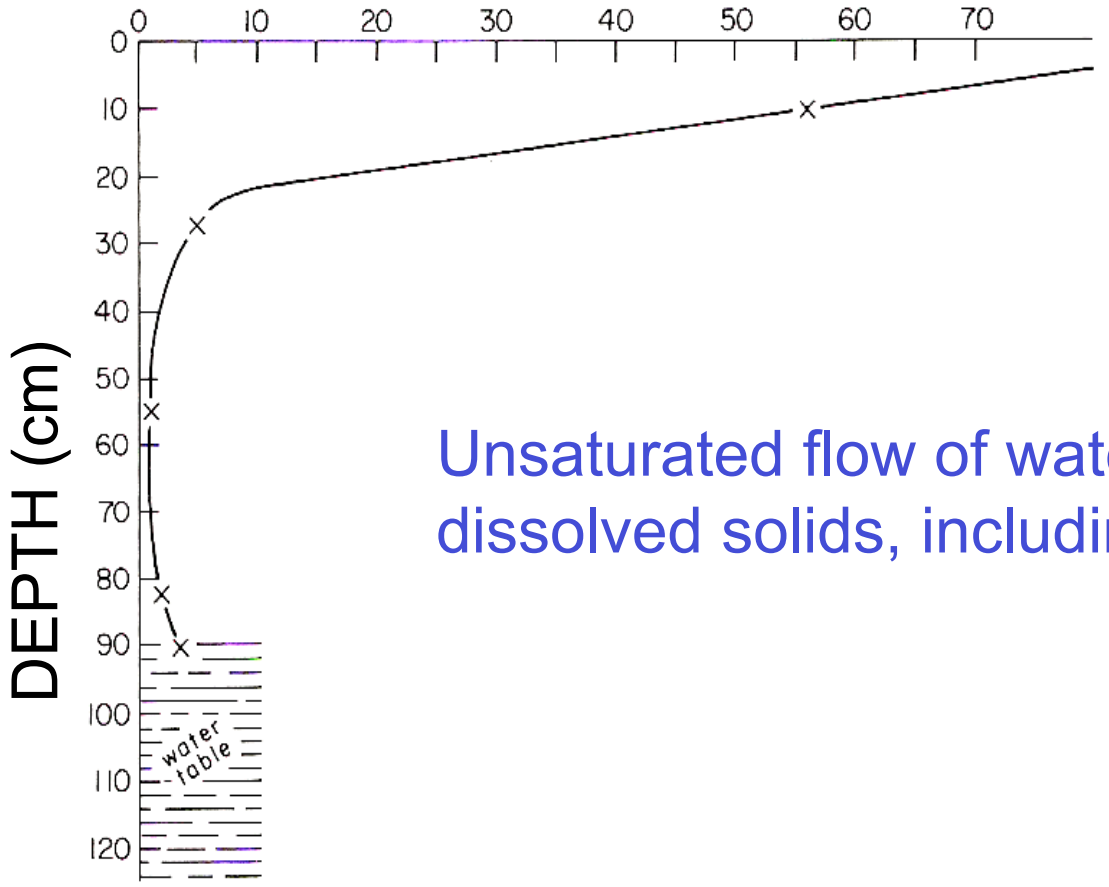
Suction
is the energy per unit volume to pull water out of the sponge


SUCTION (cm water)
10^5
10^4
10^3
10^2
10^1
10^0
10^{-1}
adsorption region
CLAY SOIL
capillary region
SANDY SOIL
air entry region
after Rogers & Gallaher, 1995
0
10
20
30
40
50
WATER FRACTION OF SOIL VOLUME (%)


1 foot
per day
1 millimeter
per year
HYDRAULIC CONDUCTIVITY (cm/second)
1x10-2
1x10-3
1x10-4
1x10-5
1x10-6
1x10-7
1x10-8
1x10-9
1x10-10
1x10-11
1x10-12
1x10-13
1x10-14
1x10-15
1x10-16
1x10-17
1x10-18
1x10-19
1x10-20
Sandy
Clay
HYDRAULIC
CONDUCTIVITY
VS
SATURATION
0
10
20
30
40
50
WATER FRACTION OF SOIL VOLUME (%)

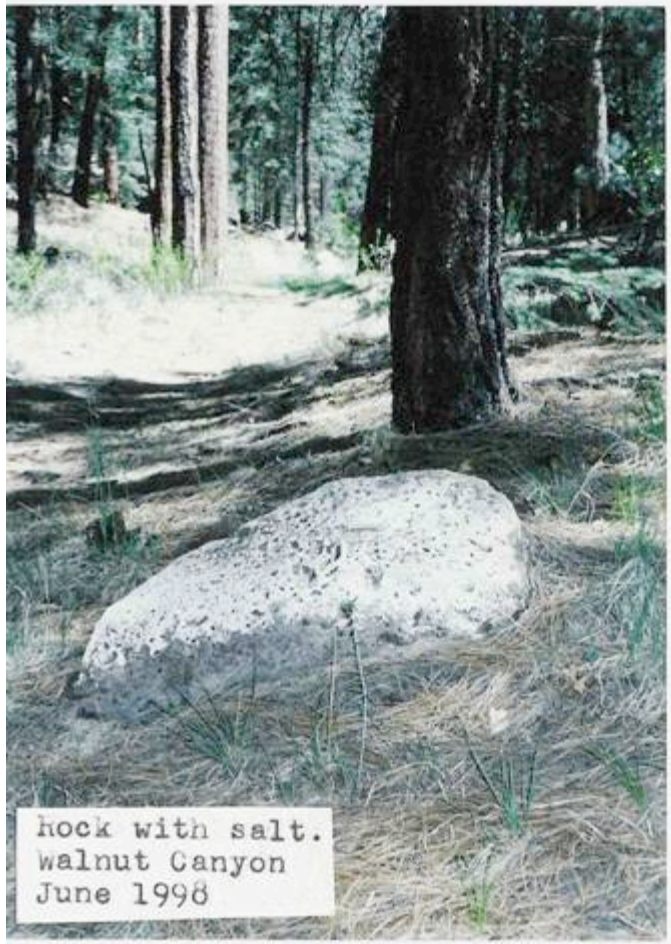
(Salt concentration)

Electrical conductivity (mmho/cm)

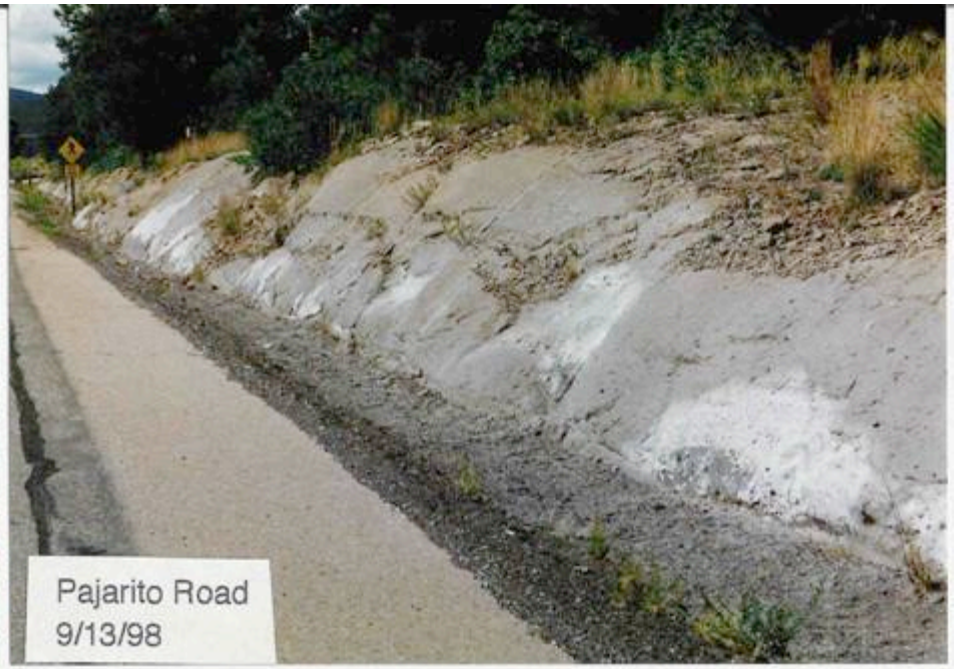


Unsaturated flow of water carries dissolved solids, including salt.

Figure 8.2 Typical salinity profile in soil exposed to a high water table. (Ayers and Westcot).



Rock with salt.
Walnut Canyon
June 1998



Pajarito Road
9/13/98

Salt growing on rock
Pajarito Road 9/13/98

EFFECTS OF SODIUM CHLORIDE ON SOIL & PLANTS

Salt affects the soil

•Destroys the soil structure by replacing calcium on clay particles. The soil becomes “sodic” (salt pan) at high salt content.

•Soil loses its ability to hold or transmit water.

Salt affects plants

•Reduces plant foods, especially calcium and potassium.

•Toxicity to sodium or chloride varies by plant species.

•Decreases osmotic potential, making it difficult for the plant to draw moisture from the soil.

•Germinating plants are the most sensitive.

SODIUM ABSORPTION RATIO

A MEASURE OF SALINITY
OF SOIL OR WATER

$$SAR = \frac{Na}{\sqrt{Ca + Mg}}$$

$$= \frac{sodium(ppm/23)}{\sqrt{calcium(ppm/40) + magnesium(ppm/2}}$$

SAR RANGES FOR PLANT DAMAGE

SAR	Problems
>3	No sodium problem.
3-6	Few problems except sensitive plants.
6-8	Increasing problems. Flush soil with gypsum.
8-14	High sodium, not recommended for crops.
>14	Probably not growing much.

SURFACE WASTE FACILITIES

PITS

- Shallow hole.
- Provide a reservoir of fluid during drilling.
- Contain used muds & cuttings after drilling--and junk.
- Usually dried, then covered, leaving wastes in place.
- Drilling fluid additives may be toxic.
- Salt water is used when drilling in salt formations.
- A liner may be left in place, but is is often torn and will degrade in time anyway.

SURFACE WASTE FACILITIES

LANDFILLS

Deeper burial than pits, although one operator proposed to “bury” wastes 10 ft above ground level.

Wastes may be debris contaminated with hydrocarbons, salt, and chemicals.

LANDFARMS

Spread hydrocarbon-containing wastes a few inches thick on the ground, stir monthly, and allow to degrade before adding the next “lift” of wastes.

Only lighter hydrocarbons are degraded by bacteria.

In arid lands, most of the light hydrocarbons are evaporated or degraded by sunlight.

Degradation time 2-3 years for a lift in New Mexico.

Until recently, some NM landfarms have improperly accepted saline wastes.

Texas landfarms may accept wastes 1/6 as salty as sea water

Salts do not evaporate or degrade.

PONDS

Evaporation ponds reduce the volume of salt water before injection into the deep subsurface.

Ponds must now be lined in NM, but seepage and windborne brine may still be problems.

Waste treatment ponds are specially permitted.

SURFACE WASTE TREATMENT, *concluded*

WHEN TO WORRY

A pit or landfill is a *permanent* sacrifice area.

Restrict burial of *soluble* or *volatile* toxic wastes to carefully selected landfills because materials move, sooner or later.

Evaporative sprays should be confined to the pond.

WHEN NOT TO WORRY

Shallow burial of *harmless* minerals.

Landfills having geological containment at bottom, sides, and top--and no useable groundwater.

NEW MEXICO SURFACE WASTE MANAGEMENT FACILITIES

according to permit records.

PITS

~50,000

LAND FARMS

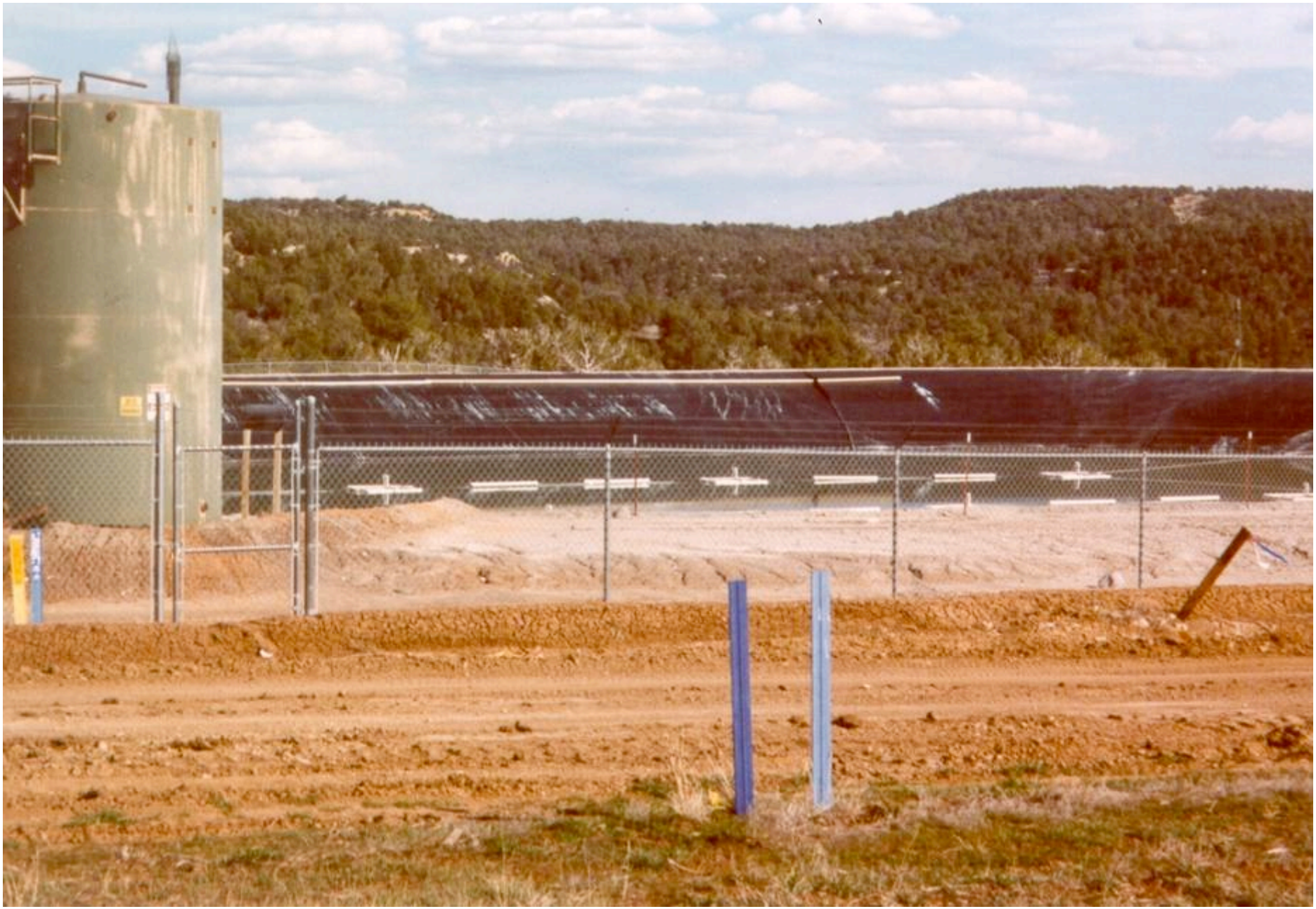
30 farms, ~350 acres

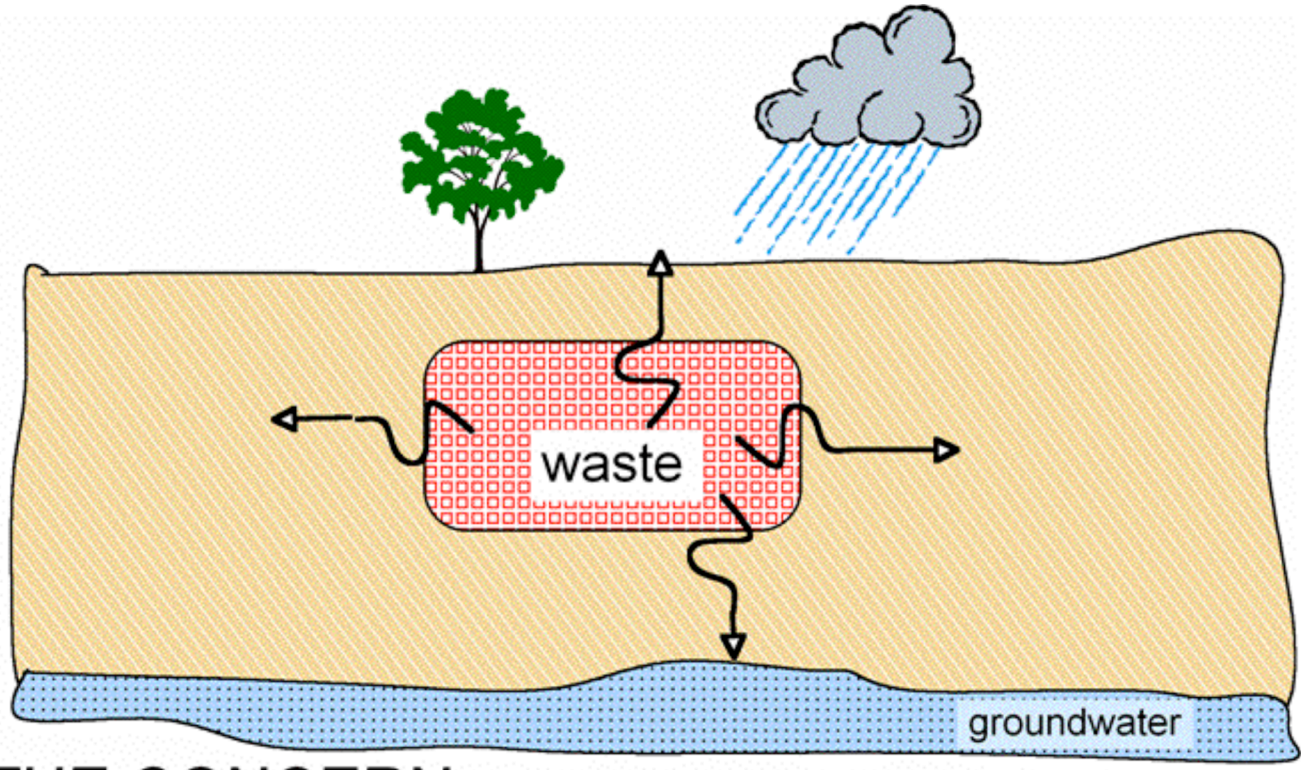
LAND FILLS

3

EVAP PONDS

5





THE CONCERN

Soluble subsurface wastes can be transported by pore water, up, down, and sideways.

Volatile wastes (BTEX) will diffuse by themselves throughout the porosity of the soil.

Vapor transport, saturated aqueous transport, or unsaturated aqueous transport will follow preferential pathways.

REMEDIATION METHODS

Salt in soil

- flush to the aquifer (agricultural practice)
- remove and re-bury

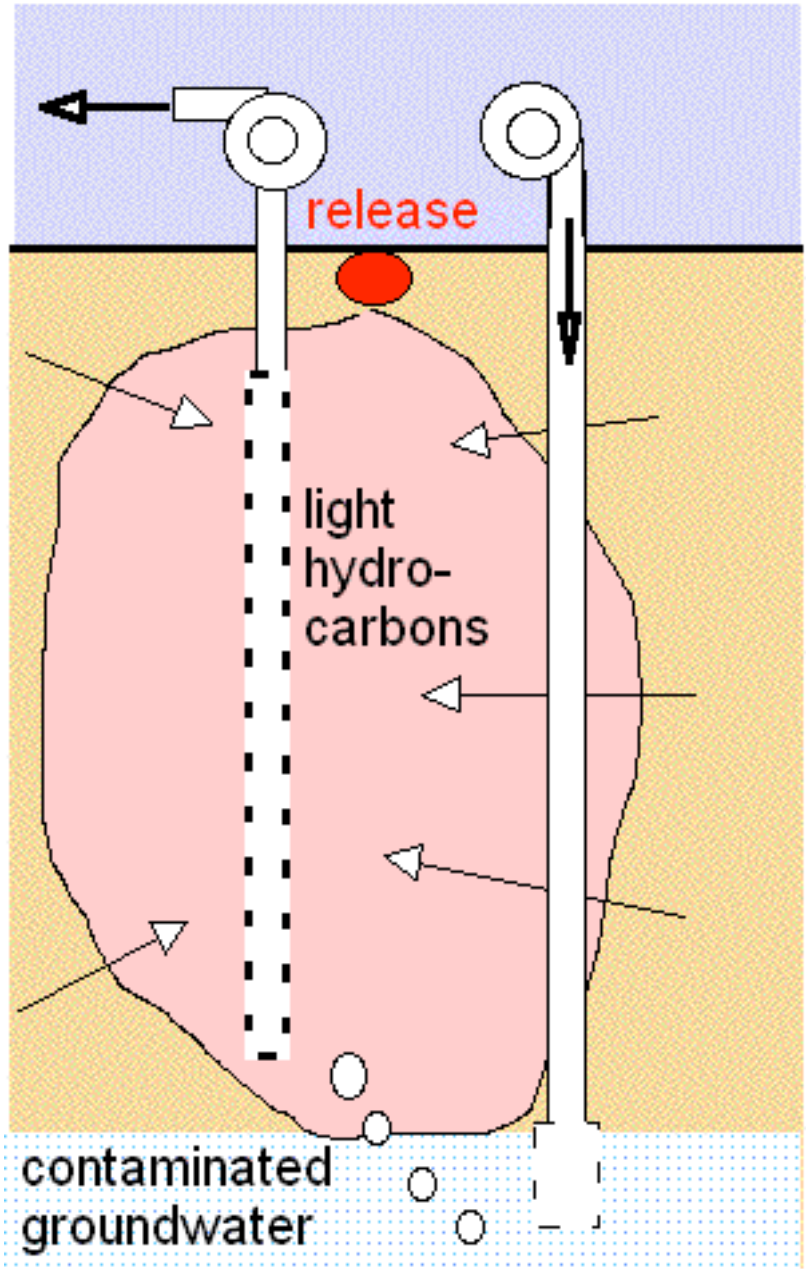
Light hydrocarbons

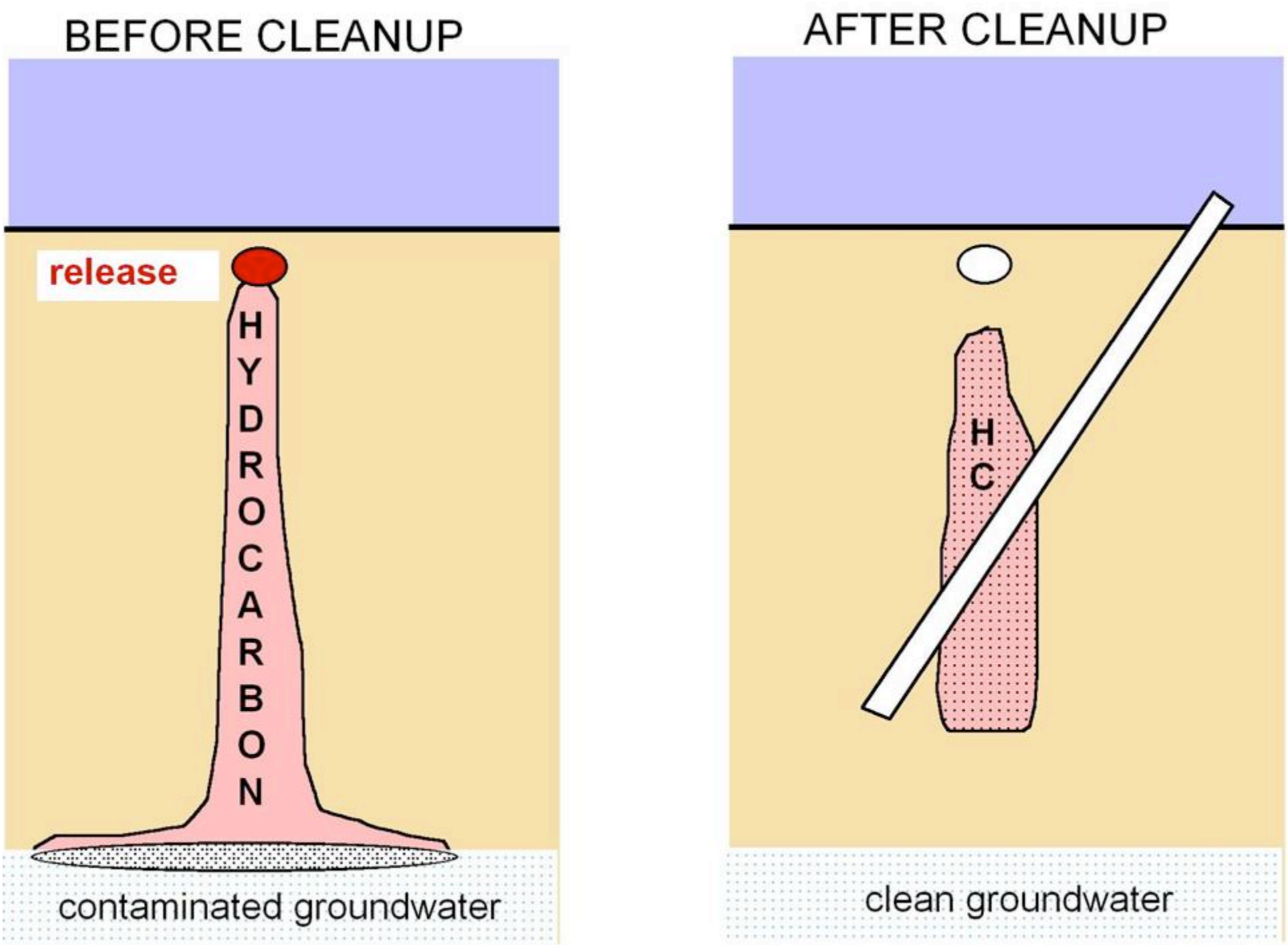
- landfarm solid wastes
- soil vacuum extraction for subsurface soils
- sparge, pump & treat for contaminated water
- “monitored natural attenuation” = do nothing

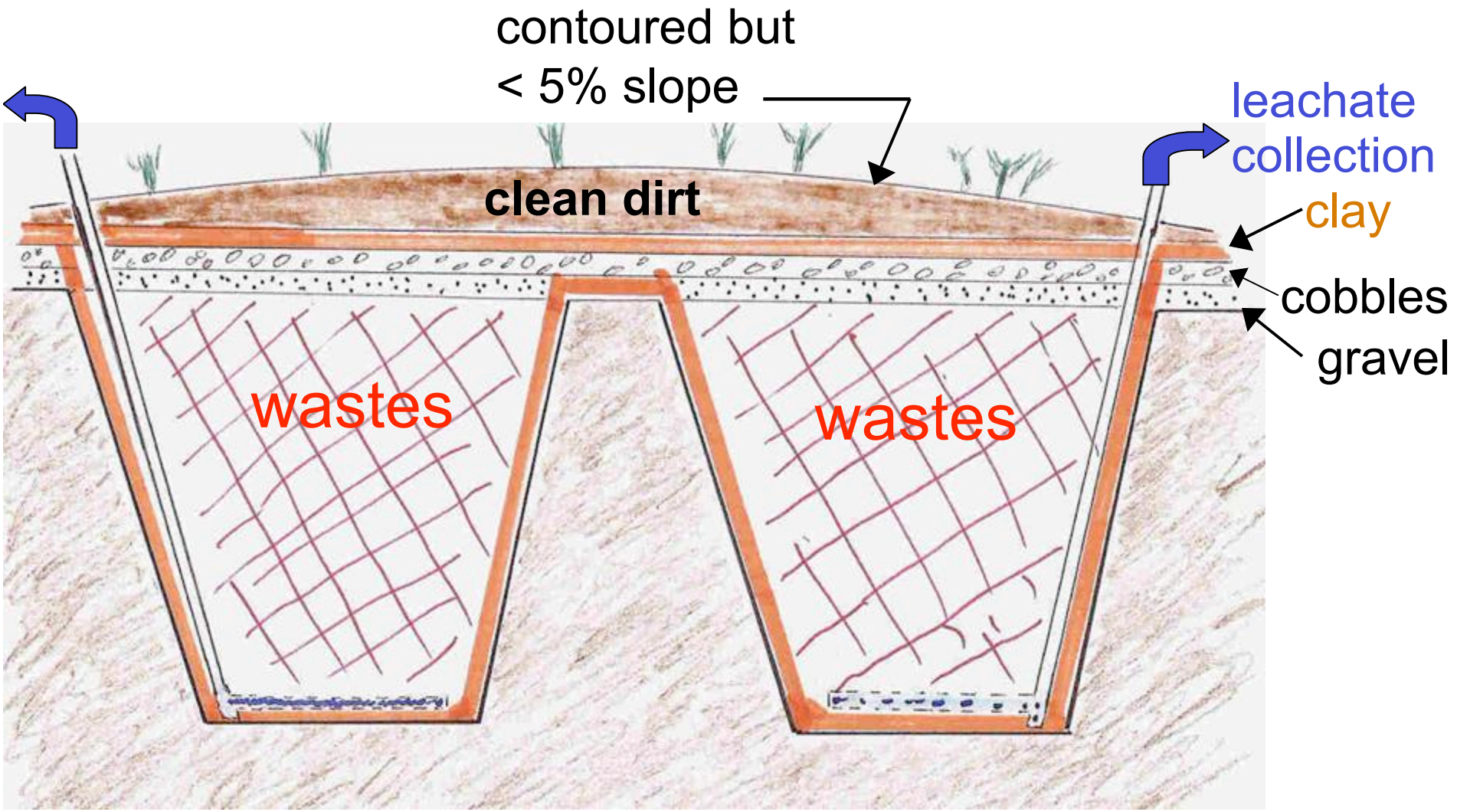
Heavy hydrocarbons

- heat treat liquids
- send solids to asphalt plant
- bury solids in a landfill

Soil Vapor Extraction and Sparging of vapors




BEFORE CLEANUP
release
HYDROCARBON
contaminated groundwater
AFTER CLEANUP
HC
clean groundwater



CLOSED LANDFILL

WHAT'S OUR CONCERN?

Surface disturbance -- can it be vegetated again?

Pits -- like little landfills almost everywhere

Burial--if insecure,toxic materials may go up or down

Spills--if ignored, they form a cumulative legacy.

WHAT MIGHT WE IGNORE?

Benign minerals--on or near ground surface.