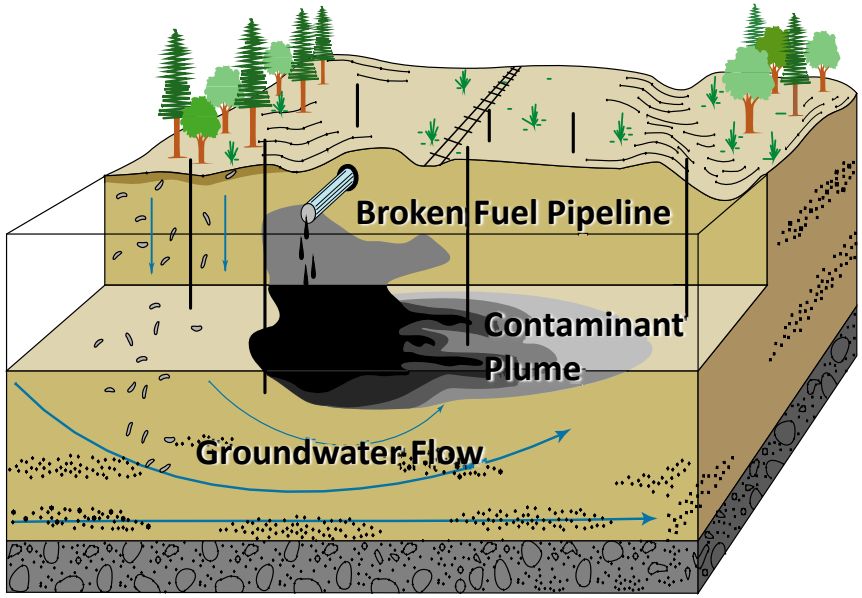
# Lecture 23: Groundwater Contamination II

## Key Questions

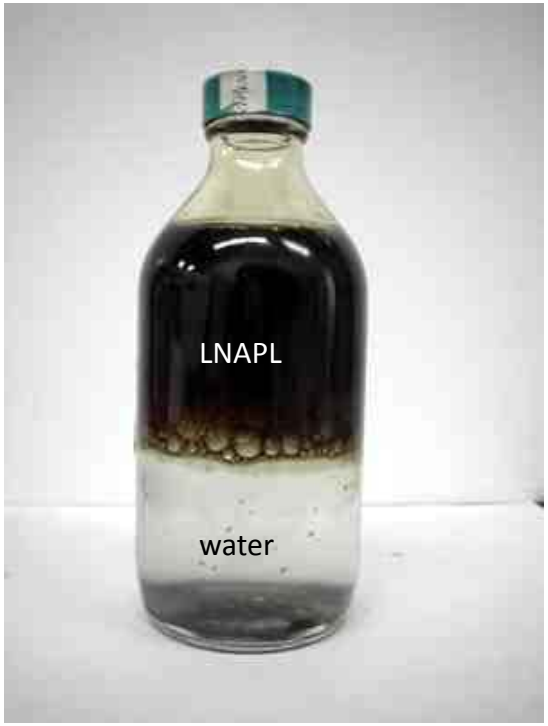
1. What is a NAPL?
2. What are some examples of a LNAPL?
3. What are some examples of a DNAPL?
4. What groundwater contaminants are polluting Area 6 at the NAS site?
5. What is a Superfund Site?
6. Where are the Superfund Sites in Whatcom County?



Organic Liquids are another common source of groundwater contamination

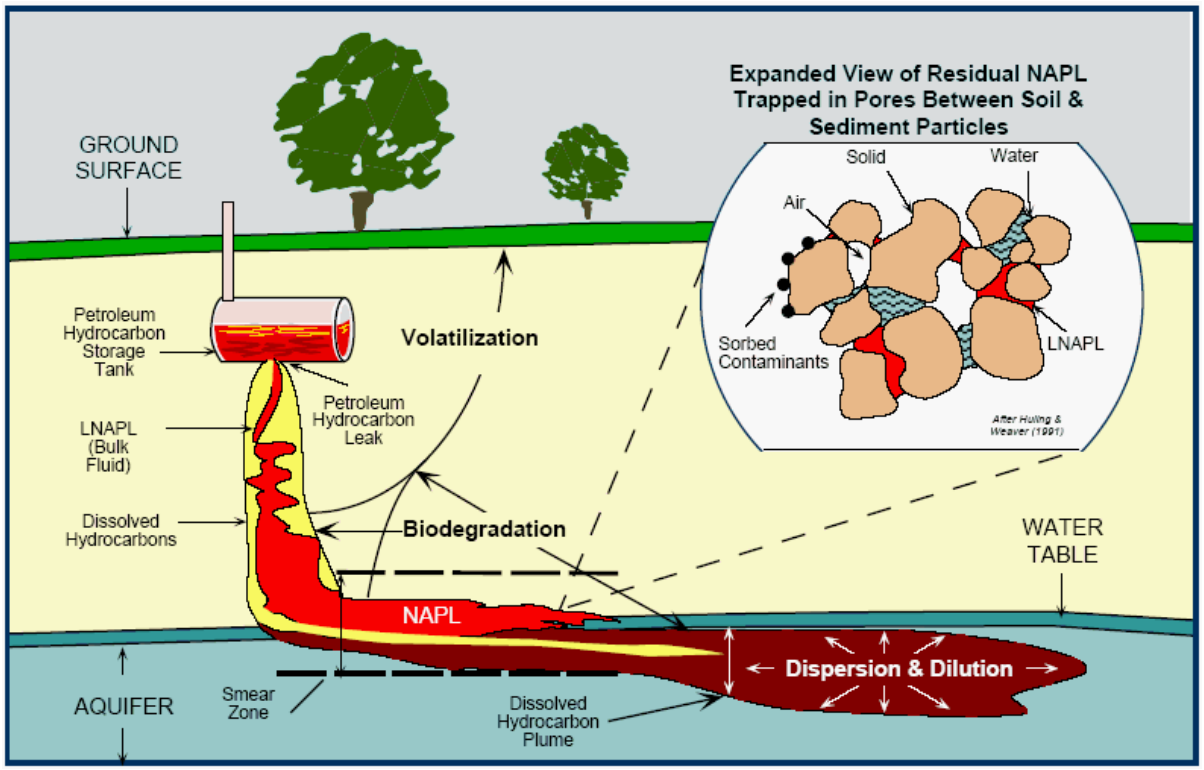

Fuels

Solvents

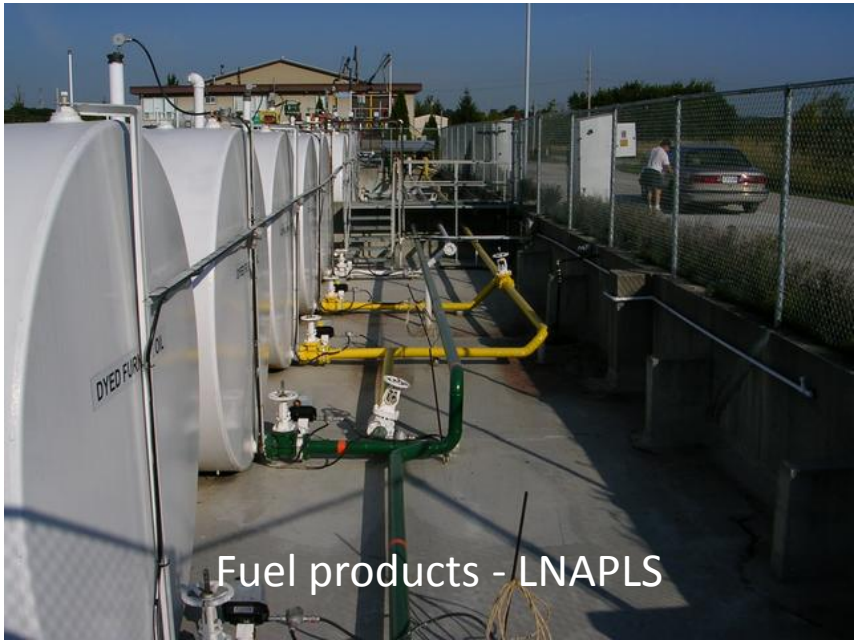



LNAPL = Light Non-Aqueous Phase Liquid

LNAPLS are lighter than water so they float



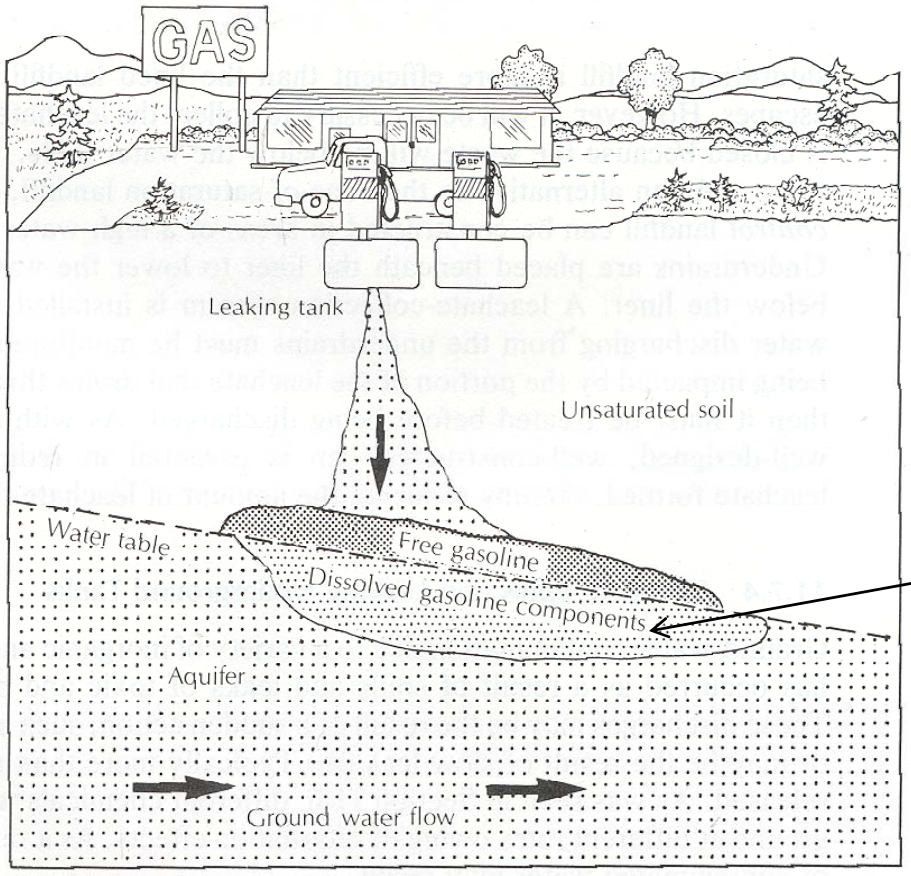

Fuels are LNAPLs


Fuel products - LNAPLS

## Examples of LNAPLs include:

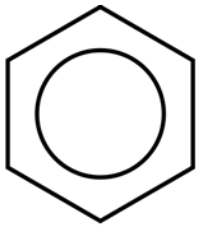
- Gasoline
- Kerosine
- Fuel oil
- Jet fuel
- Diesel fuel

Fuels are chemically processed and contain many different types of organic chemicals

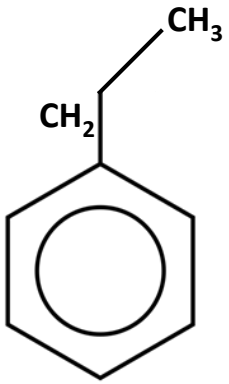



BTEX compounds will slowly dissolve out of the gasoline into the groundwater and create a plume that will flow with the groundwater

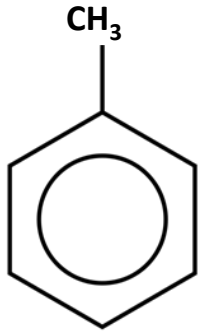
# BTEX Compounds



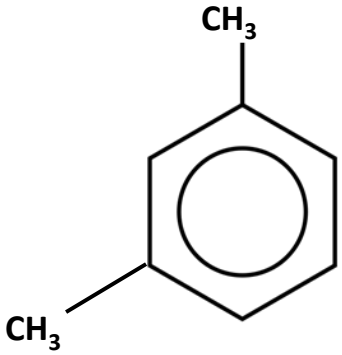
Benzene



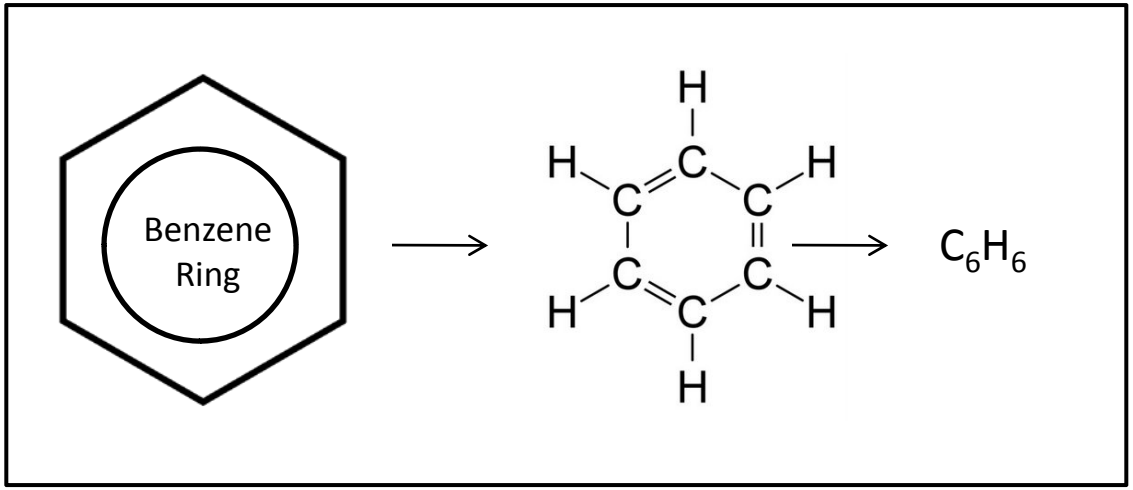

Ethylbenzene




Toluene



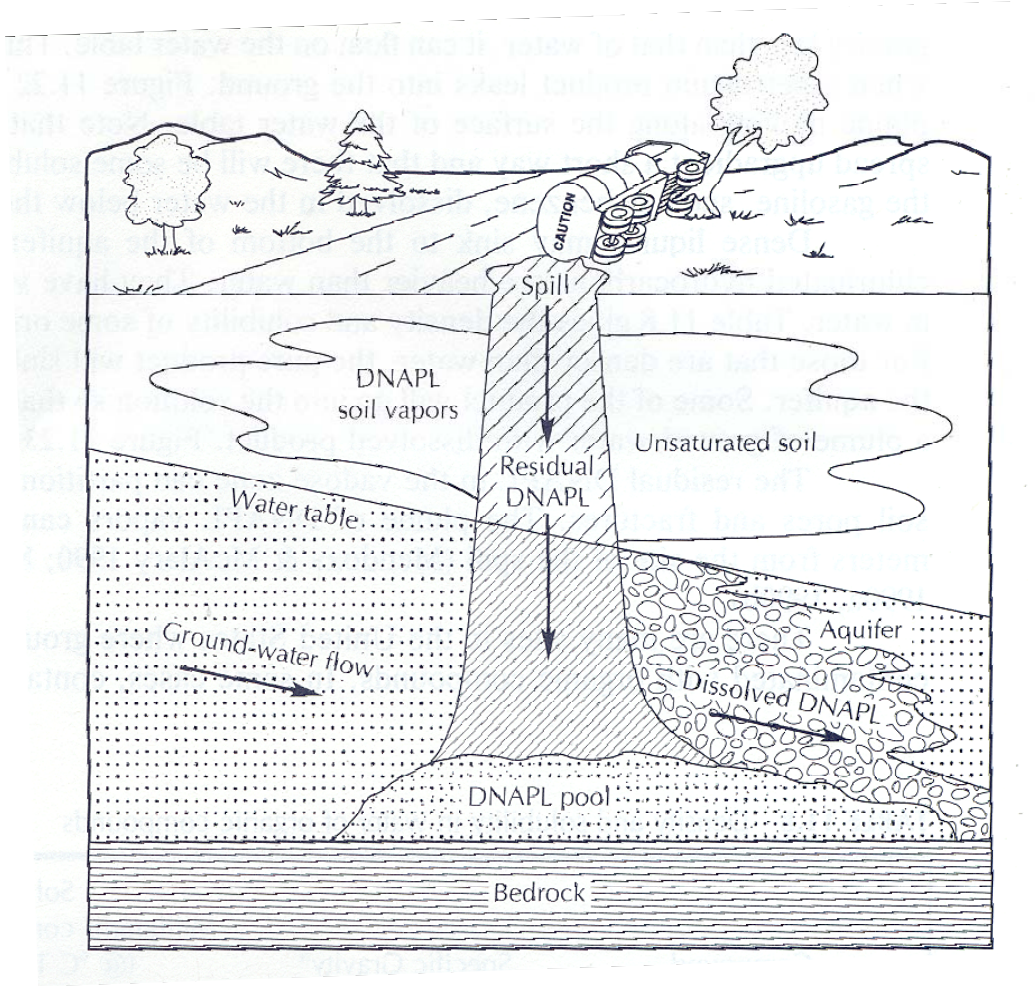

Xylene

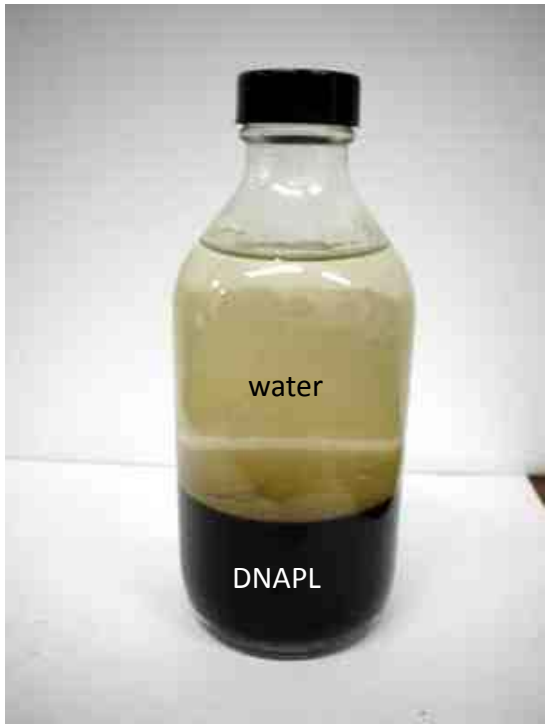


One cup of gasoline will make a volume of water equivalent to an Olympic-size swimming undrinkable!

Olympic swimming pool is 660,000 gallons

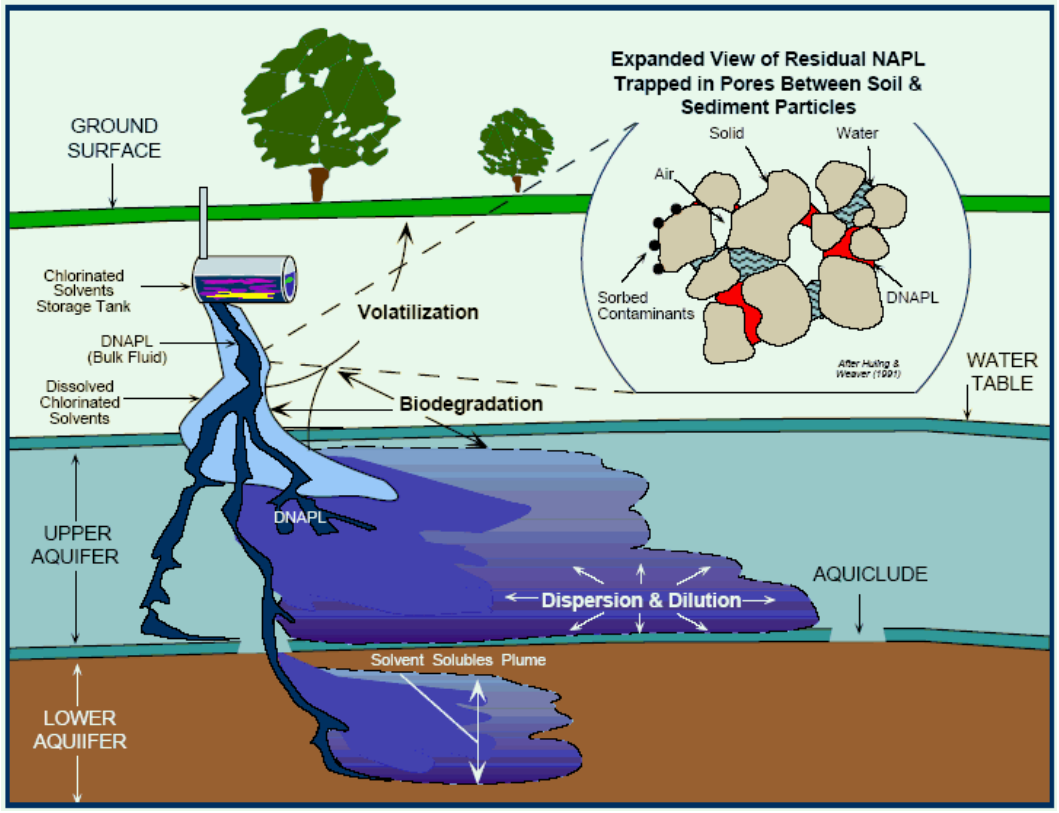
# Organic Solvents, are different than fuels






DNAPL = Dense Non-Aqueous Phase Liquid

DNAPLS are heavier than water so they sink




Solvents are DNAPLs

# Oragnic solvents are examples of DNAPLs

- Trichloroethylene (TCE) or dry-cleaning fluid
- Trichloroethane (TCA) e.g., parts cleaner, degreaser
- Carbon tetrachloroide (CTET) is a reagent
- Toluene – paint thinner
- Turpentine – paint thinner

Whidbey Island Naval Air Station (NAS)

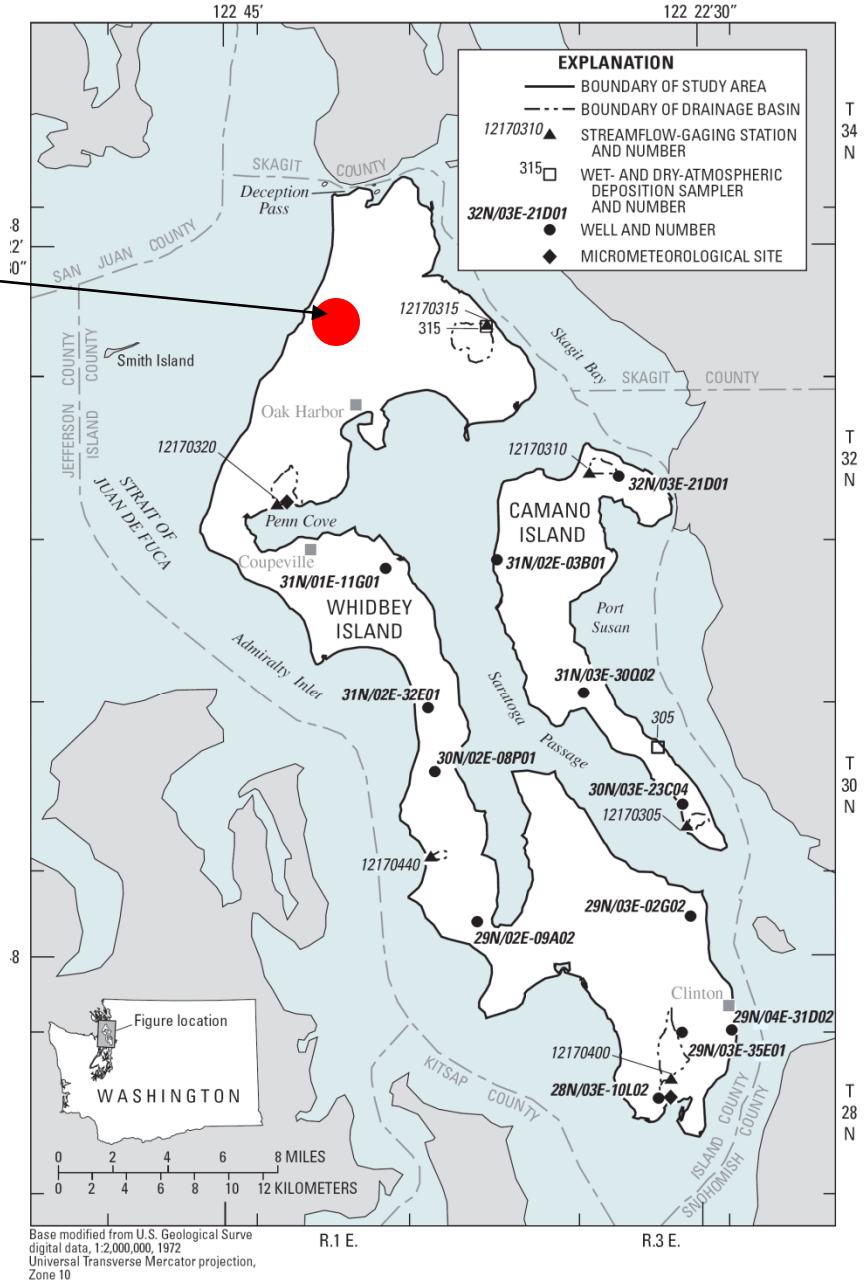



**Figure 1.** Locations of six study basins on Whidbey and Camano Islands, Island County, Washington.

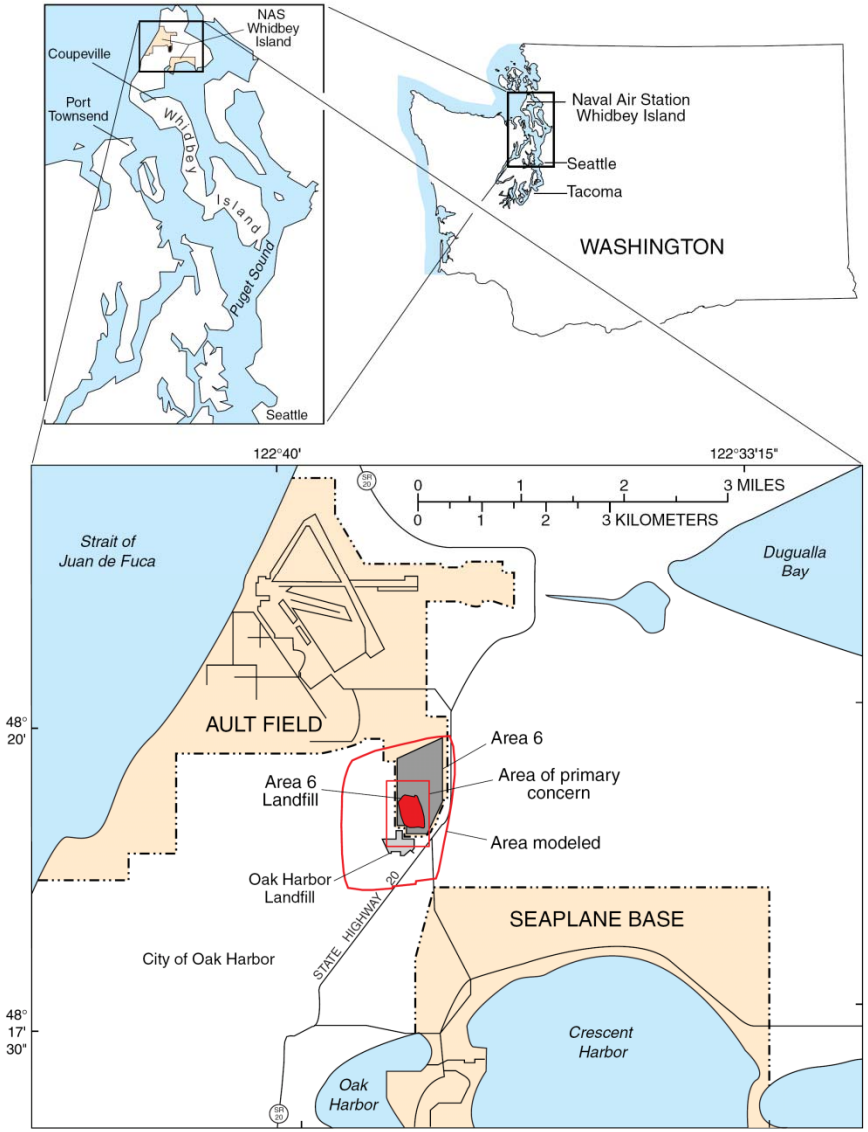
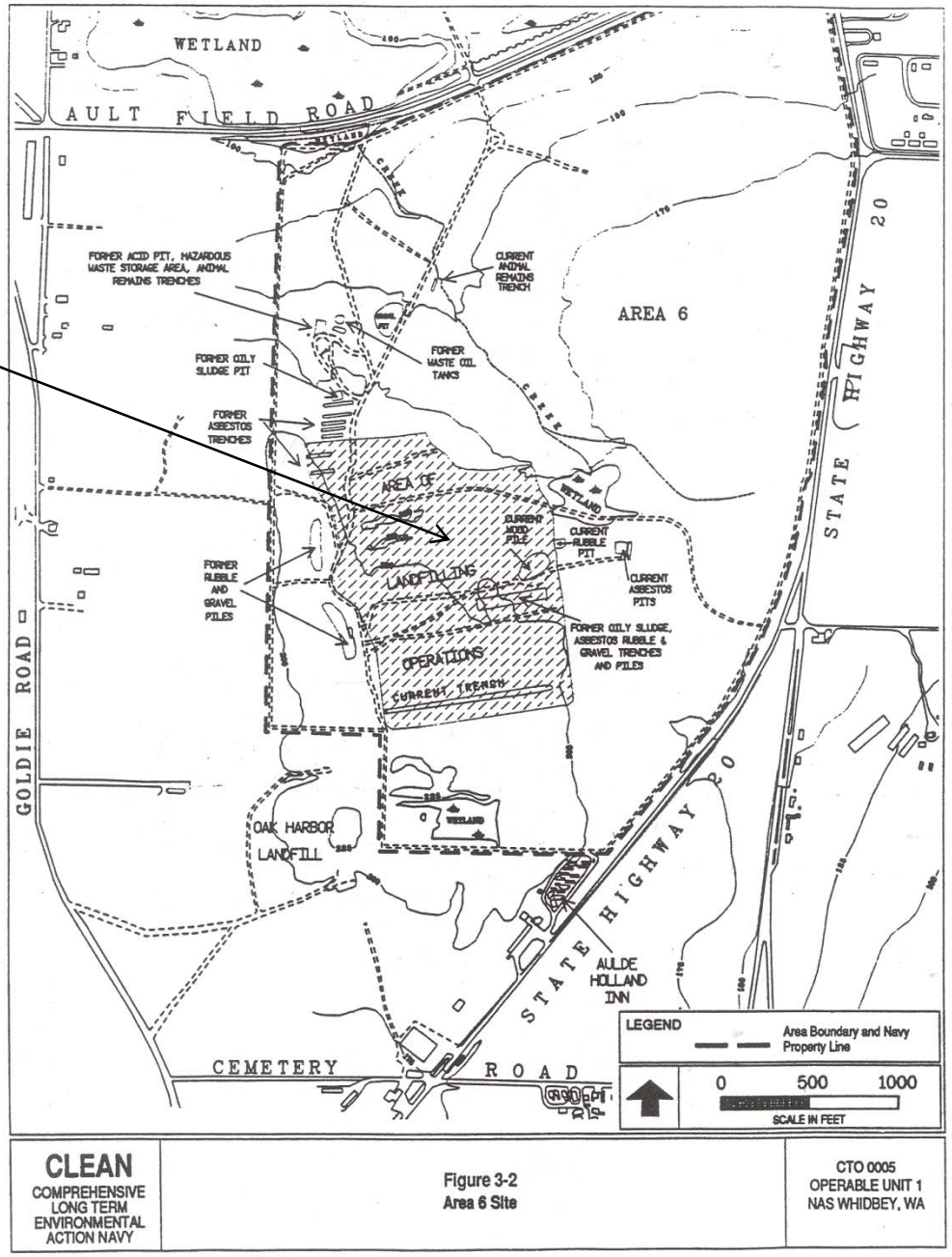
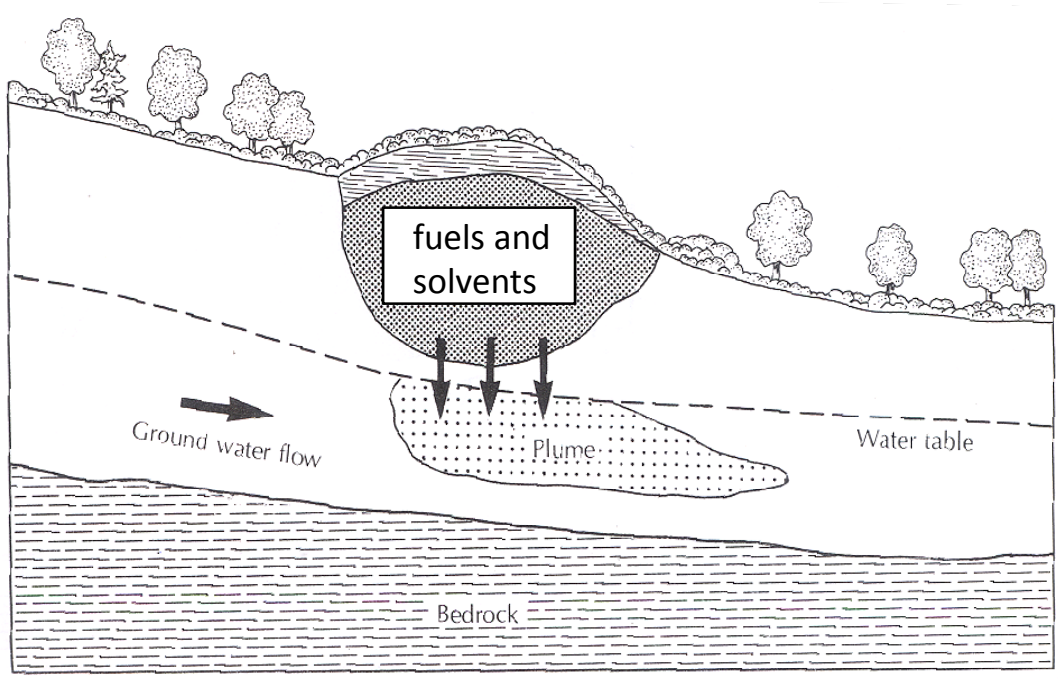



**Figure 1.** Location of the Whidbey Island Naval Air Station and Area 6 landfill study area, Island County, Washington.
(From URS Consultants, 1993a.)

Landfill with fuel products and organic solvents



# Area 6 Landfill



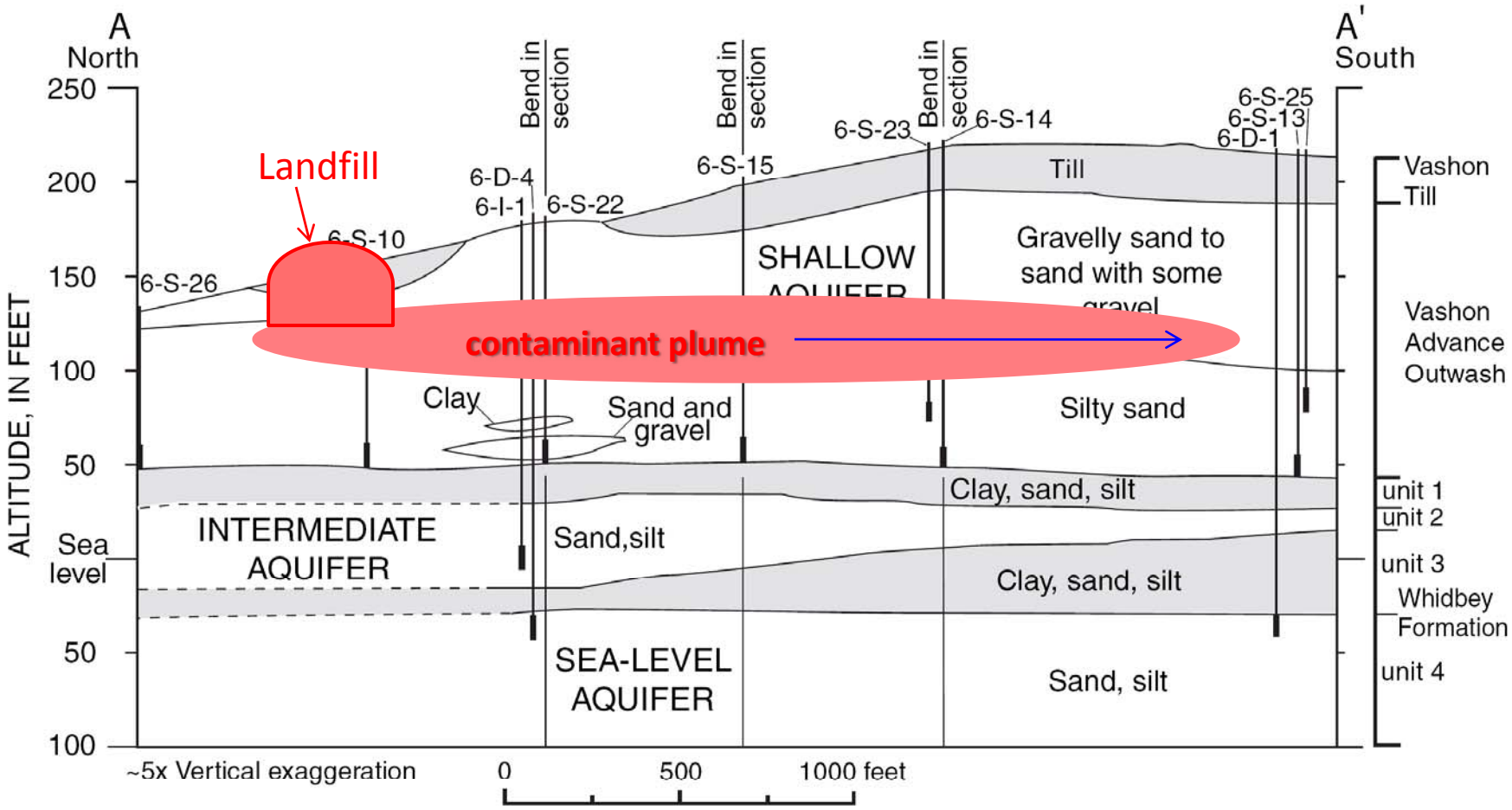



**Figure 2.** Generalized hydrogeologic section showing stratigraphic units at Area 6. (From URS Consultants, 1993a.)

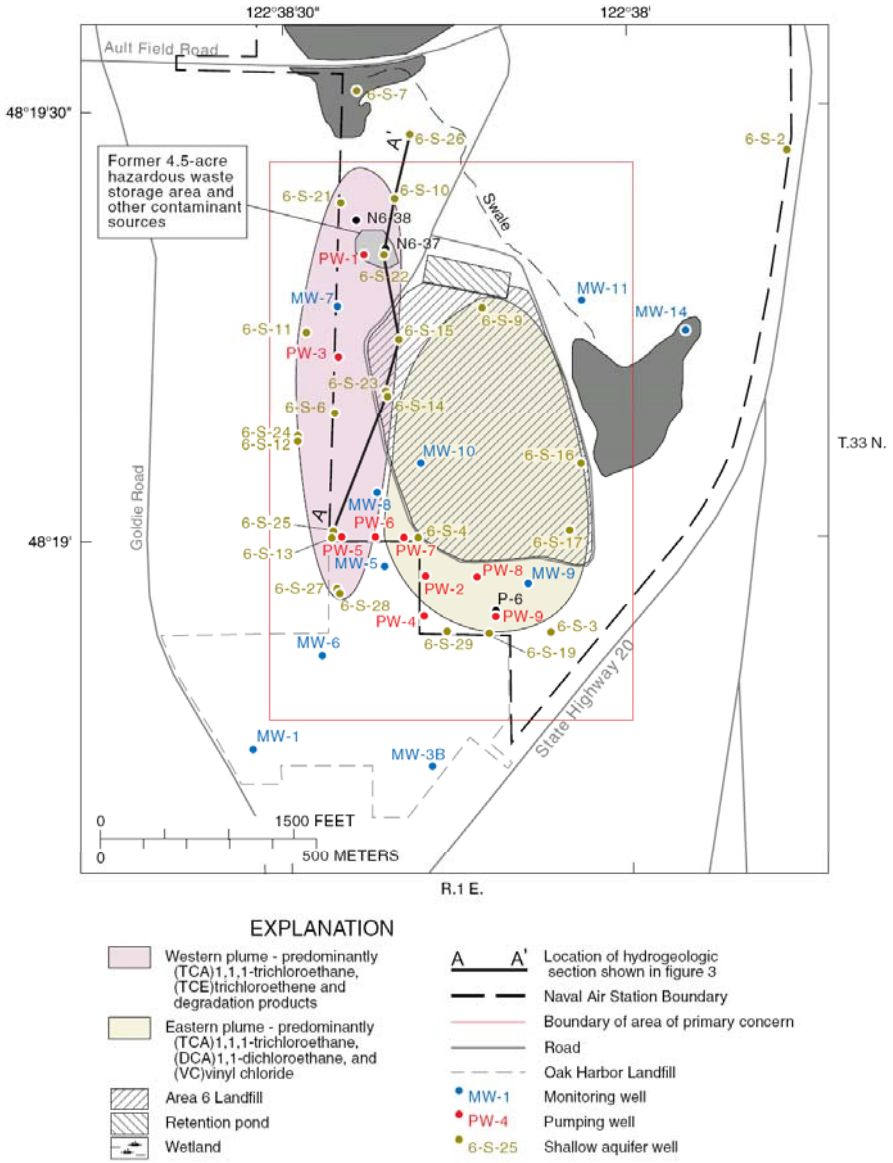


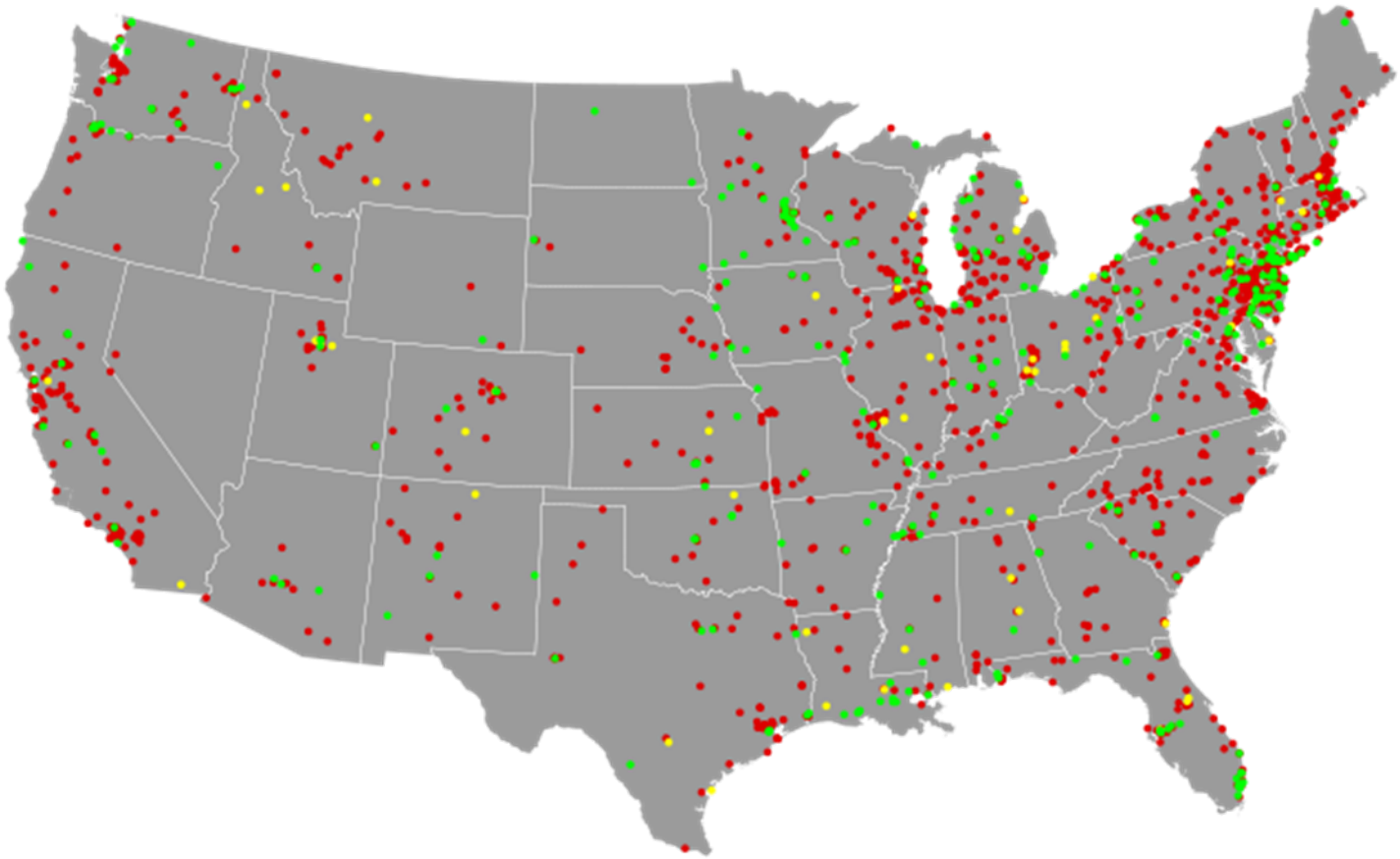

**Figure 2.** Location of Area 6 landfill and surrounding features, including selected wells, hazardous waste storage area, and contaminant plumes.

# The NAS site is a [Superfund Site]

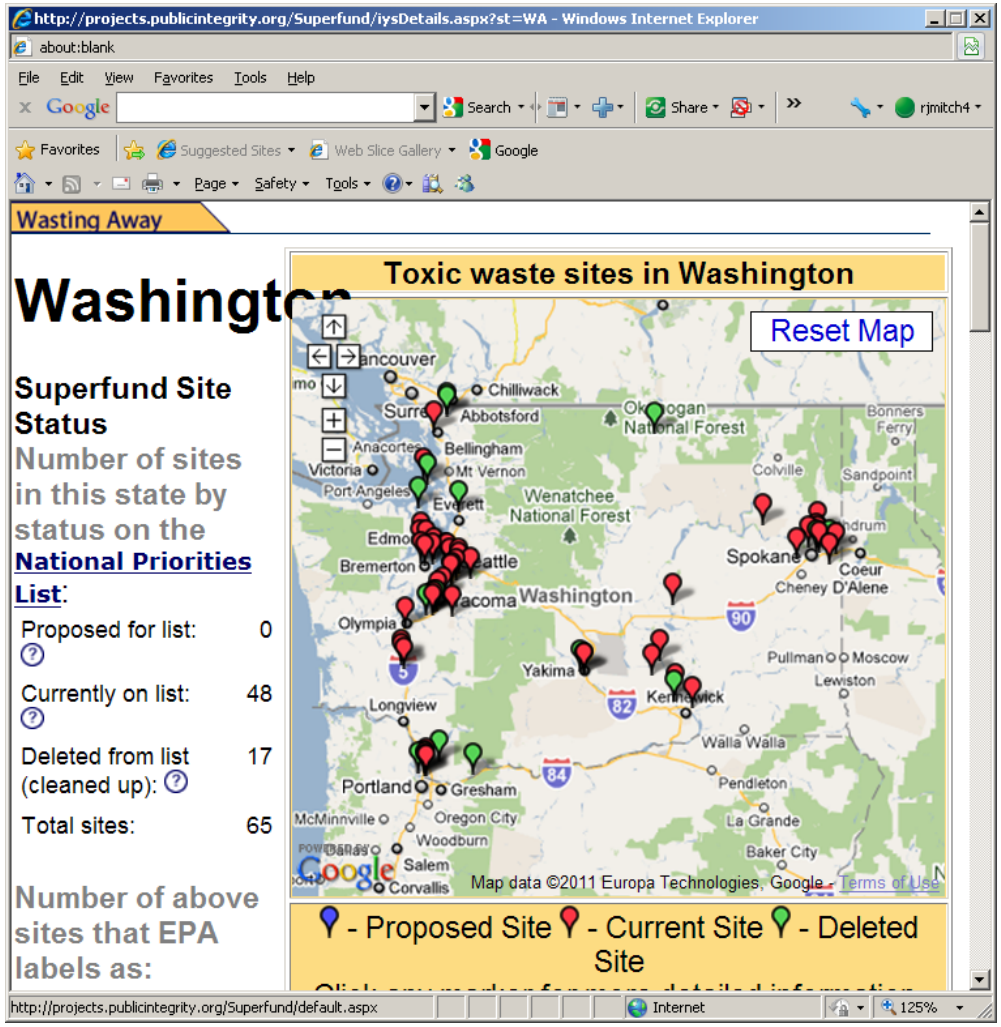
Superfund is the federal government's program to clean up the nation's uncontrolled hazardous waste sites


**Figure 1.** Locations of six study basins on Whidbey and Camano Islands, Island County, Washington.

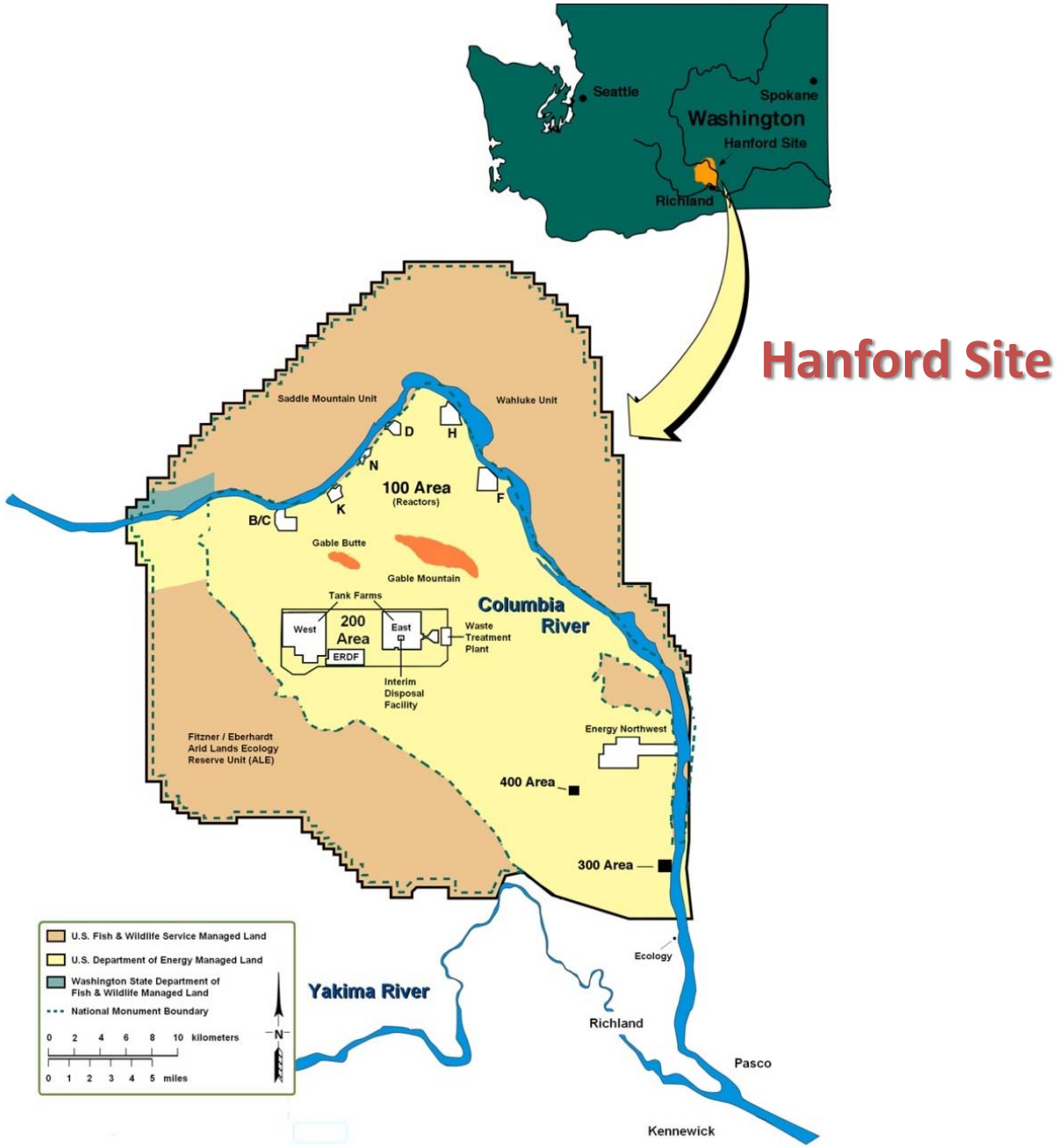
**Superfund sites**. Red equals current; green equals cleaned up; yellow indicates proposed site. As of November 29, 2010, there are currently 1,280 sites listed on the National Priority List, an additional 347 have been de-listed, and 62 new sites have been proposed

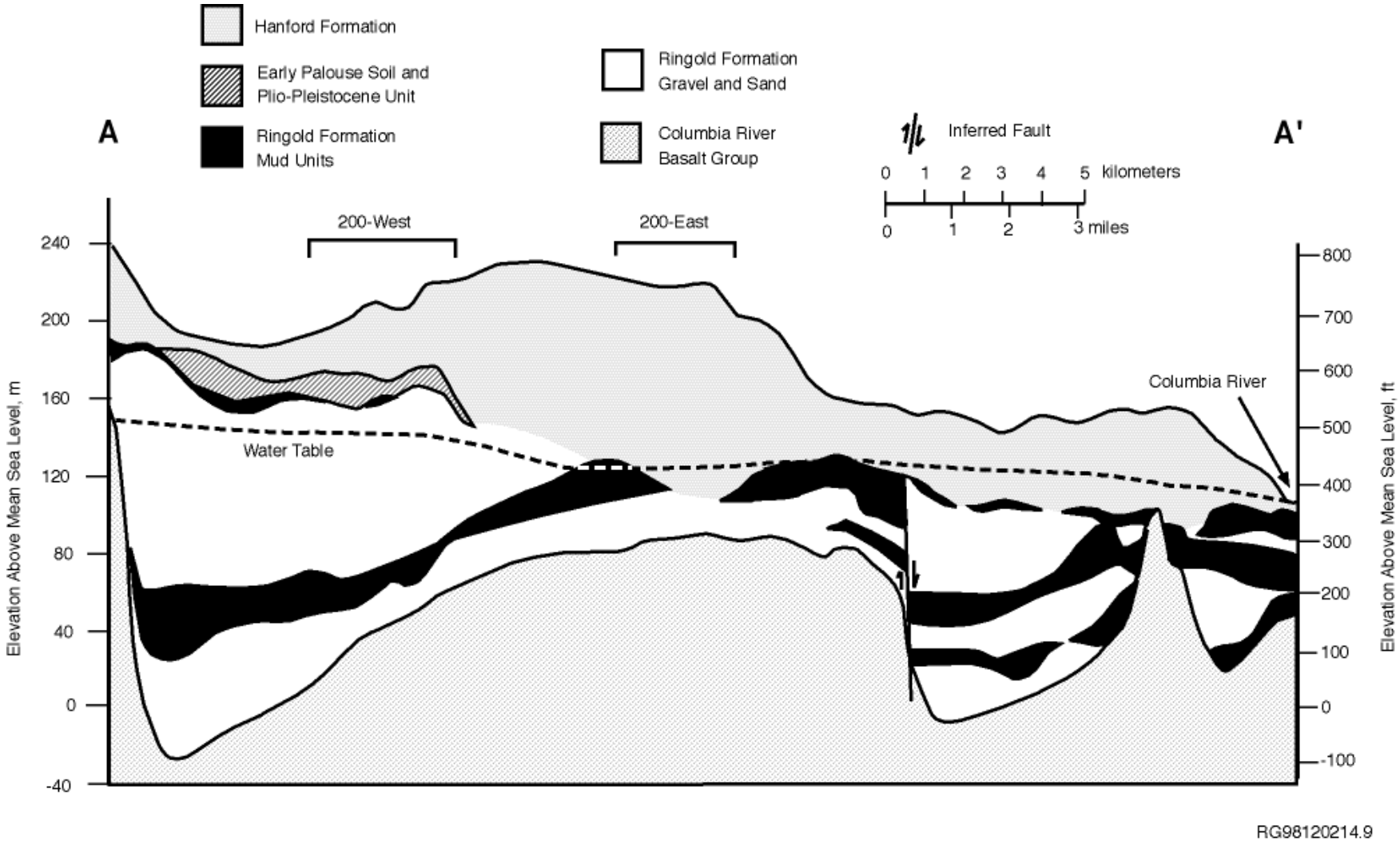


# Superfund sites in Washington State



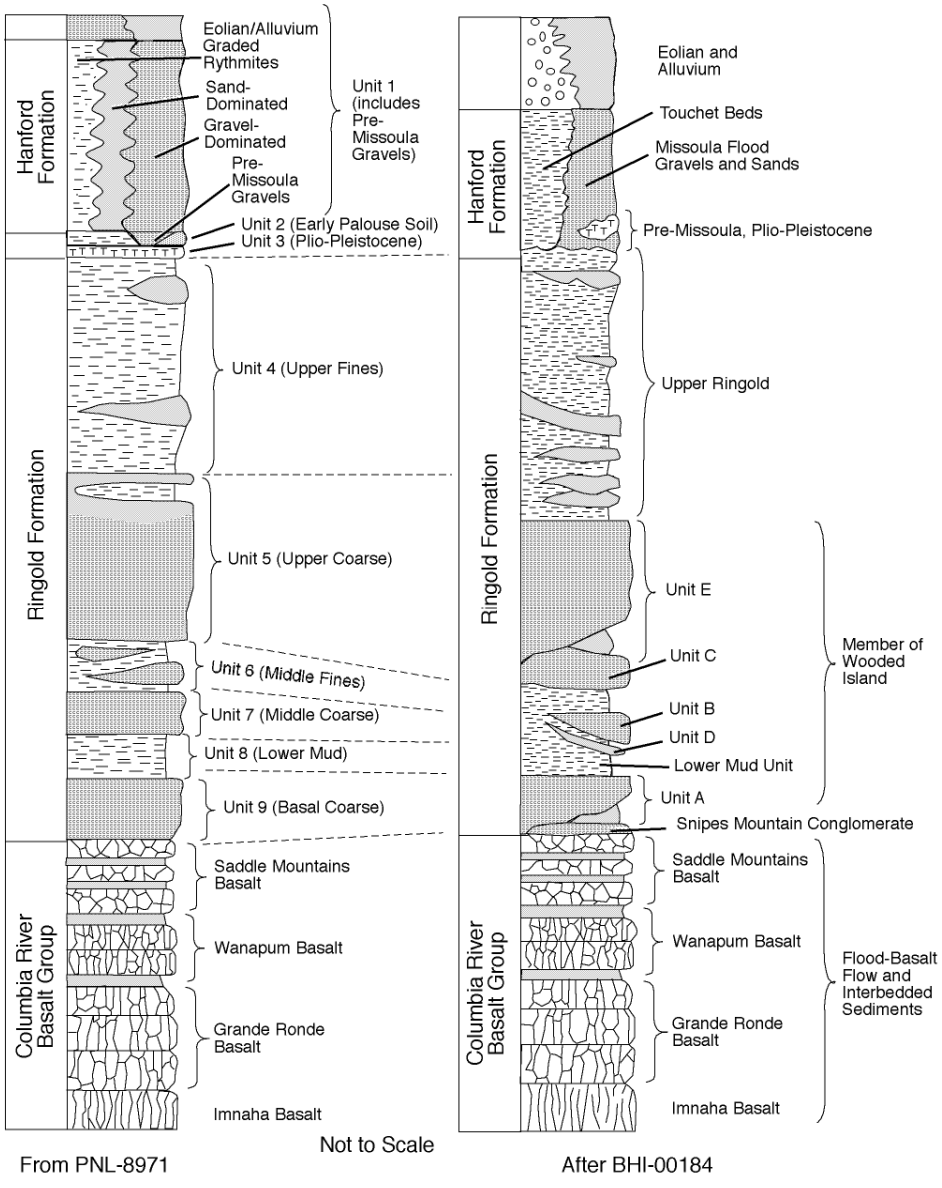

Another source is [EPA's Washington State ] List

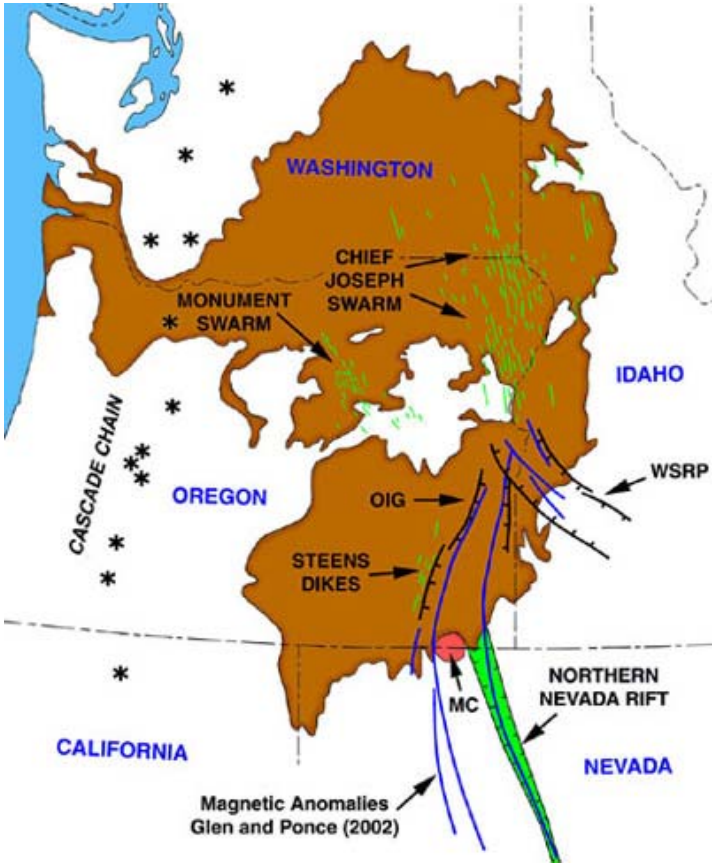

Seattle
Spokane
Washington
Hanford Site
Richland
Hanford Site
Saddle Mountain Unit
Wahluke Unit
D
H
N
100 Area
(Reactors)
F
K
B/C
Gable Butte
Gable Mountain
Tank Farms
West
200
Area
East
ERDF
Waste
Treatment
Plant
Columbia
River
Interim
Disposal
Facility
Fitzner / Eberhardt
Arid Lands Ecology
Reserve Unit (ALE)
Energy Northwest
400 Area
300 Area
Ecology
Yakima River
Richland
Pasco
Kennewick
U.S. Fish & Wildlife Service Managed Land
U.S. Department of Energy Managed Land
Washington State Department of
Fish & Wildlife Managed Land
National Monument Boundary
0 2 4 6 8 10 kilometers
0 1 2 3 4 5 miles
N




Generalized cutaway (cross-section) view of the layered sediments under the Hanford Site. The water table is shown by a dashed line and separates the saturated aquifer below from the vadose zone above.

# Stratigraphic units underlying the Hanford Site.




WASHINGTON
CHIEF JOSEPH SWARM
MONUMENT SWARM
IDAHO
CASCADE CHAIN
OREGON
OIG
WSRP
STEENS DIKES
NORTHERN NEVADA RIFT
MC
CALIFORNIA
NEVADA
Magnetic Anomalies
Glen and Ponce (2002)


Missoula Flood Deposits
(Hanford Formation)

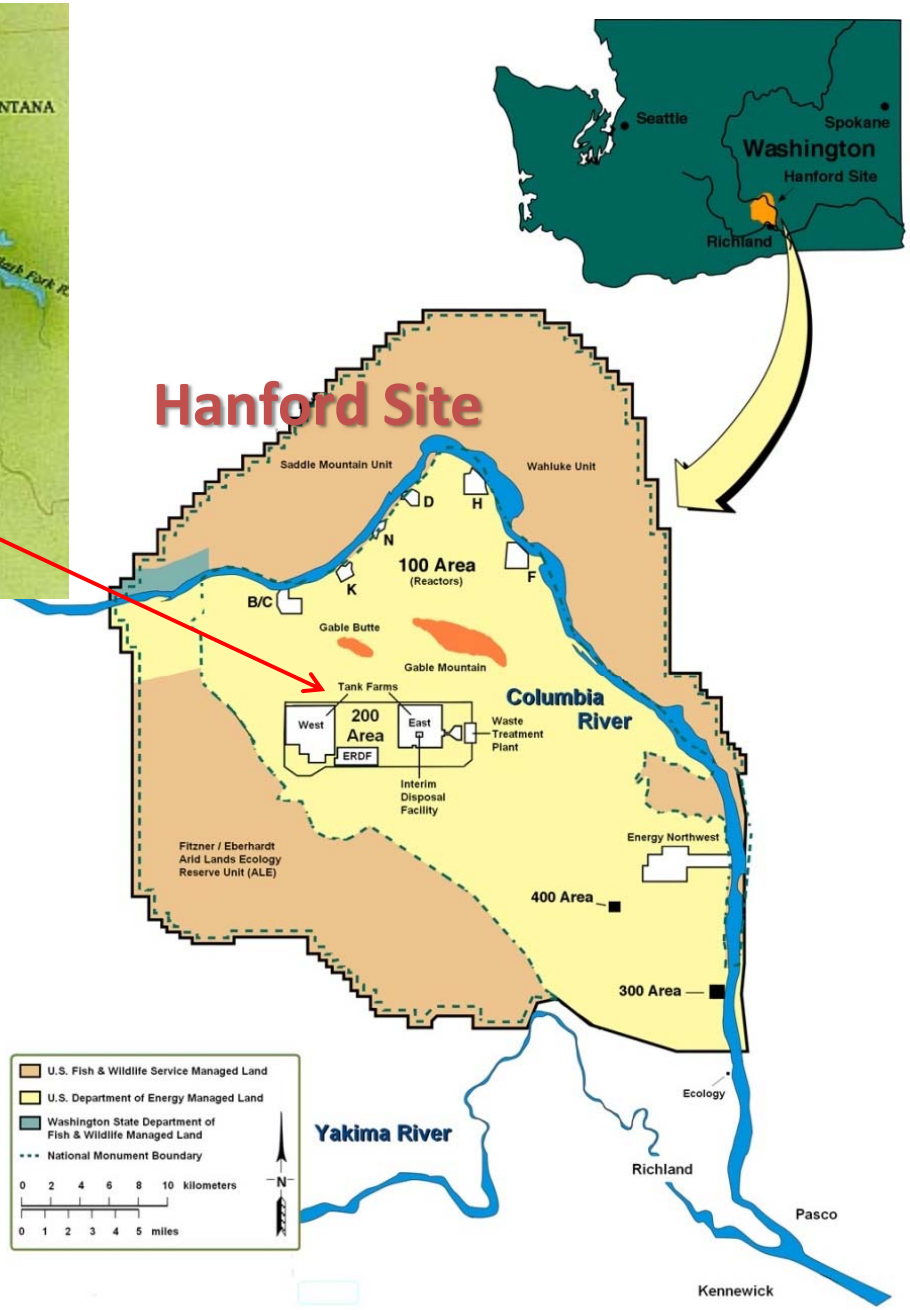
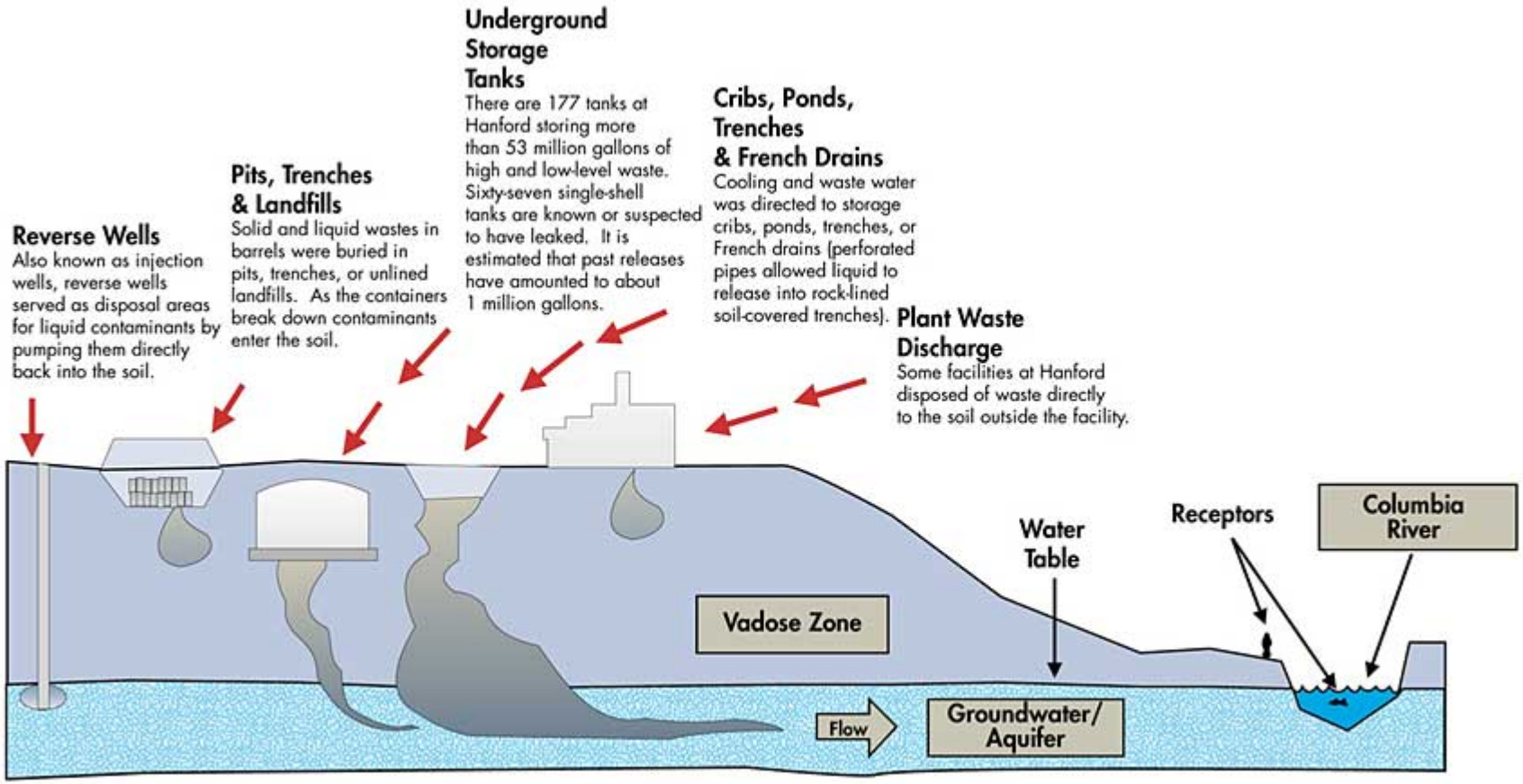


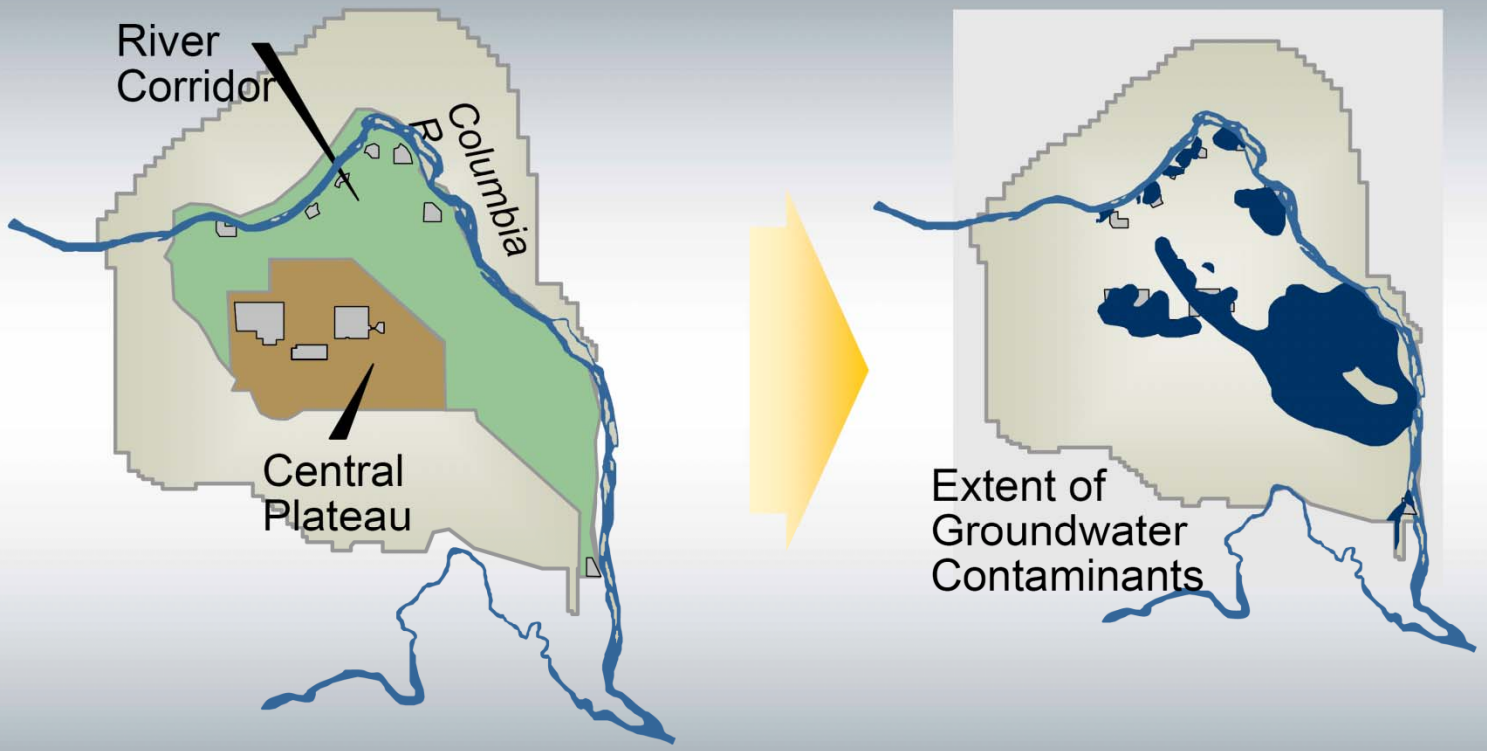
Figure C-4. Gravel-Dominated Sediments of the Hanford formation Exposed in Pit #30.

Figure C-5. Sand-Dominated Sediments of the Hanford formation Exposed at the Integrated Disposal Facility.


Reverse Wells
Also known as injection wells, reverse wells served as disposal areas for liquid contaminants by pumping them directly back into the soil.
Pits, Trenches & Landfills
Solid and liquid wastes in barrels were buried in pits, trenches, or unlined landfills. As the containers break down contaminants enter the soil.
Underground Storage Tanks
There are 177 tanks at Hanford storing more than 53 million gallons of high and low-level waste. Sixty-seven single-shell tanks are known or suspected to have leaked. It is estimated that past releases have amounted to about 1 million gallons.
Cribs, Ponds, Trenches & French Drains
Cooling and waste water was directed to storage cribs, ponds, trenches, or French drains (perforated pipes allowed liquid to release into rock-lined soil-covered trenches).
Plant Waste Discharge
Some facilities at Hanford disposed of waste directly to the soil outside the facility.
Water Table
Receptors
Columbia River
Vadose Zone
Flow
Groundwater/ Aquifer

# Hanford Site Groundwater Overview

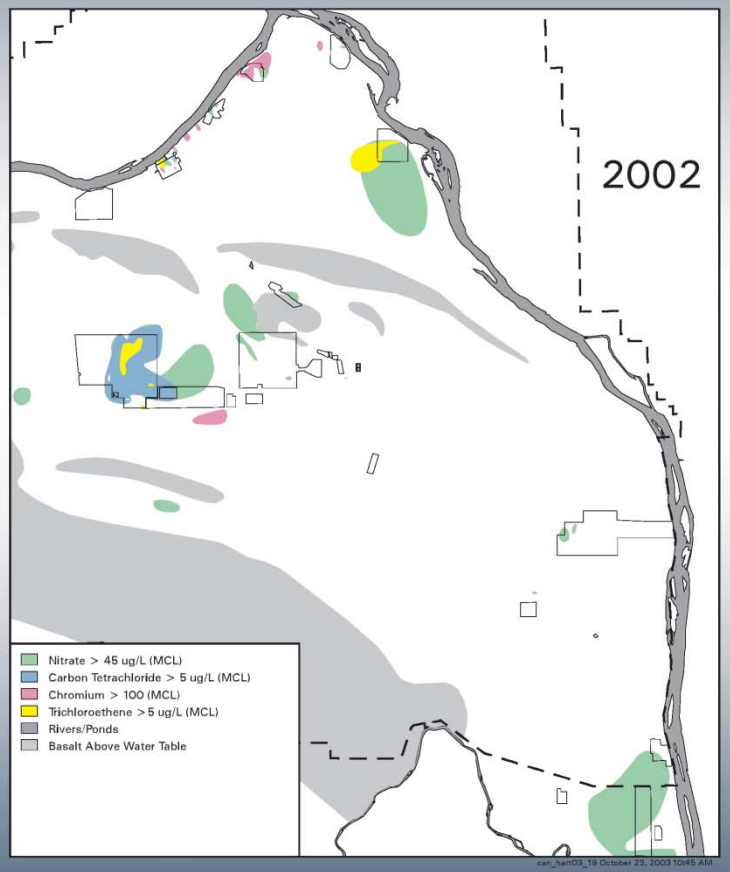
## Current Extent of Groundwater Contamination



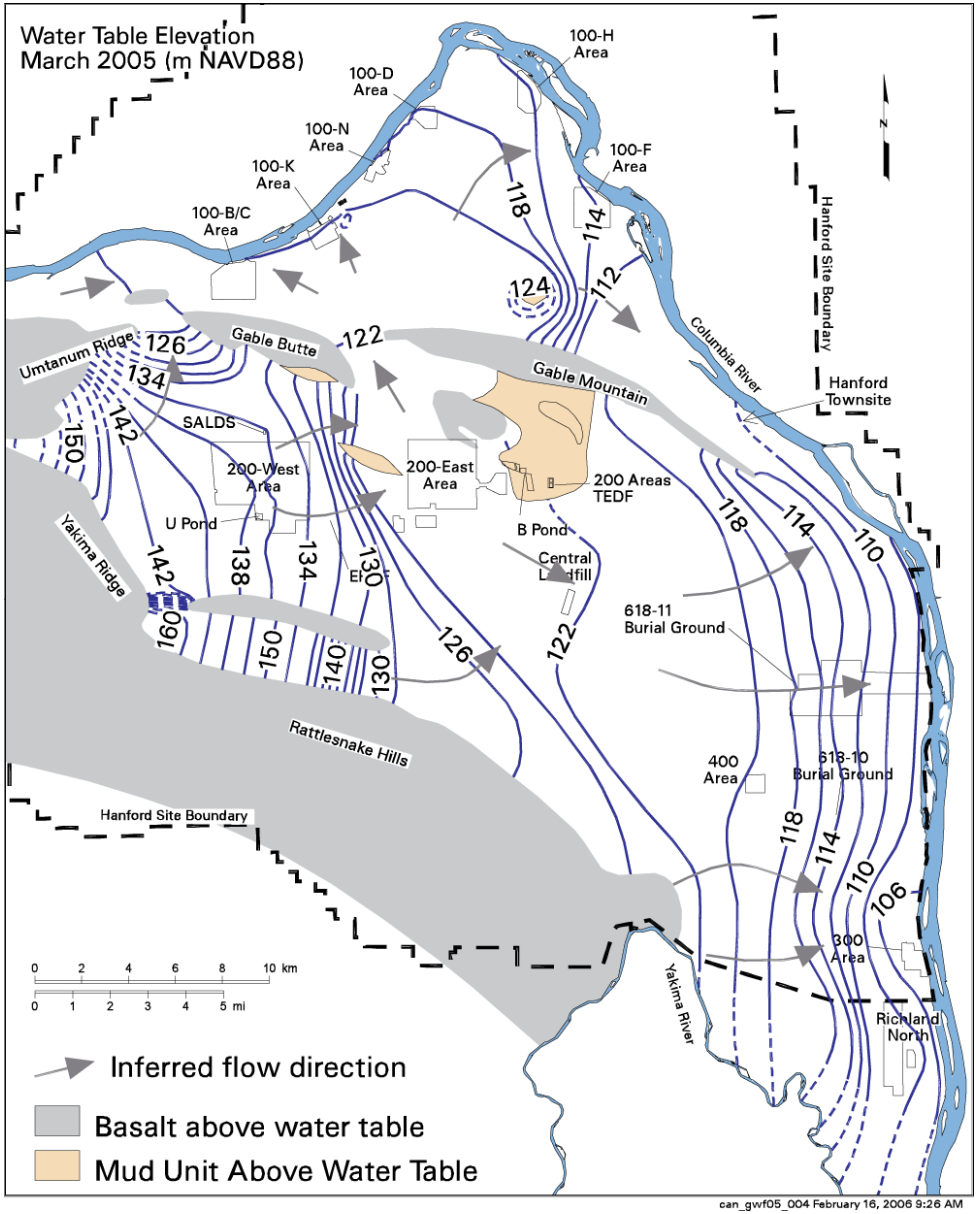

- Approximately 80 square miles of groundwater contaminated above drinking water standards

# Chemical Contaminants

- Nitrate
- Carbon tetrachloride
- Trichloroethene
- Hexavalent chromium



# Water table and inferred flow directions

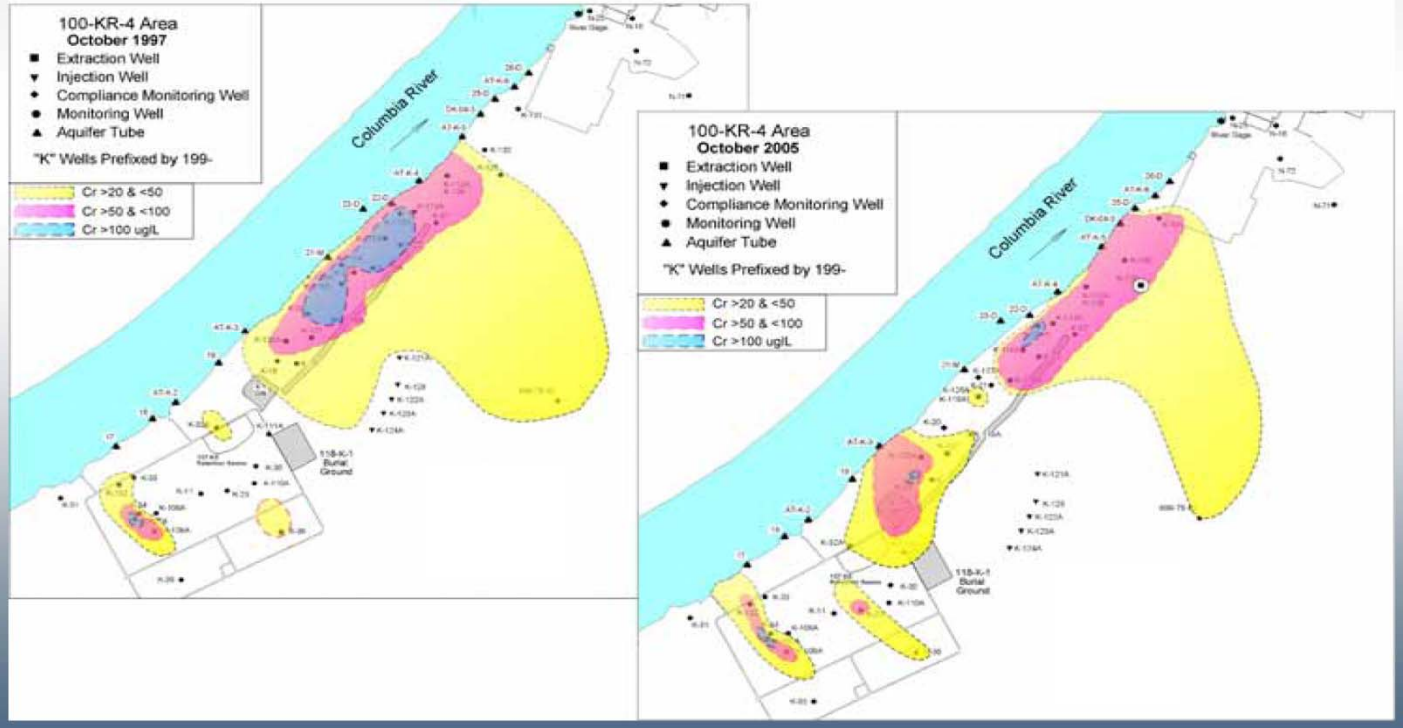


# 100 Area (Reactors)

# 100-K Area
# Chromium Plume Distribution

## 100-K Pump & Treat Operations

Operated Since 1997
~265 Kg Removed
Observed elevated Chromium in Aquifer Tubes Near The KW Reactor Area in 2004



# 200 Areas

Figure ES-1. This plan focuses on the remediation of the deep vadose zone in the Central Plateau of the Hanford Site (shown above in October 2007; photo is looking east).

As a result of past practices, up to 580 $m^3$ carbon tetrachloride (CT) was discharged to waste sites at the 200 West Area of the USDOE's Hanford Site near Richland, WA.

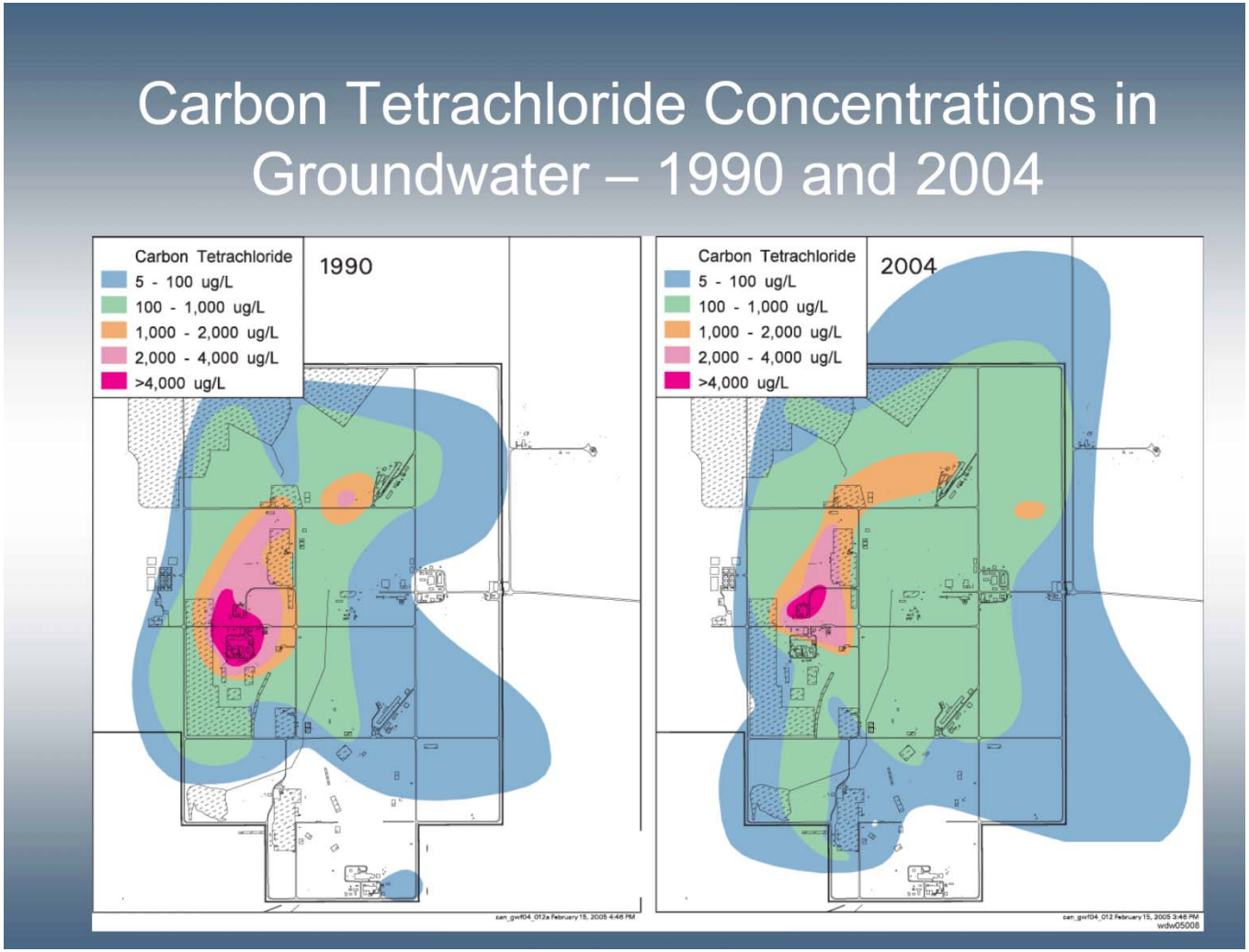


**Figure C-8. Schematic of Transport Mechanisms and Distributions of Carbon Tetrachloride Phases (Rohay 1999).**