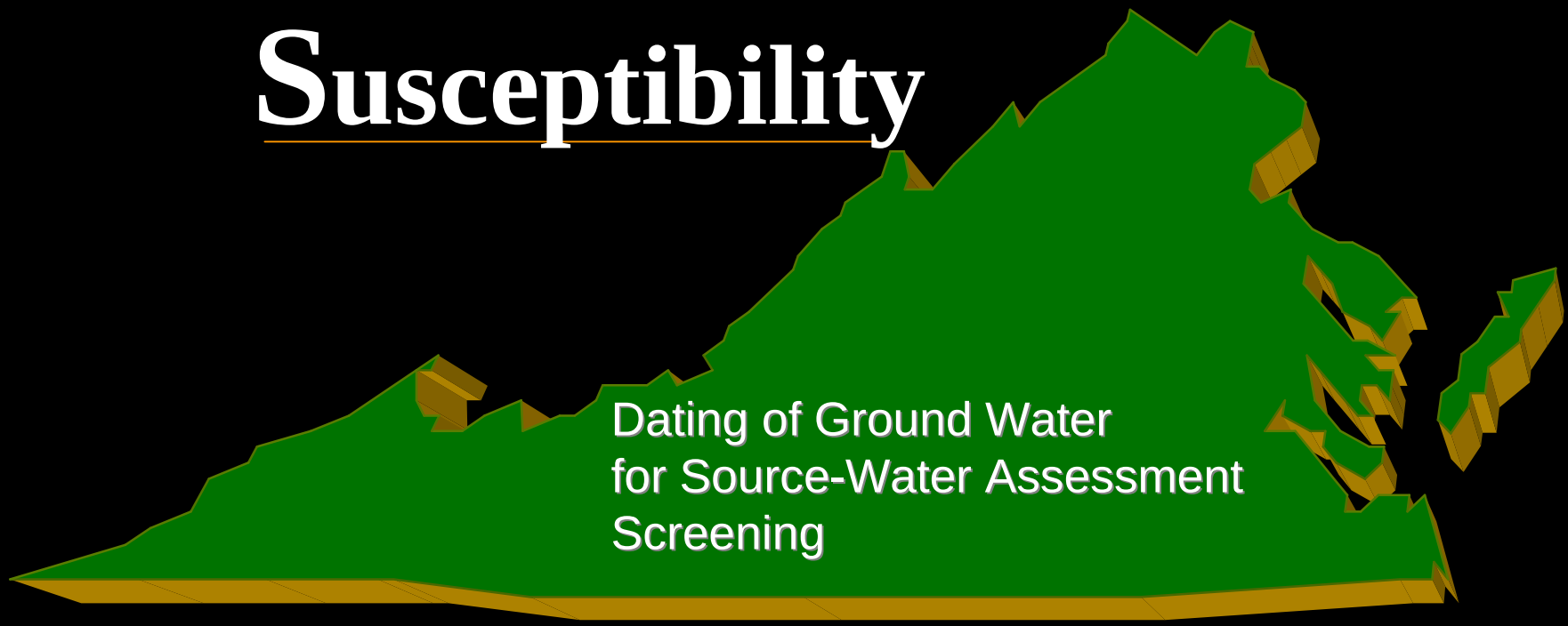
Virginia Aquifer Susceptibility



Dating of Ground Water
for Source-Water Assessment
Screening

USGS

Objective

- **Identify the intrinsic natural susceptibility of regional aquifers in Virginia**

- **Apply susceptibility determinations in screening public ground-water supplies and identifying those that require detailed source-water assessments**

USGS

Sampling Activities - Ground-Water Dating

CHLOROFLUOROCARBONS

- F-11, F-12, and F-113
- Young waters (<50 years)

TRITIUM

- Nuclear weapons testing
- Political isotope
- Young waters (<50 years)

TRITIUM/HELIUM

- Radioactive decay of ^{3}H
- Young waters (<30 years)

SULFUR HEXAFLUORIDE

- Experimental
- Young waters (<30 years)

CARBON-14

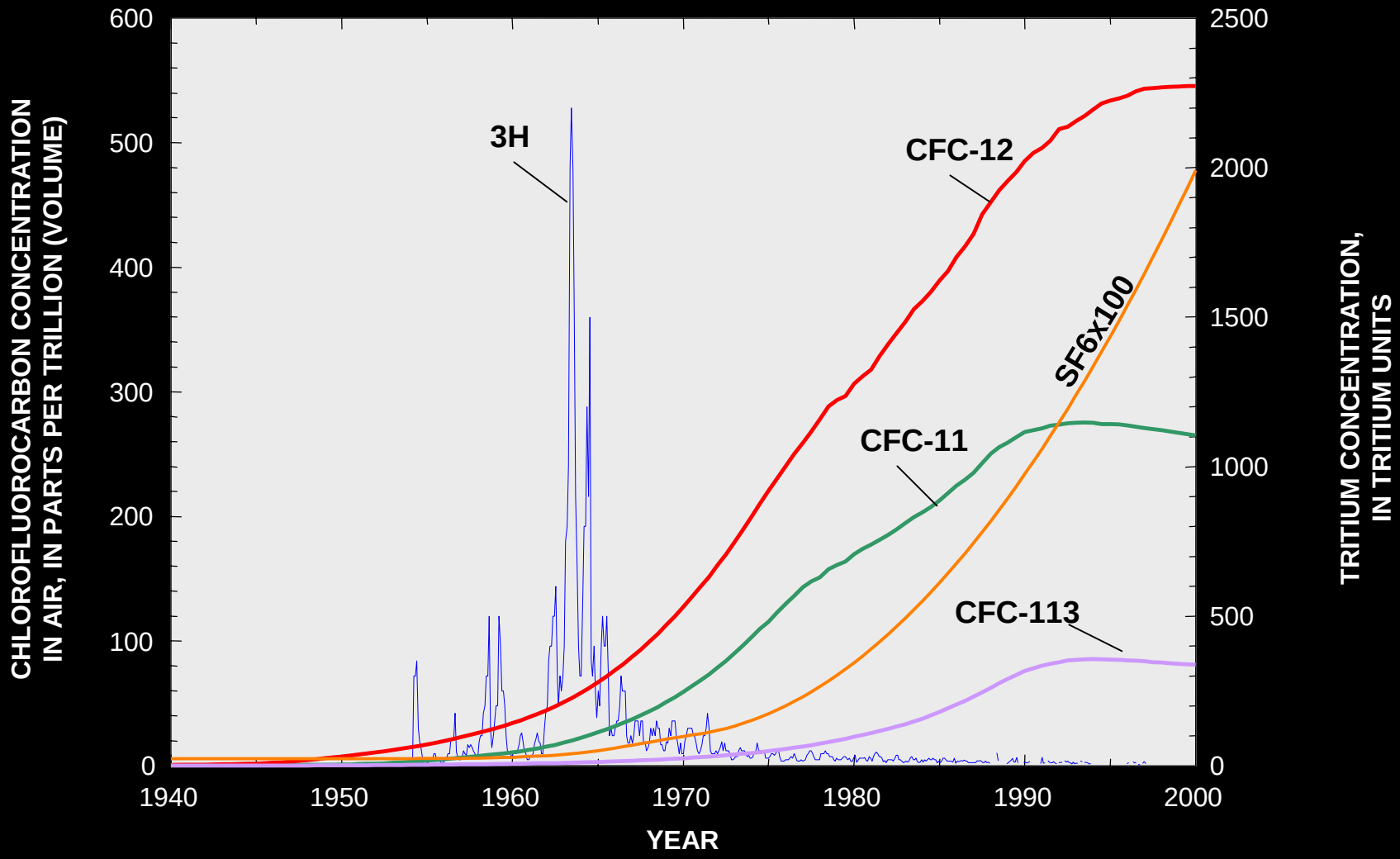
- Dissolved inorganic carbon
- Paleowaters (1,000 - 30,000 years)

HELIUM-4

- Paleowaters

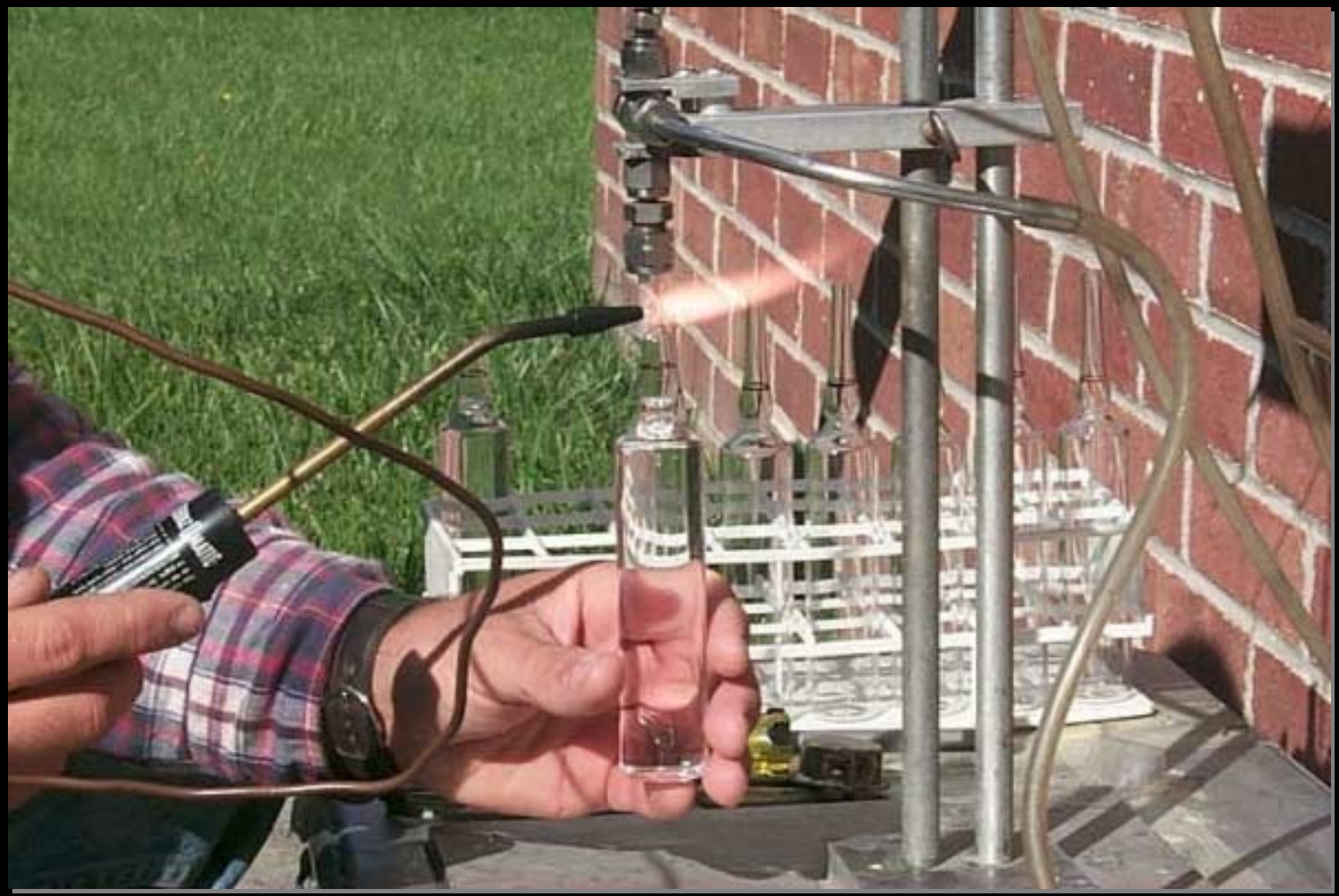
USGS

Atmospheric concentrations



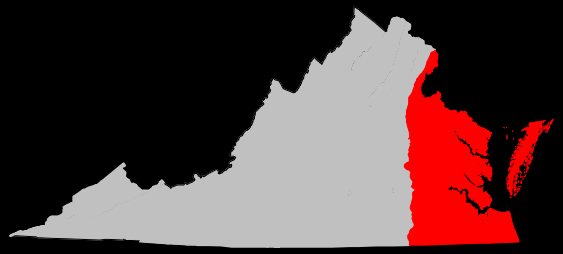
USGS

CFCs Sampling



USGS

USGS VAS Sampling Phases

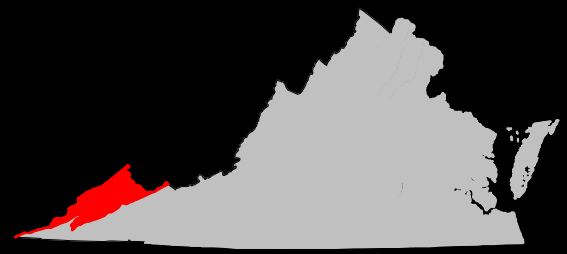


Phase I — FY 1998

Coastal Plain

Phase II — FY 1999

Piedmont, Blue Ridge, and
Valley and Ridge



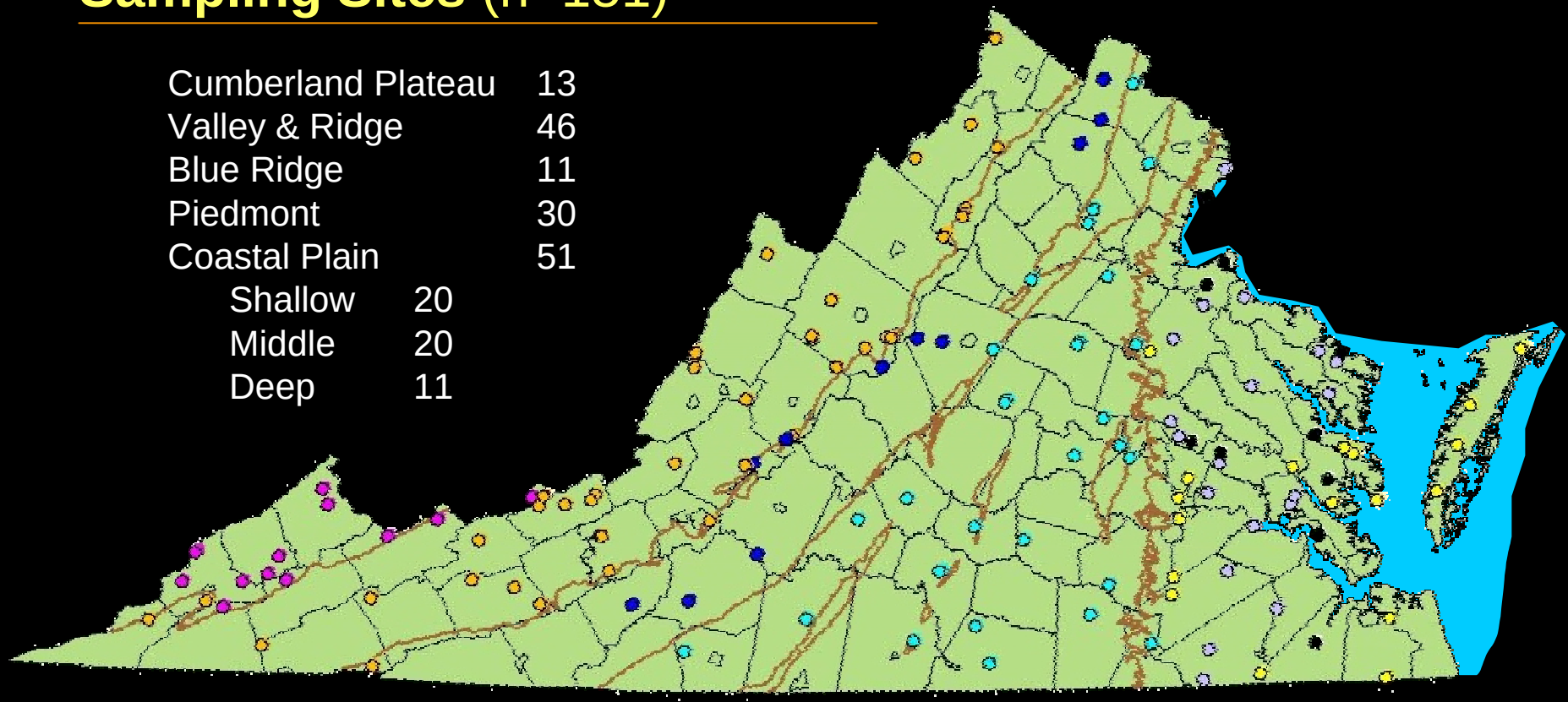
Phase III — FY 2000

Cumberland Plateau

USGS

Virginia Aquifer Susceptibility Sampling Sites (n=151)

Cumberland Plateau		13
Valley & Ridge		46
Blue Ridge		11
Piedmont		30
Coastal Plain		51
	Shallow	20
	Middle	20
	Deep	11



USGS

Virginia Source Water Assessment Program

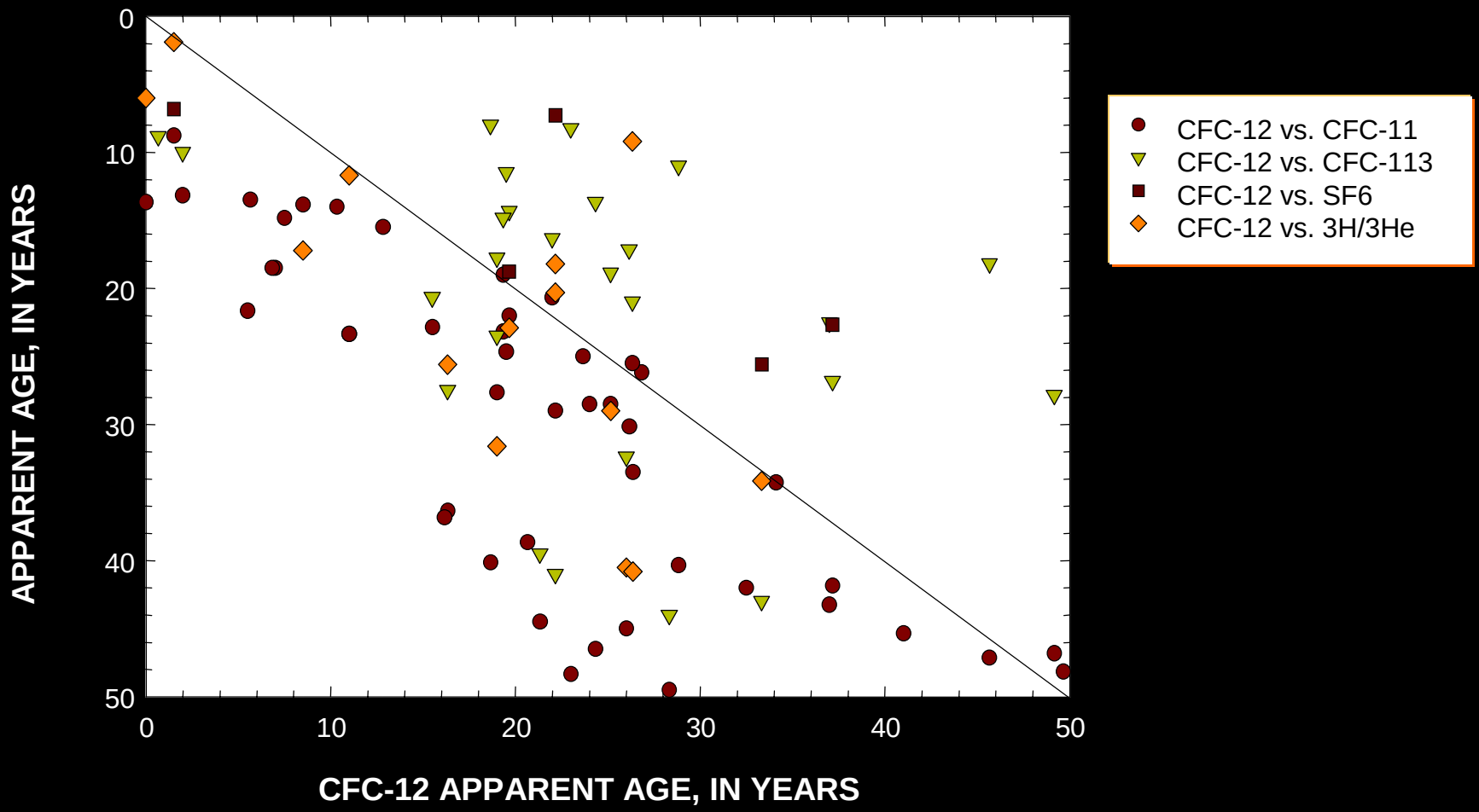
(http://www.vdh.state.va.us/owp/water_supply.htm)

Type of source water	Sensitive source	LUA present in source area	Susceptibility
Ground water	No	No	Very Low
Ground water	No	Yes	Low
Ground water	Yes	No	Moderate
Ground water	Yes	Yes	High

LUA -- Land-use Activity

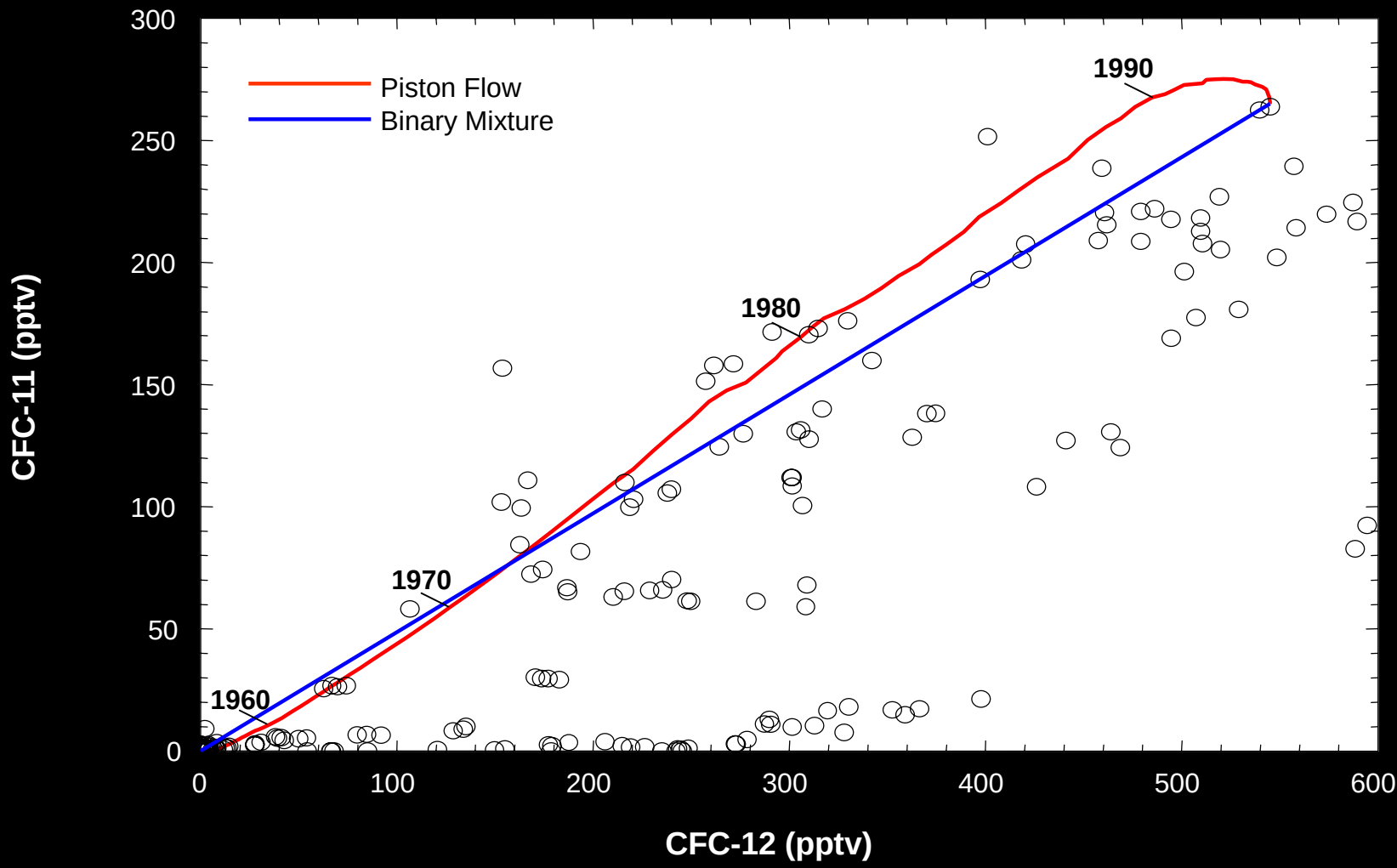
USGS

CFC-12 Apparent Age vs. Ages From Other Tracers



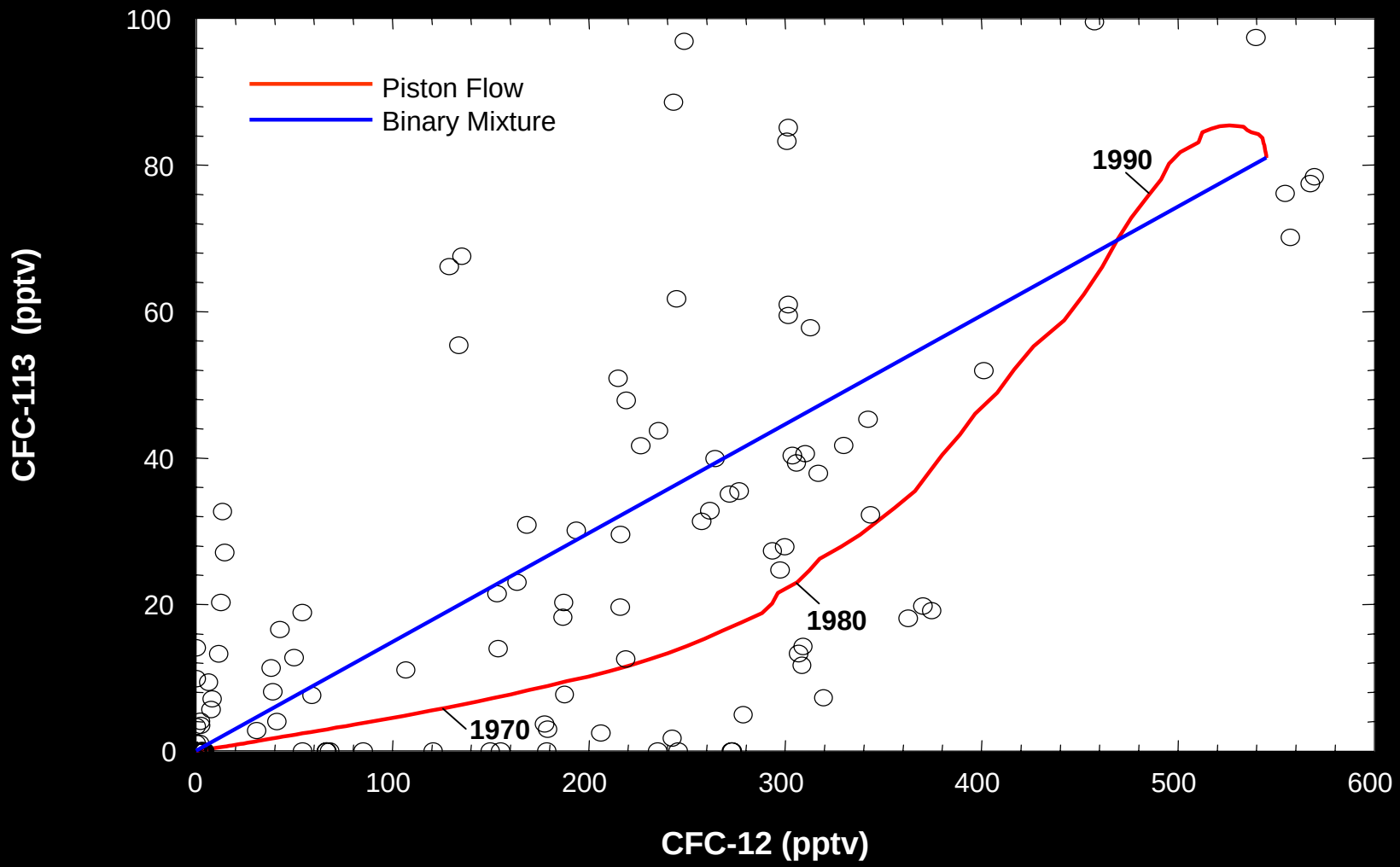
USGS

CFC-12 vs. CFC-11 Mixing Models



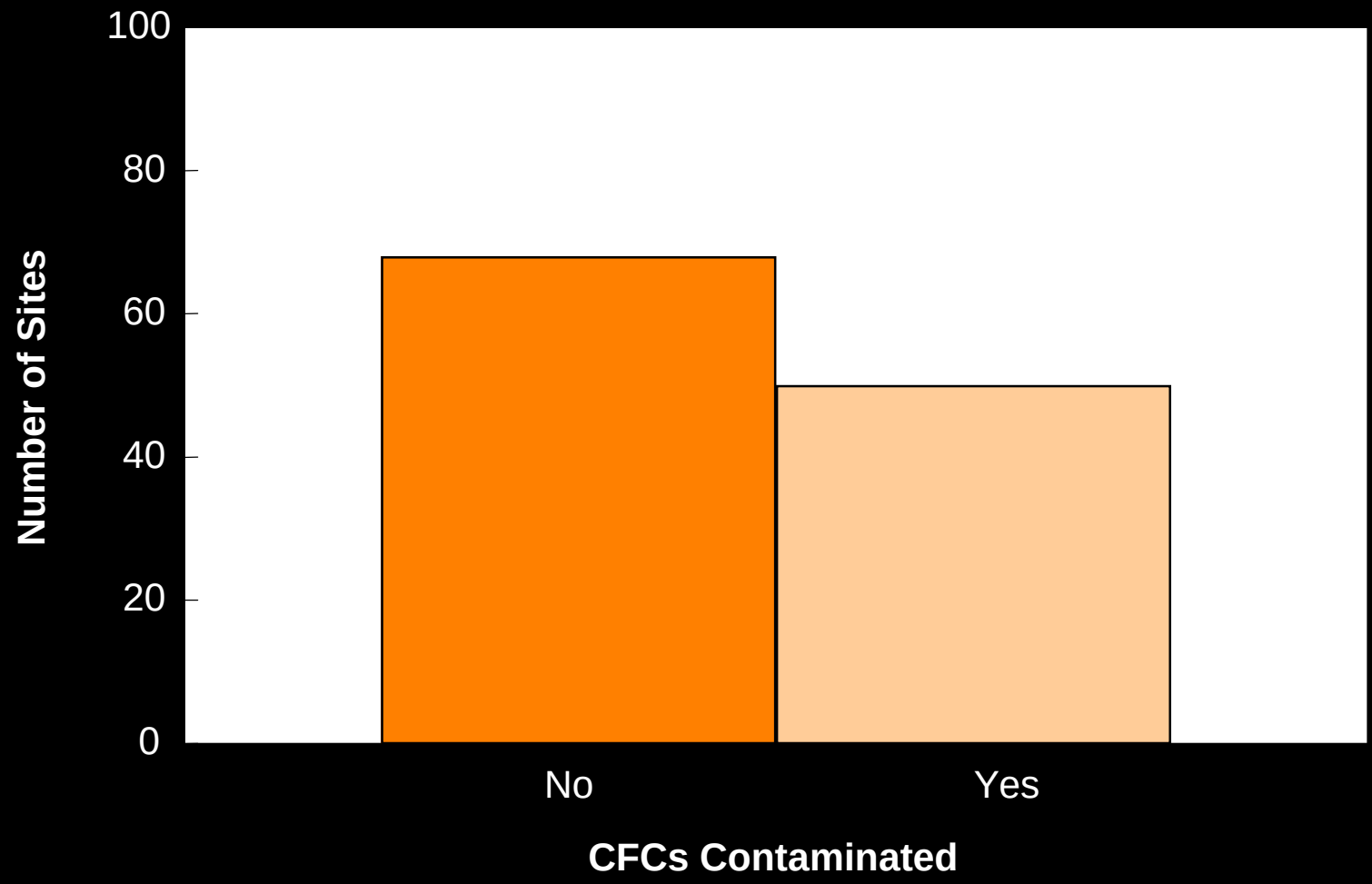
USGS

CFC-12 vs. CFC-113 Mixing Models



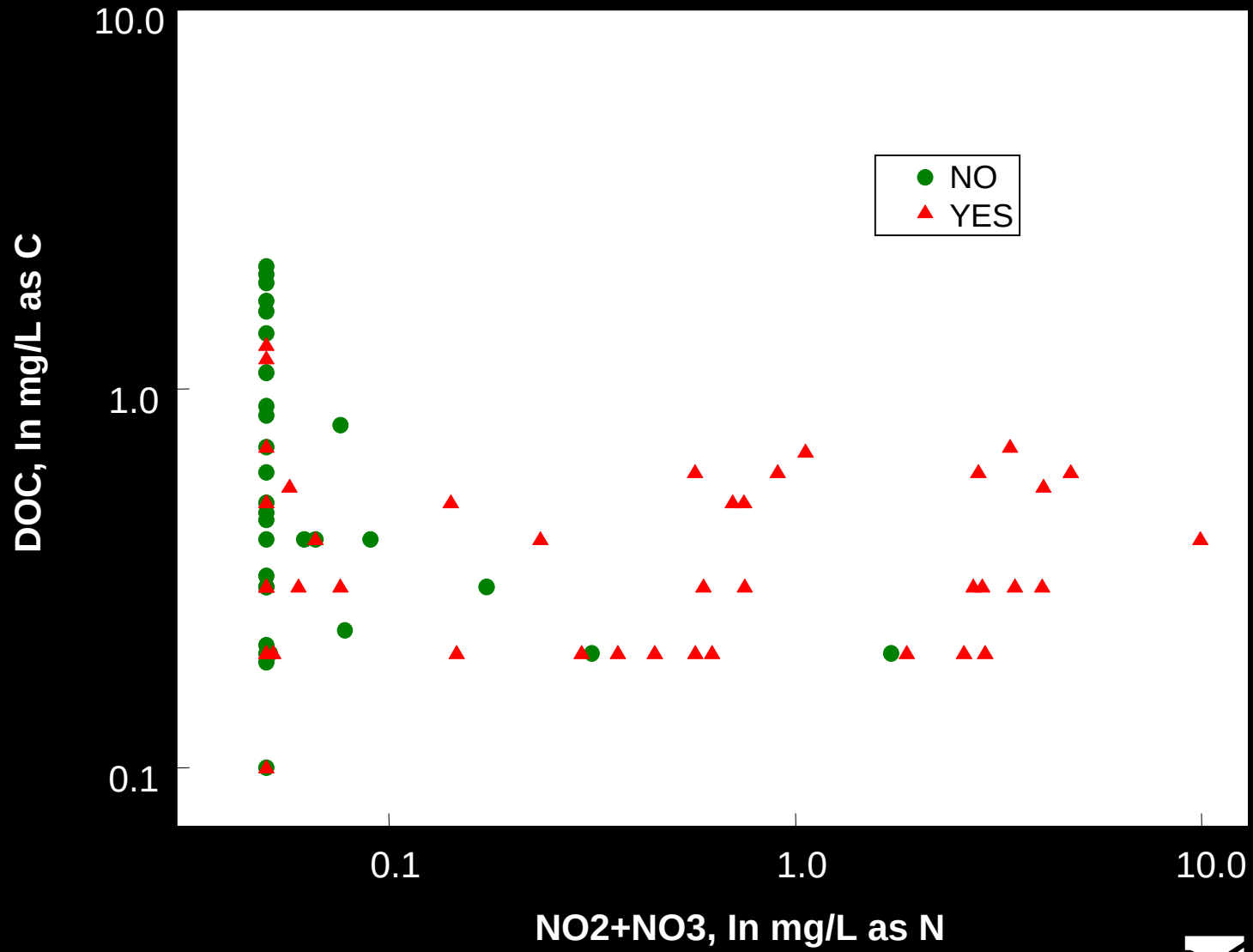
USGS

Number of Sites with CFCs Contamination



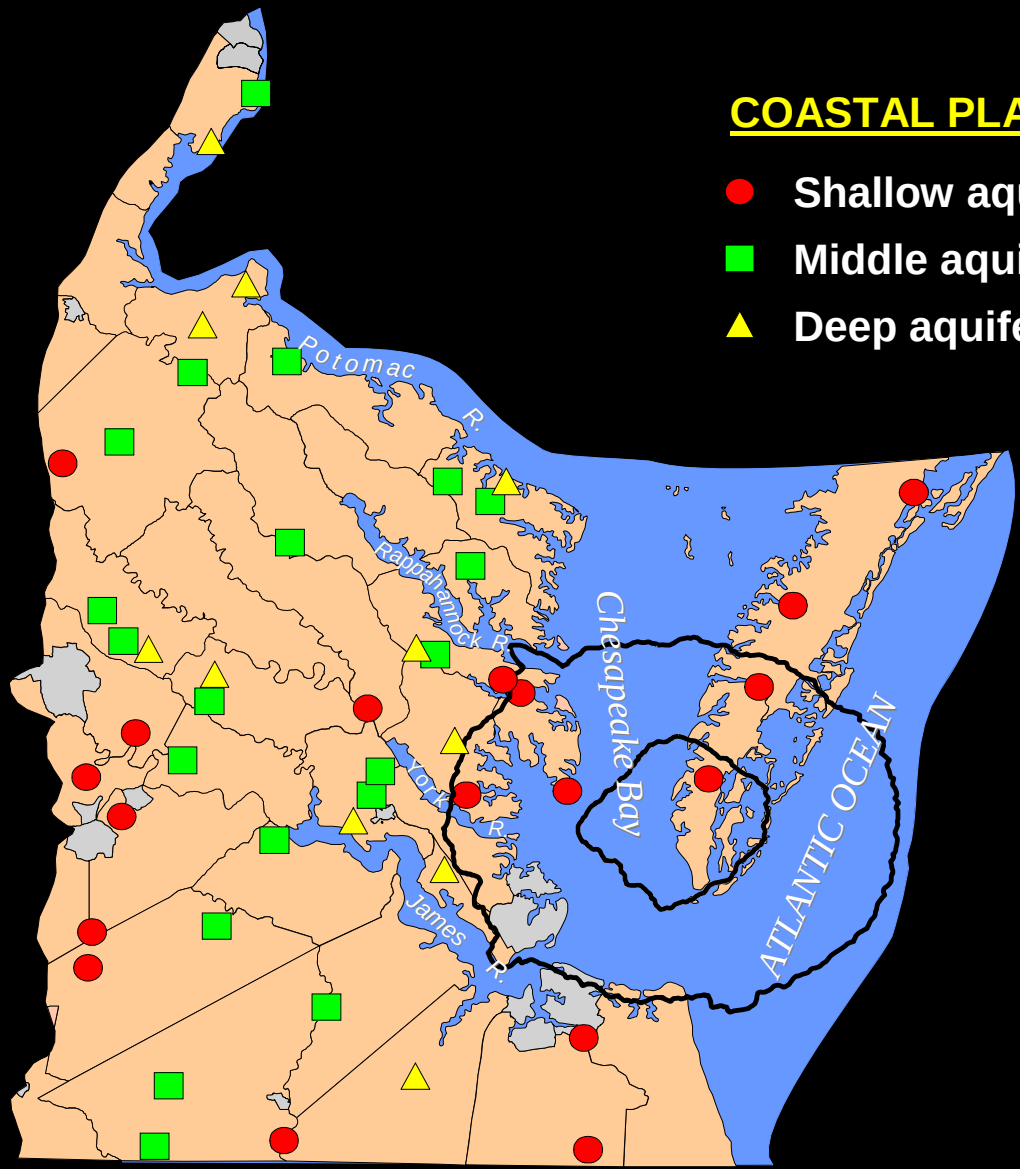
USGS

NO_3 vs. DOC and CFCs Contamination



USGS

USGS VAS Sampling Activities - Coastal Plain 1998



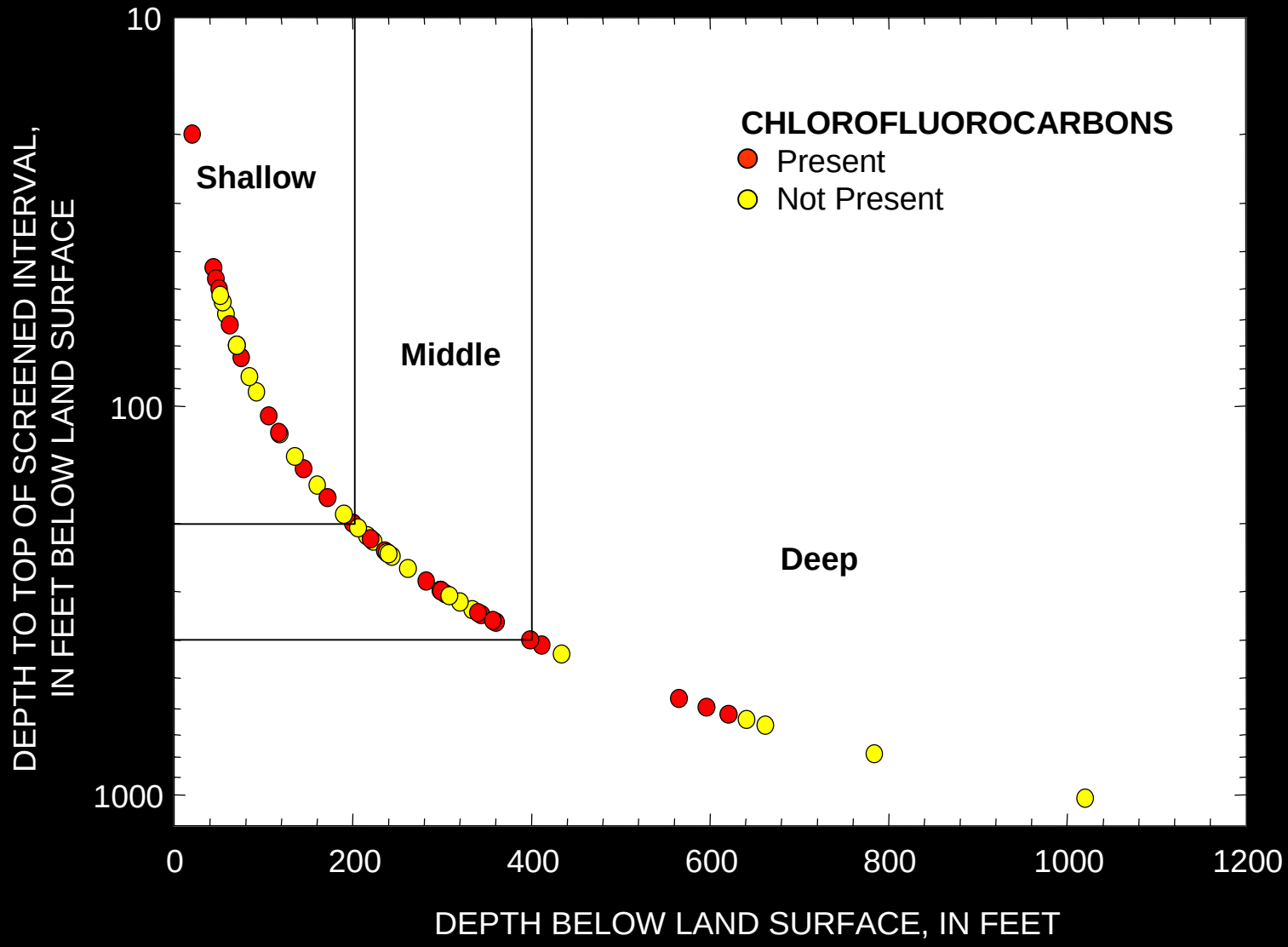
COASTAL PLAIN AQUIFER SYSTEMS

- Shallow aquifer system (0-200 feet)
- Middle aquifer system (200-400 feet)
- Deep aquifer system (>400 feet)

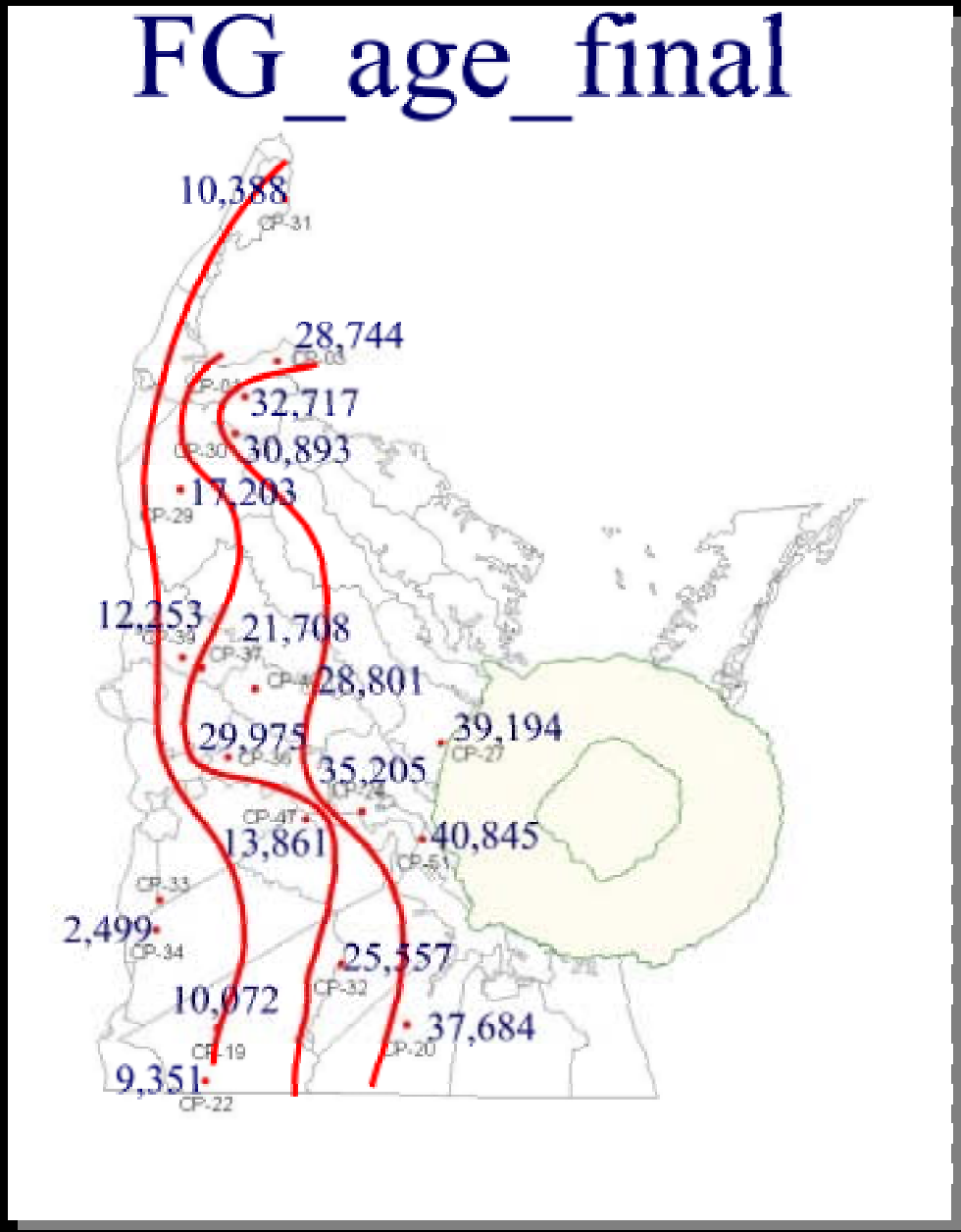
Virginia Aquifer Susceptibility

USGS

Depth versus CFCs Occurrence (Coastal Plain)



USGS

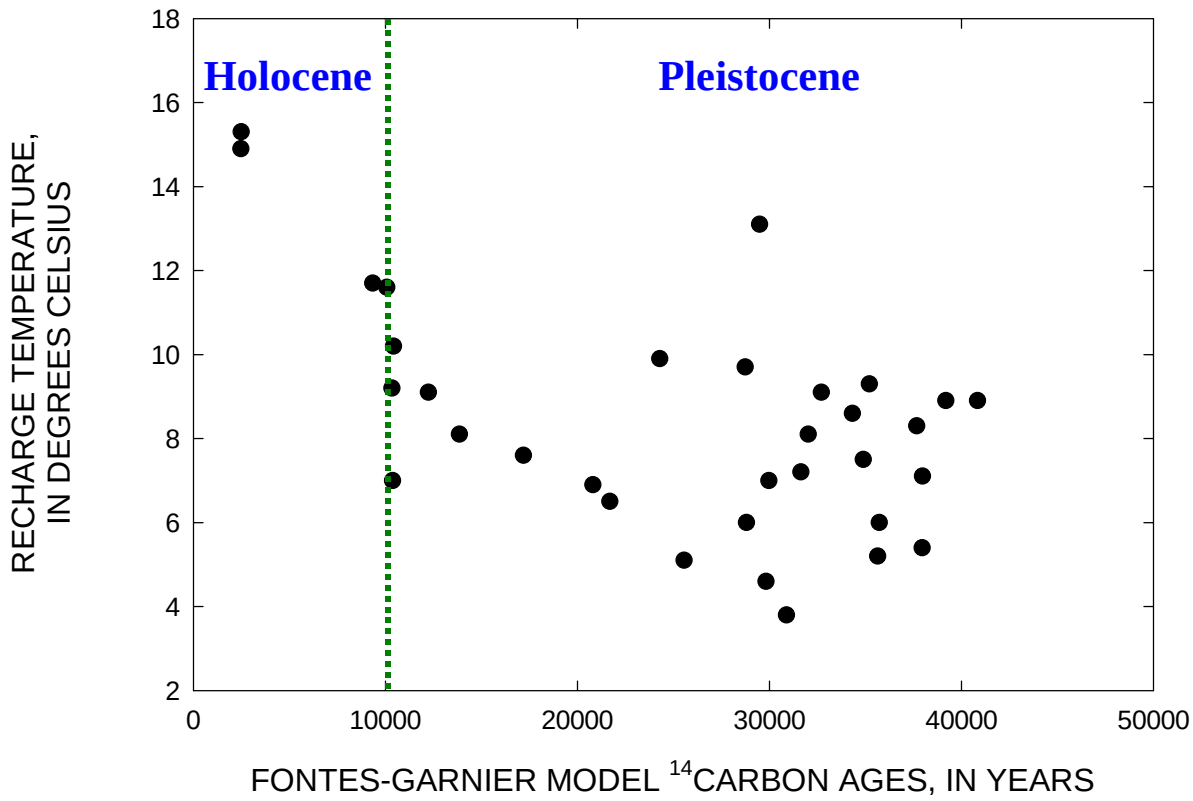


Fontes-Garnier Model ^{14}C Ages

Middle Potomac Aquifer

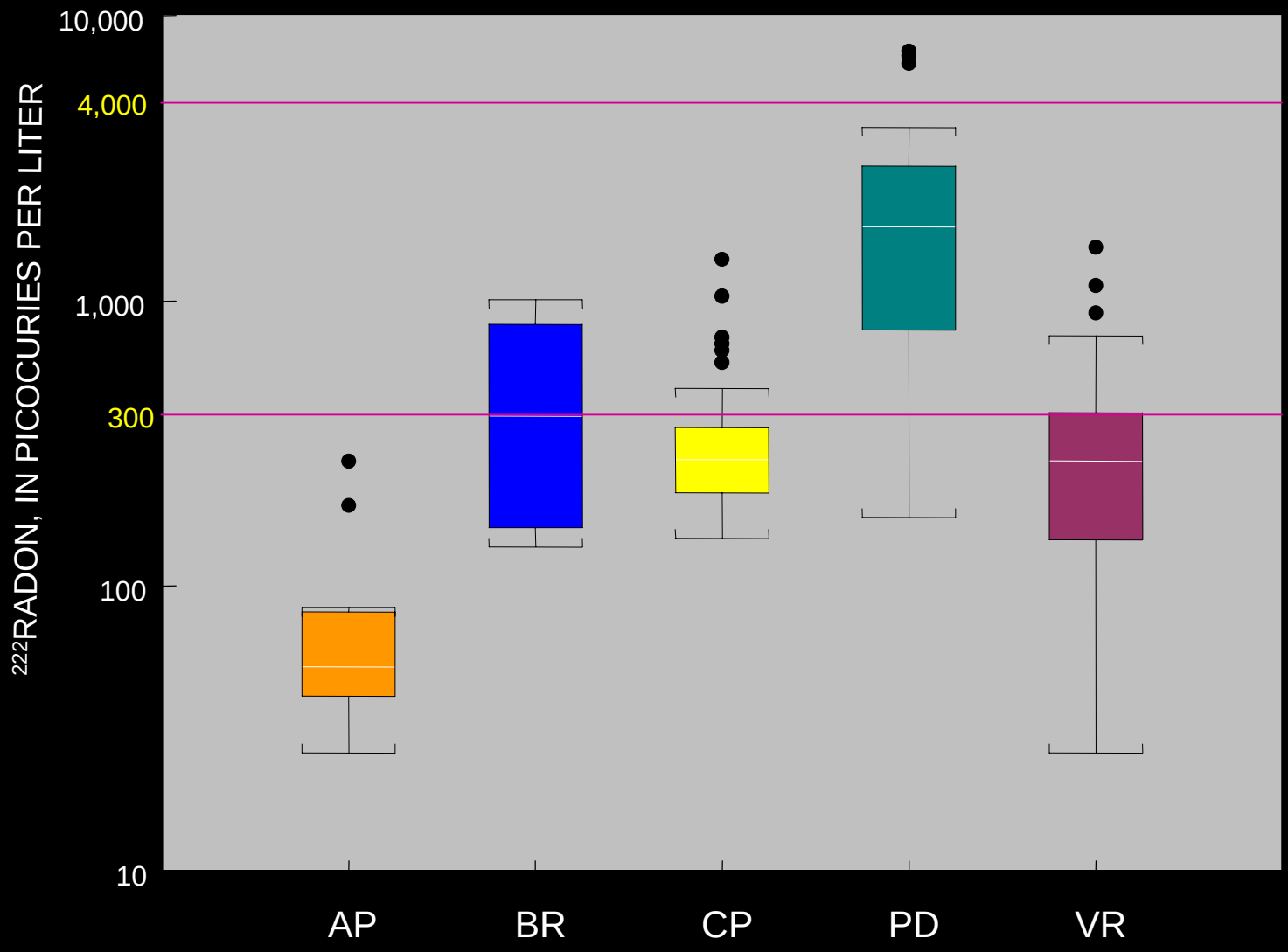
USGS

Nitrogen-Argon Recharge Temperatures (Coastal Plain)



USGS

Radon in Ground Water



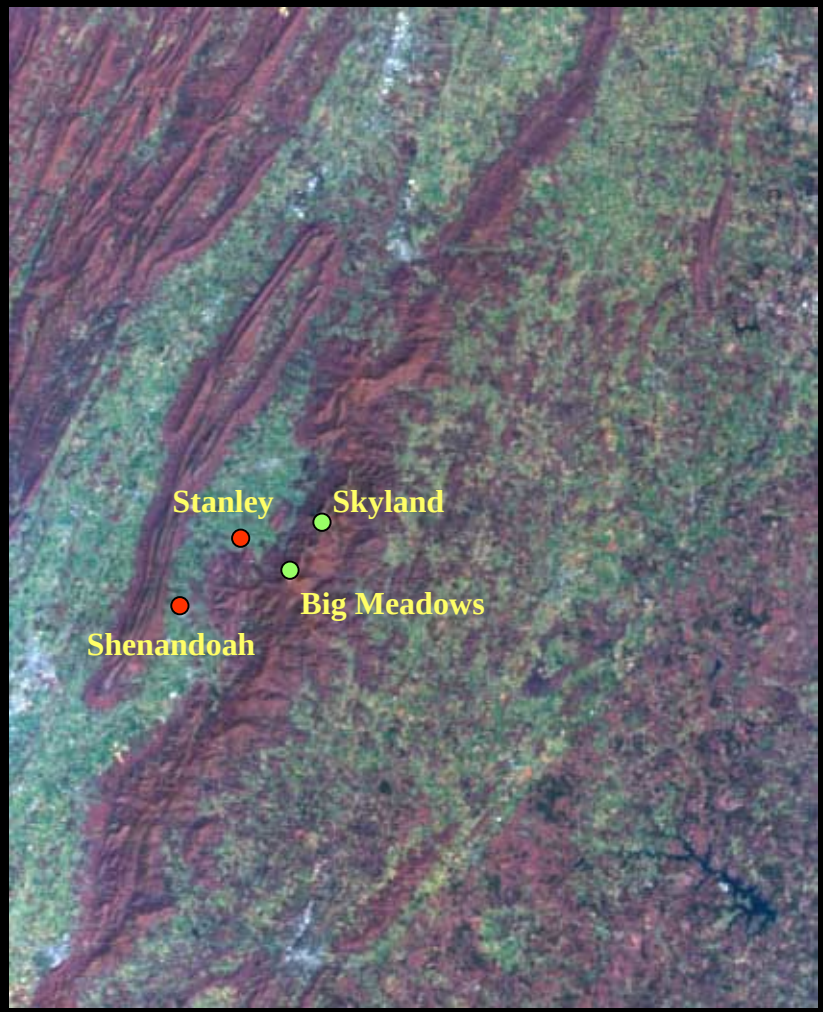
USGS

Multiple Scales

Statewide to Local

USGS

USGS/VDCR and VDH SWAP

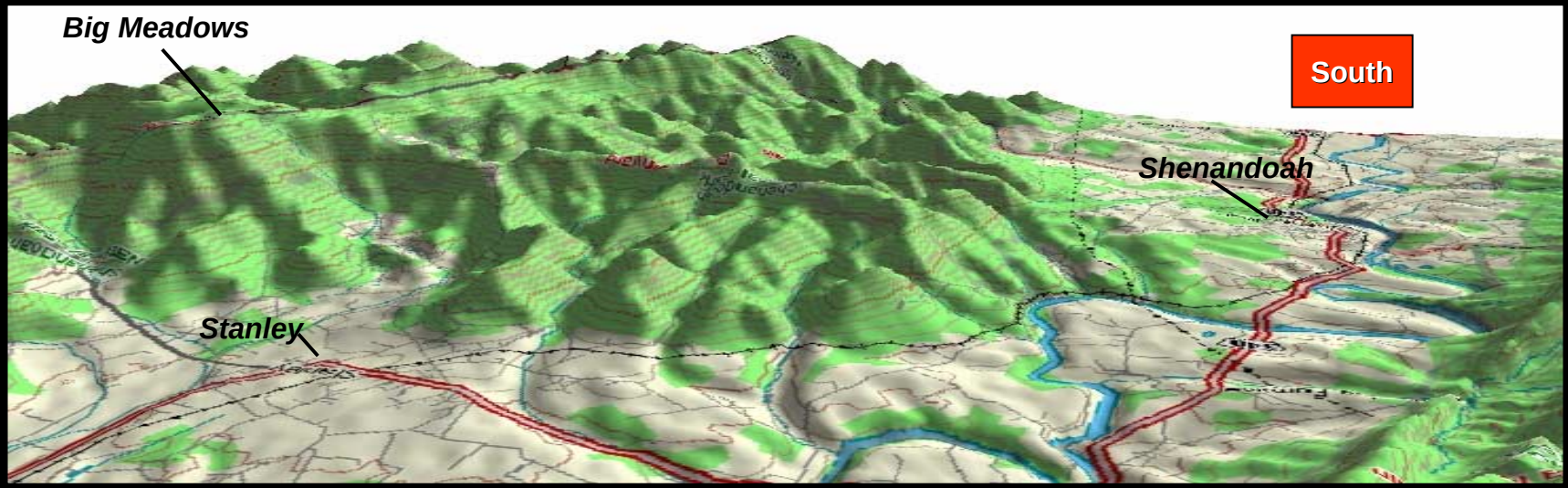


Collaborative effort with several projects…

- USGS NRP
- VDCR Karst Project

USGS

USGS/VDCR and VDH SWAP



Vertical exaggeration 4x

VAS Study-Ground-water dating

NRP-Ground-water dating research in Shenandoah National Park

Karst Project-Dye-Tracer studies & delineations

SWAP-Location & Construction Information
Land-Use Activity inventories

Data collected by VAS study

WATER RESOURCES RESEARCH, VOL. 36, NO. 10, PAGES 3011–3030, OCTOBER 2000

Dating young groundwater with sulfur hexafluoride: Natural and anthropogenic sources of sulfur hexafluoride

Eurybiades Busenberg and L. Niel Plummer
U.S. Geological Survey, Reston, Virginia

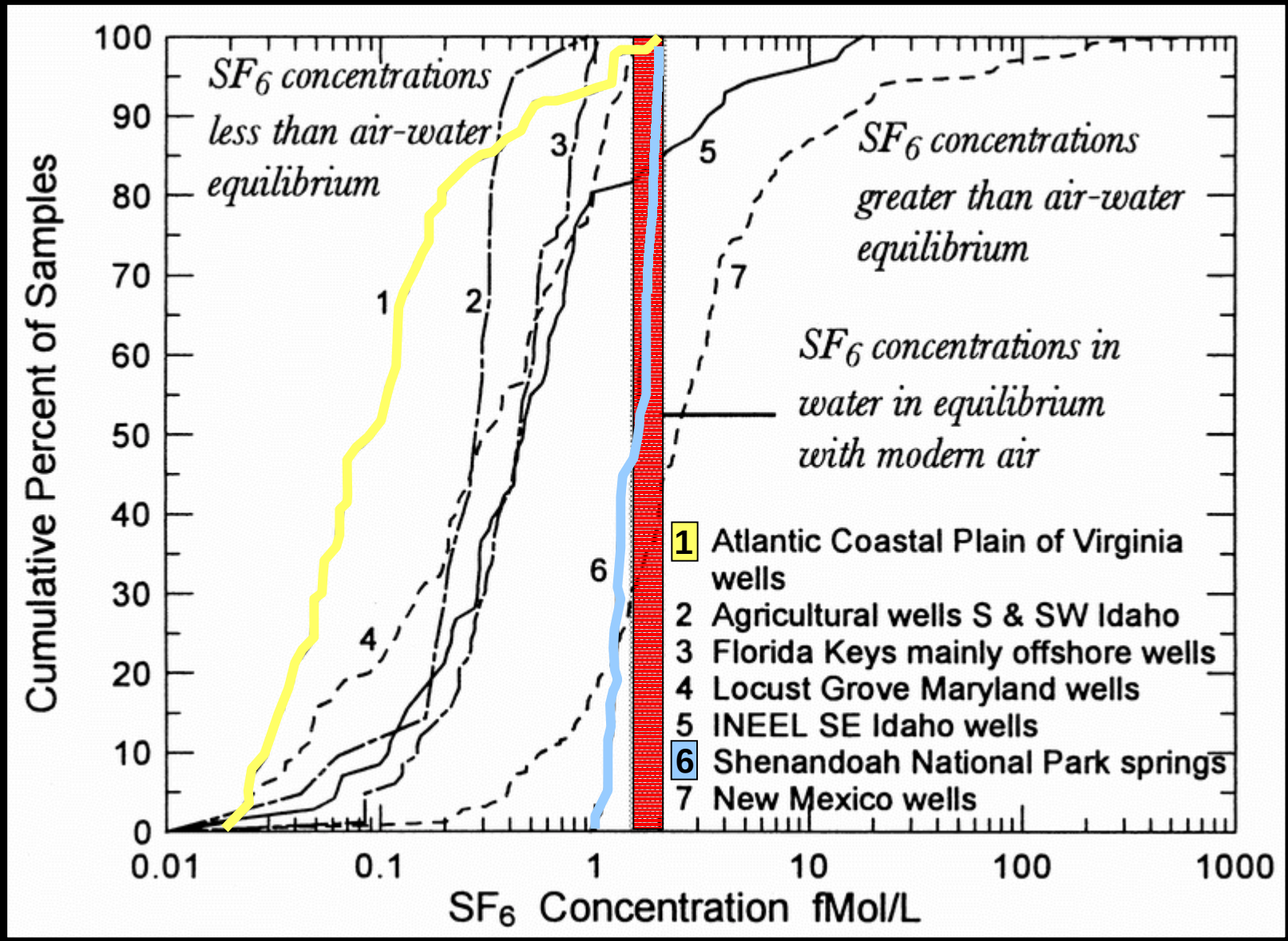
Abstract. Sulfur hexafluoride (SF_6) is primarily of anthropogenic origin but also occurs naturally. The troposphere concentration of SF_6 has increased from a steady state value of 0.054 ± 0.009 to more than 4 parts per trillion volume during the past 40 years. An analytical procedure was developed for measuring concentrations of SF_6 to less than 0.01 fmol/L in water. Groundwater can be dated with SF_6 if it is in equilibrium with atmospheric SF_6 at the time of recharge and does not contain significant SF_6 from other sources. The dating range of SF_6 is currently 0 to 30 years. The tracer was successfully used to date shallow groundwater of the Atlantic Coastal Plain sand aquifers of the United States and springs issuing near the top of the Blue Ridge Mountains of Virginia. Significant concentrations of naturally occurring SF_6 were found in some igneous, volcanic, and sedimentary rocks and in some hydrothermal fluids.

1. Introduction

SF_6 is a colorless, odorless, nonflammable, nontoxic, stable gas with excellent electrical insulating and arc-quenching properties. It is mainly used as an electrical insulator in high-voltage switches and transformers and as a blanket gas in the melting operations of magnesium metal production [*Maiss and Brenninkmeijer*, 1998]. Industrial production of SF_6 began in 1953 with the introduction of SF_6-filled electrical switches, and an-

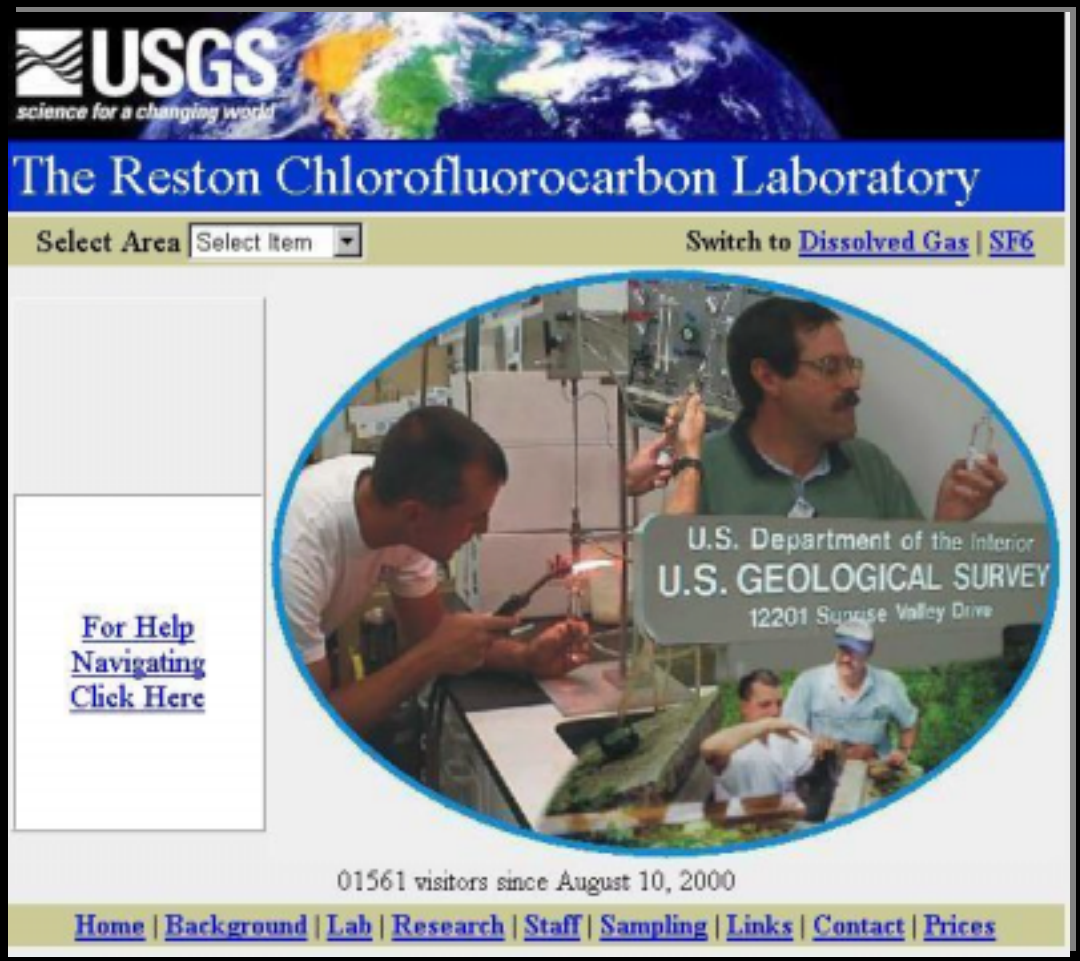
atmospheric tracer [*Lovelock and Ferber*, 1982; *Levin and Hesshaimer*, 1996; *Patra et al.*, 1997; *Geller et al.*, 1997; *Hall and Waugh*, 1998; *Zahn et al.*, 1999]. The gas has been injected into the oceans to determine longitudinal dispersion, diapycnal and isopycnal diffusion, and mixing [*Ledwell et al.*, 1986; *Watson et al.*, 1987; *Ledwell and Watson*, 1988, 1991; *Watson et al.*, 1991; *Law et al.*, 1998; *Ledwell et al.*, 1998] and air-sea gas exchange and dispersion [*Watson et al.*, 1991; *Wanninkhof*, 1992; *Wanninkhof et al.*, 1993, 1997; *Asher and Wanninkhof*, 1998]. SF_6

USGS


Cumulative Percent of Samples
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
1000
SF6 Concentration fMol/L
SF6 concentrations less than air-water equilibrium
SF6 concentrations greater than air-water equilibrium
SF6 concentrations in water in equilibrium with modern air
1
2
3
4
5
6
7
1 Atlantic Coastal Plain of Virginia wells
2 Agricultural wells S & SW Idaho
3 Florida Keys mainly offshore wells
4 Locust Grove Maryland wells
5 INEEL SE Idaho wells
6 Shenandoah National Park springs
7 New Mexico wells

USGS

Ground-water dating on the Internet…



http://water.usgs.gov/lab/cfc/

USGS