Groundwater occurrence, age, and contribution to streamflow in Loch Vale

David Clow, Lothar Schrott, and Bob Michel

Loch Vale

Alpine/Subalpine

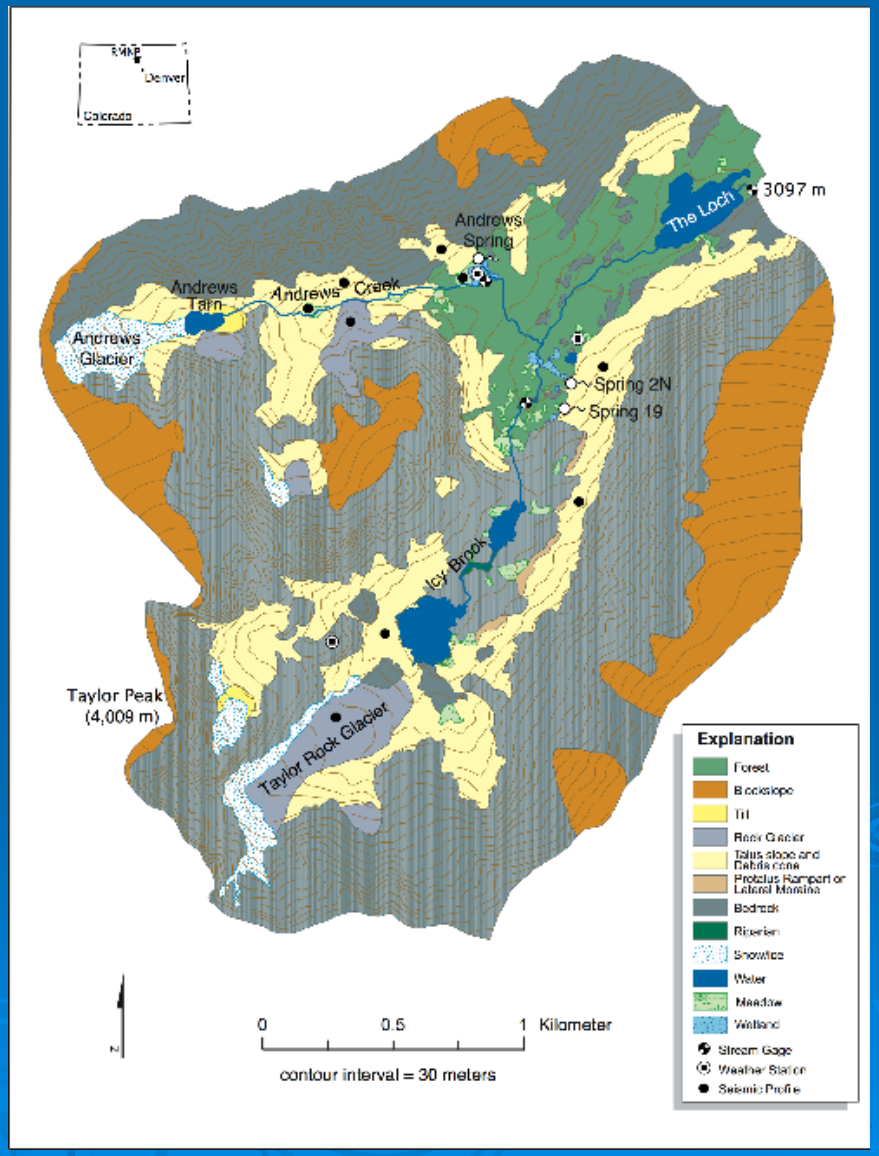
- Mostly bare rock and talus
- Pockets of alpine meadow

Photo of talus cones

Hydrogeology map

Objectives

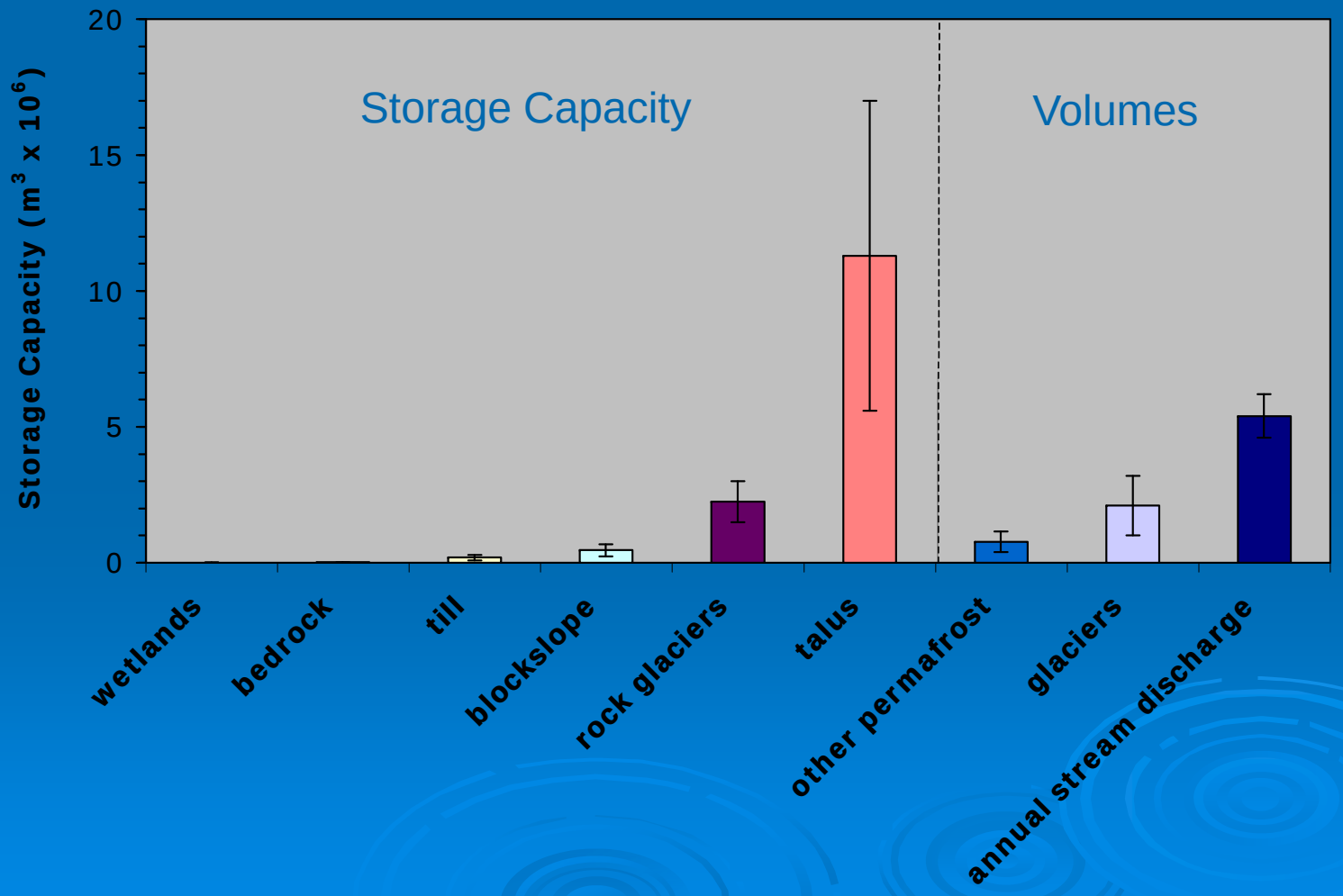
- Map occurrence of groundwater reservoirs
- Quantify groundwater contributions to surface waters
- Determine the age (residence time) of groundwater



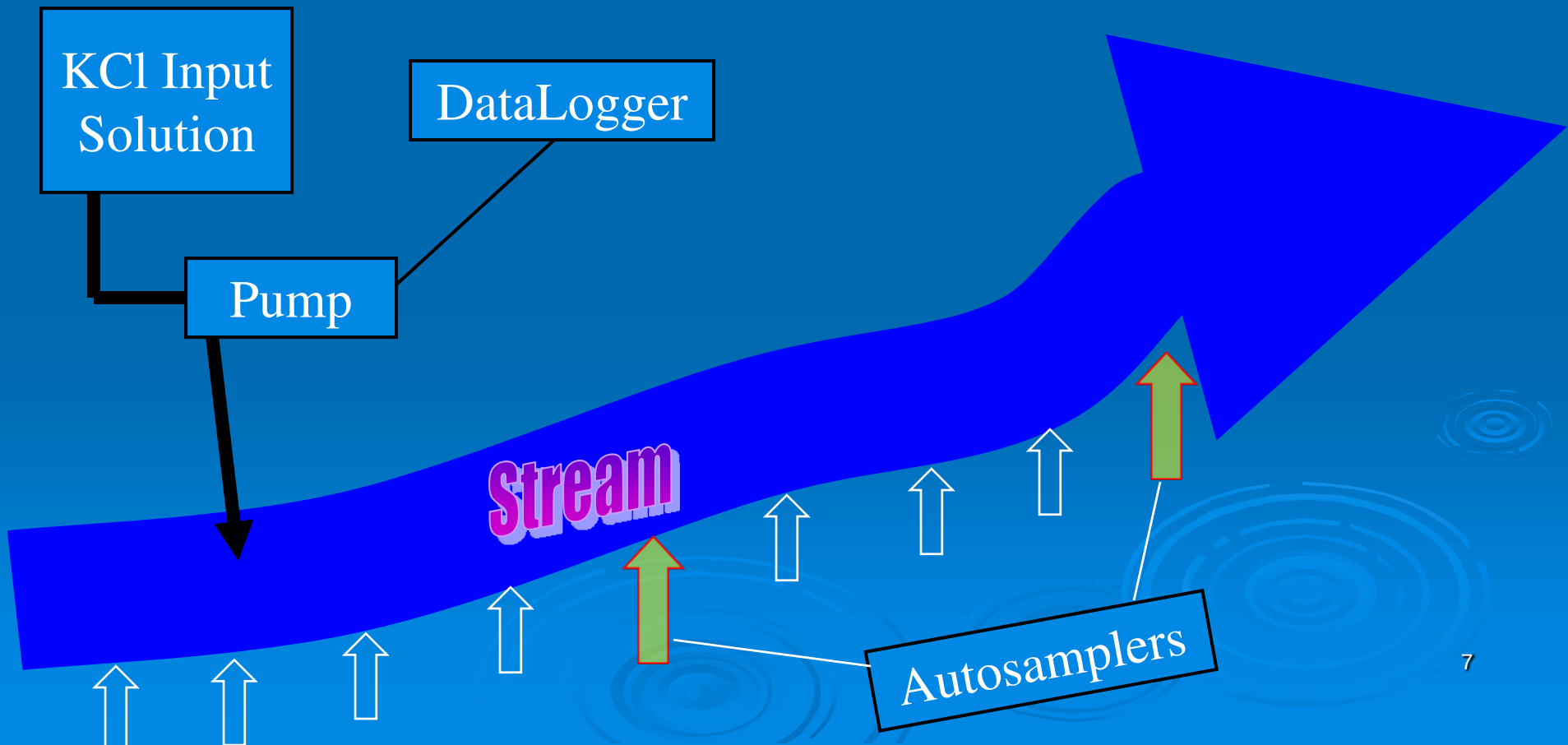
Seismic Surveys

Survey of rock glacier

Water Volumes/ StorageCapacity

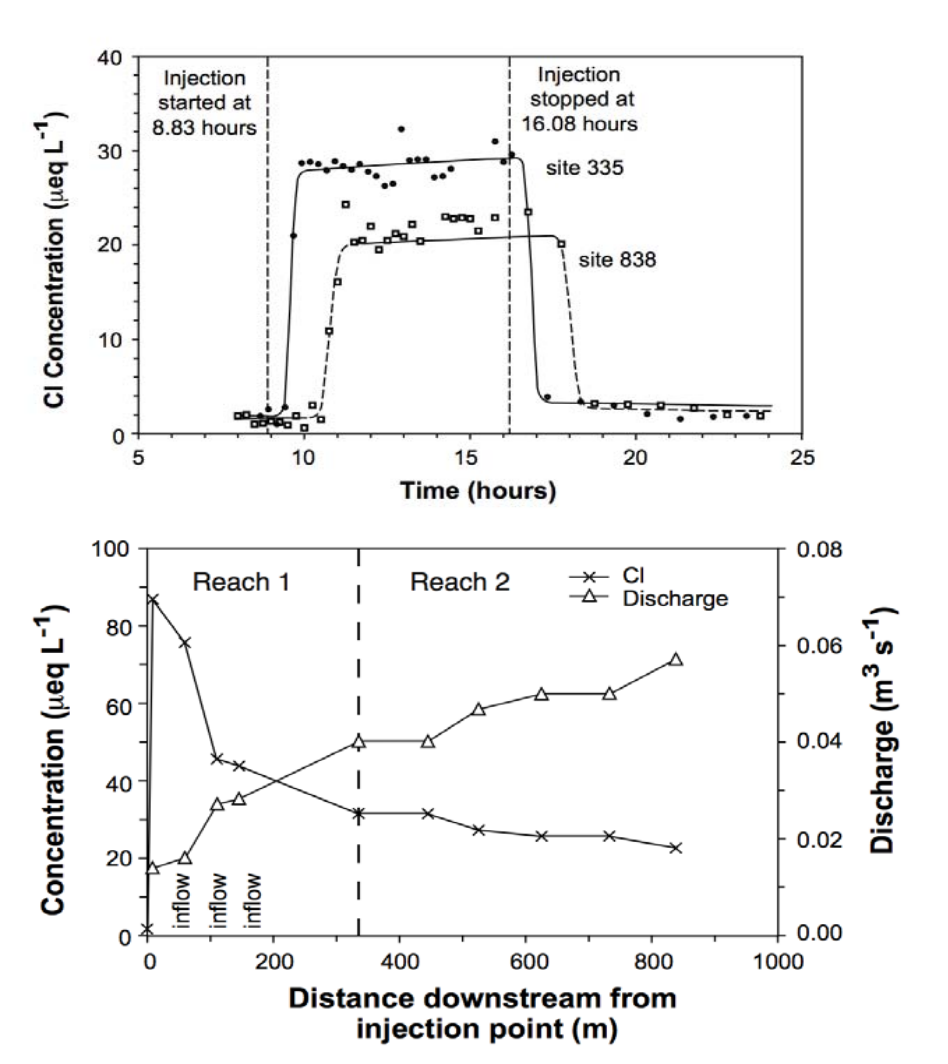


Groundwater contributions to stream flow: Tracer Experiment



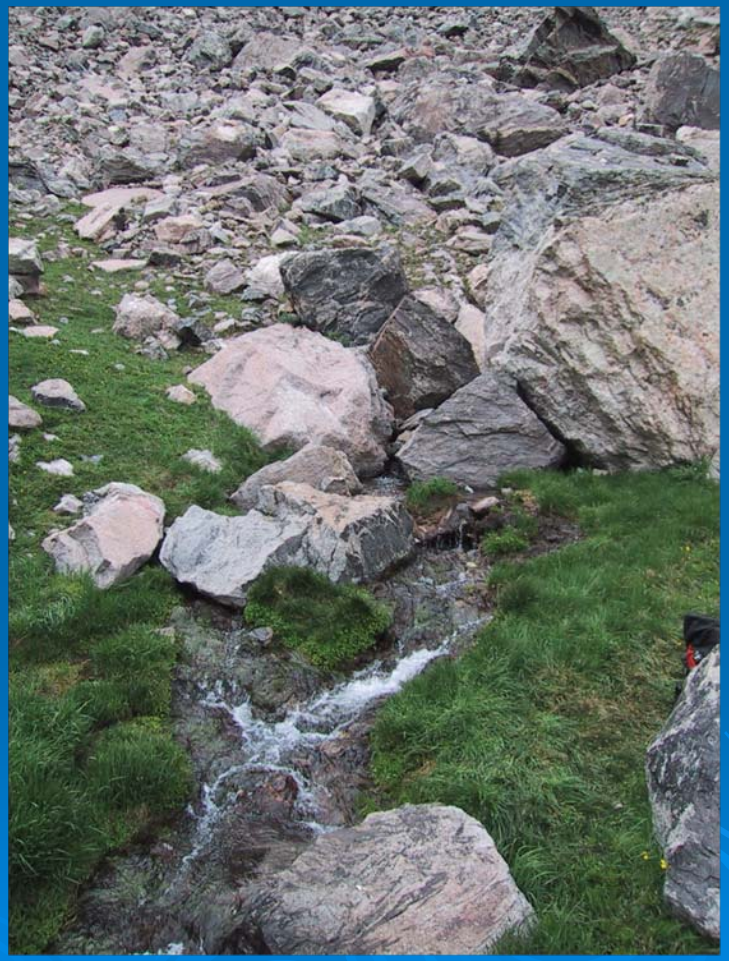
Tracer Experiment Results

- Cl concentrations responded quickly to tracer injection
- Discharge at each sampling location calculated based on changes in Cl concentrations
- Differences in discharge along Reach 2 due solely to groundwater inputs
- Results indicate 40% increase in discharge due to groundwater inputs

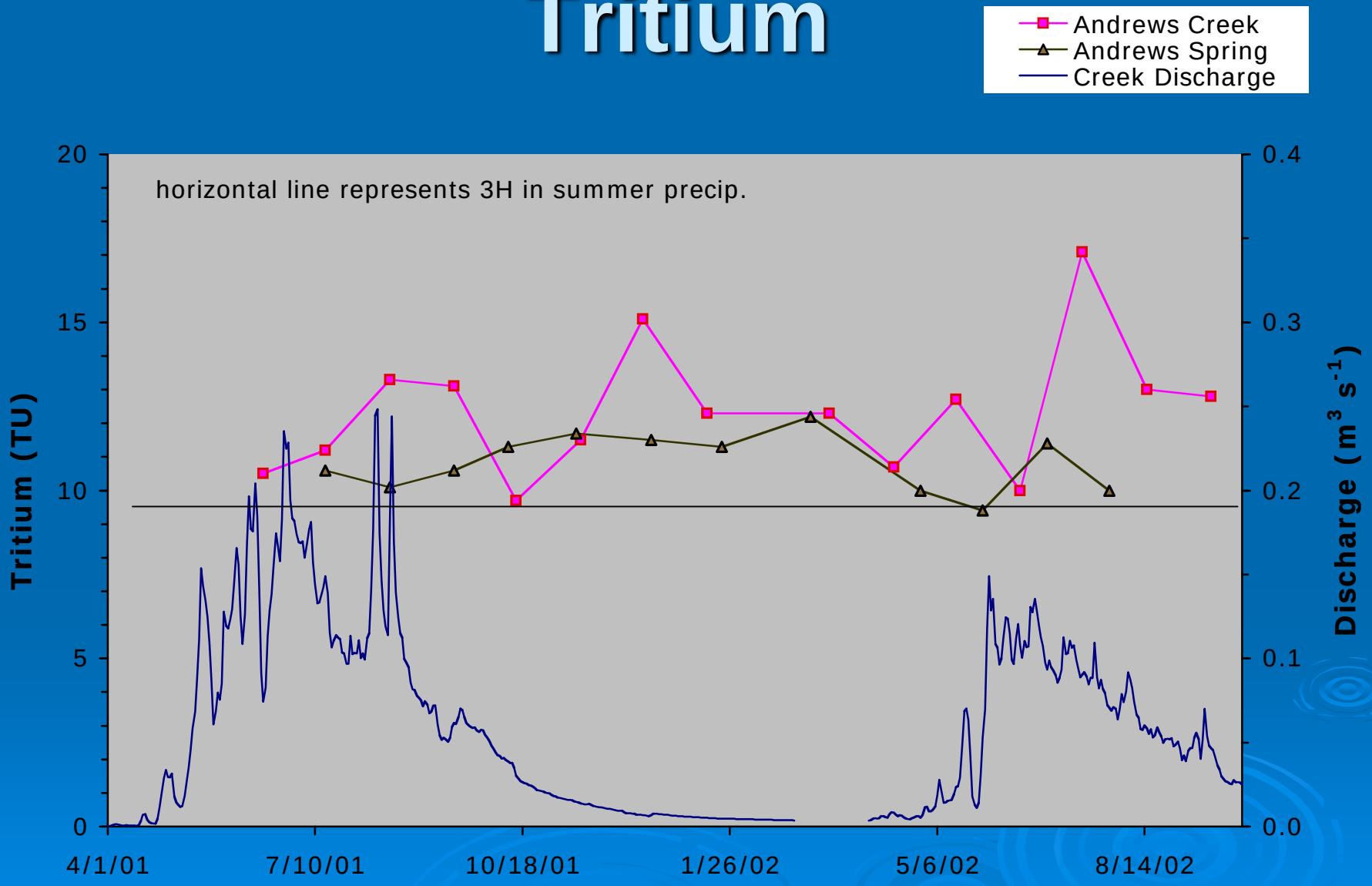


Age Dating

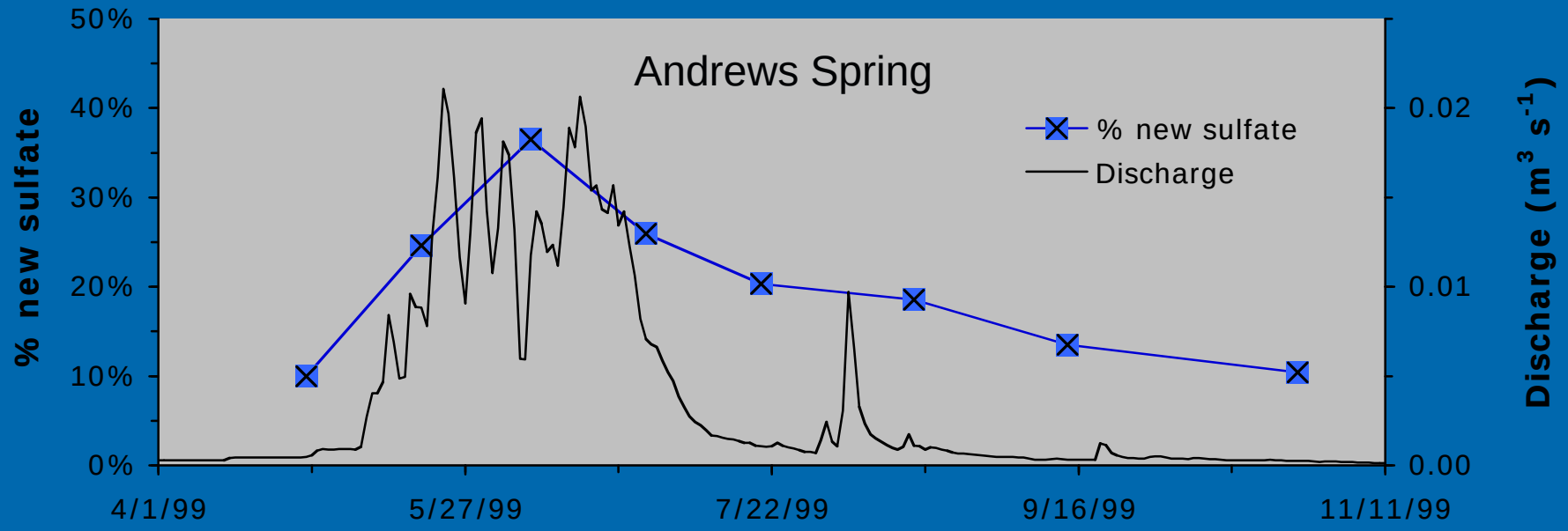
- Multi-tracer approach
  - Tritium
    - Nuke testing signal (peak in 1963)
  - ^{35}S
    - cosmogenic
    - 87 day half life
  - CFCs
    - Increasing signal from 1950's until 1990s
  - SF6
  - $^{36}Cl/Cl$

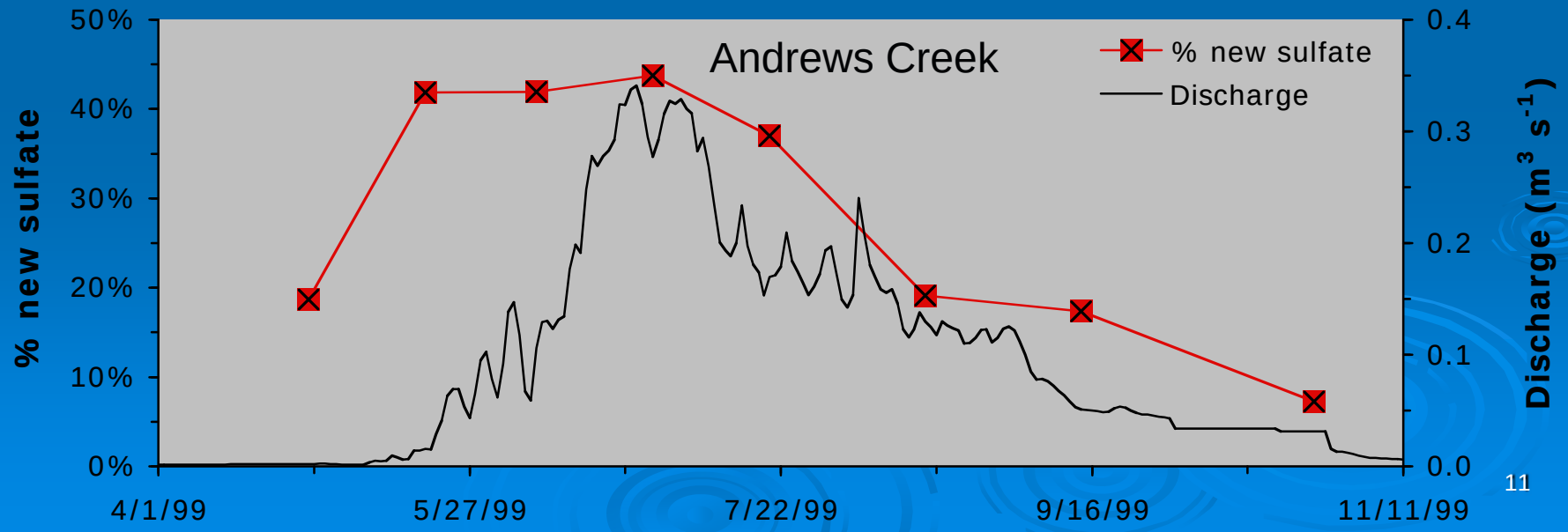


Tritium

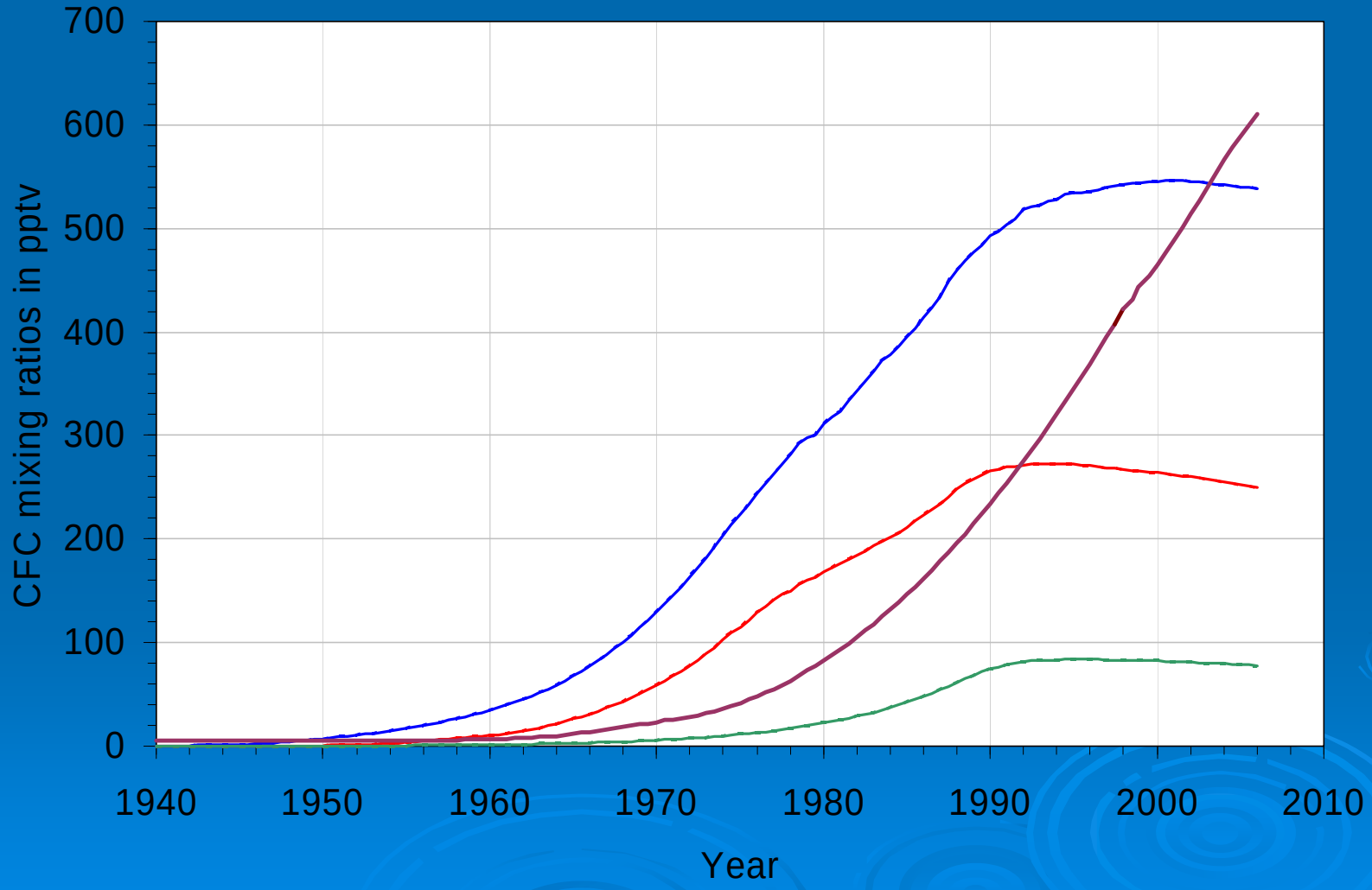

Andrews Creek
Andrews Spring
Creek Discharge
horizontal line represents 3H in summer precip.
Tritium (TU)
Discharge (m3 s-1)
20
15
10
5
0
0.4
0.3
0.2
0.1
0.0
4/1/01
7/10/01
10/18/01
1/26/02
5/6/02
8/14/02

^{35}S


Andrews Spring
% new sulfate
Discharge
% new sulfate
Discharge (m3 s-1)
50%
40%
30%
20%
10%
0%
0.02
0.01
0.00
4/1/99
5/27/99
7/22/99
9/16/99
11/11/99

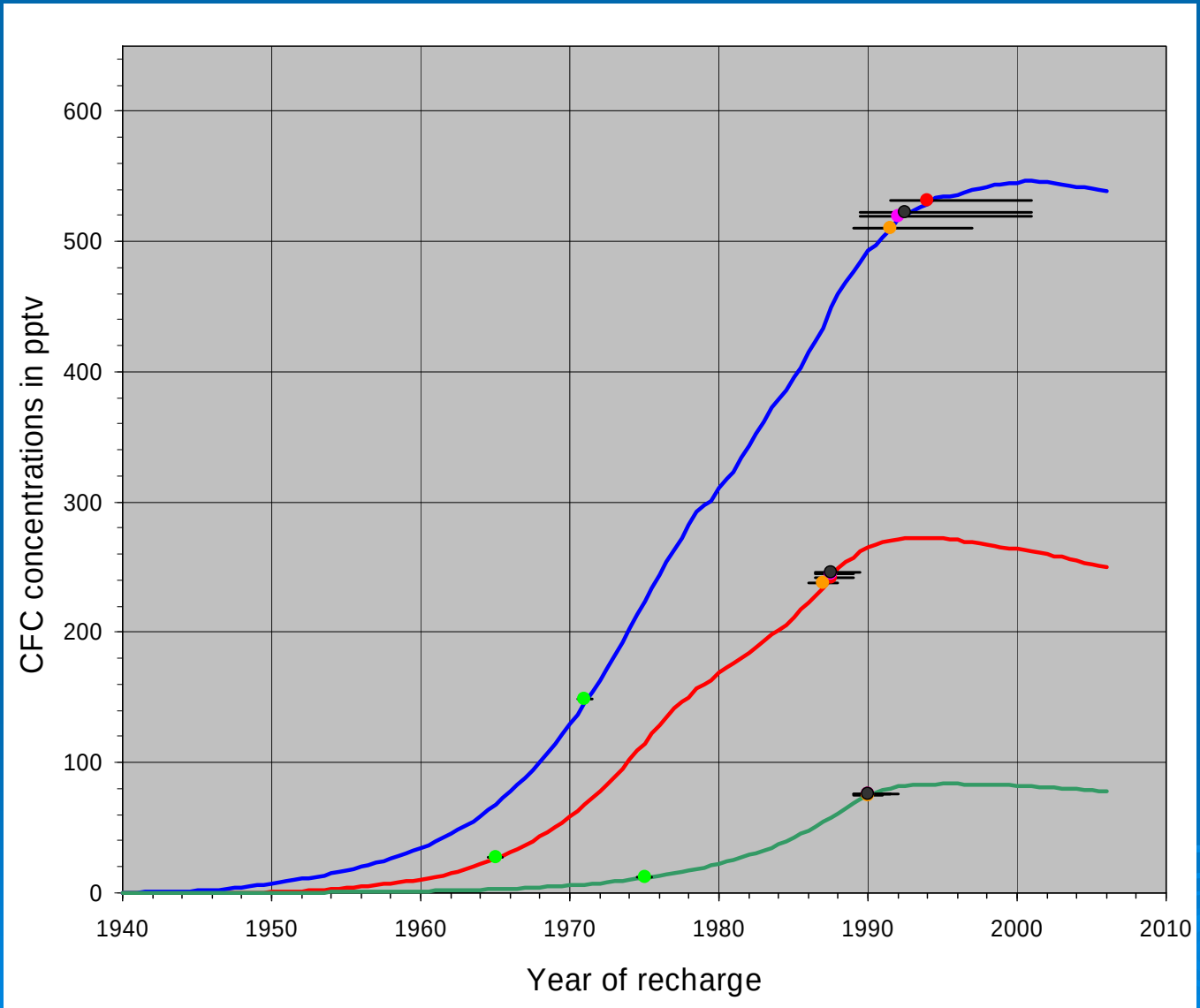

Andrews Creek
% new sulfate
Discharge
% new sulfate
Discharge (m3 s-1)
50%
40%
30%
20%
10%
0%
0.4
0.3
0.2
0.1
0.0
4/1/99
5/27/99
7/22/99
9/16/99
11/11/99

CFCs in atmosphere



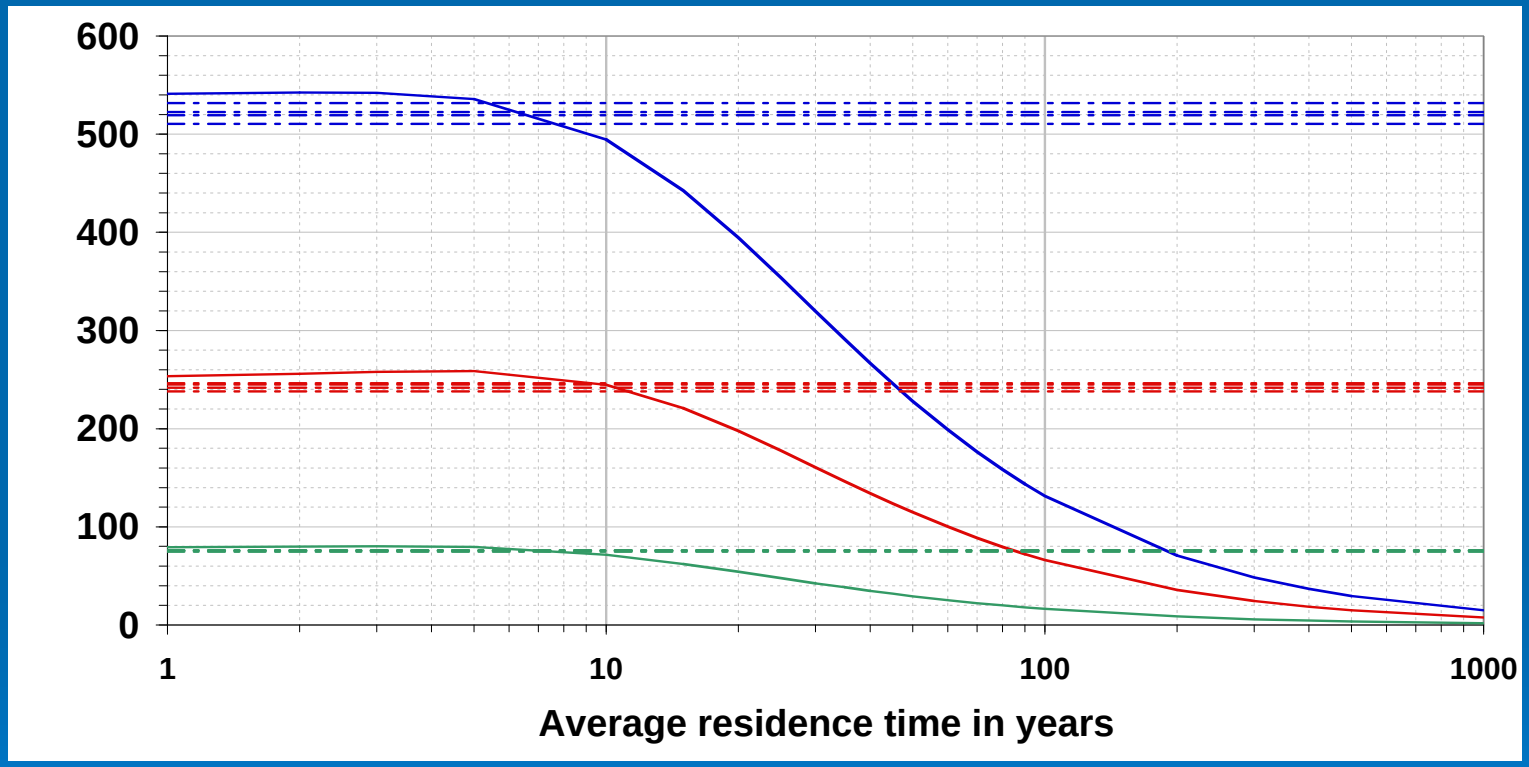
Blue – CFC12 **Red – CFC11** **Green – CFC113** **Black – SF6**

CFC Results from 2005



Blue – CFC12 **Red – CFC11** **Green – CFC113**

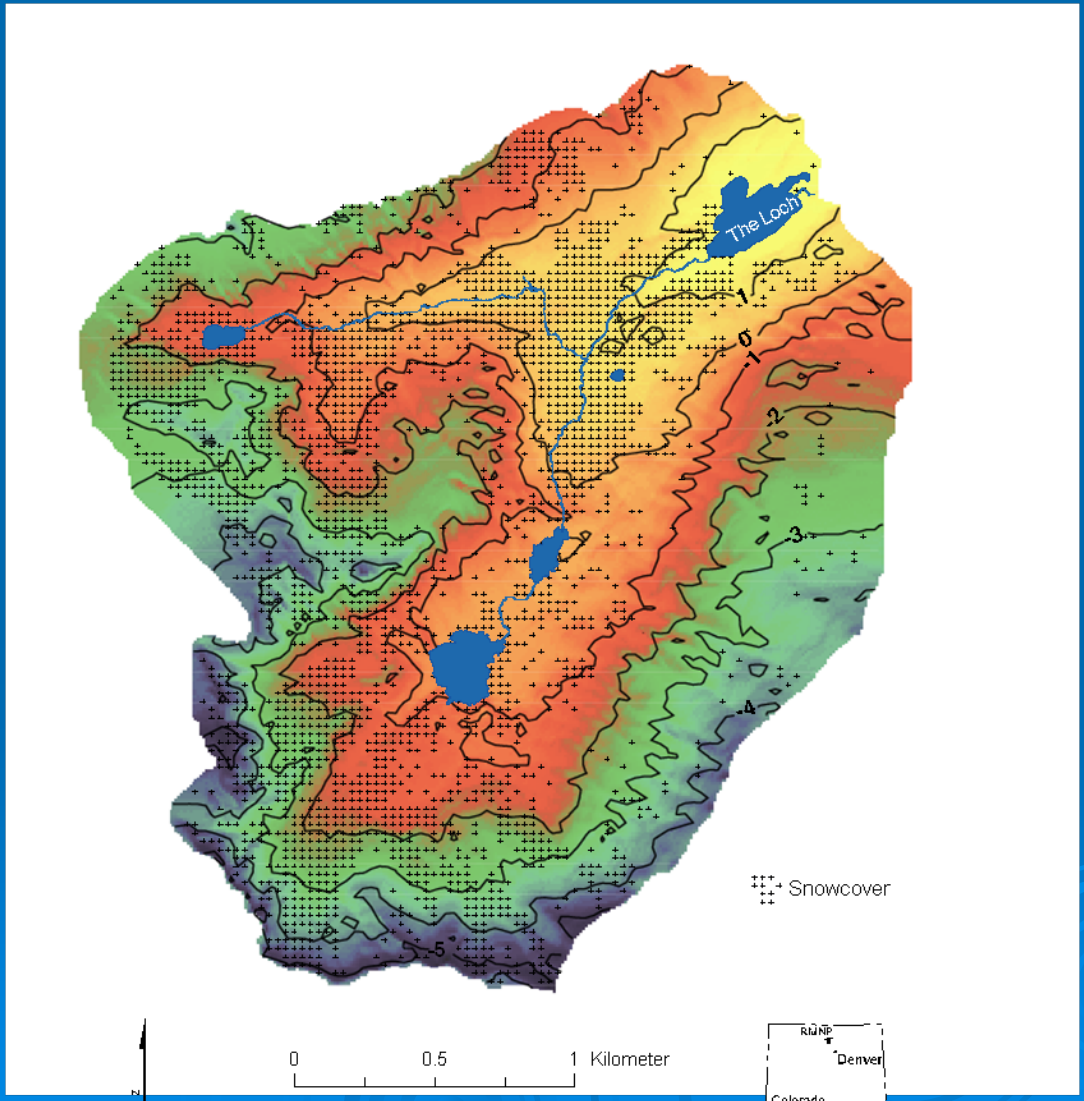
Water is Surprisingly Old

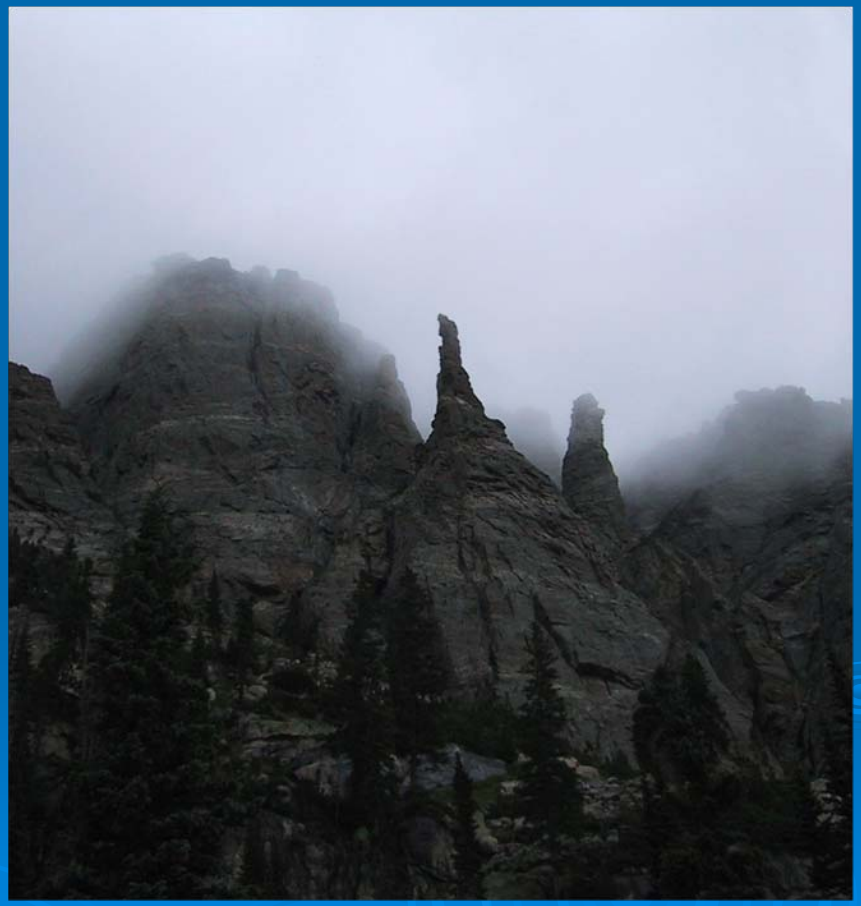


Exponential Model

Blue – CFC12 Red – CFC11 Green – CFC113

Potential Permafrost Areas



Conclusions

- Talus provides substantial storage capacity, although it is seldom filled
- Rock glaciers hold about as much water as snow glaciers
- Groundwater ages are older than expected given high porosity of surficial material
- Melting permafrost may explain the surprisingly “old” water ages