Expert Elicitation: Viewpoint on the Process and Results

Gaylon S. Campbell
Dept. of Crop and Soil Sciences
Washington State University
Pullman, WA

Yucca Mountain UZ Flow

- Can it be understood?
- Can it be understood by "outside experts"?
- Can it be understood by public?

Specific UZ Flow Questions

- What approaches have been used to estimate percolation flux in YM?
- How reliable are the models that are being used for these estimates?
- What is the percolation flux in the mountain and what are the uncertainties?

Modeling UZ Flow in YM

- Modeling water flow using numerical simulation and computer codes
- Modeling water flow by observation and measurements in the mountain
- Modeling water flow using tracer studies

UZ Codes for Percolation

- USGS Surface water balance models
- LBNL Tough2 Finite difference multiphase fluid and heat flow model
- LANL Finite element water, heat, and solute model

UZ Flow from Observations

- Observations of weeps and moisture in ESF
- Measurements of water potential and hydraulic properties in PTn

UZ Flow from Tracers

- ^{36}Cl tracer studies
- Tritium distributions
- ^{14}C tracer studies
- Heat flow and temperature gradients
- Calcite and opal deposition

Surface Water Balance

Percolation =

Precipitation

- Evaporation
- Transpiration
- Runoff

Surface Water Balance

Important Site Factors

- Soil depth
- Soil water holding capacity
- Plant root depth
- Topography
- Infiltrability

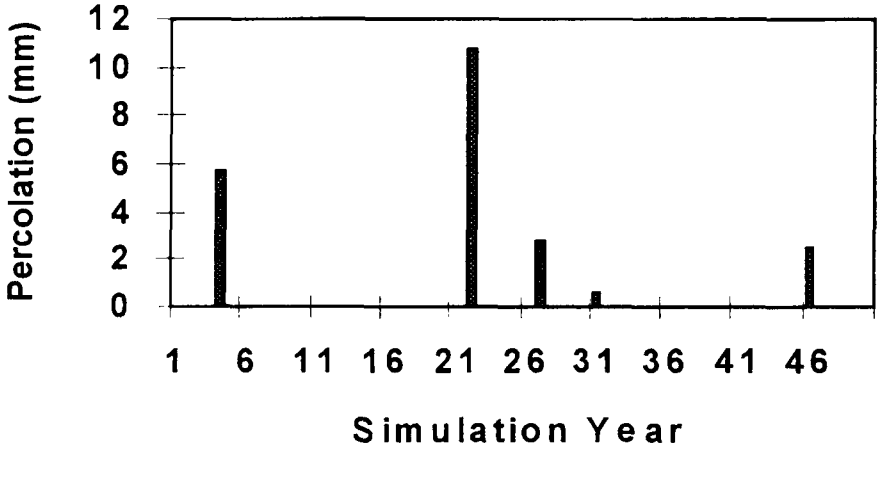
Environmental Factors

- Precipitation
- Potential evapotranspiration
- Solar radiation
- Temperature
- Vapor pressure
- Wind

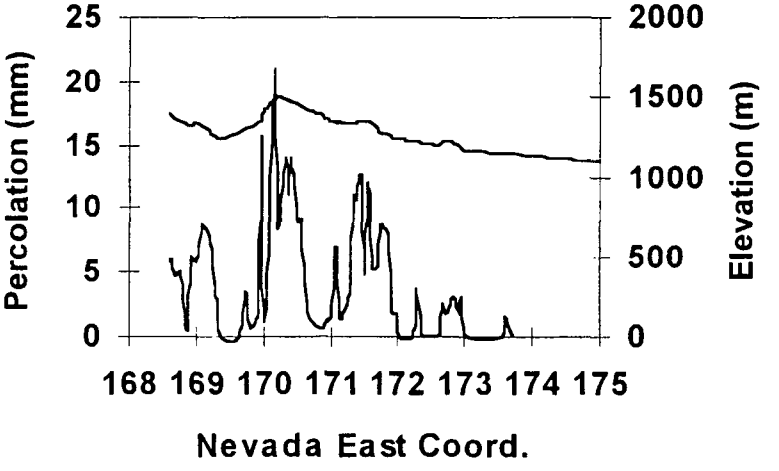
Water Balance Simulation

- Temperature from 50 year Beatty, NV record
- Precipitation from 15 year Yucca Mountain record
- Soils map of YM: depths and water holding capacity

Temporal Distribution



Spatial Distribution



Surface Water Balance

	max	min	mean
Precipitation	300	71	170
Evaporation	187	62	119
Transpiration	115	13	52
Percolation	11	0	0.5

0.5 m deep profile

Unsaturated Flow in PTn

- Psychrometers and core samples show zero matric potential gradient
- High porosity (0.5) and high permeability makes fracture flow unlikely
- Flow must be at least as high as matrix flow estimate

Unsaturated Flow Equations

$$q_w = k\left(\frac{dh}{dz} + 1\right)$$

$$k = k_s\left(\frac{h_e}{h}\right)^n$$

k	*hydraulic conductivity*
k_s	*saturated conductivity*
h	*water potential*
h_e	*air entry potential*

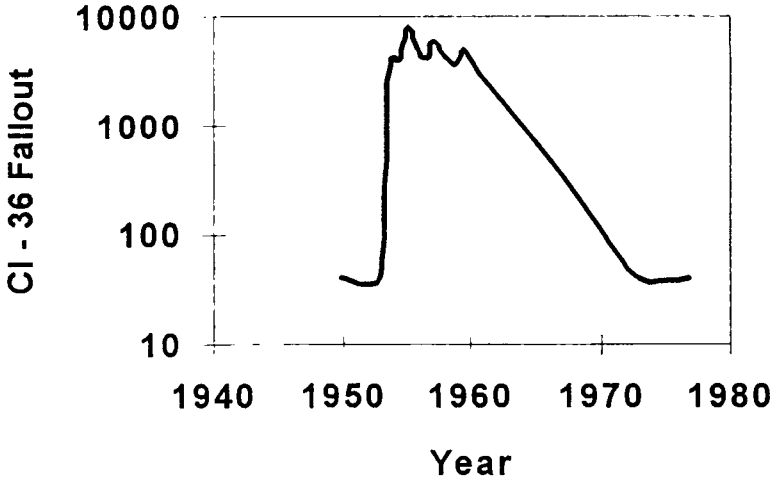
Estimated Flux in PTn

Potential - Bars	Flux - mm/yr
0.1	100
0.2	17
0.5	1.7
1	0.3
2	0.05
5	0.005

^{36}Cl as a Water Tracer

- Generated by cosmic rays
- Half life of 301,000 years
- Modern $^{36}Cl/Cl$ ratio 5×10^{-13}
- Levels 10,000 years ago were 2 to 3 times present
- Nuclear tests elevated levels by a factor of 400 from 1952-1972

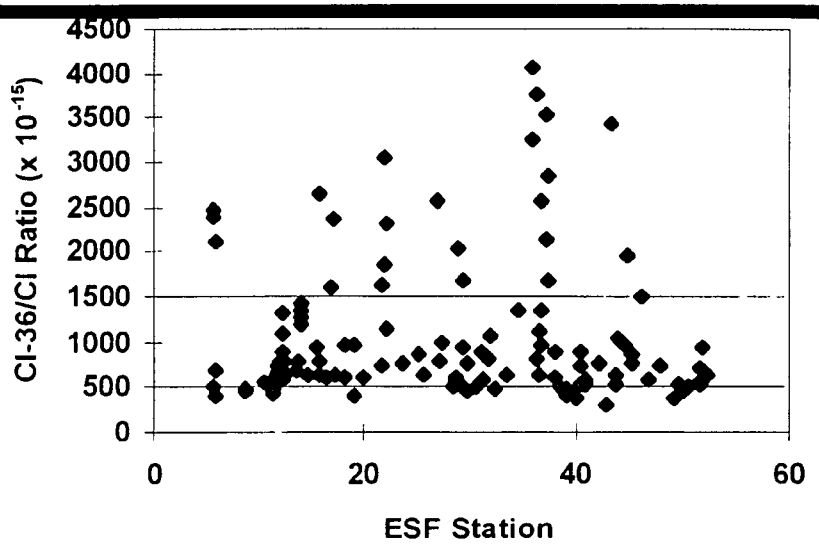
^{36}Cl Bomb Pulse



^{36}Cl Sampling

- Bore hole sampling
- Samples every 100 m in ESF
- Feature-based sampling in ESF (faults and fractures)

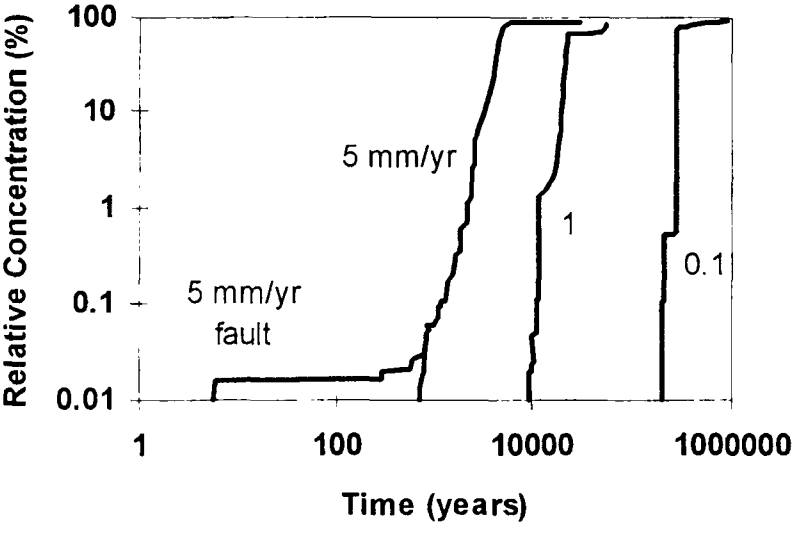
$^{36}Cl/Cl$ Ratios in ESF Tunnel



^{36}Cl: Flux from Simulation

- Finite element heat and water model
- Dual permeability implementation (flow in matrix and fractures; equilibrium not required)
- Can implement fast flow in fault regions

Chloride Breakthrough



Conclusions

- There is downward flow of water under Yucca Mountain
- Some water reaches repository levels within decades
- Fast flow of water in faults and fractures is likely

More Conclusions

- Recharge is highly variable in space and time
- Recharge occurs about 1 year in 10
- Recharge occurs under shallow soils
- Flow mostly in fractures except in PTn non-welded tuff layer
- Probable range 1 - 20 mm/yr

What is Most Needed Now

- Accurate water potential measurements of rocks in ESF
- Unsaturated hydraulic conductivity measurements, especially in PTn
- Inverse modeling to understand perched water