GROUNDWATER AGE
AT LOS ALAMOS, NEW MEXICO

BY

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Introduction
Hydrology
Radioactive Isotopes
Tritium/Helium Dating of Groundwater
Carbon-14 Dating of Groundwater
Summary and Conclusions
Motivation of Study

Establish an understanding of the groundwater flow system at Los Alamos (water sources, mixing relations flow paths, and travel times) that is independent of numerical models.

This understanding can be used either to guide the development or evaluate results of corresponding flow models.

Of particular interest is the vulnerability of water supply wells and sustainability of groundwater resources.
LANL Hydrostratigraphy and White Rock Canyon Springs

No WRC Springs discharge from the Bandelier Tuff.

Perched Zones (Bandelier Tuff)

Perched Zones and Regional Aquifer (Cerros del Rio basalt)

WRC Springs
Ancho Spring, 5 series, 6 series, 7, 8, 9 series, and 10

Perched Zones and Regional Aquifer (Puye Formation, Phreatomagmatic Deposits)

WRC Springs
1, 2 series, 3 series, 4 series, 5 series, 6 series, La Mesita, and Sandia

Regional Aquifer (Santa Fe Group)
Generalized Cross Section Showing Groundwater Type and Expected Trends in Groundwater Age for Conceptual Model of Groundwater Flow

- **Zone 1 – Perched in Mountain Block/Front (Modern and Mixed)**
- **Zone 2 – Alluvial (Modern)**
- **Zone 3 – Intermediate Beneath Plateau (Modern and Mixed)**
- **Zone 4 – Regional (Submodern and Mixed)**

Recharge Paths:
- West to East

Legend:
- Tuff
- Basalts
- Dacite
- Sediments

Scale:
- 10x VE
- 1 cm = 1000 m
Average Mixing Ratios for the Regional Aquifer Containing Chloride from Alluvial Groundwater, Pajarito Plateau, New Mexico
ISOTOPES

STABLE AND RADIOACTIVE ISOTOPES

- **Stable Isotopes**
  - Do not decay spontaneously over time
  - Examples: $^{18}O$, $^2H$, $^{13}C$, $^{15}N$

- **Radioactive Isotopes**
  - Emit alpha and beta particles and decay over time
  - Examples: $^3H$, $^{14}C$, $^{238}U$

**Environmental Isotopes**

**USED AS TRACERS**

**USED FOR DATING**
STABLE AND RADIOACTIVE ISOTOPES

Atoms: composed of protons, neutrons and electrons

Isotopes: elements with different numbers of neutrons

Hydrogen

Protium
Deuterium
Tritium

proton
neutron
electron
Radioactive Isotopes

- $^{14}$C half-life is 5730 years
- Tritium half-life is 12.32 years
Sampling Stations for Tritium/Helium and Radiocarbon ($^{14}$C) Dating
Ranges of Apparent $^3$H/$^3$He Ages in the Regional Aquifer
Summary and Conclusions

- The regional aquifer at Los Alamos consists of submodern (pre-1943) or mixed (pre- and post-1943) ages.
- Submodern-groundwater is common in the regional aquifer. Average ages for the regional aquifer range from 570 to 12,518 years based on unadjusted $^{14}$C results.
Summary and Conclusions

- Groundwater with younger unadjusted $^{14}$C ages are associated with canyon bottom recharge (Frijoles, Water, Pajarito, Mortandad, and Los Alamos Canyons).

- Application of $^{14}$C ages with chloride, tritium, and other mobile chemicals define preferred groundwater flow paths within the regional aquifer.
Supplemental Material
Analytical Methods (LANL and NMED)

**Major Ions**
Ion chromatography, titration, and inductively coupled plasma-optical emission spectroscopy

**Trace Elements**
Inductively coupled plasma-optical emission spectroscopy and (high resolution) inductively coupled plasma-mass spectrometry

**Field Parameters**
Dissolved oxygen, pH, ORP, temperature, specific conductance, and turbidity
Analytical Methods (LANL and NMED)

Stable Isotopes
Isotope ratio mass spectrometry (δ²H, δ¹⁸O, δ¹⁵N, and ¹³δC)

Carbon 14 (NMED)
Accelerator mass spectrometry

Tritium-Helium
Electrolytic enrichment (³H) and mass spectrometry (³,⁴He) for He ingrowth
Generalized Trends in Groundwater Age for Conceptual Model of Groundwater Flow

- Modern (post-1943) water is present at zones of aquifer recharge
- Mixed (older) water is present in mixing zones and/or where recent recharge has occurred
- Submodern (pre-1943) water is present far from recharge zones
Infiltration of natural- and Laboratory-derived tritium

Cosmogenic $^3$H (6 TU, 19 pCi/kg)

$^{14}$N + n $\rightarrow$ $^3$H + $^{12}$C

Loss of $^3$He(g) in unsaturated zone

Regional Aquifer

Groundwater Flow

Terrigenic tritium ($^6$Li + n $\rightarrow$ $^3$H + $^4$He) (<0.01 TU, <0.03 pCi/kg)

$^4$He derived from natural U and Th in aquifer material and from decay of Pu and Am in waste streams

Recharge
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