Application of $^{129}I/I$ Ratios in Groundwater Studies Conducted at Los Alamos National Laboratory, New Mexico

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- **Natural and Anthropogenic Sources of ^{129}Iodine**
- **Analytical Methods**
- **Hydrogeochemical and Hydrological Setting (groundwater mixing) at LANL**
- **Distribution of ^{129}I and $^{129}I/I$ ratios in groundwater**
- **Summary and Conclusions**

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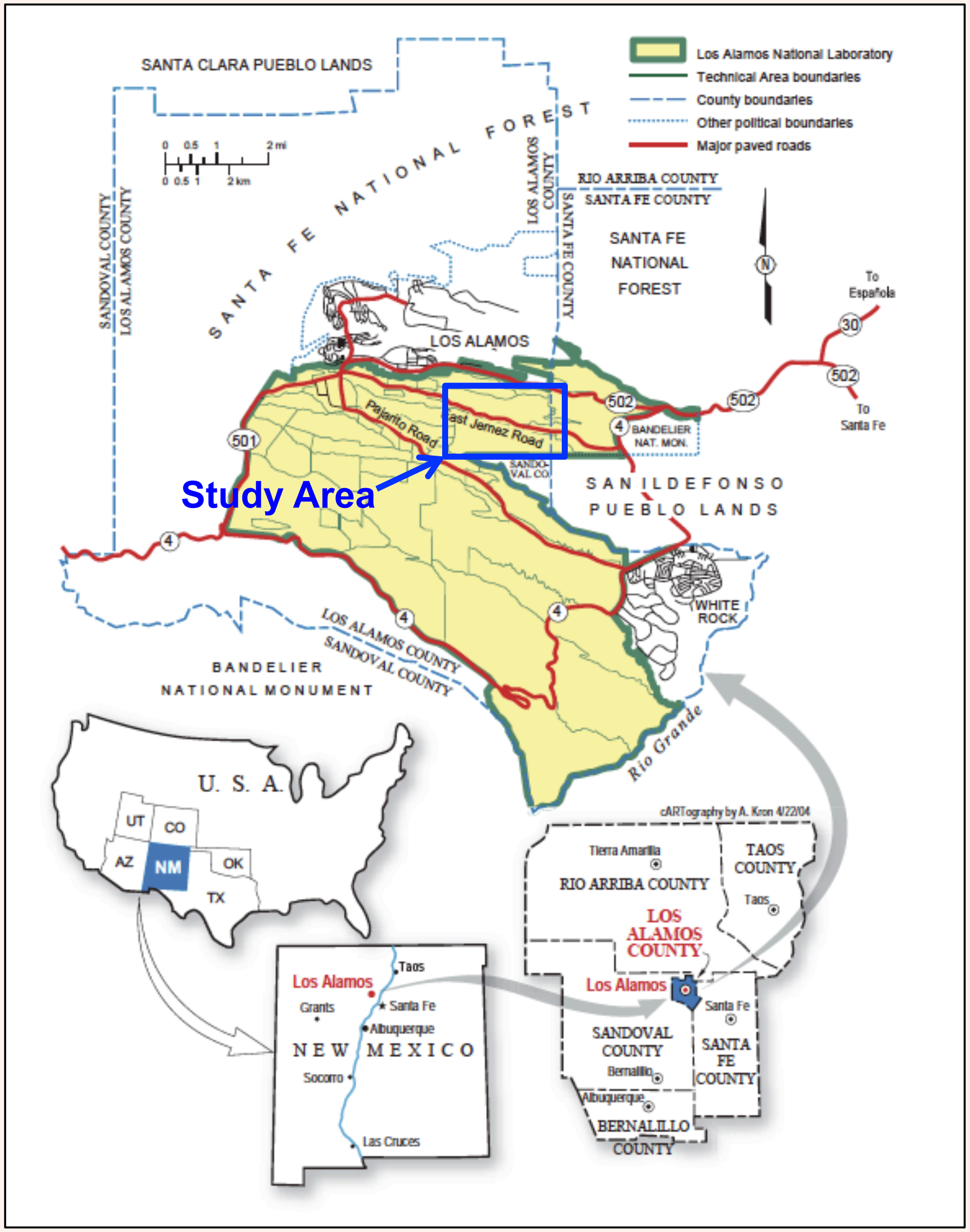
Los Alamos National Laboratory, New Mexico



Source: LANL 2007

Natural and Anthropogenic Sources of ^{129}Iodine

Natural sources of ^{129}I include cosmic spallation of xenon and fission of uranium occurring in the subsurface.

Fission of uranium releases ^{129}I to groundwater and the atmosphere from volcanic emissions. Residence times for ^{129}I in the atmosphere and oceans are two weeks and 40,000 years, respectively.

Anthropogenic ^{129}I is a fission product of ^{235}U and ^{239}Pu processing at nuclear facilities. Isotope ratios of $^{129}I/I$ increased in some parts of the world during the 1960’s resulting from atmospheric nuclear testing. Atmospheric $^{129}I/I$ ratios ranged from 10^{-7} to 10^{-4} in the past.

Analytical Methods

^{129}Iodine and ^{36}Chlorine

Accelerator mass spectrometry

^{239}Plutonium and Tritium

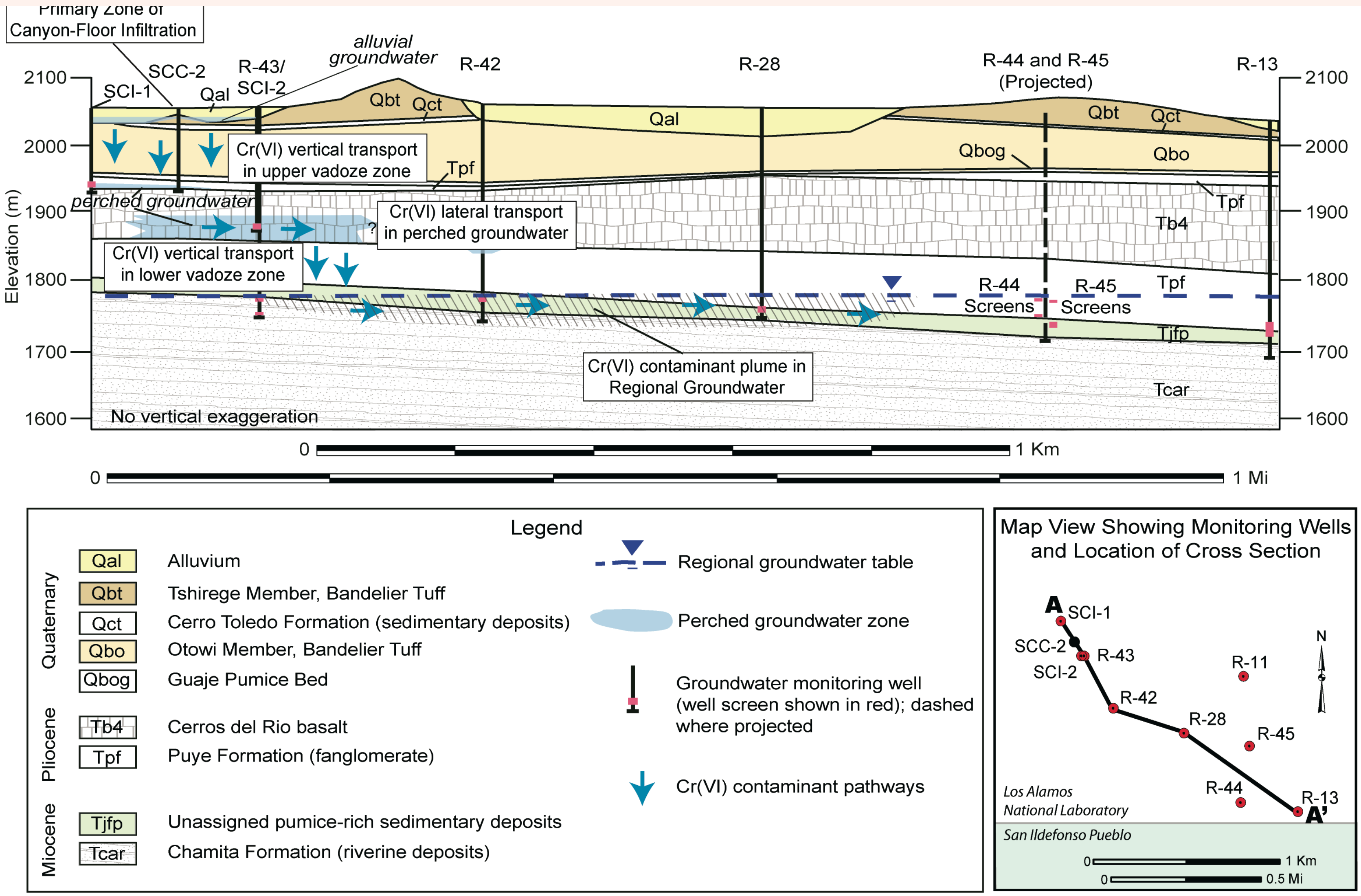
Alpha spectrometry

Electrolytic enrichment and liquid scintillation

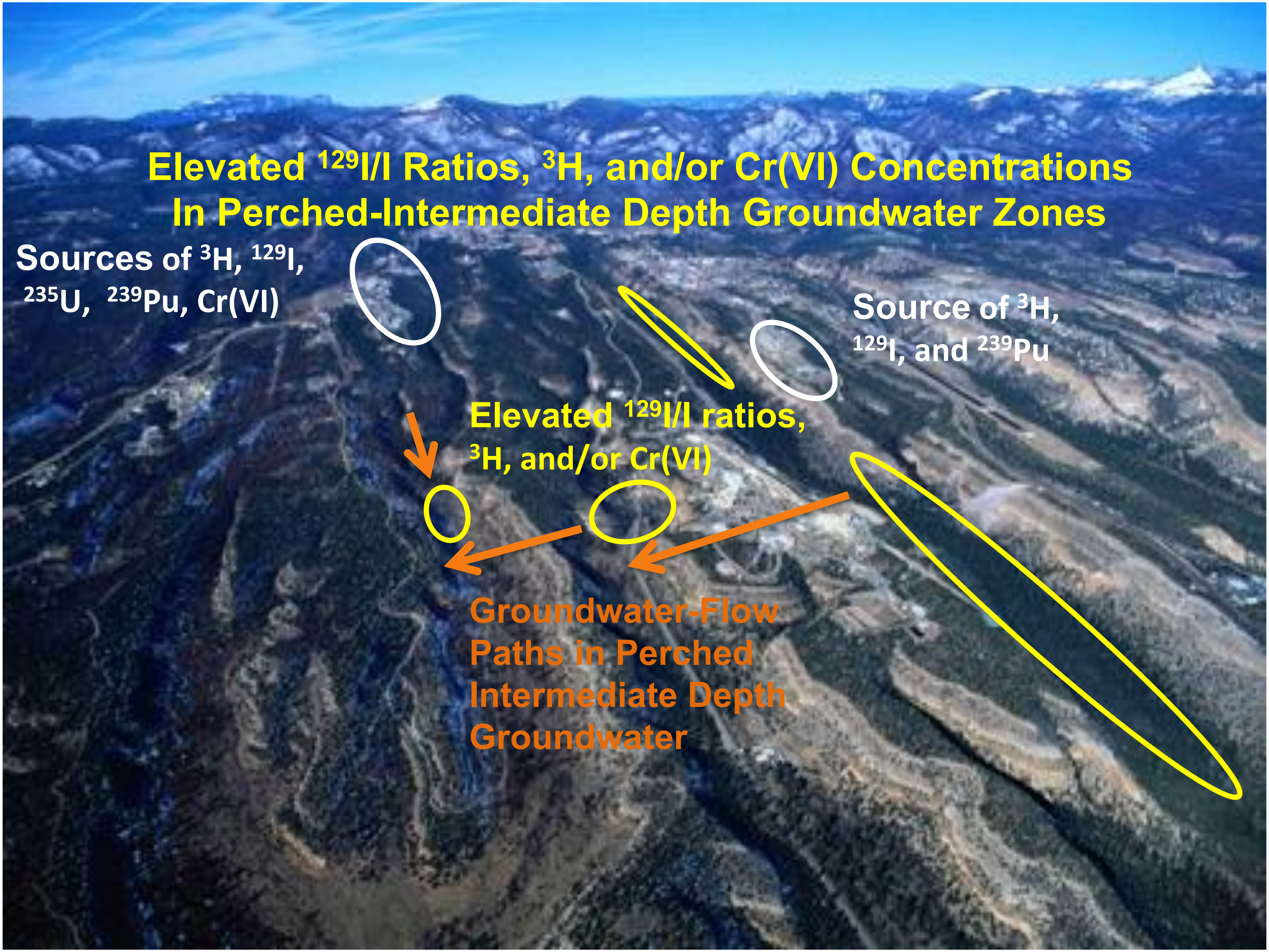
Oxyanions

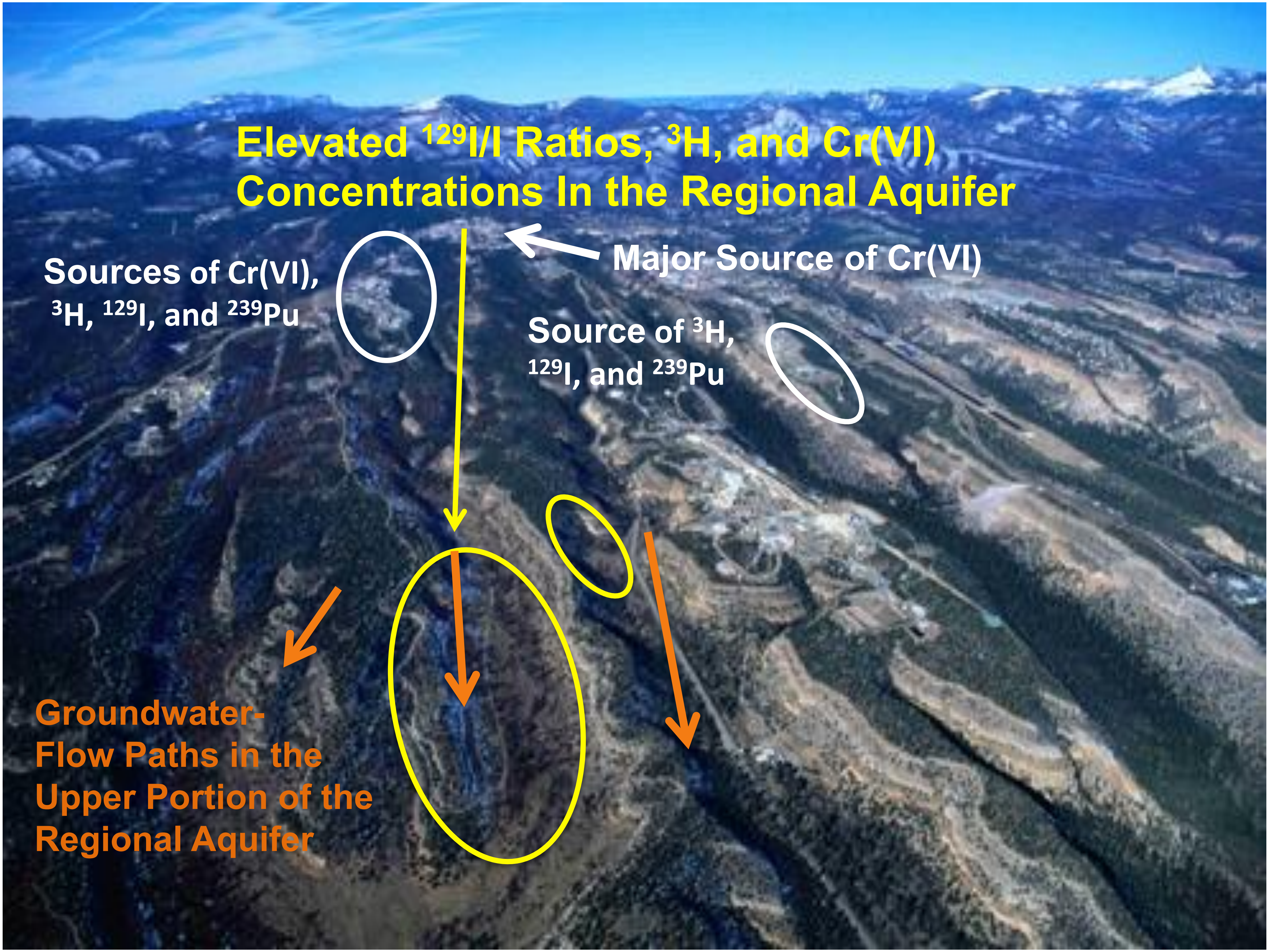
Liquid chromatography/mass spectrometry-mass/spectrometry

Conceptual Model of Groundwater Movement Through the Vadose Zone to the Regional Aquifer, Los Alamos National Laboratory, New Mexico



Source: LANL 2012


Elevated $^{129}I/I$ Ratios, ^{3}H, and/or Cr(VI) Concentrations
In Perched-Intermediate Depth Groundwater Zones
Sources of ^{3}H, ^{129}I, ^{235}U, ^{239}Pu, Cr(VI)
Source of ^{3}H, ^{129}I, and ^{239}Pu
Elevated $^{129}I/I$ ratios, ^{3}H, and/or Cr(VI)
Groundwater-Flow Paths in Perched Intermediate Depth Groundwater


Elevated $^{129}I/I$ Ratios, ^{3}H, and Cr(VI) Concentrations In the Regional Aquifer
Sources of Cr(VI), ^{3}H, ^{129}I, and ^{239}Pu
Major Source of Cr(VI)
Source of ^{3}H, ^{129}I, and ^{239}Pu
Groundwater-Flow Paths in the Upper Portion of the Regional Aquifer

Distributions of Radionuclides in Corehole MCB-5, Mortandad Canyon, New Mexico

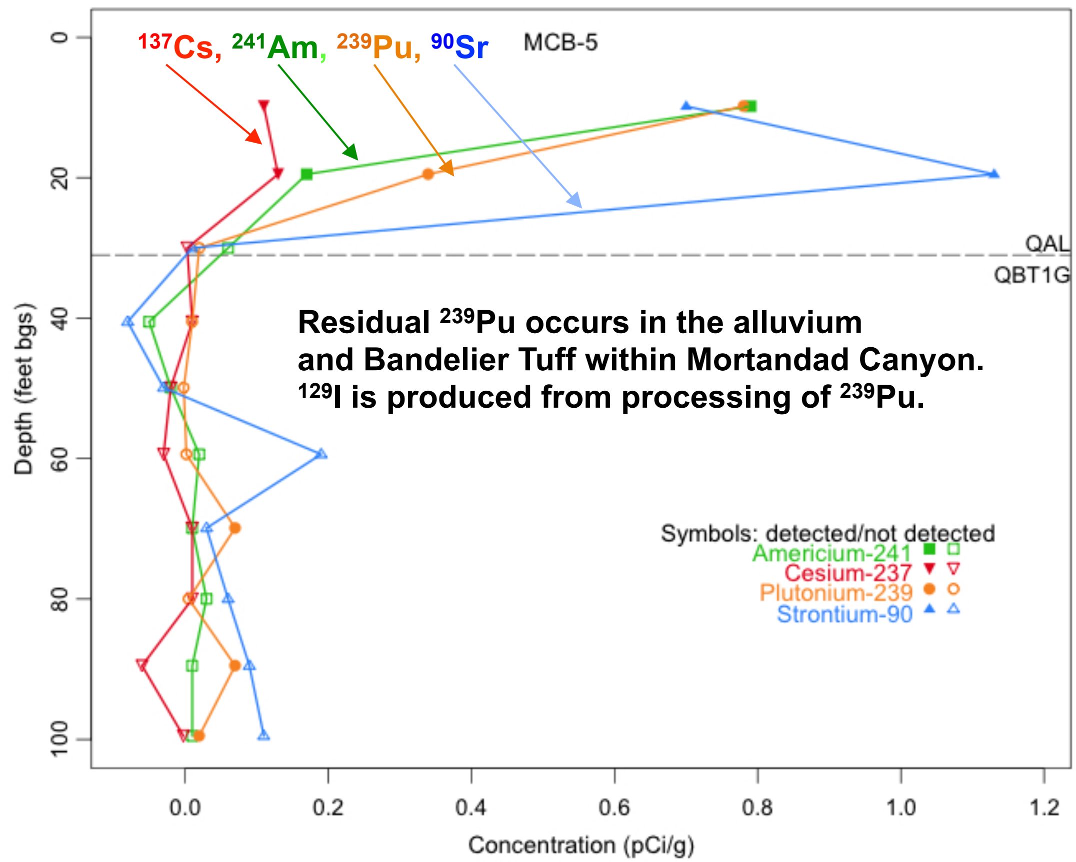
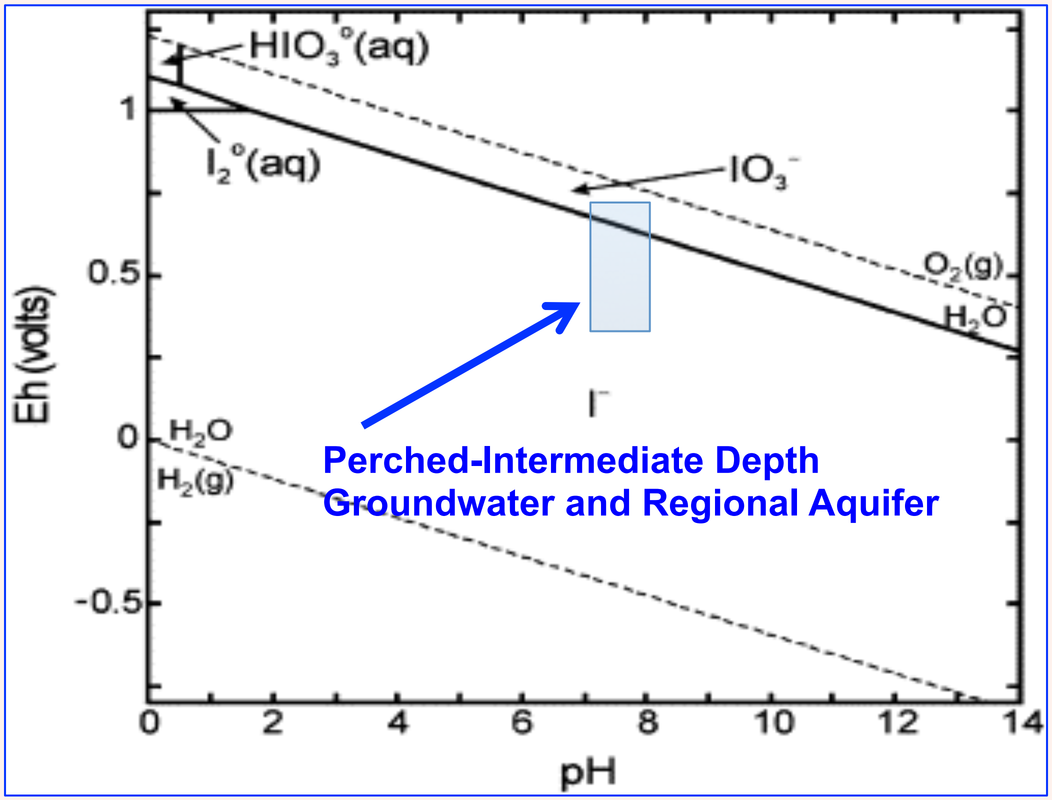


Figure D-2.4-24. Radionuclide distribution in cores at MCB-5

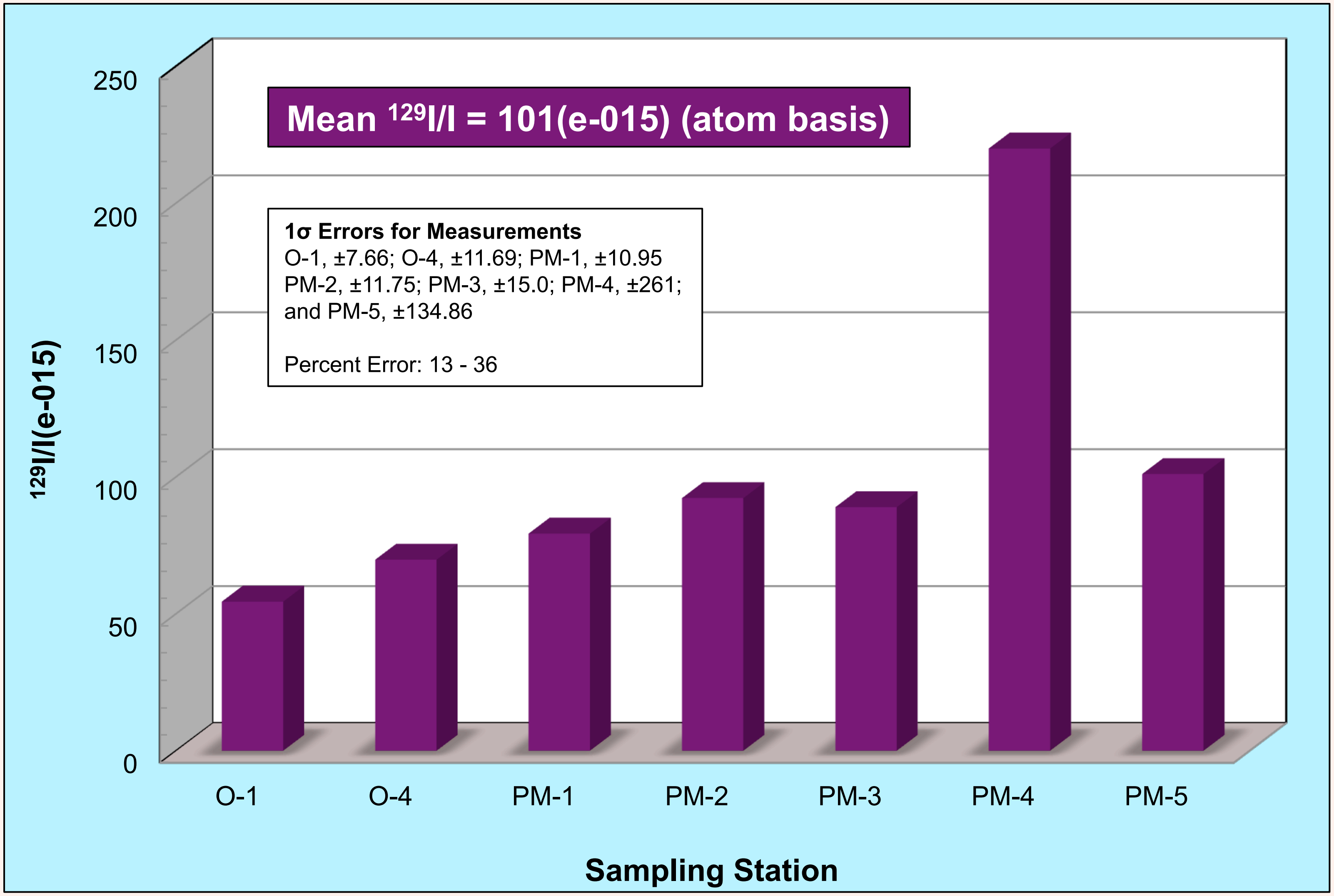
Source: Los Alamos National Laboratory, 2006, Mortandad Canyon Investigation Report, Environmental Restoration Project: Los Alamos National Laboratory, LA-UR-06-6752.

Eh-pH Diagram for Iodine at 25°C and 1 Bar

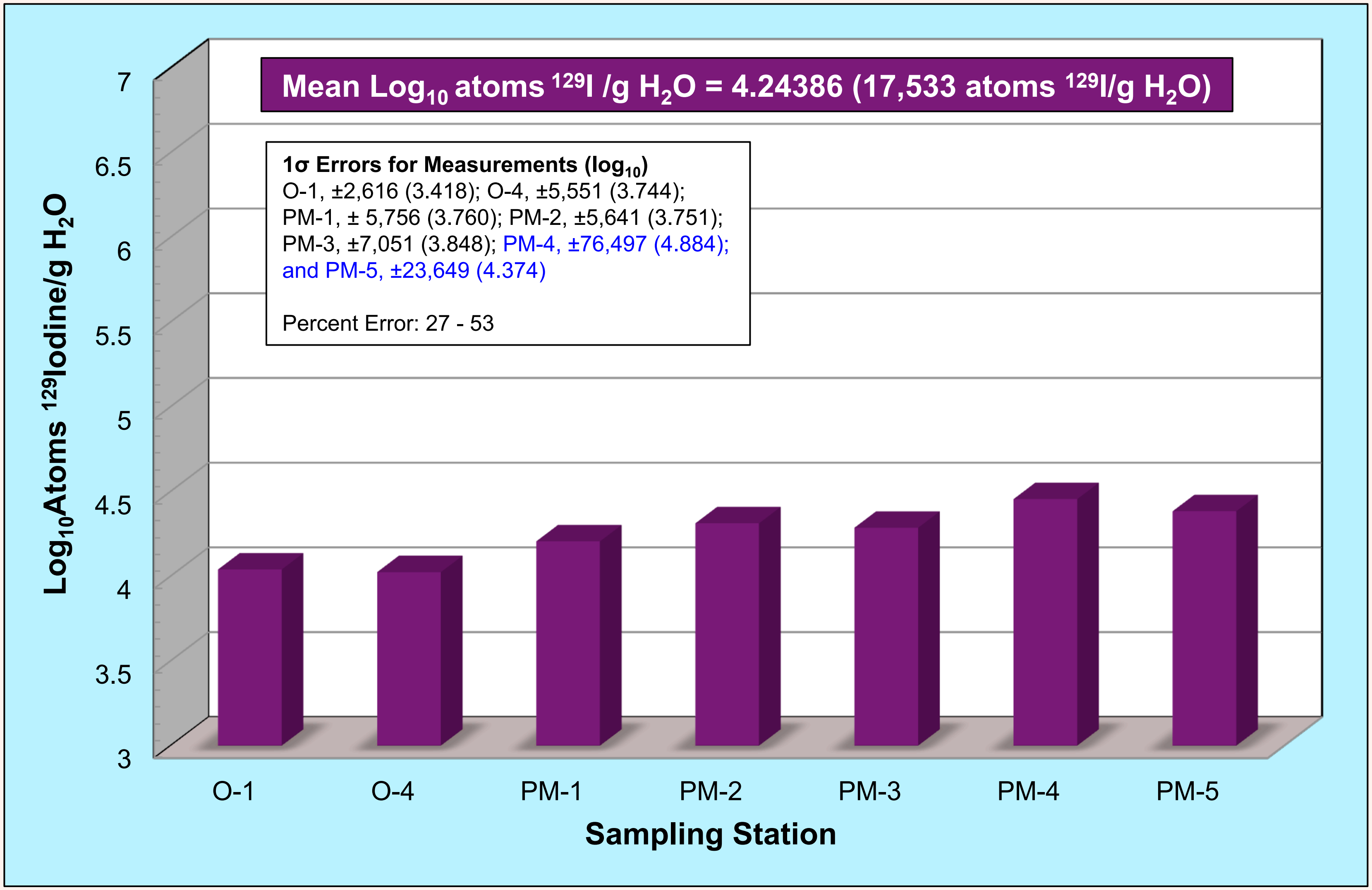
(Total dissolved I concentration = 10^{-8} mol/L. Source: Um et al., 2004)



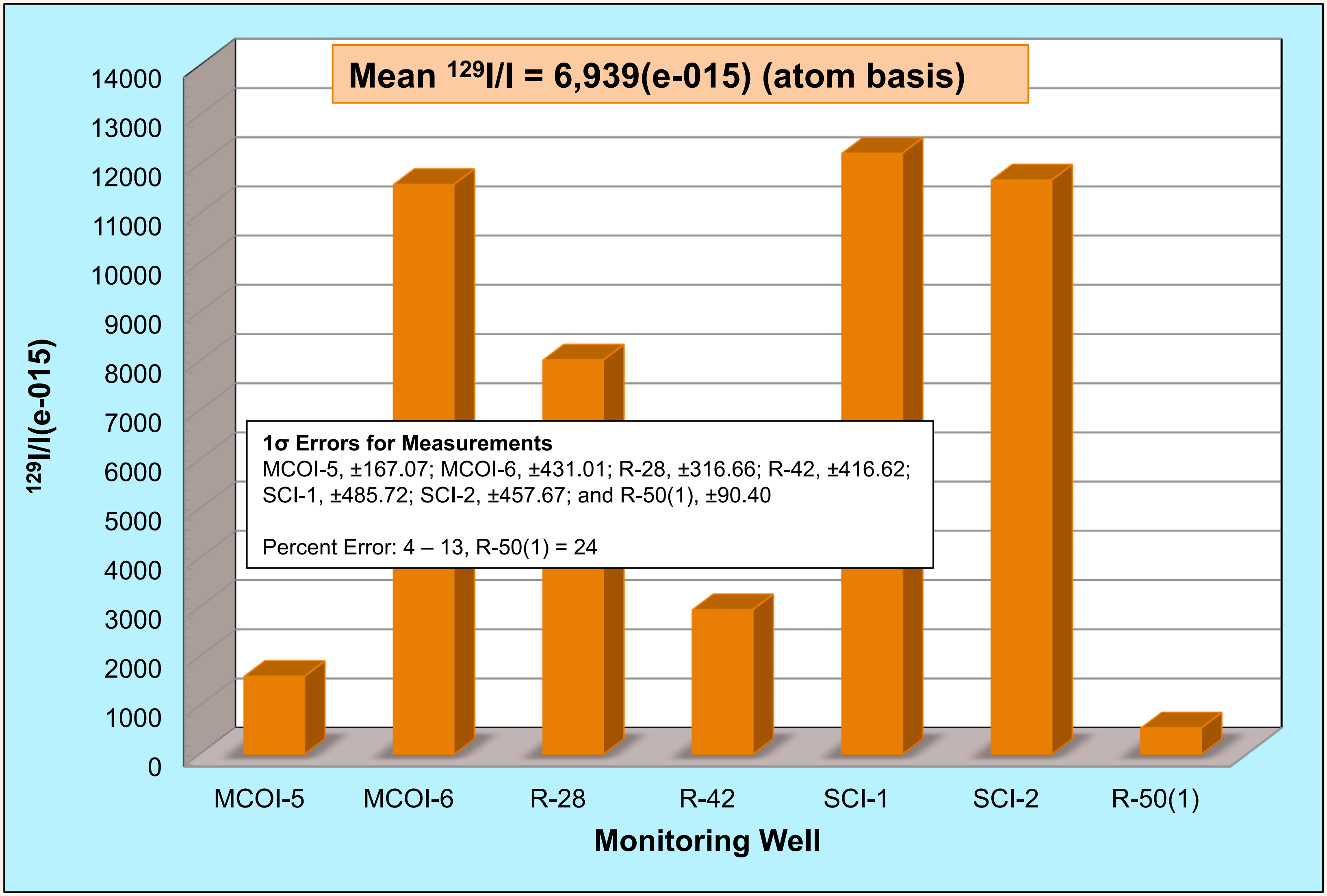
$^{129}I/I$ Ratios in Los Alamos County Supply Wells, New Mexico



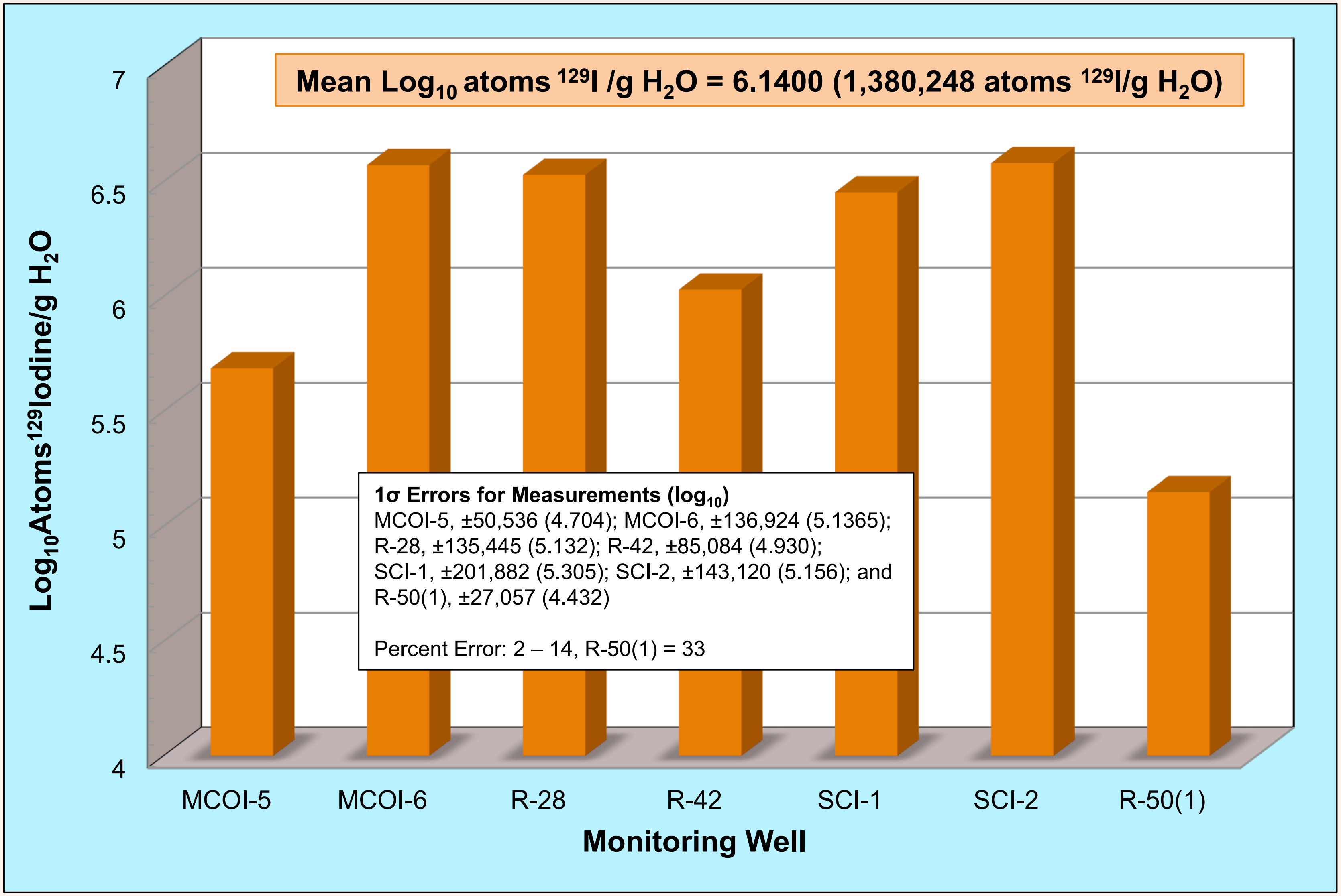
Atoms ^{129}I/g Water in Supply Wells, Los Alamos County, New Mexico



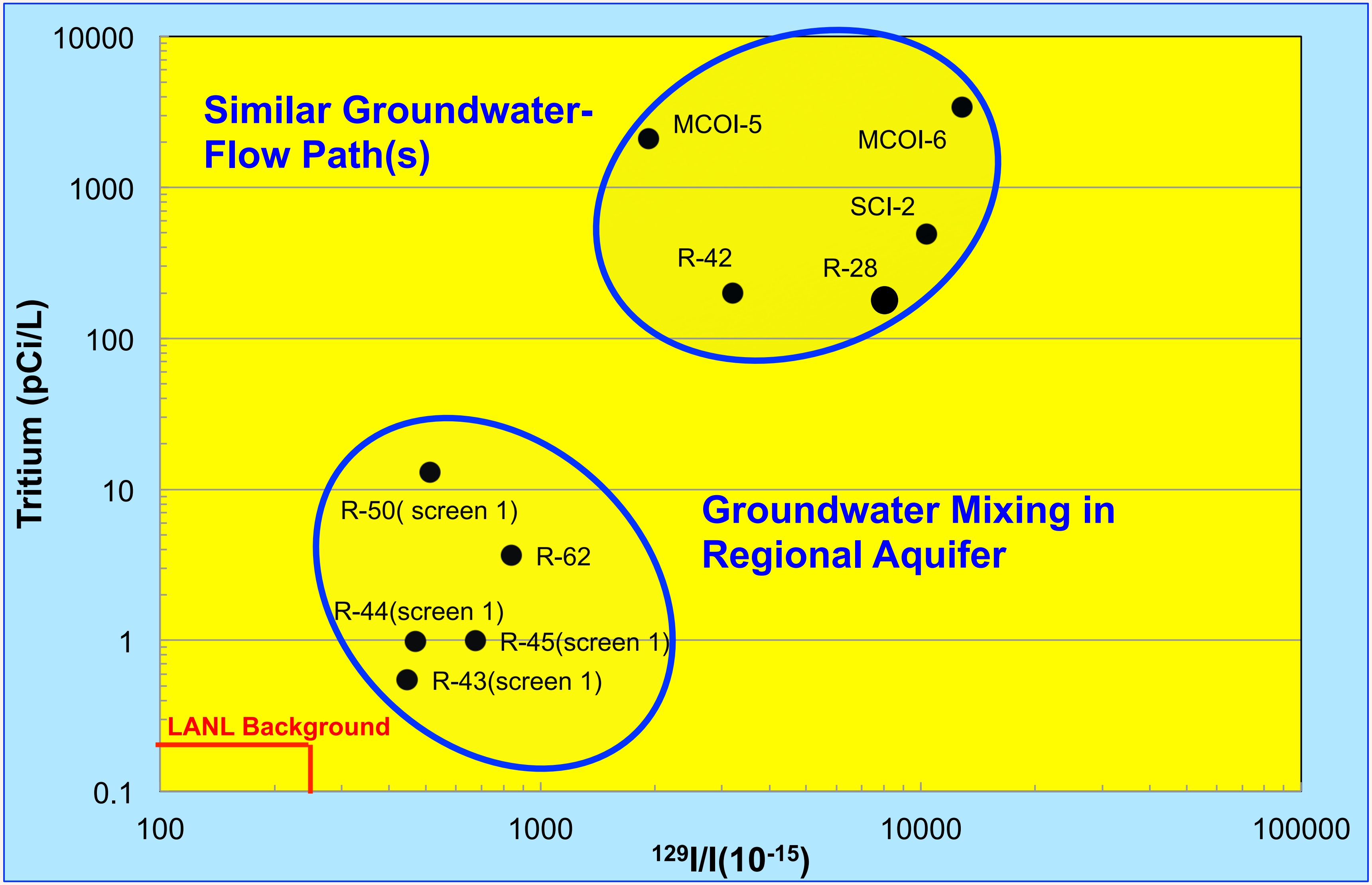
Average $^{129}I/I$ Ratios in Selected Monitoring Wells Downgradient From Sources of ^{129}Iodine, Los Alamos National Laboratory, NM



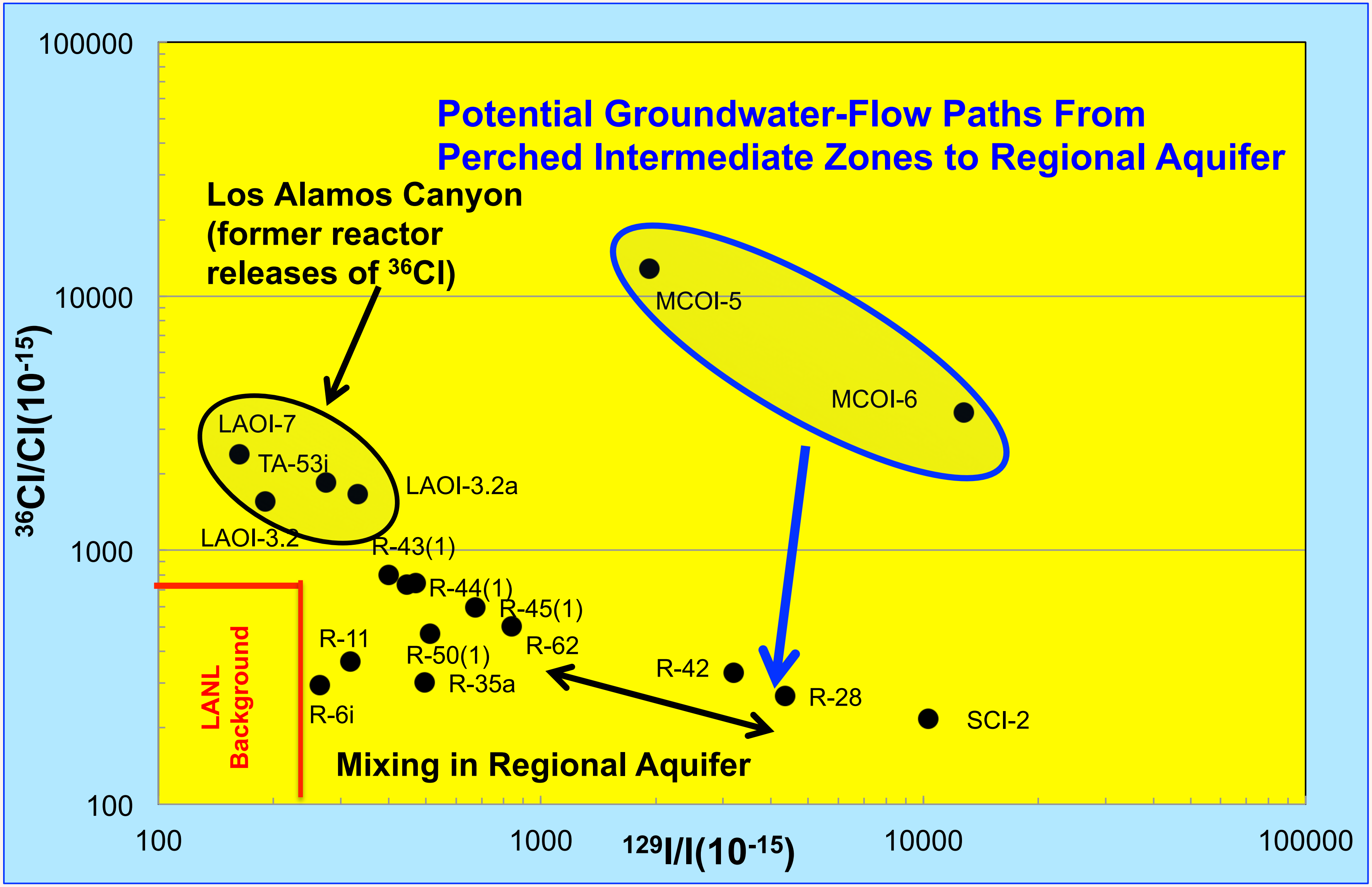
Atoms ^{129}I/g Water in Selected Monitoring Wells Downgradient From Sources of ^{129}Iodine, Los Alamos National Laboratory, NM



^{129}I/I Ratios Versus Tritium in Groundwater, Los Alamos National Laboratory, New Mexico



^{129}I/I Ratios Versus ^{36}Cl/Cl Ratios in Groundwater, Los Alamos National Laboratory, New Mexico



Summary and Conclusions

- **The radioisotope ^{129}I ($T_{1/2}$ = 15.7 Myrs) derived from ^{235}U and ^{239}Pu processing at Los Alamos National Laboratory is locally detected in groundwater above background ^{129}I activities.**
- **This isotope provides a unique tracer for groundwater investigations conducted at LANL that helps to identify source releases linked to groundwater-flow paths in aquifers.**
- **Aquifer systems are subject to binary and ternary mixing of natural- and industrial-derived waters containing iodate, chromate, and other chemicals.**
- **Local background ratios of $^{129}I/I$ vary from 54×10^{-15} to 220×10^{-15} in the regional aquifer (supply wells).**

Summary and Conclusions

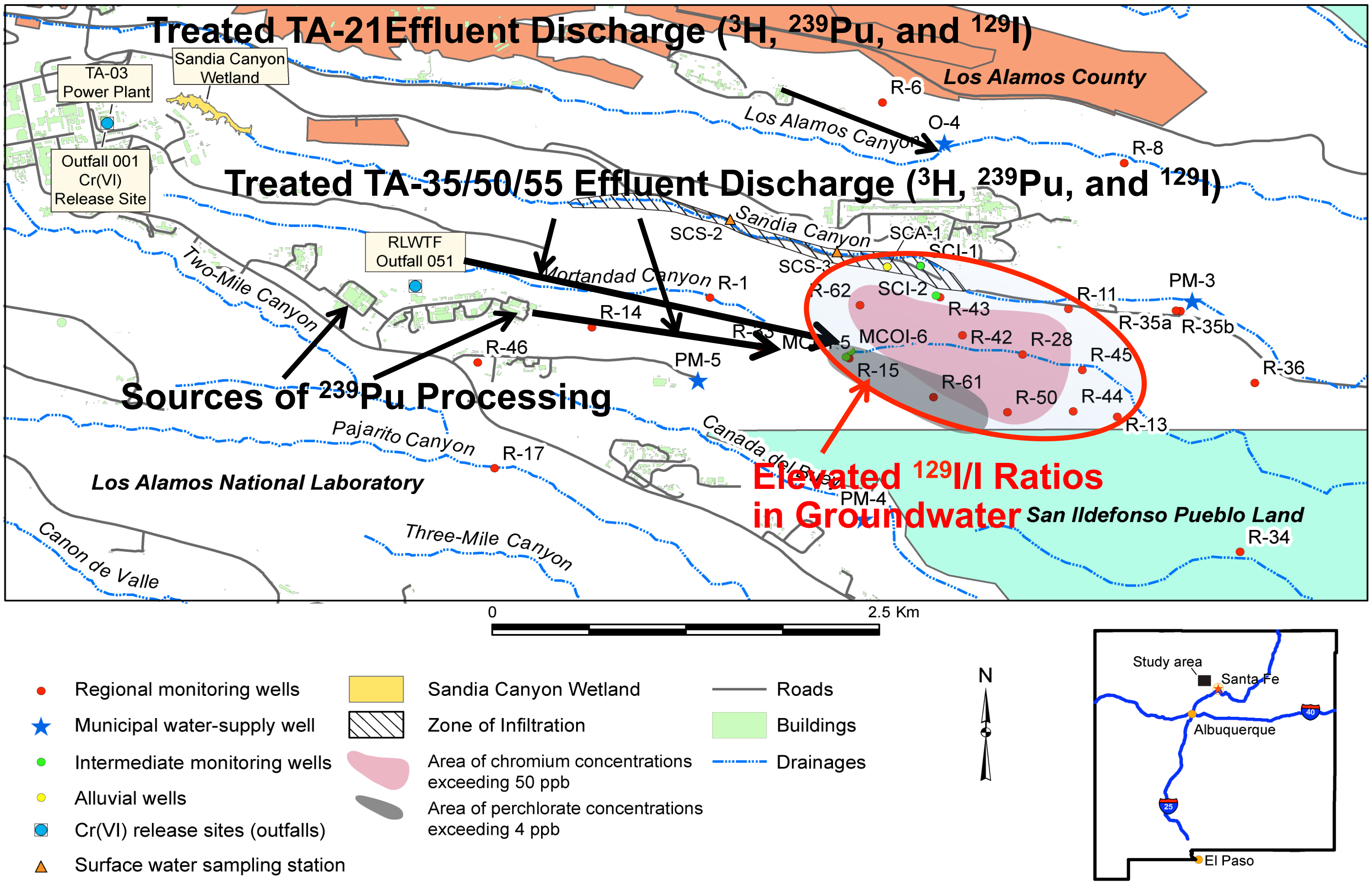
- Anthropogenic ratios of $^{129}I/I$ range from 1,252 X 10^{-15} to 17,367 X 10^{-15} within perched-intermediate depth groundwater in Mortandad Canyon.

- Anthropogenic ratios of $^{129}I/I$ range from 2,690 X 10^{-15} to 11,688 X 10^{-15} within the regional aquifer in Mortandad Canyon (centroid of chromium plume).

- Variability in $^{129}I/I \times 10^{-15}$ ratios and concentrations of anthropogenic iodate is controlled by non-uniform source releases of this isotope and iodate over time and non-uniform mixing (ternary) of groundwater in different aquifers.

Supplemental Slides

Plume Map of Total Dissolved Chromium and Elevated Above Background ^{129}I/I Ratios within the Regional Aquifer, Los Alamos National Laboratory

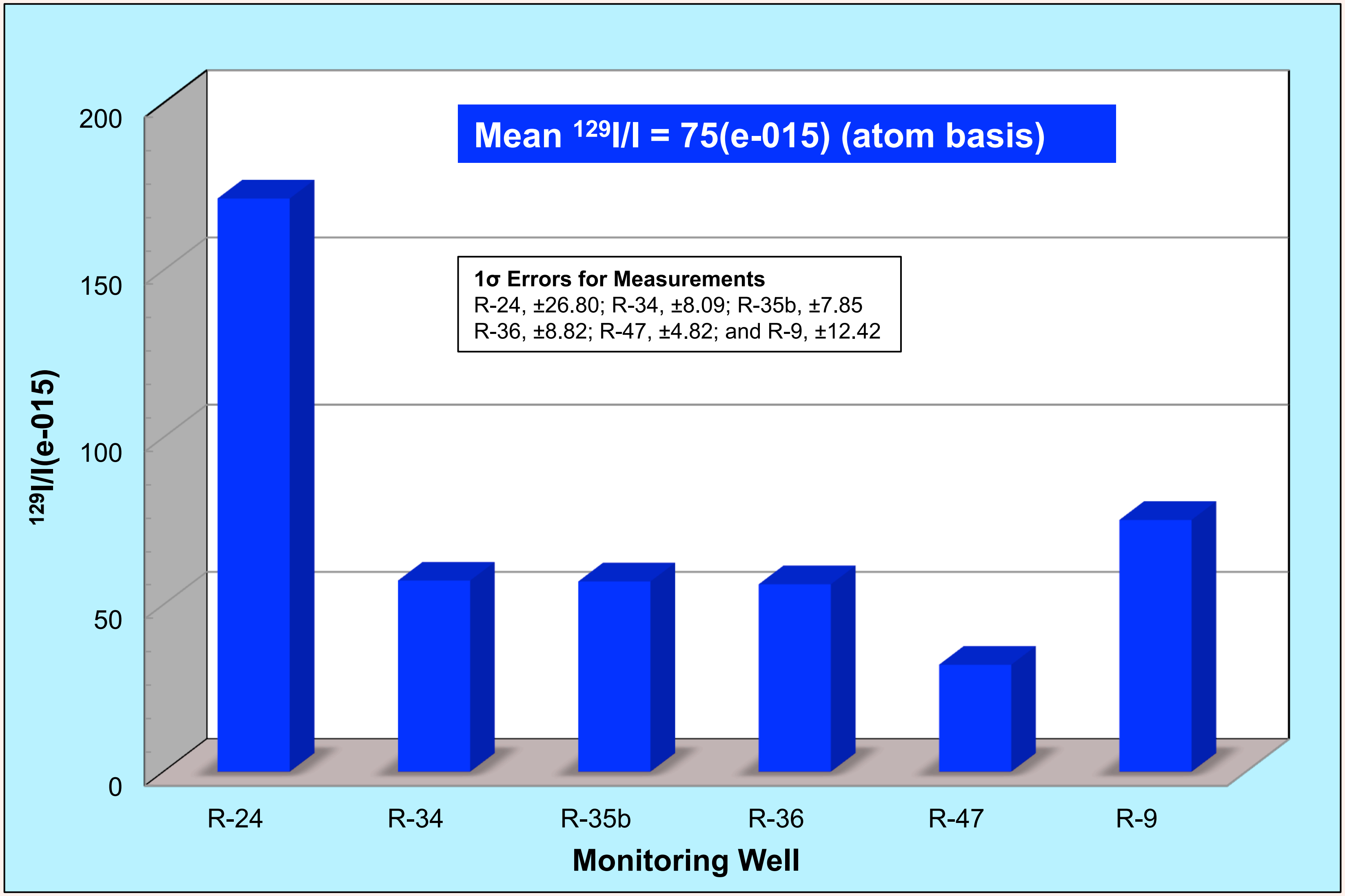


^{129}Iodine Yield, Percent Per Fission

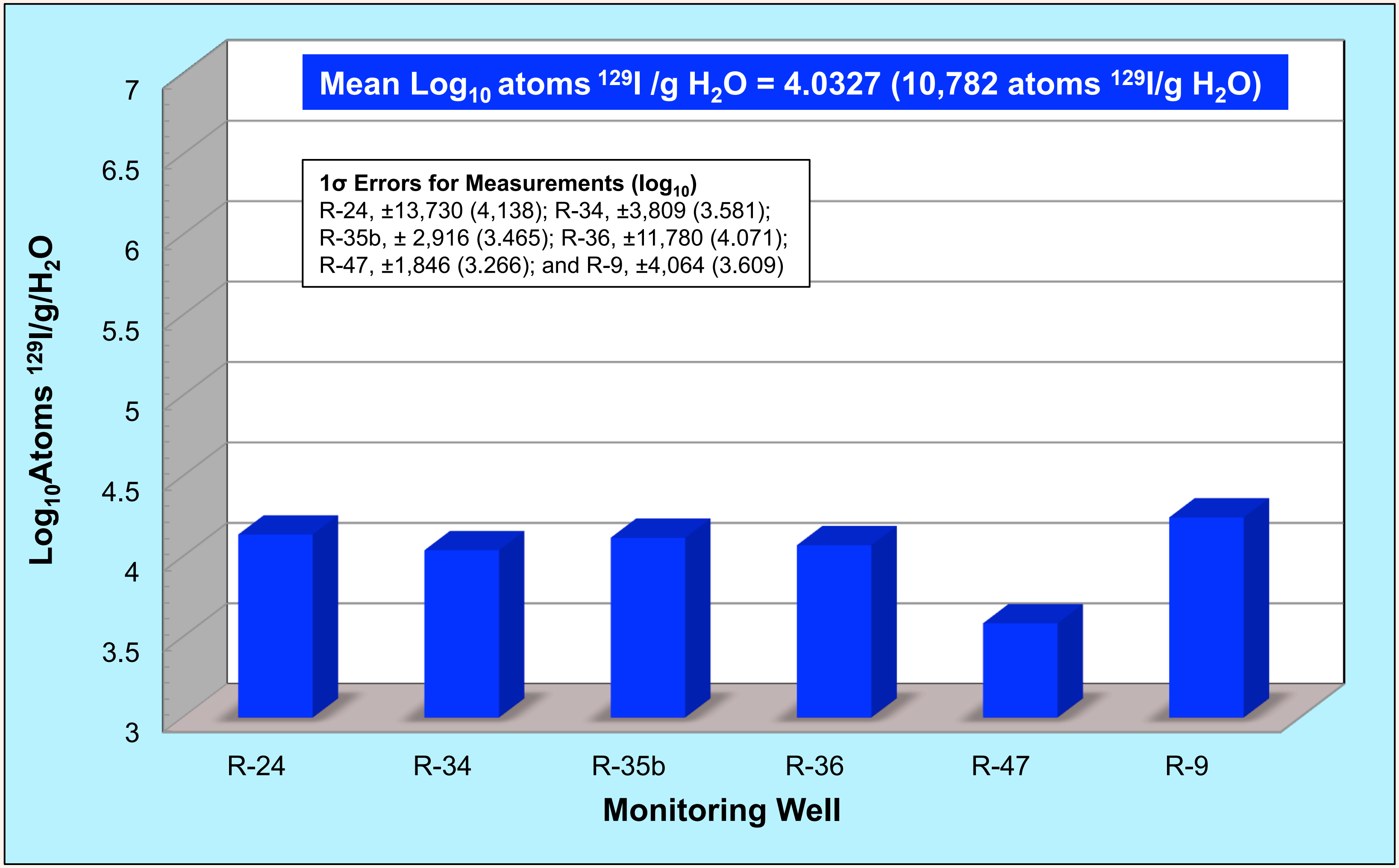
(http://www-nds.iaea.org/sgnucdat/c3.htm)

Isotope	Thermal	Fast
^{232}Th	not fissile	0.431 ± 0.089
^{233}U	1.63 ± 0.26	1.73 ± 0.24
^{235}U	0.706 ± 0.032	1.03 ± 0.26
^{238}U	not fissile	0.622 ± 0.034
^{239}Pu	1.407 ± 0.086	1.31 ± 0.13
^{241}Pu	1.428 ± 0.36	1.67 ± 0.36

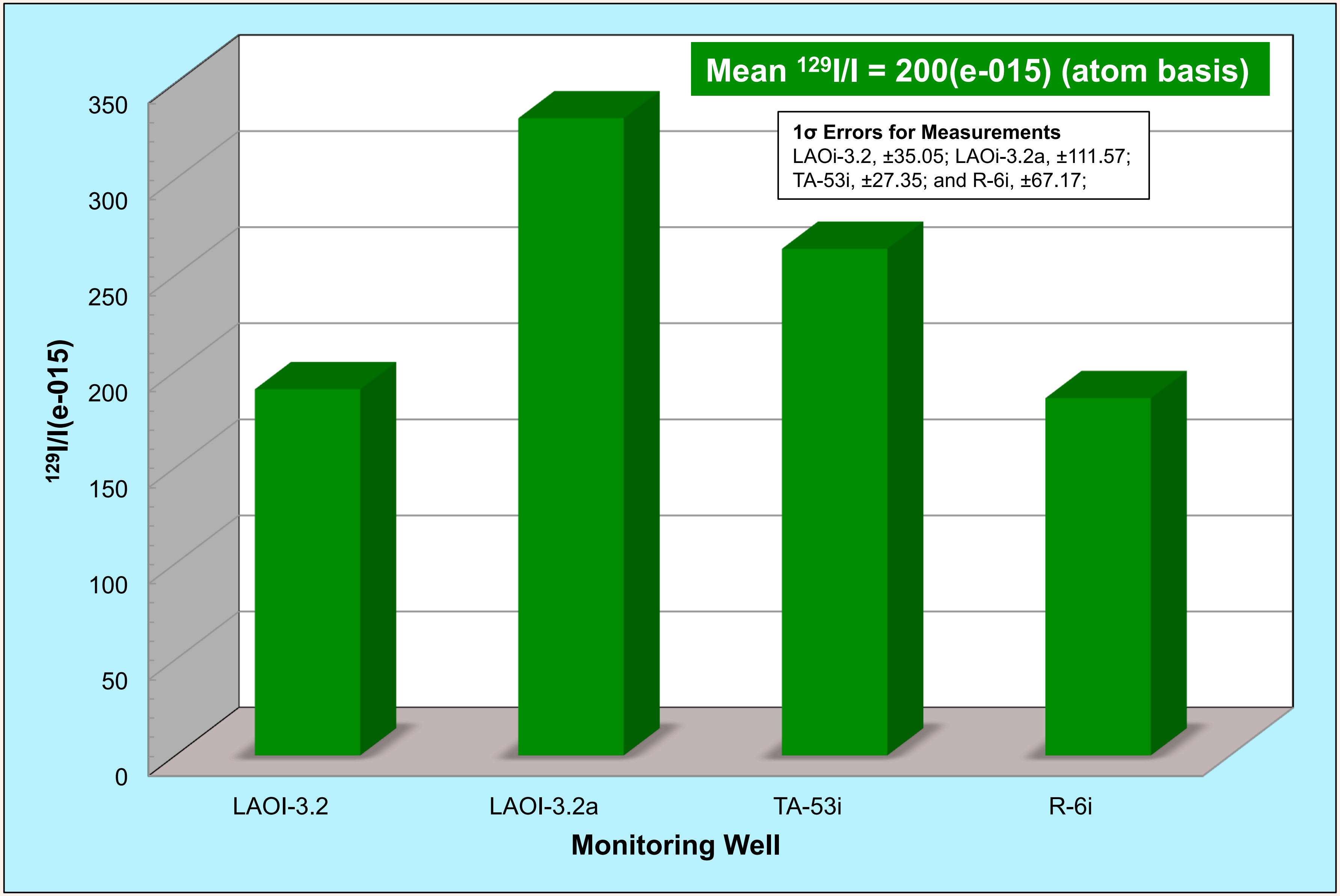
$^{129}I/I$ Ratios in Upper Portion of the Regional Aquifer, Los Alamos National Laboratory, New Mexico



Atoms ^{129}I/g Water in the Upper Portion of the Regional Aquifer, Los Alamos National Laboratory, New Mexico



$^{129}I/I$ Ratios in Selected Monitoring Wells Near or in Los Alamos Canyon, Los Alamos National Laboratory, New Mexico



Atoms ^{129}I/g Water in Selected Monitoring Wells Near or in Los Alamos Canyon, Los Alamos National Laboratory, New Mexico