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Using Geochemical Tracers To Characterize Groundwater Flowpaths

HARNEY BASIN STUDY ADVISORY COMMITTEE
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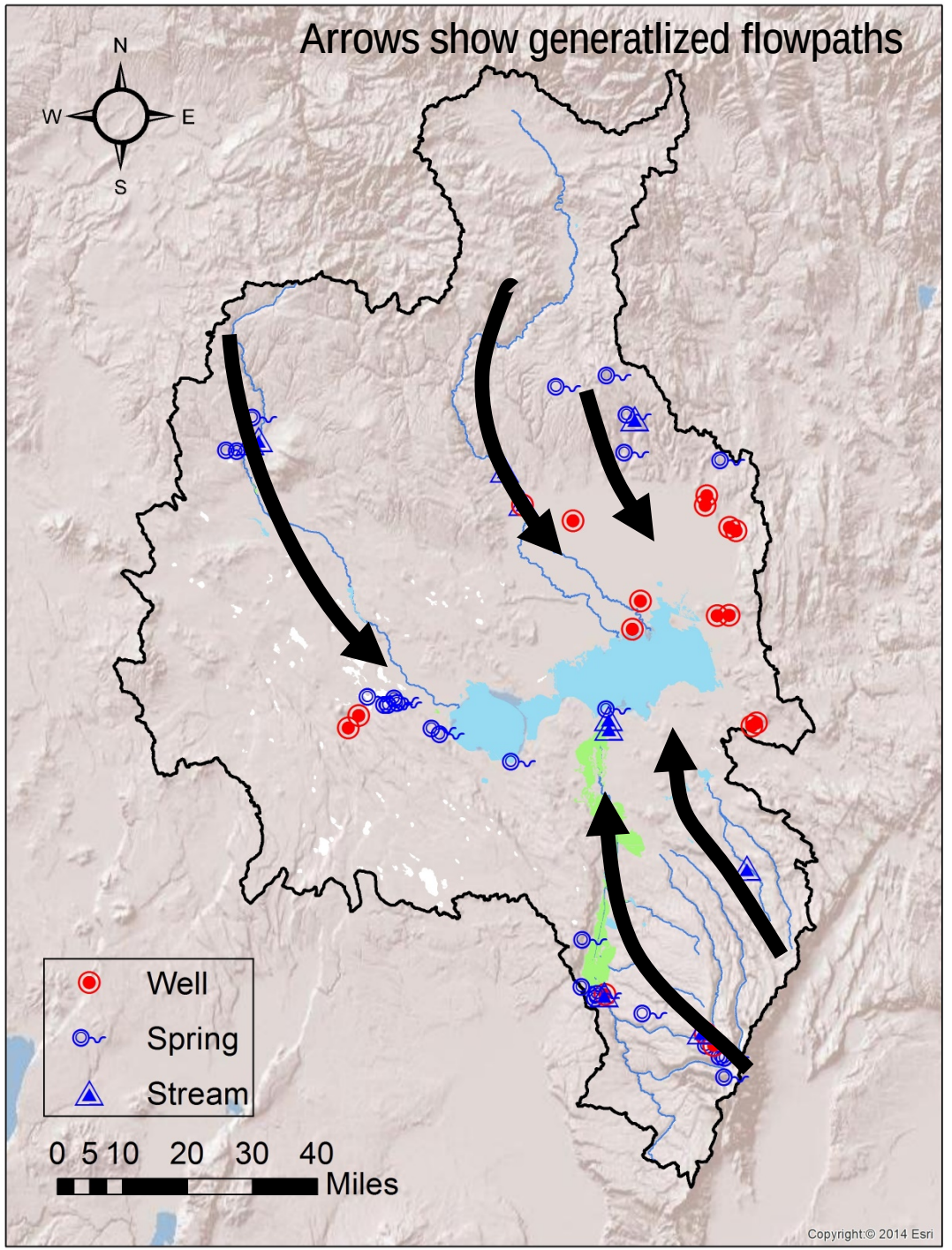
U.S. Department of the Interior
U.S. Geological Survey

Uses of Geochemical Tracers:

- clarify flowpaths
- estimate travel times
- identify mixing
- identify paleowater
- calibrate numerical models



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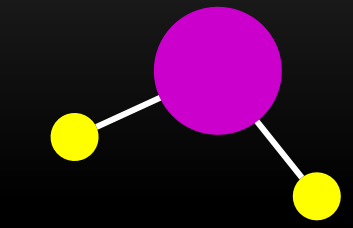
Stable Isotopes of Oxygen and Hydrogen

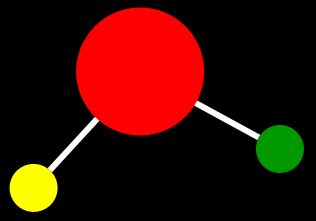
- Oxygen-18; ^{18}O
- Hydrogen-2; Deuterium; ^{2}H
- “stable isotopes”
- Reported in units of “per mil”
- Values are negative



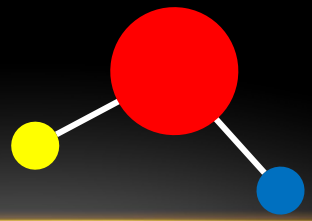
$^{1}H - ^{18}O - ^{1}H$

Radioactive Isotope of Hydrogen

- Hydrogen-3; Tritium; ^{3}H
- Half-life of 12.32 years
- “tritium”



$^{1}H - ^{16}O - ^{2}H$



$^{1}H - ^{16}O - ^{3}H$

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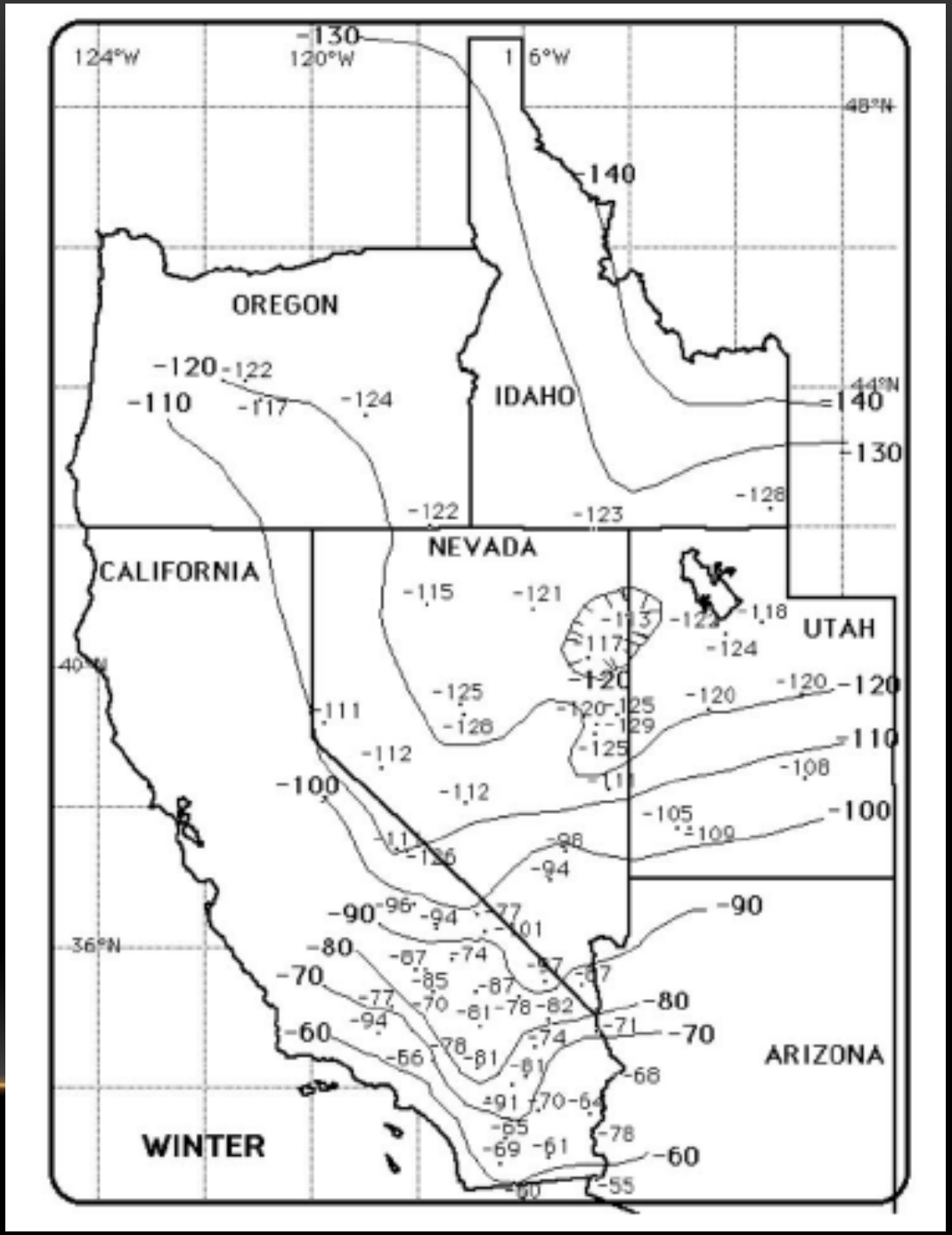
How do we use these tools?

Deuterium (^2H) in winter precipitation

(Friedman et al., 2002)



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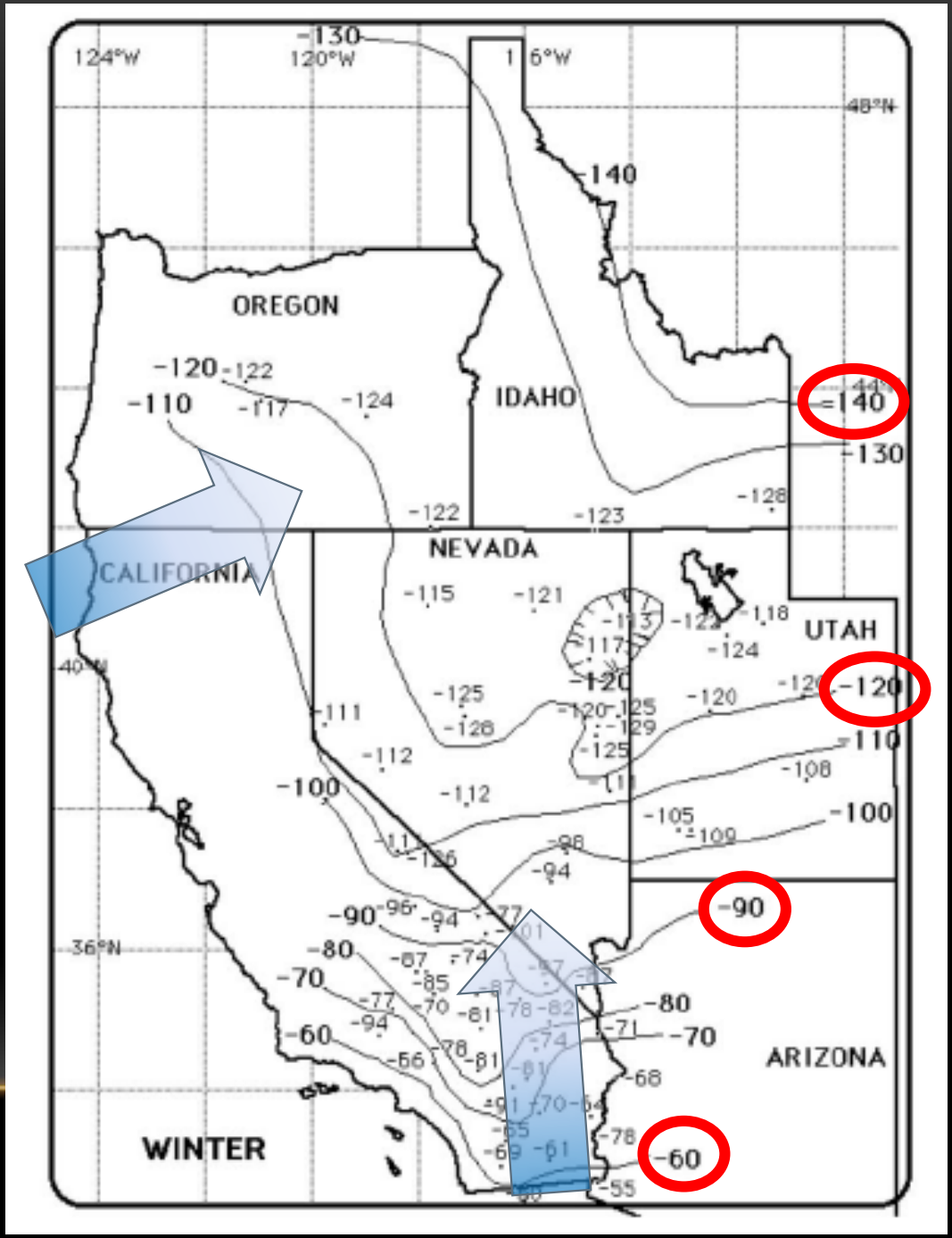
Deuterium (^{2}H) in winter precipitation

(Friedman et al., 2002)

Precipitation gets “lighter” as vapor masses move inland

Condensation of cloud vapor into rain or snow preferentially removes water molecules containing the heavier isotopes, ^{2}H and ^{18}O



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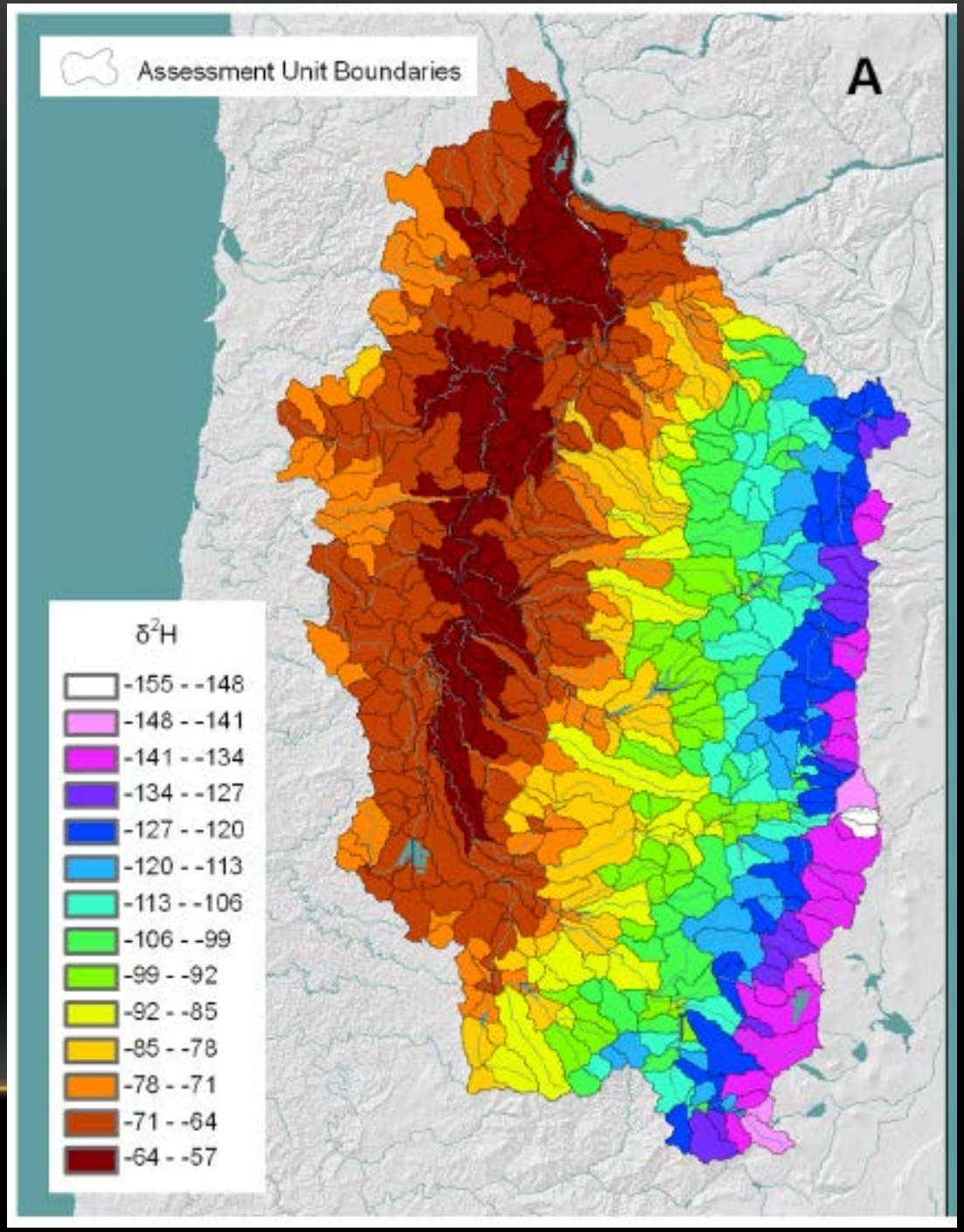
Deuterium (^2H) in stream baseflow

(Brooks et al., 2012)



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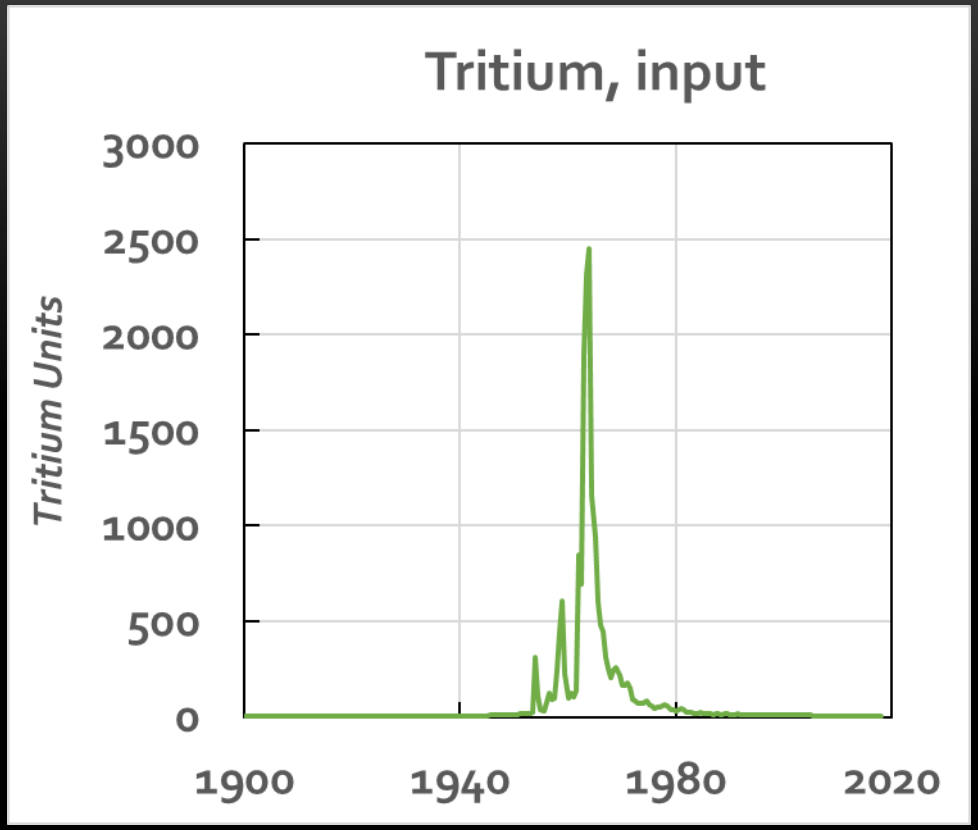

Tritium concentrations from Jurgens et al., 2012

Measured in precipitation

Half-life of 12.32 years

Pre-1945, ^{3}H concentrations were about 3-7 TU

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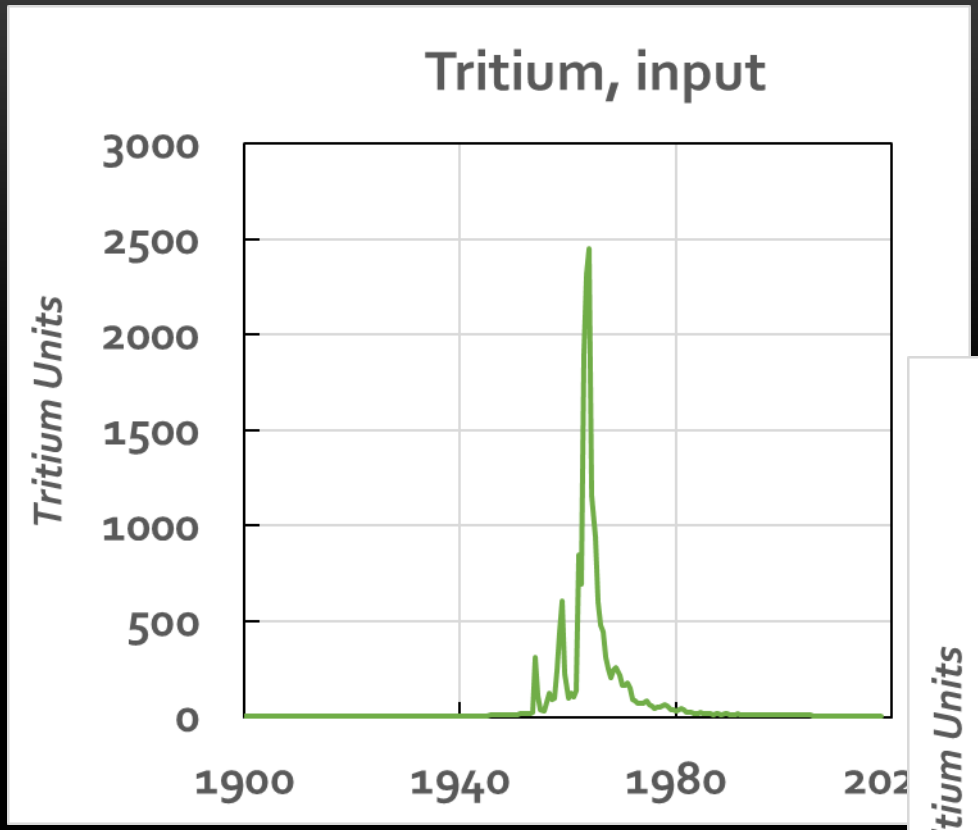

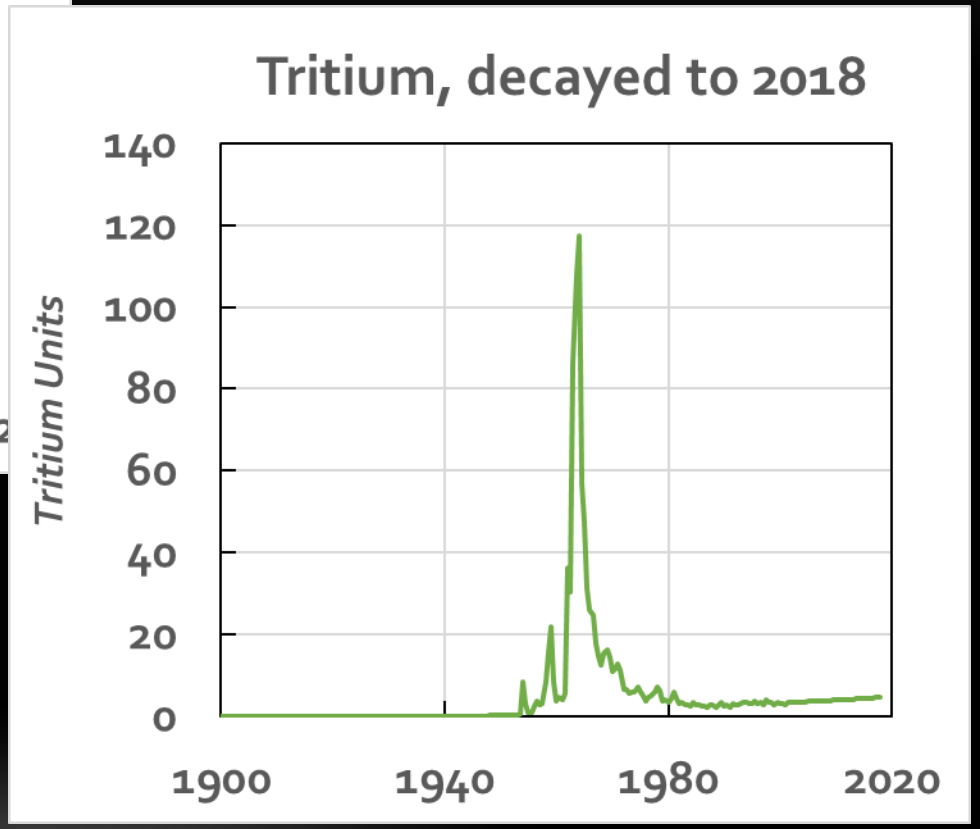

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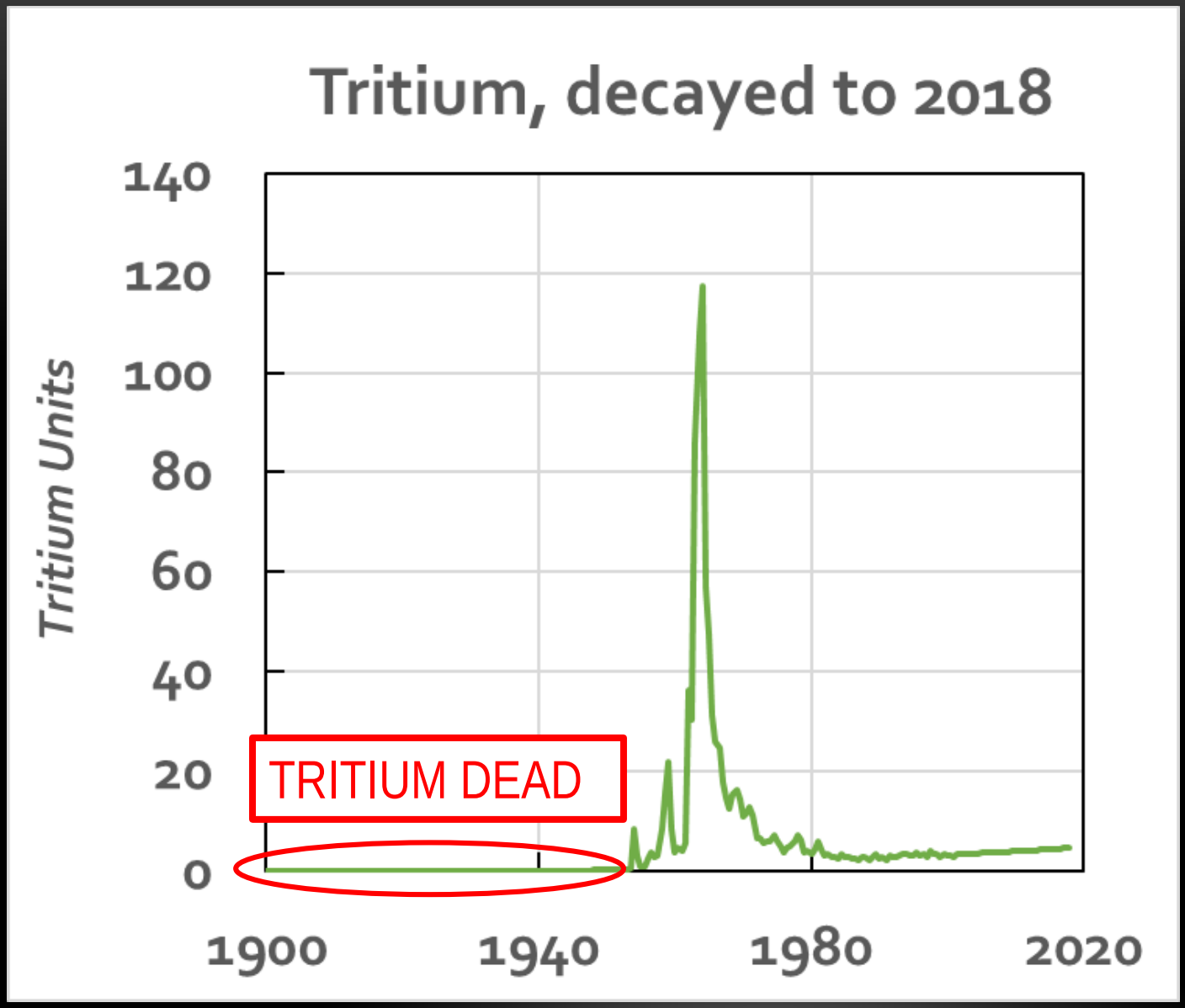

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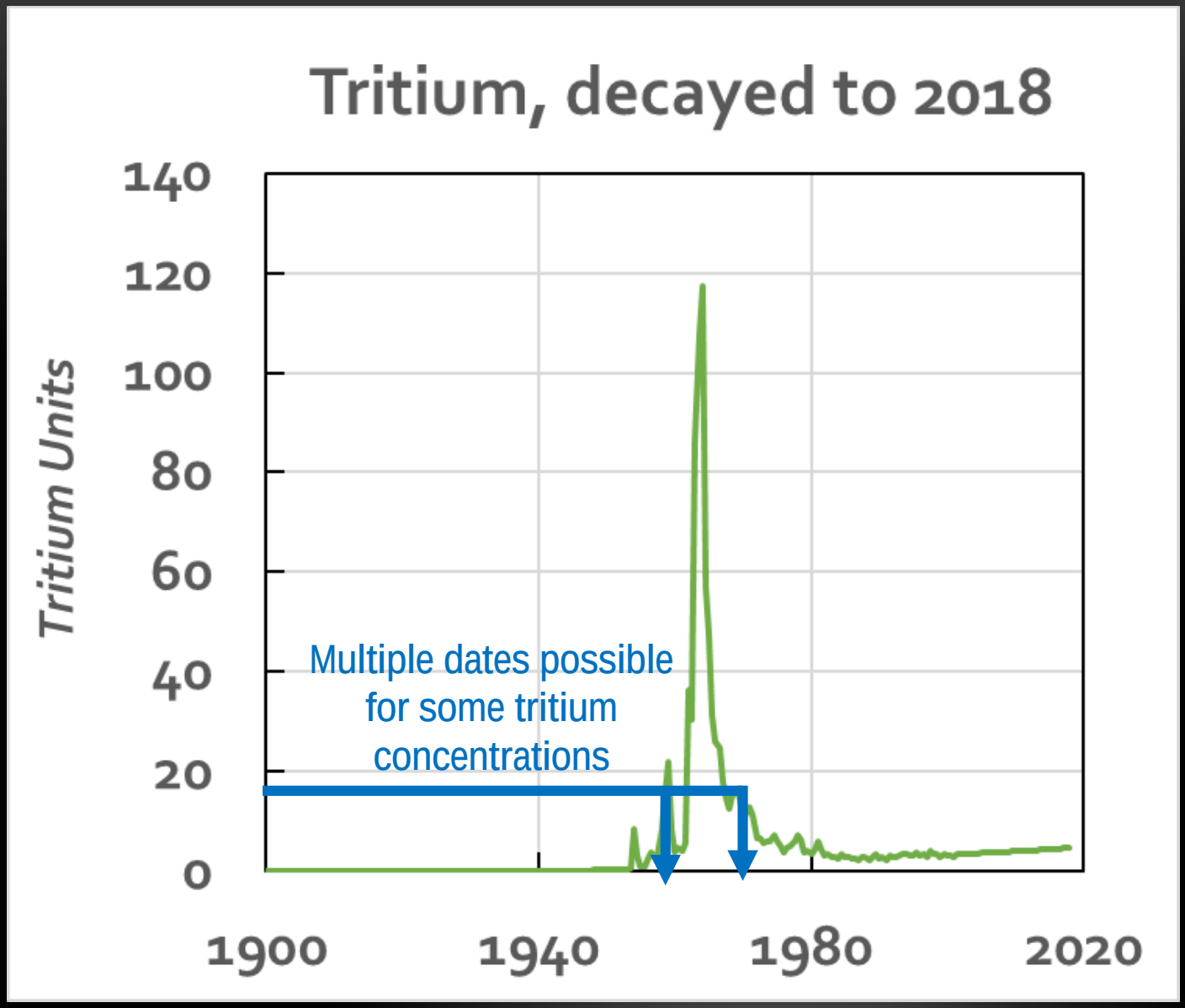

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Results from Harney Basin…

so far…

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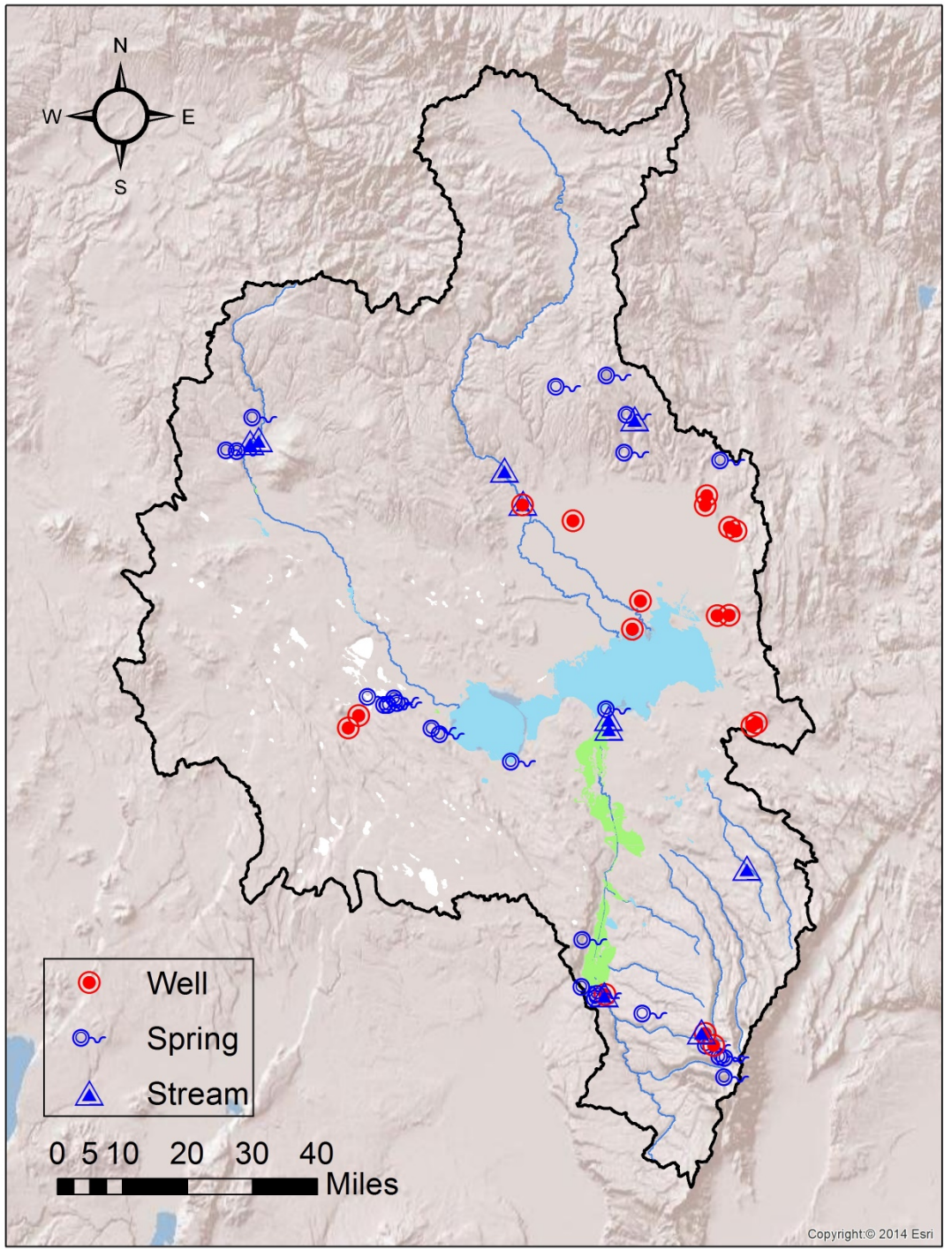
Stable Isotope Approach

- Upland baseflow and cold springs are proxies for integrated annual recharge
- Wells provide discrete sample of a flowpath
- Time series characterize variability and test our assumptions
- Evaluate data w/r/t hydraulic head and hydrogeology



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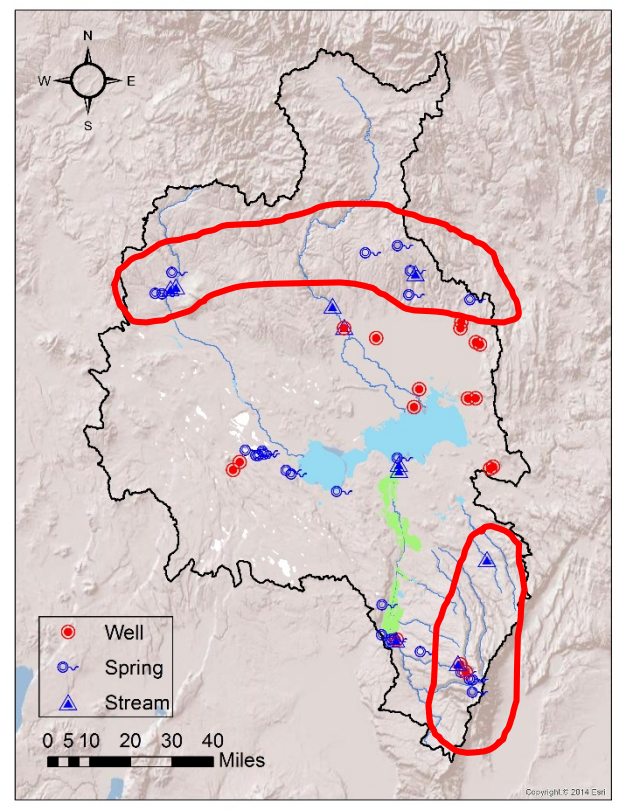
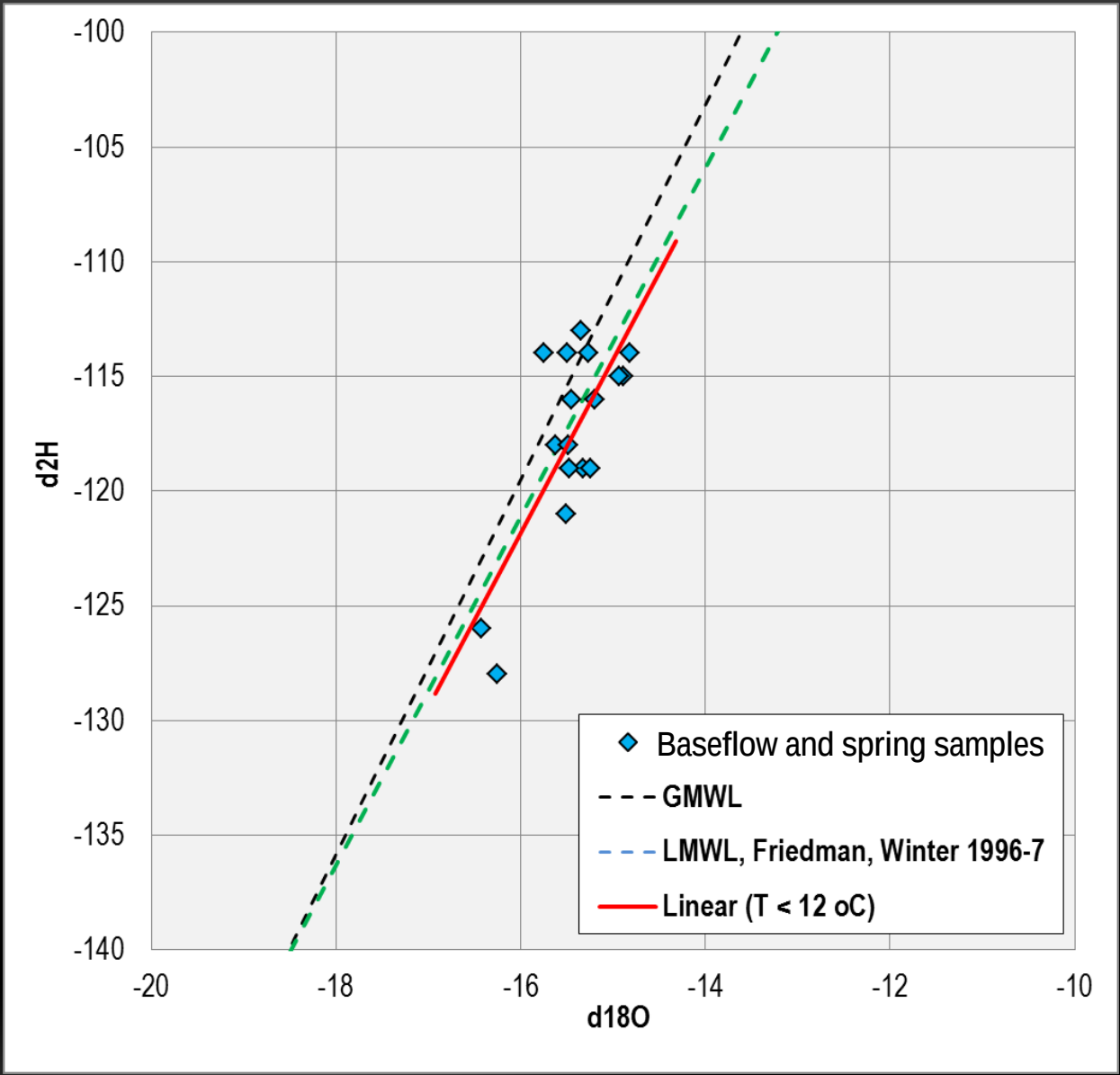
Stable isotopic composition of upland baseflow and upland cold springs (Temp < 12°C)





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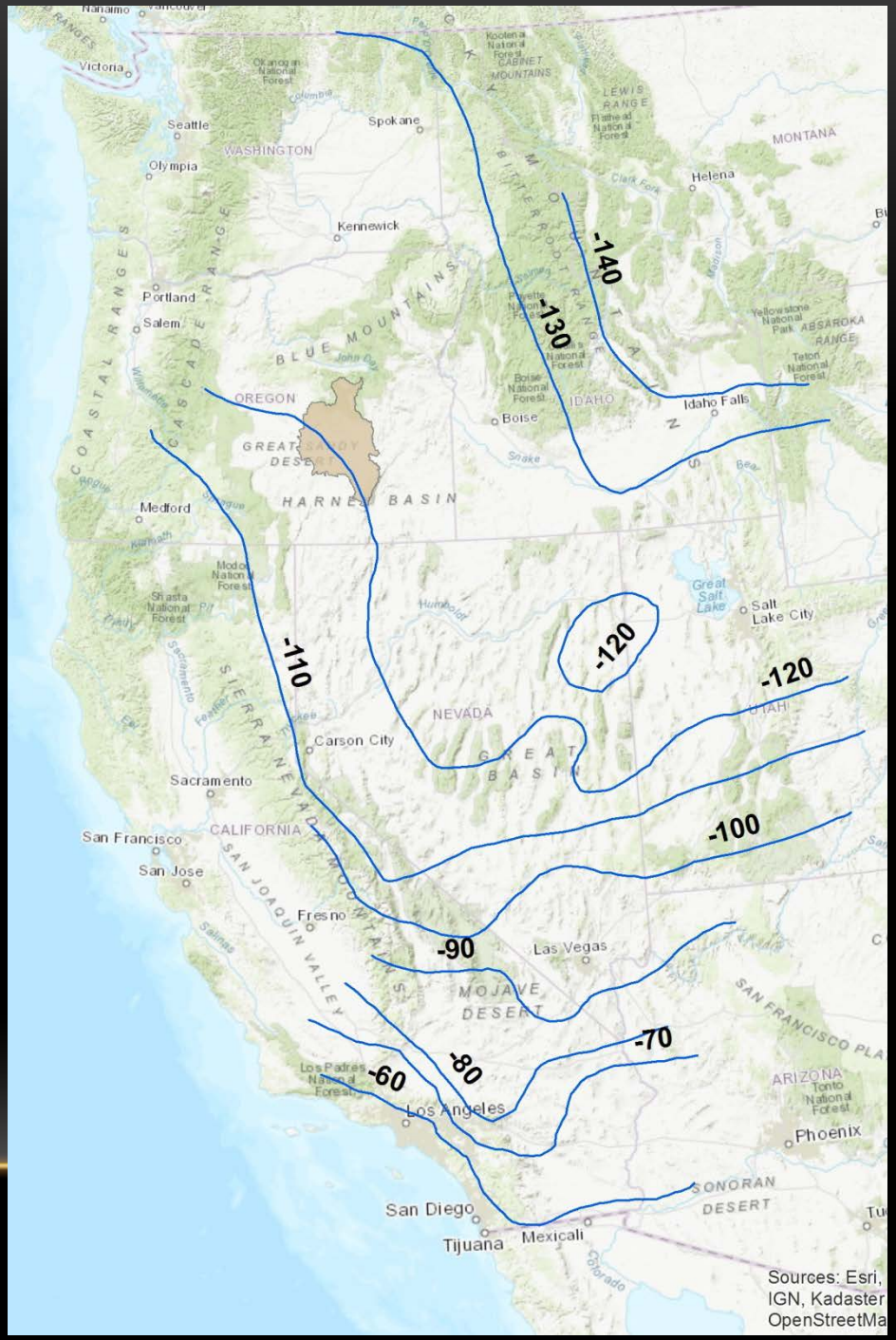
USGS Provisional Data. Subject To Change.

Deuterium values of winter precipitation in the Great Basin (*Friedman et al., 2002*)

Upland baseflow and cold springs from our study: -113 to -128



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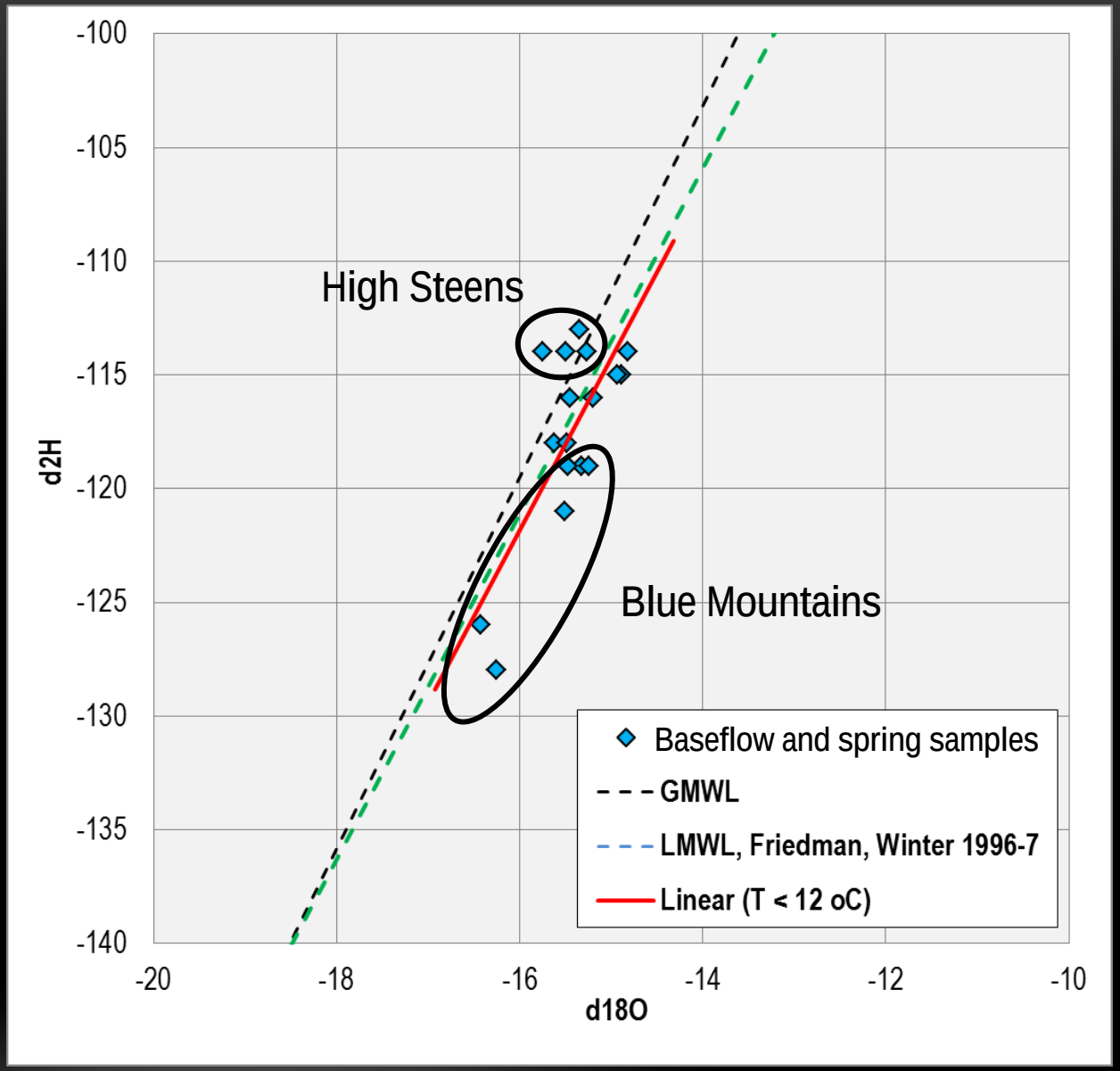
Some regional differences apparent in samples collected so far



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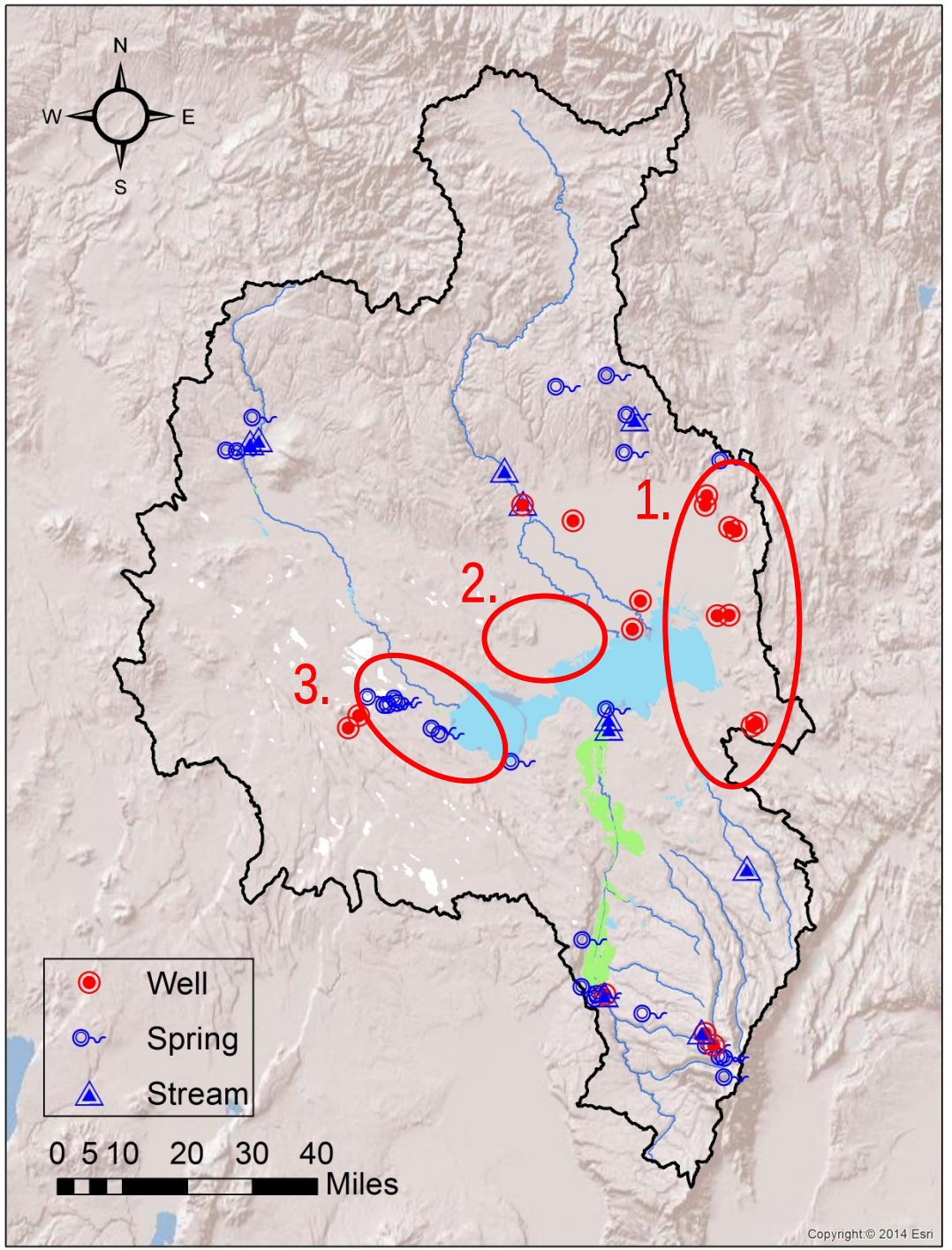
Regional Questions

1. Source(s) of water in the Buchanan – Crane – New Princeton corridor

2. Source(s) of water to Weaver Springs / Sunset Valley

3. Source(s) of water to Warm Springs Valley



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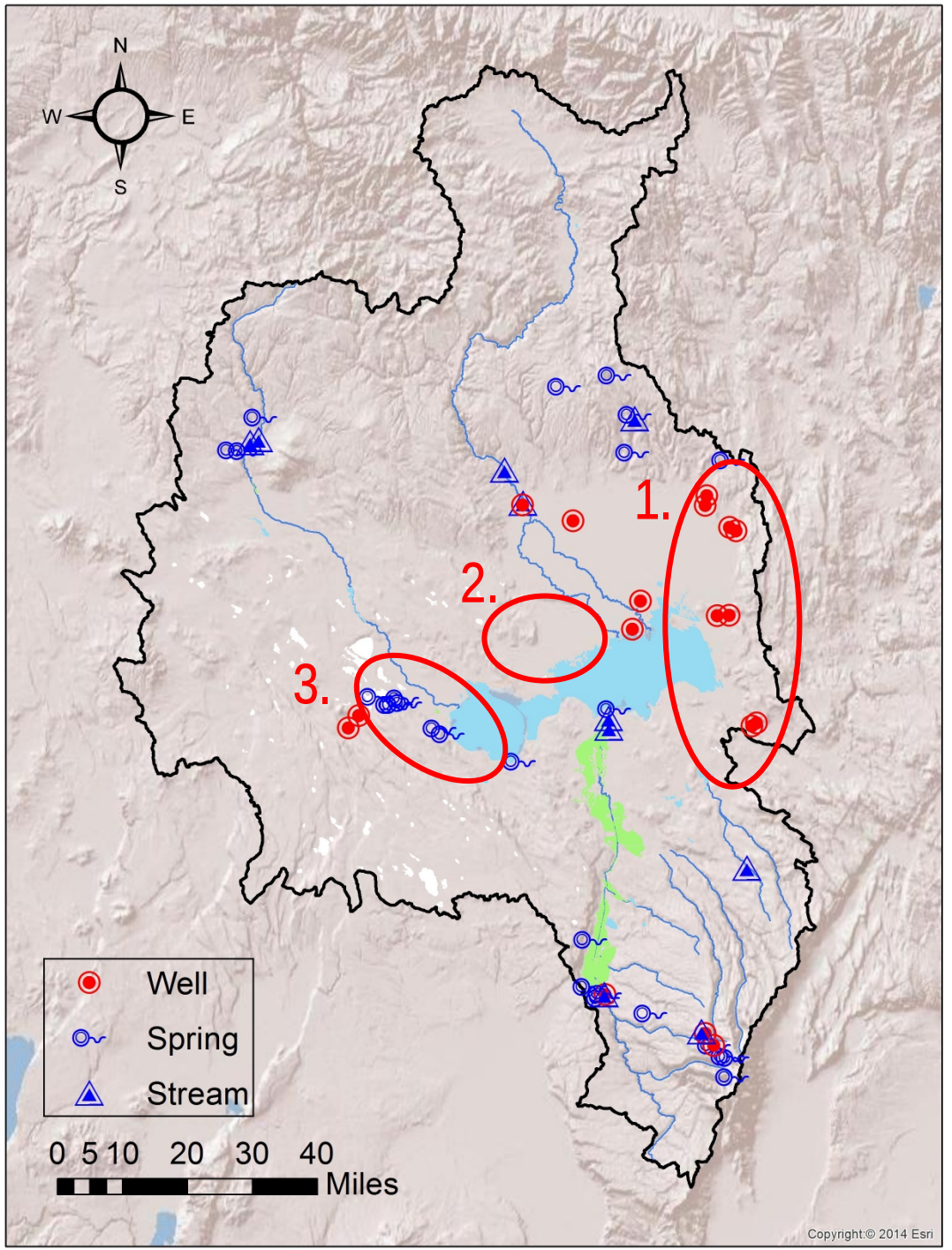

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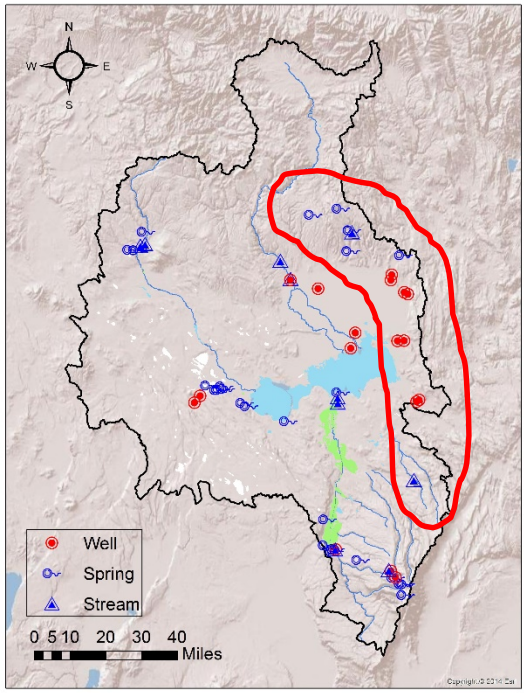

LMWL, Friedman, Winter 1996-7

GMWL

- North Source
- South Source
- High Steens Source

recharge sources

- Buchanan
- Buchanan South
- Crane
- New Princeton

wells

d2H

-120
-125
-130
-135
-140

-20
-18
-16
-14
-12
-10

d18O

Natural fractionation processes

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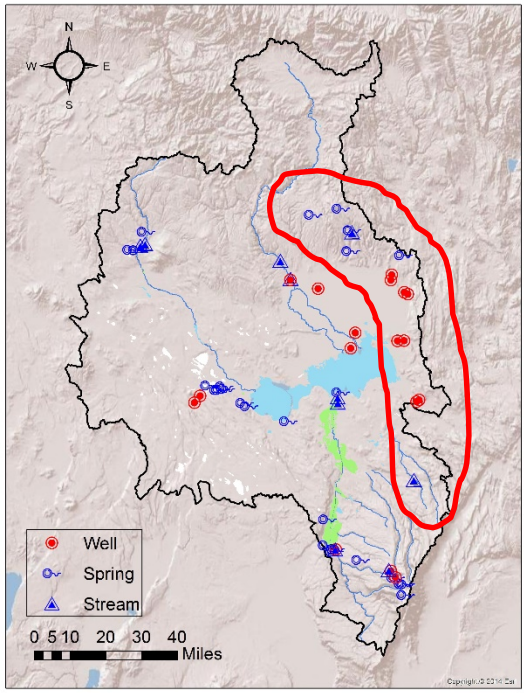

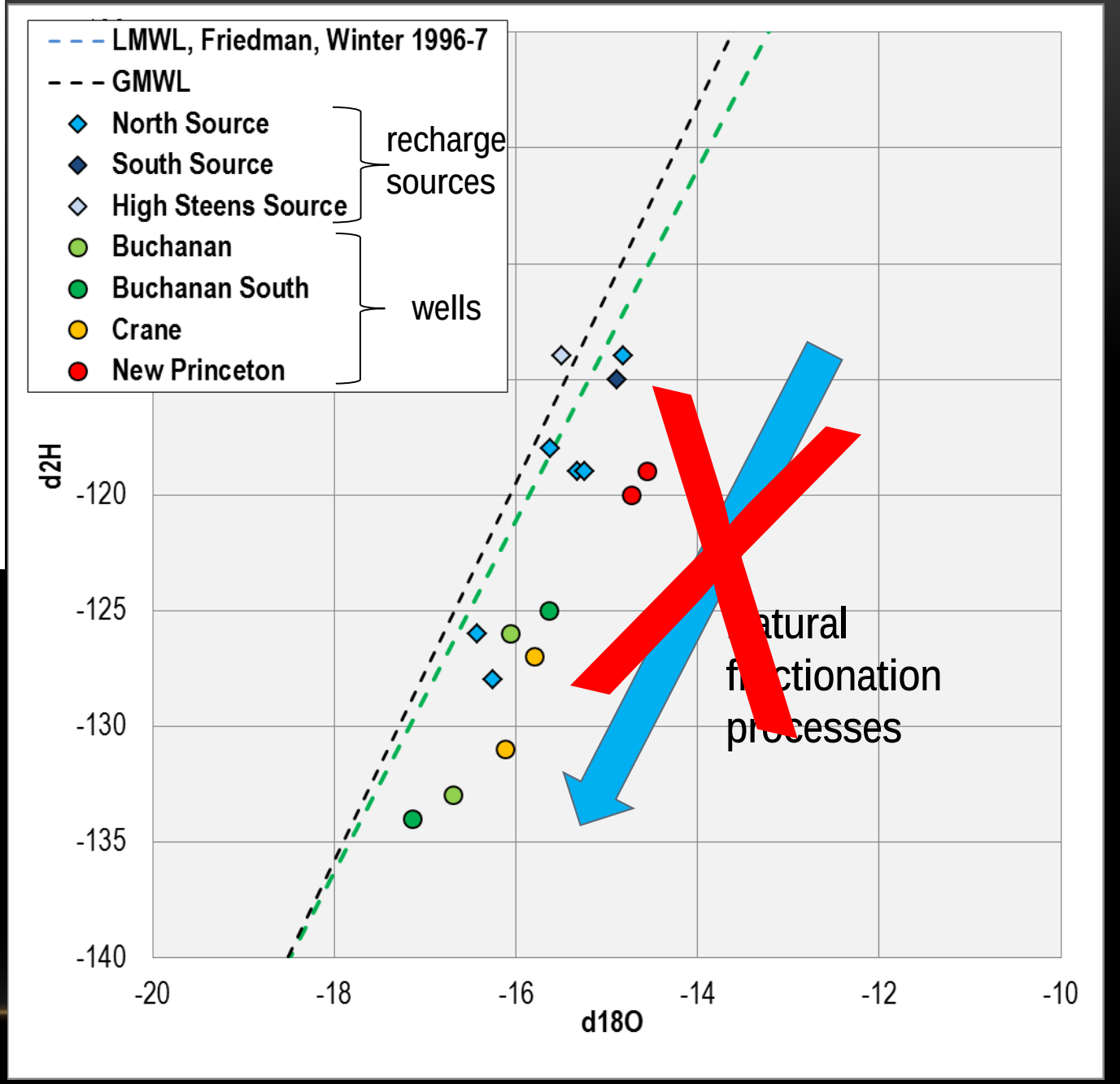

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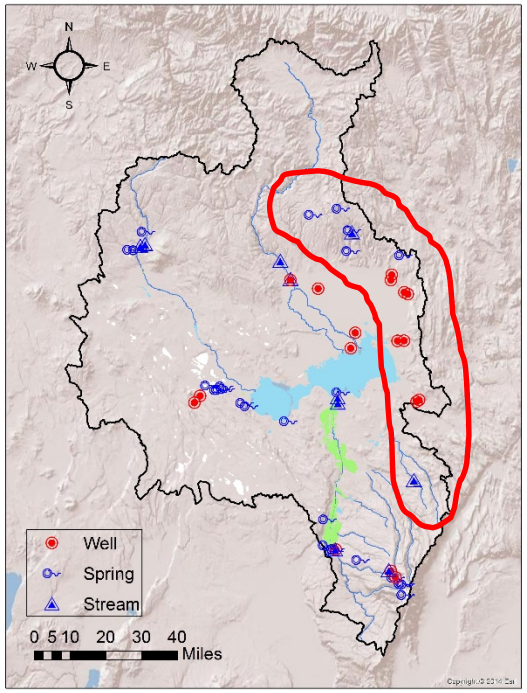

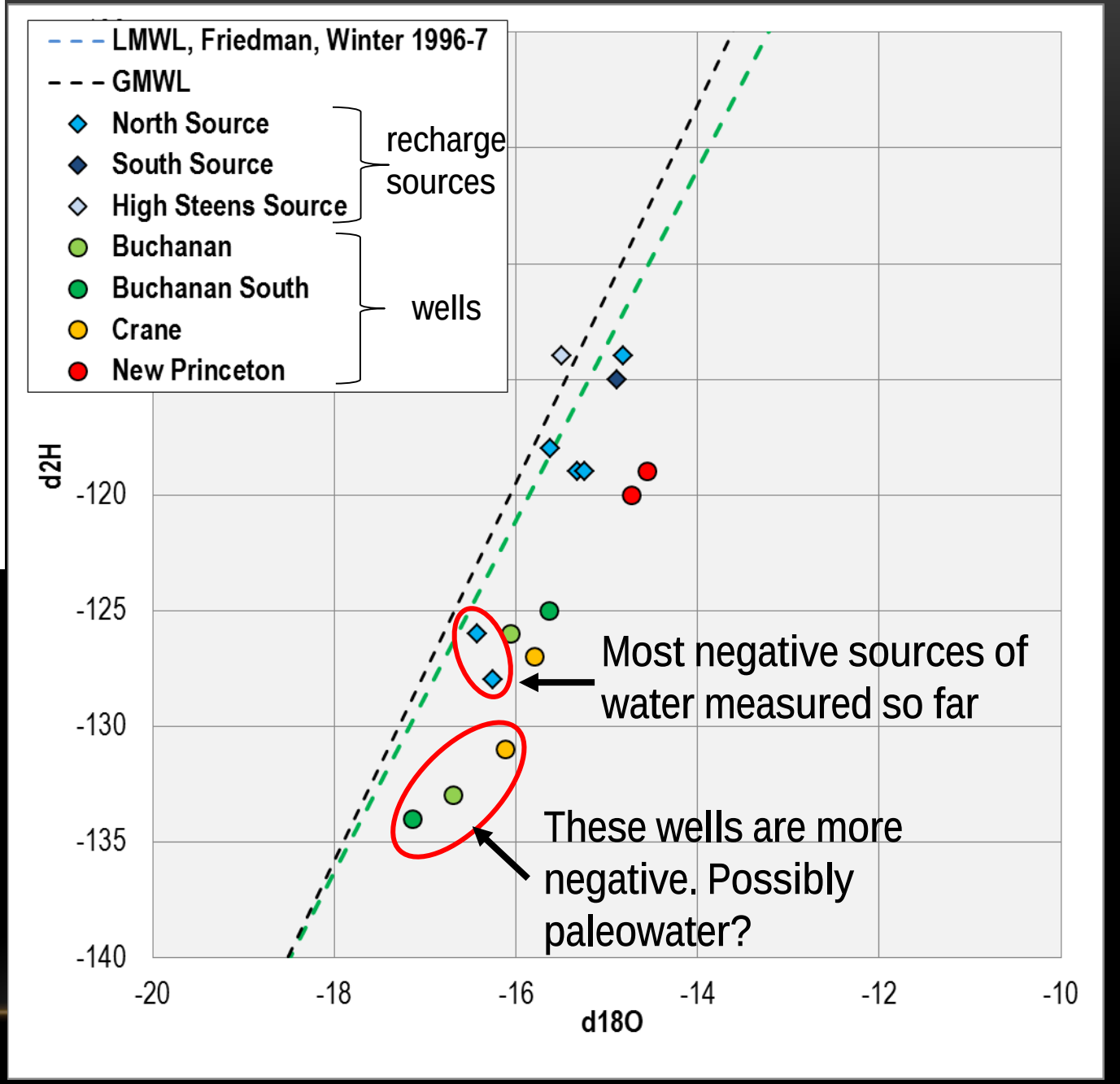

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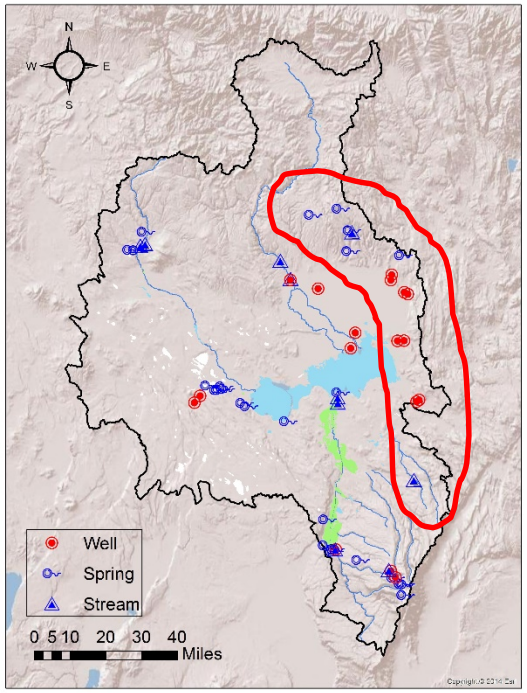

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GMWL

- North Source
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recharge sources

- Buchanan
- Buchanan South
- Crane
- New Princeton

wells

NO

Water in the two wells sampled near New Princeton probably does not originate on Steens Mountain

d2H

-120
-125
-130
-135
-140

-20
-18
-16
-14
-12
-10

d18O

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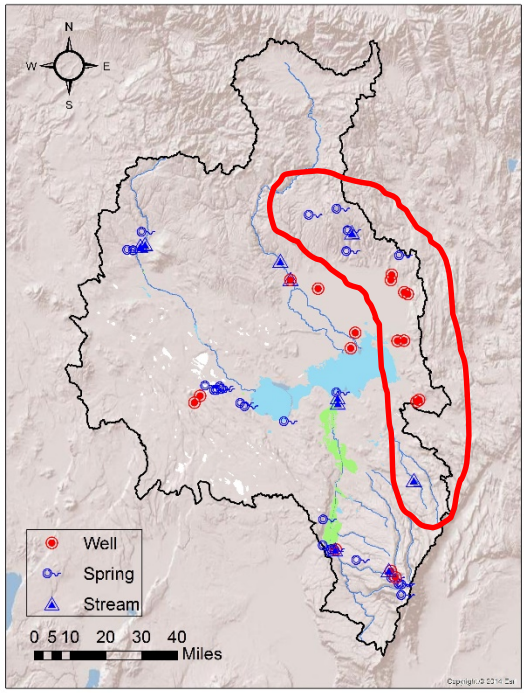

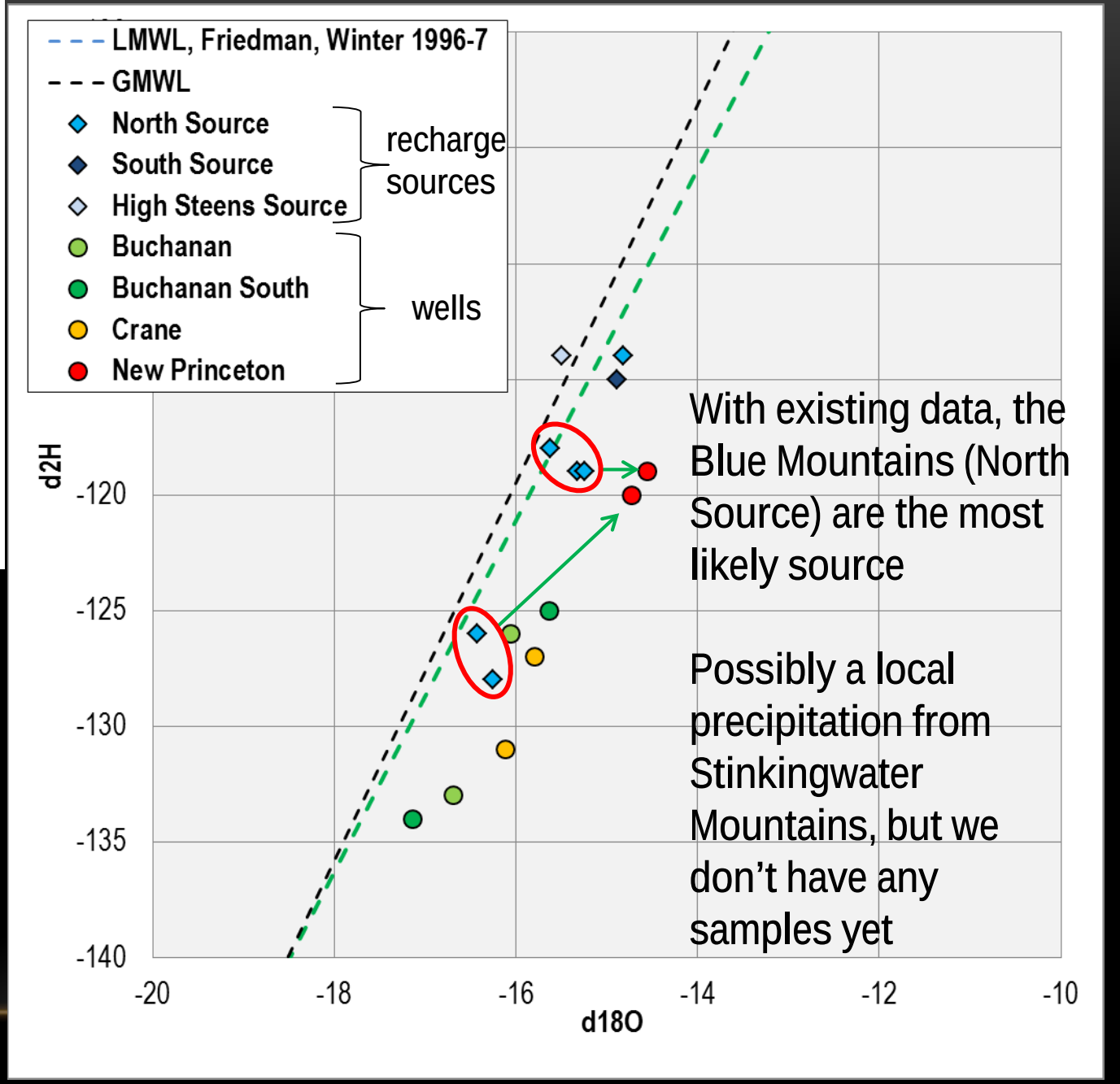

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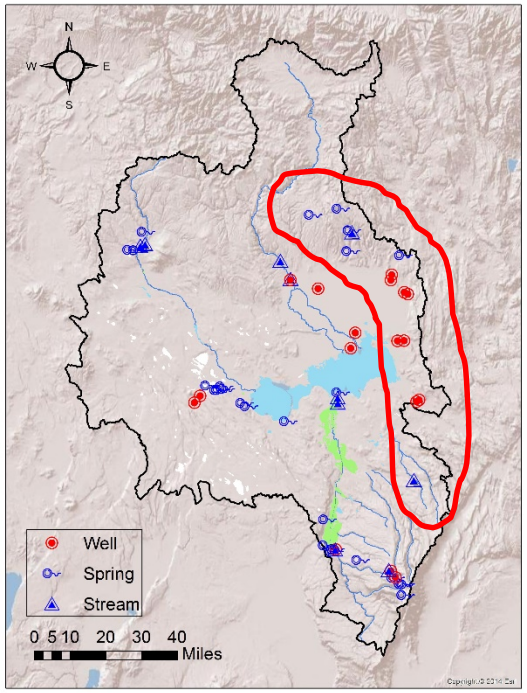

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d2H

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-20 -18 -16 -14 -12 -10

d18O

All wells shifted to higher d18O…

Mixing with thermal water source?

Paleowater falling on a different LMWL?

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Tritium

High-elevation Steens Mountain	Tritium Age	Spec. Cond., uS/cm
Fish Lake Campground Well, 110 ft blsd	2013-Present; 1975-1981; 1955-1961	52
Wells near New Princeton	**Tritium Age**	
HARN 1495, 150 ft blsd	pre-1945	1222
HARN 1494, 125 ft blsd	pre-1950	1907
Malheur Refuge	**Tritium Age**	
Sodhouse Spring	2005-2010; 1979-1982; 1955-1961	296
Warm Spring nr Frenchglen	pre-1950	171
Warm Springs Valley	**Tritium Age**	
Hibbard Spring	pre-1945	291
Lower Sizemore Spring	pre-1950	296
OO Cold Spring	pre-1945	272

2018 Geochemistry Work

- Continue quarterly sampling of springs & Blitzen River on MNWR
- Sample additional upland springs and wells to fill gaps
- Select DEQ samples for tritium and stable isotope analysis
- Evaluate geochemistry data collected by Crane HS
- Collect new age-tracer data from selected wells and springs

References Cited

Brooks, J.R., Wigington, P.J., Phillips, D.L., Comeleo, R., and Coulombe, R., 2012, Willamette River Basin surface water isoscape (δ18O and δ2H): temporal changes of source water within the river: Ecosphere, v. 3, no. 5, p. 21.

Friedman, I., Smith, G.I., Johnson, C.A., and Moscati, R.J., 2002, Stable isotope compositions of waters in the Great Basin, United States 2. Modern precipitation: Journal of Geophysical Research: Atmospheres, v. 107, no. D19, p. ACL 15-11-ACL 15-22.

Jurgens, B.C., Böhlke, J.K., and Eberts, S.M., 2012, TracerLPM (Version 1): An Excel® workbook for interpreting groundwater age distributions from environmental tracer data: U.S. Geological Survey Techniques and Methods Report 4-F3, 60 p.