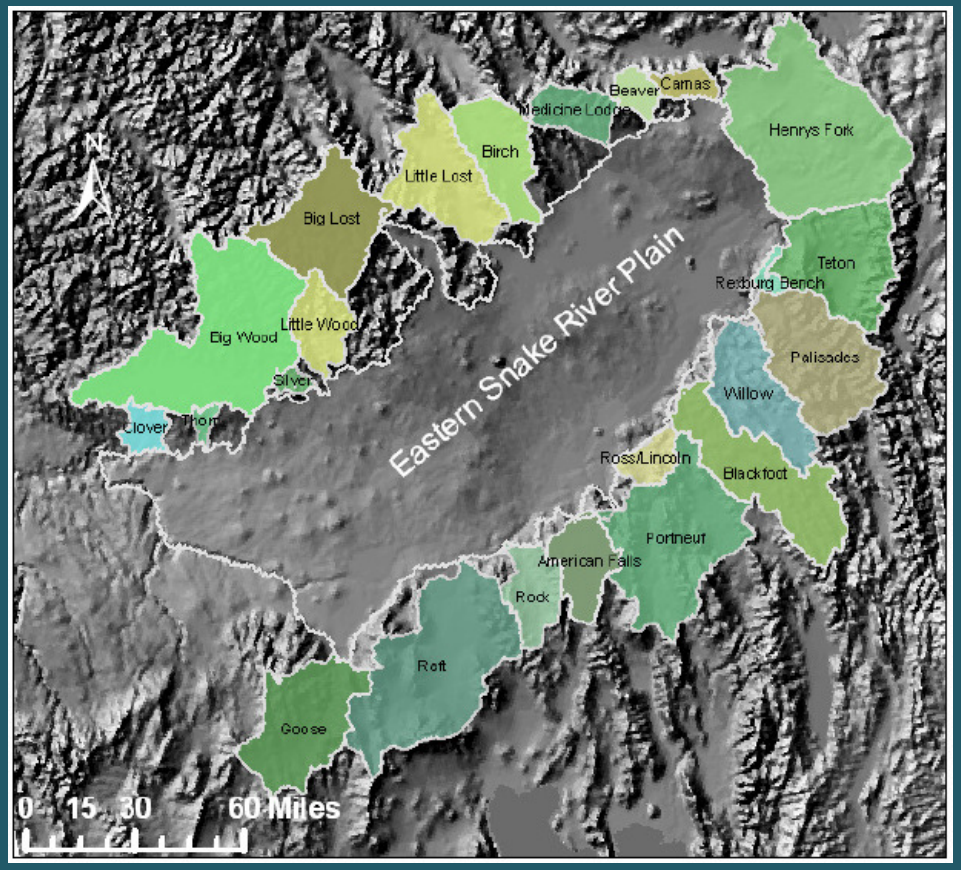
Recent Research: Tributary Underflow to the Eastern Snake River Plain Aquifer



ESHMC Meeting

March 14, 2011

Presented by:

Stacey Taylor

Outline

- How the work was funded
- Brief ESPAM1.1 and ESPAM2.0 review
- Method of choice for recent work

Funding

- USGS 104B Grant
- IDWR (Mike McVay) aided the project

ESPAM1.1 and ESPAM2

- About 20% of the water budget is tributary underflow
- Based on Kjelstrom (1986) estimates
- Garabedian (1992) underflow values were used
- Flux for each basin was shaped using Silver Creek as a proxy because it is spring fed and we assume it reflects temporal changes in underflow
- Silver Creek discharge was damped (2/3 the amplitude) to decrease the variation
- Average annual underflow values for each tributary were multiplied by dampened Silver Creek normalized flow

New Method

- “Langbein method”

  Published in Nace et al. (1961)
- Used for the Raft River Basin (Nace et al. 1961)
- Used for the Little Lost Basin (Clebsch et al. 1974)

Langbein Method

- Estimates annual Basin Yield
  - Basin yield =

    Total amount of water produced by a basin
- Data needed:
  - Annual precipitation data
  - Average temperature data

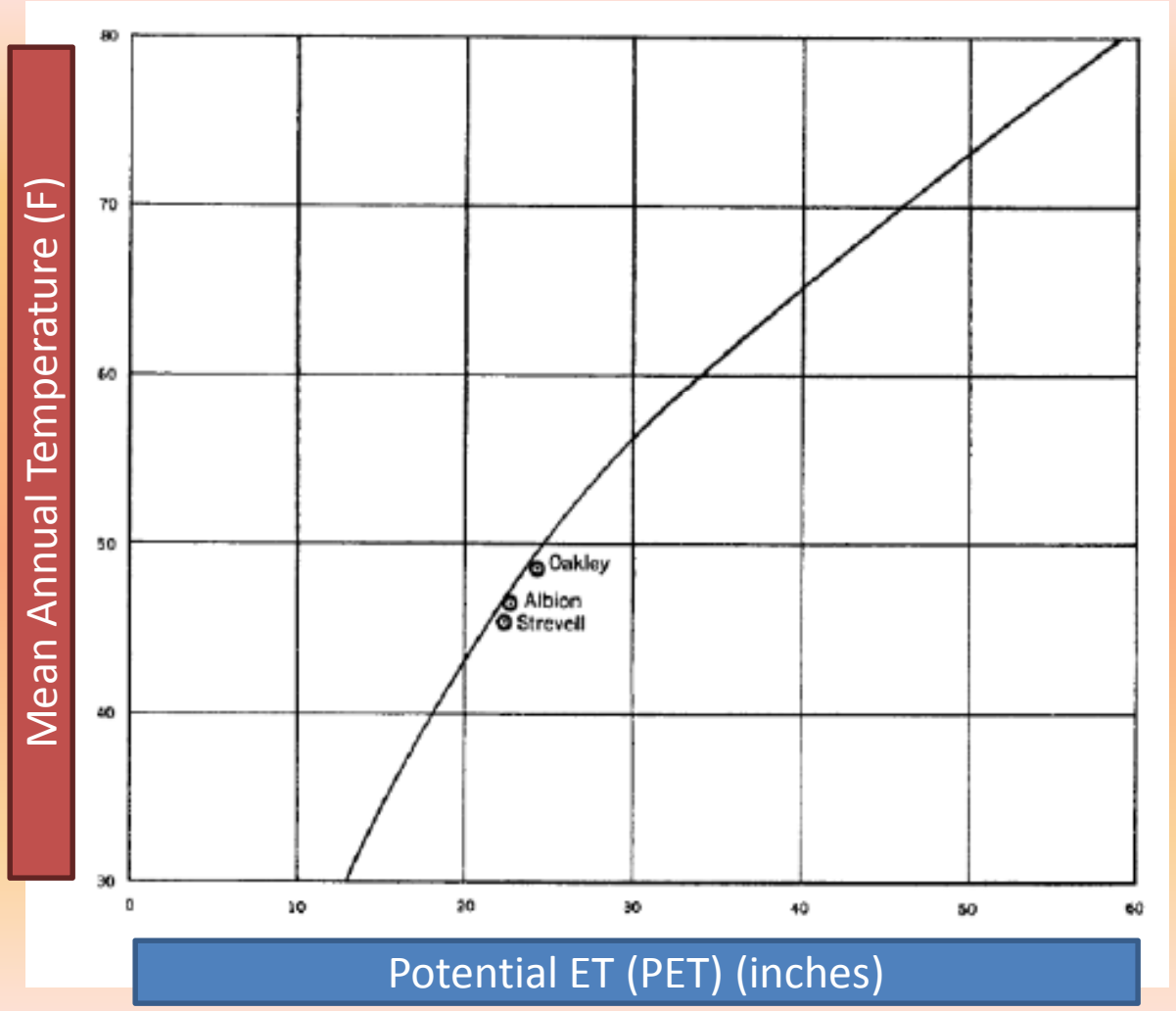
Langbein Method (cont.)

Use a defined relationship between

mean annual temp and

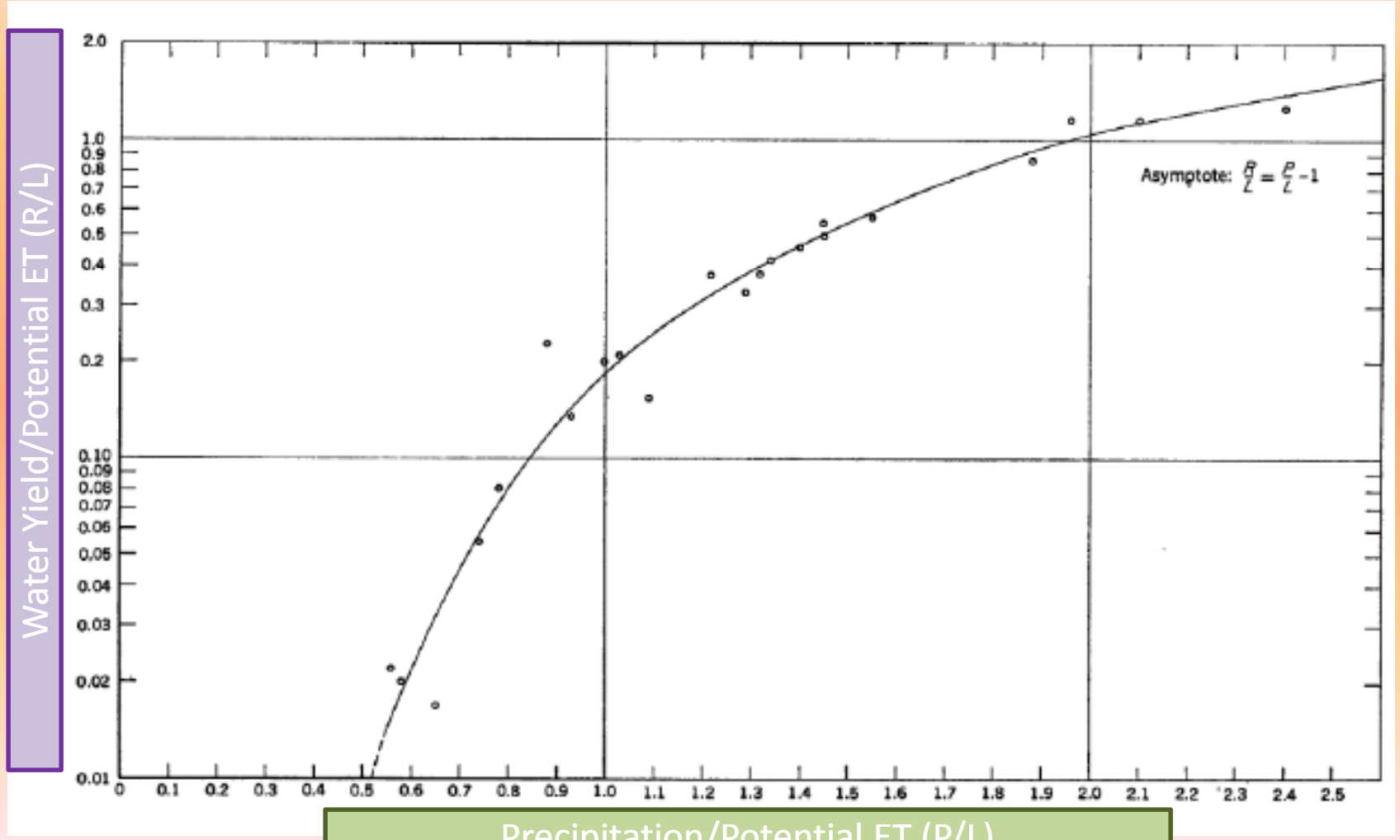
potential ET

*Plotted points represent values tested against Thornthwaite (1948) potential ET method



Langbein Method (cont.)

Ratio of **precip to PET** allows you to find ratio of Annual **Water Yield (R) to PET (L)**

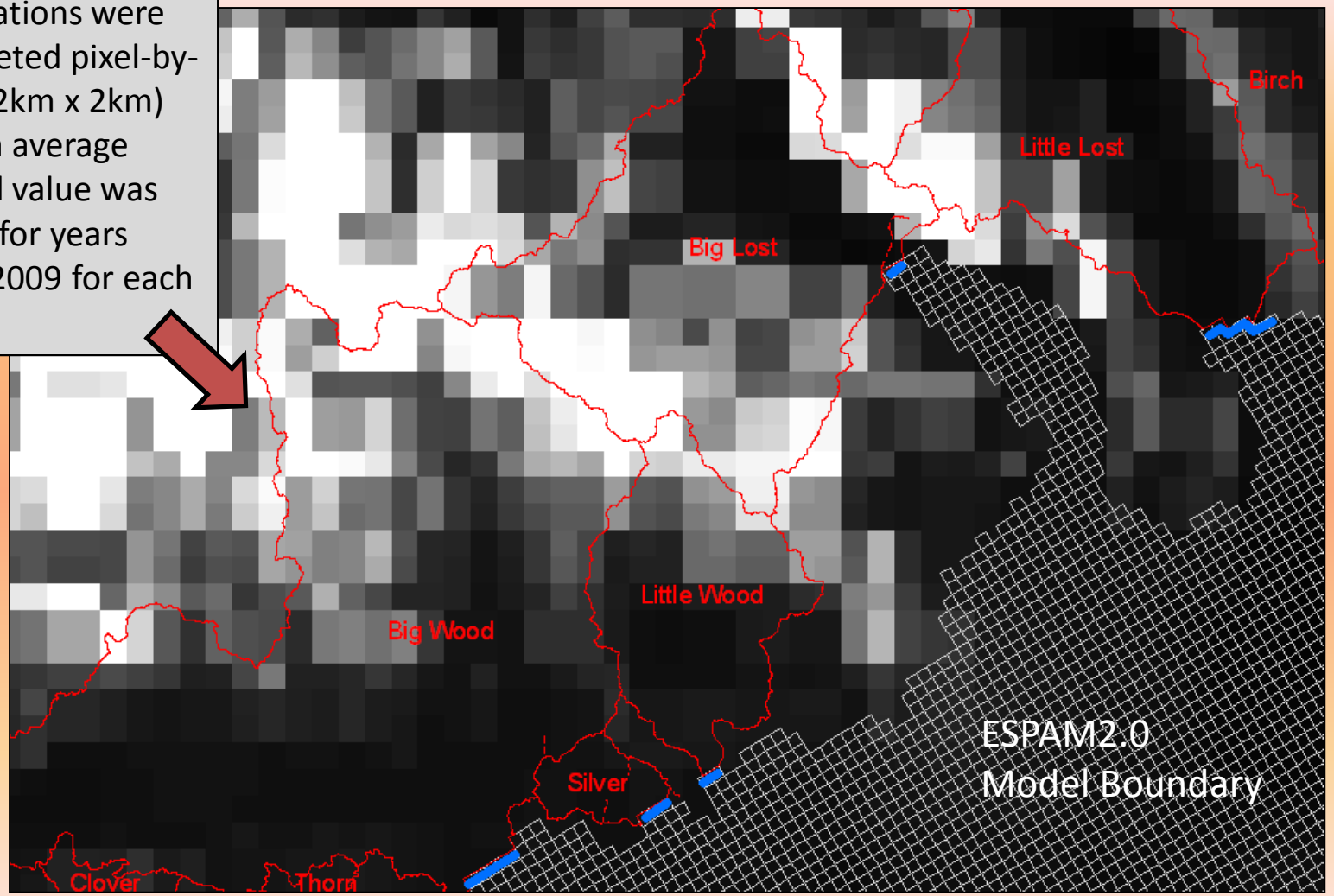


Langbein Method (cont.)

- Once you have ratio of Water Yield to Potential ET, multiply by Potential ET to get Water Yield for the Year

Calculating Basin Water Yield

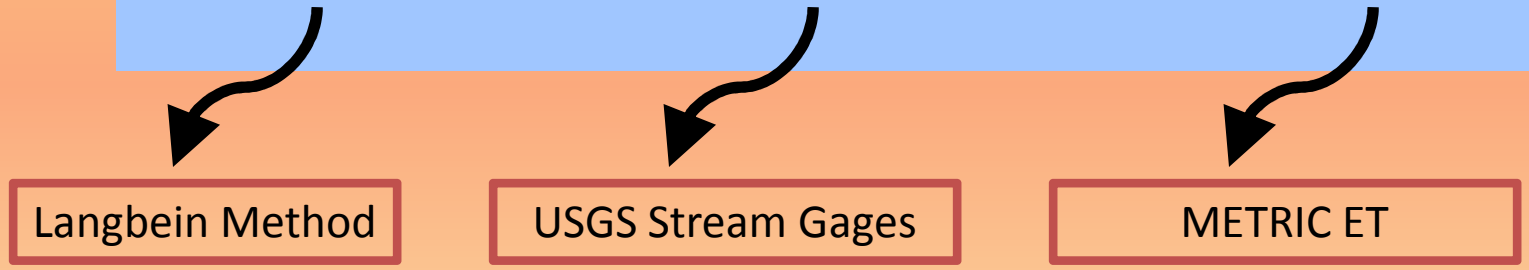
Calculations were completed pixel-by-pixel (2km x 2km) and an average annual value was found for years 1980-2009 for each basin



Calculating Tributary Underflow

Tributary Underflow =

Water Yield – Surface Flow Exiting the Basin – ET from Irrigation Lands

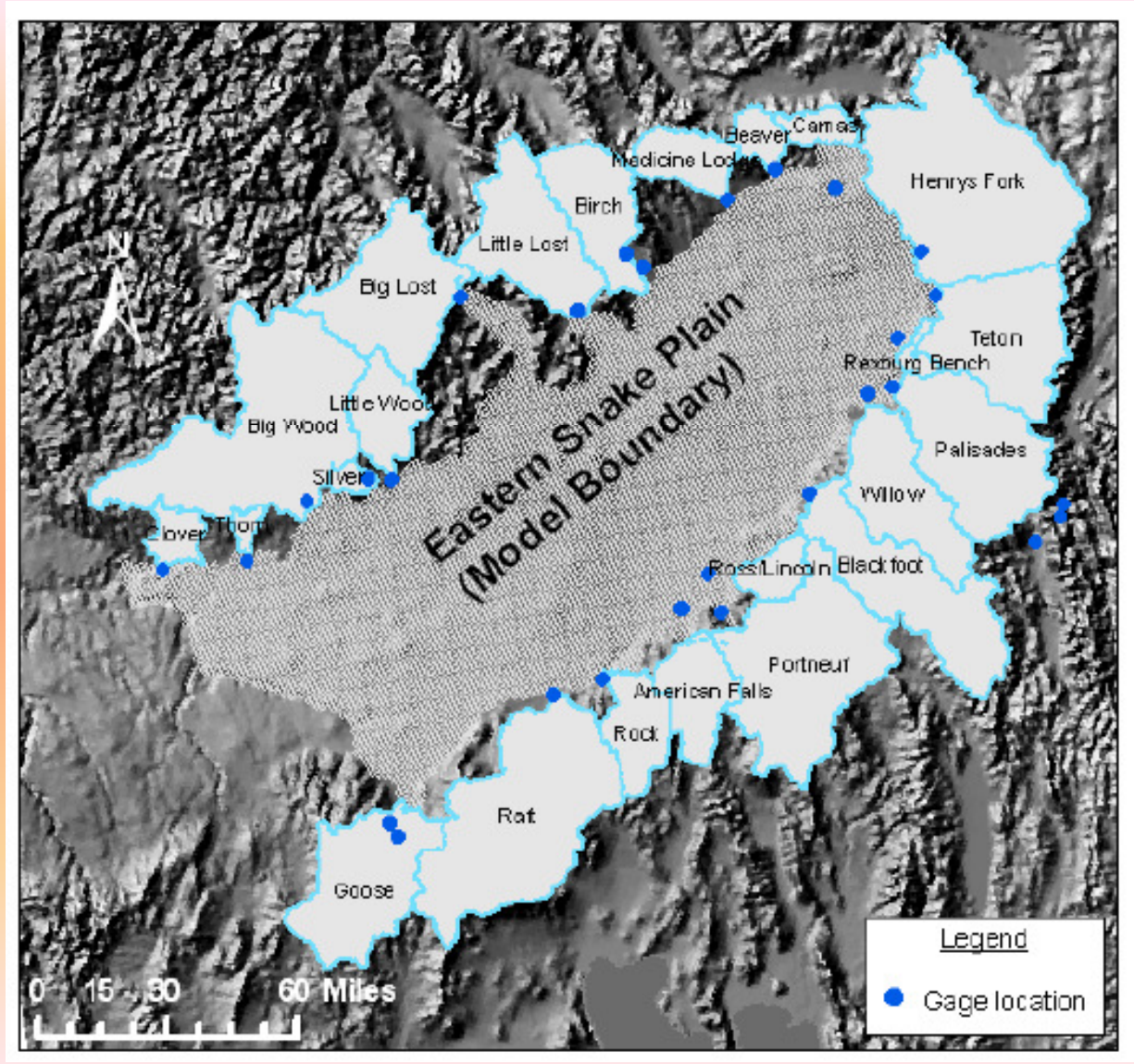


Calculating Tributary Underflow
(for Palisades)

Tributary Underflow =

Water Yield – Outflow from the Basin + Inflow to the Basin – Change in Storage of the Reservoir – ET from Irrigated Lands

USGS Streamflow Gages

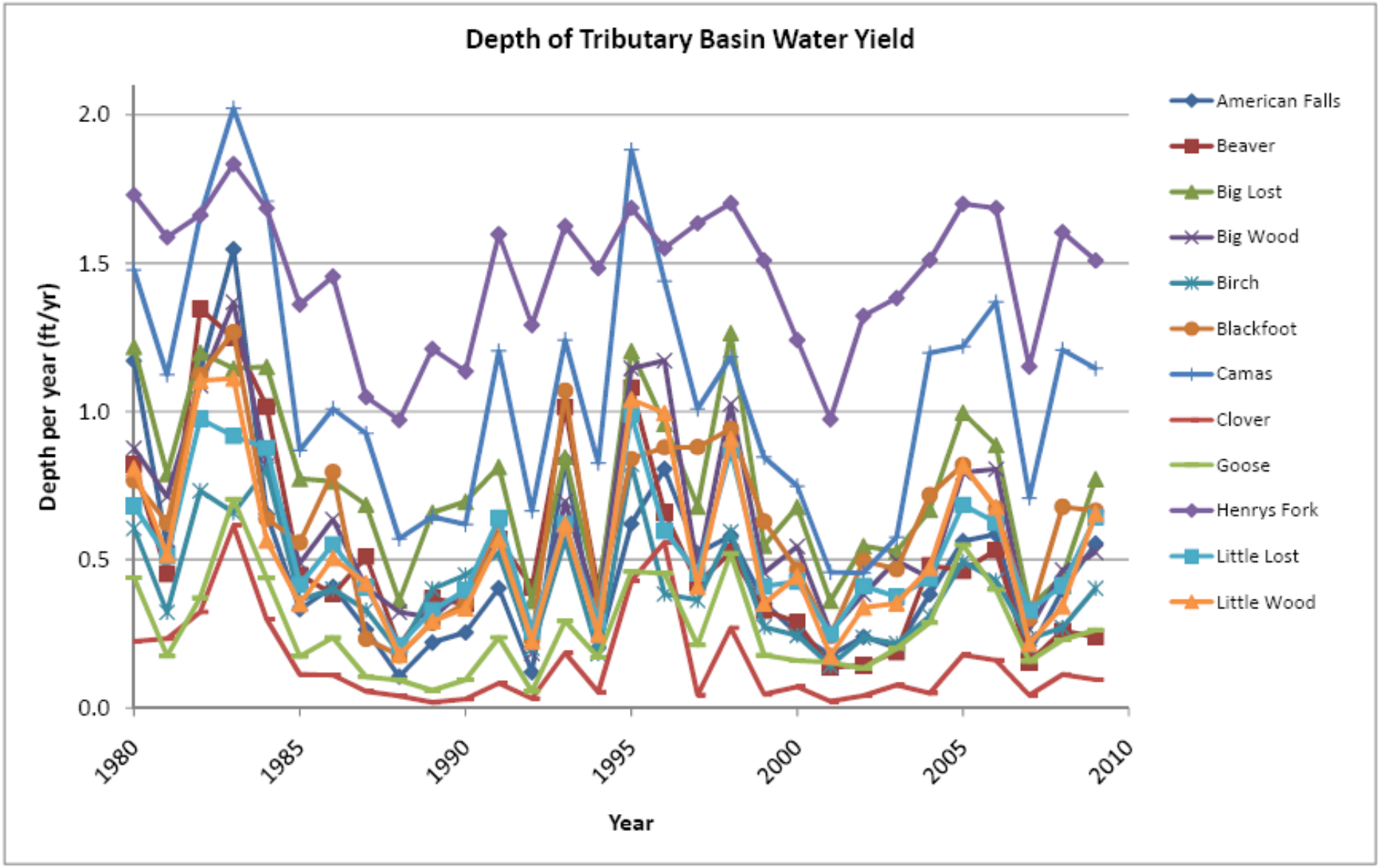


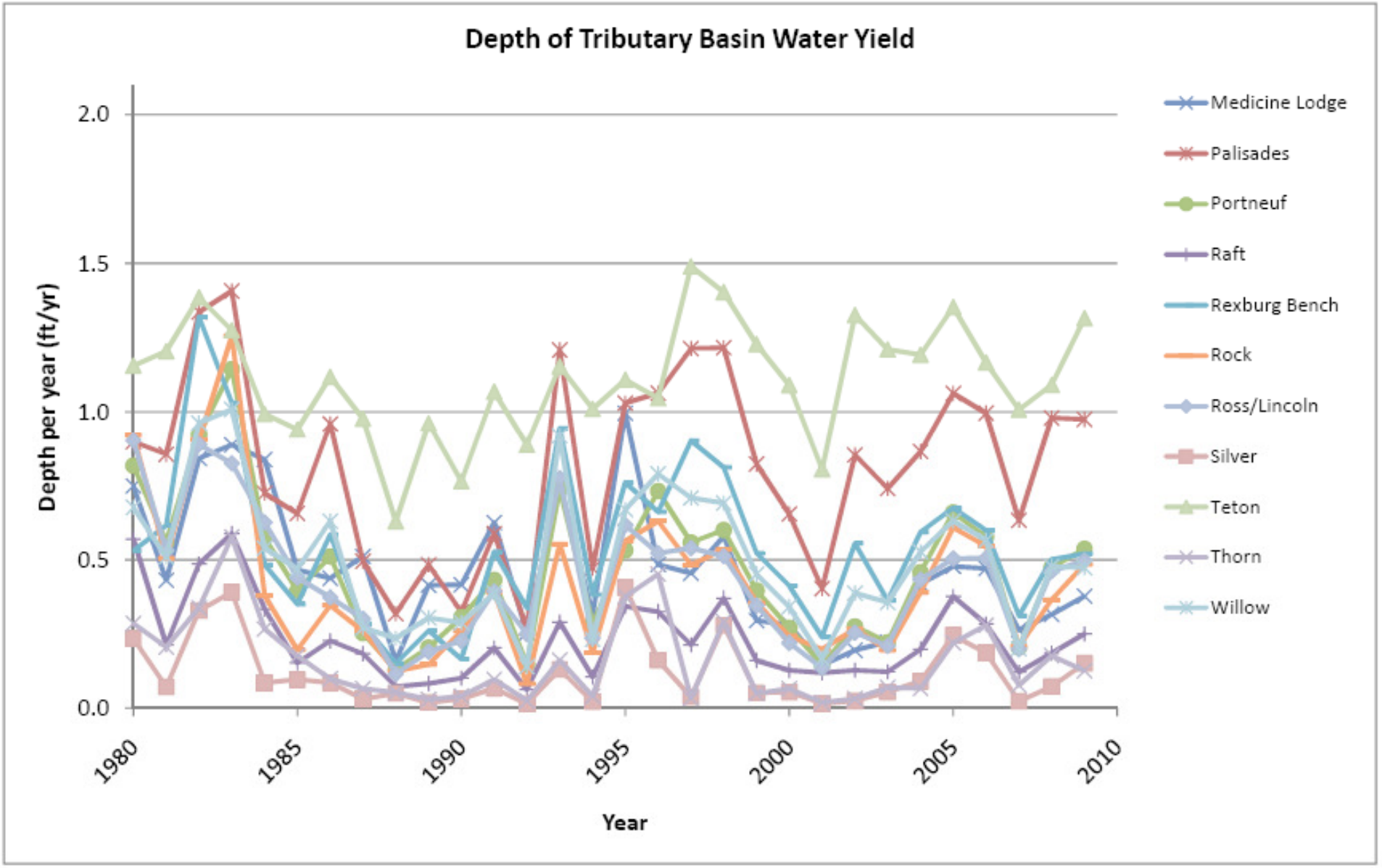
METRIC ET

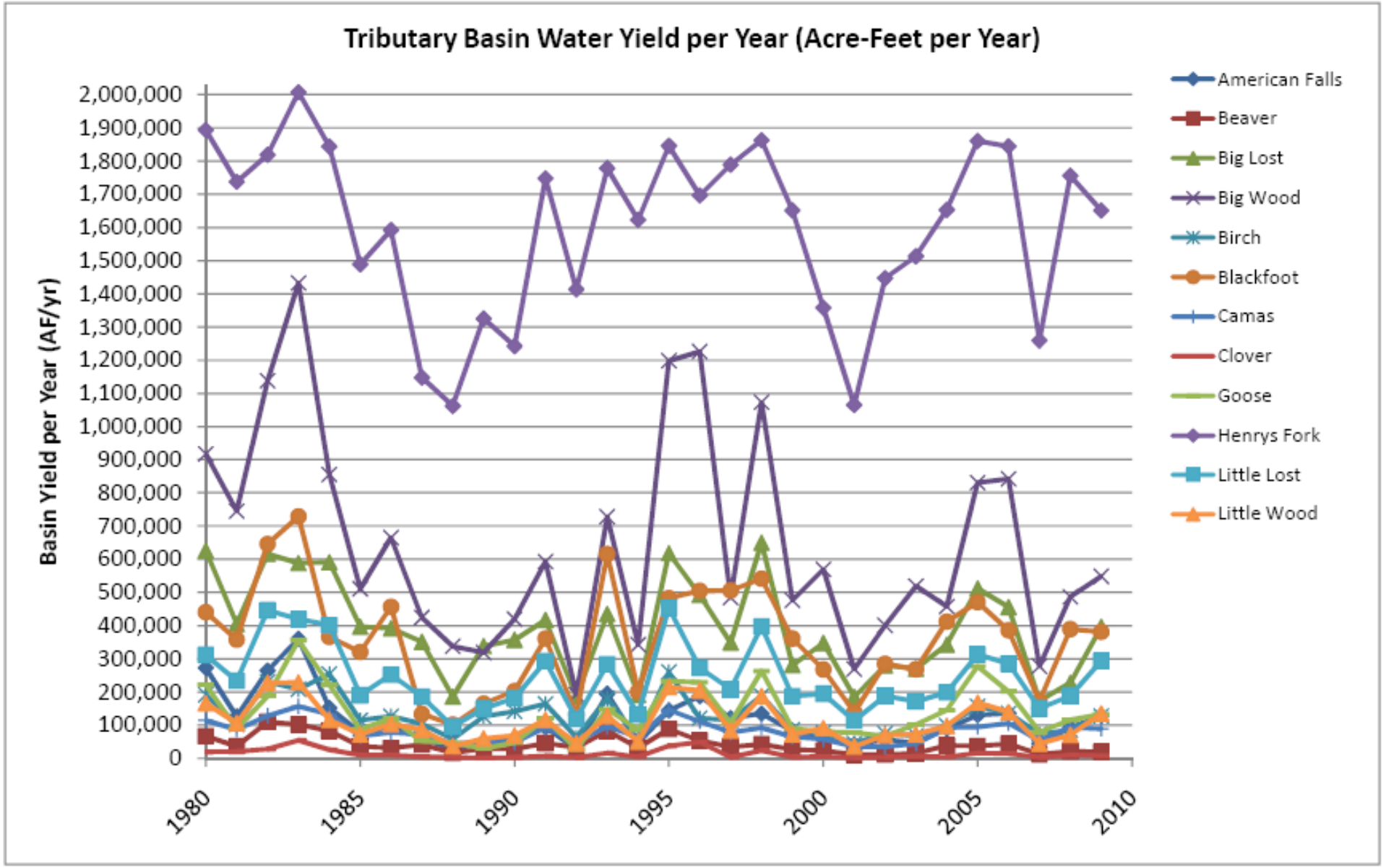
- Used 1992 irrigated lands (these went far enough up into the tributary basins)
- METRIC ET for 2000, 2002, and 2006 were used
  - Averaged this data and assumed values for entire 1980-2009 period as irrigation ET

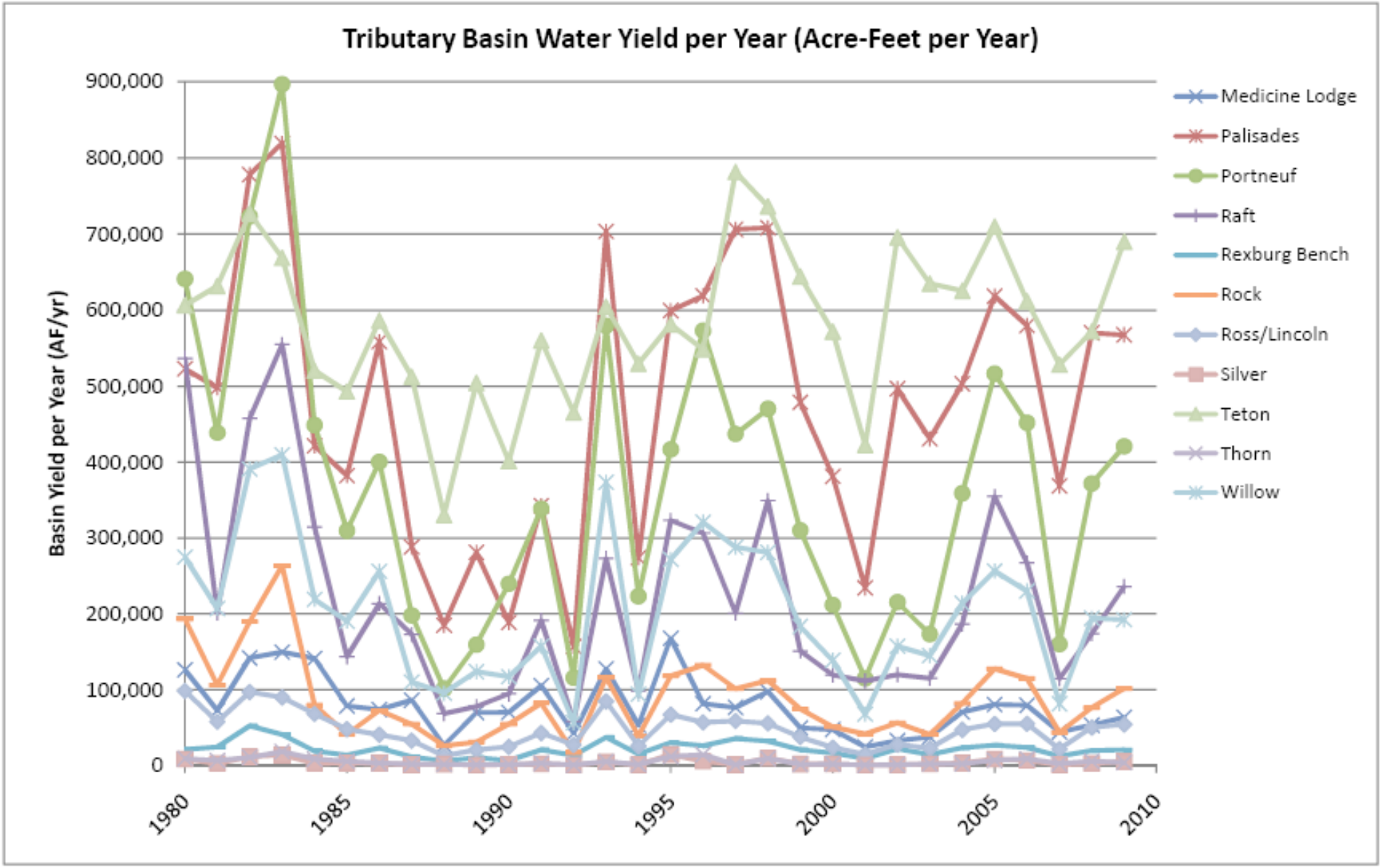
RESULTS

BASIN YIELD

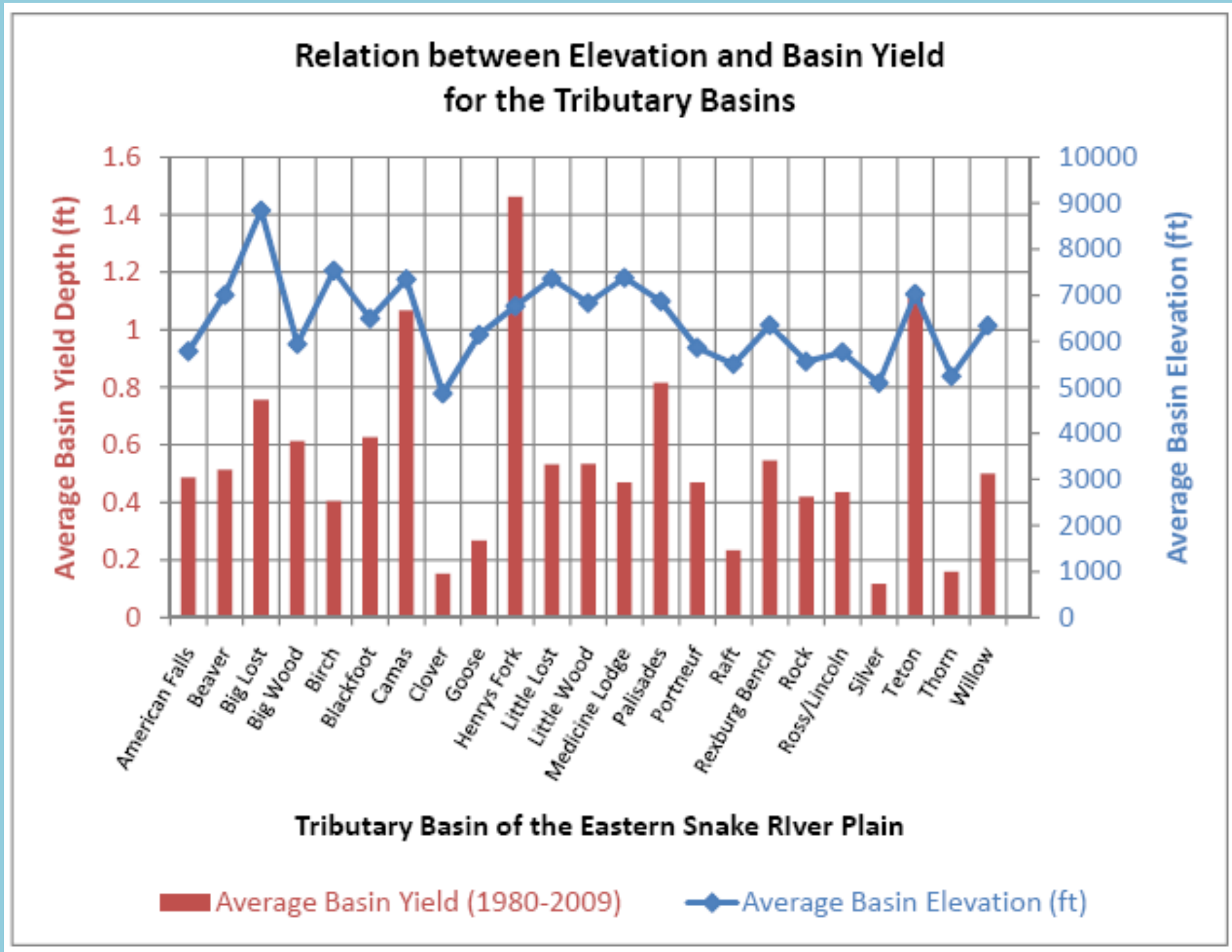

Depth of Tributary Basin Water Yield
Depth per year (ft/yr)
2.0
1.5
1.0
0.5
0.0
1980
1985
1990
1995
2000
2005
2010
Year
American Falls
Beaver
Big Lost
Big Wood
Birch
Blackfoot
Camas
Clover
Goose
Henrys Fork
Little Lost
Little Wood

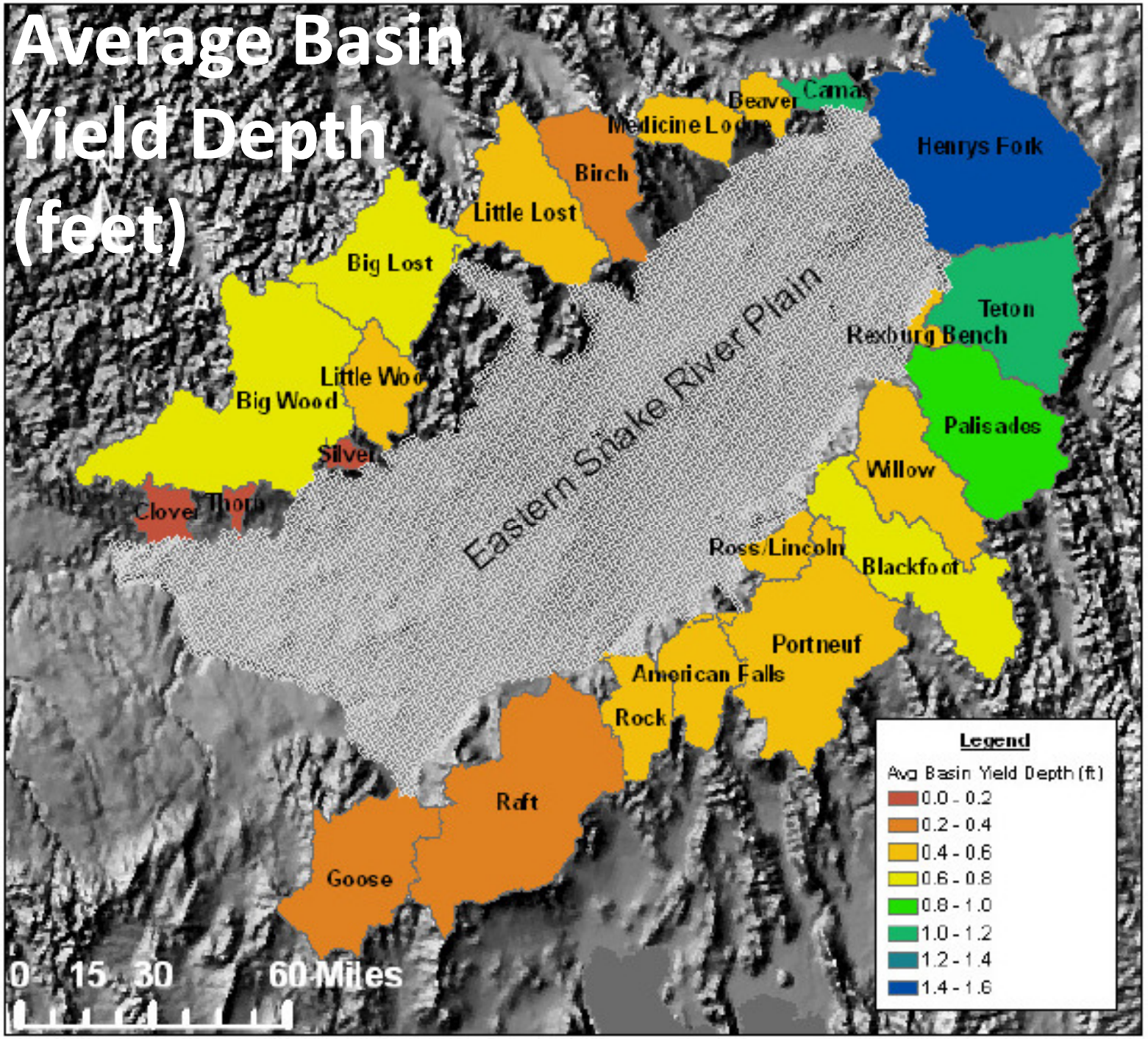

Depth of Tributary Basin Water Yield
Depth per year (ft/yr)
2.0
1.5
1.0
0.5
0.0
1980
1985
1990
1995
2000
2005
2010
Year
Medicine Lodge
Palisades
Portneuf
Raft
Rexburg Bench
Rock
Ross/Lincoln
Silver
Teton
Thorn
Willow


Tributary Basin Water Yield per Year (Acre-Feet per Year)
Basin Yield per Year (AF/yr)
2,000,000
1,900,000
1,800,000
1,700,000
1,600,000
1,500,000
1,400,000
1,300,000
1,200,000
1,100,000
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
1980
1985
1990
1995
2000
2005
2010
American Falls
Beaver
Big Lost
Big Wood
Birch
Blackfoot
Camas
Clover
Goose
Henrys Fork
Little Lost
Little Wood

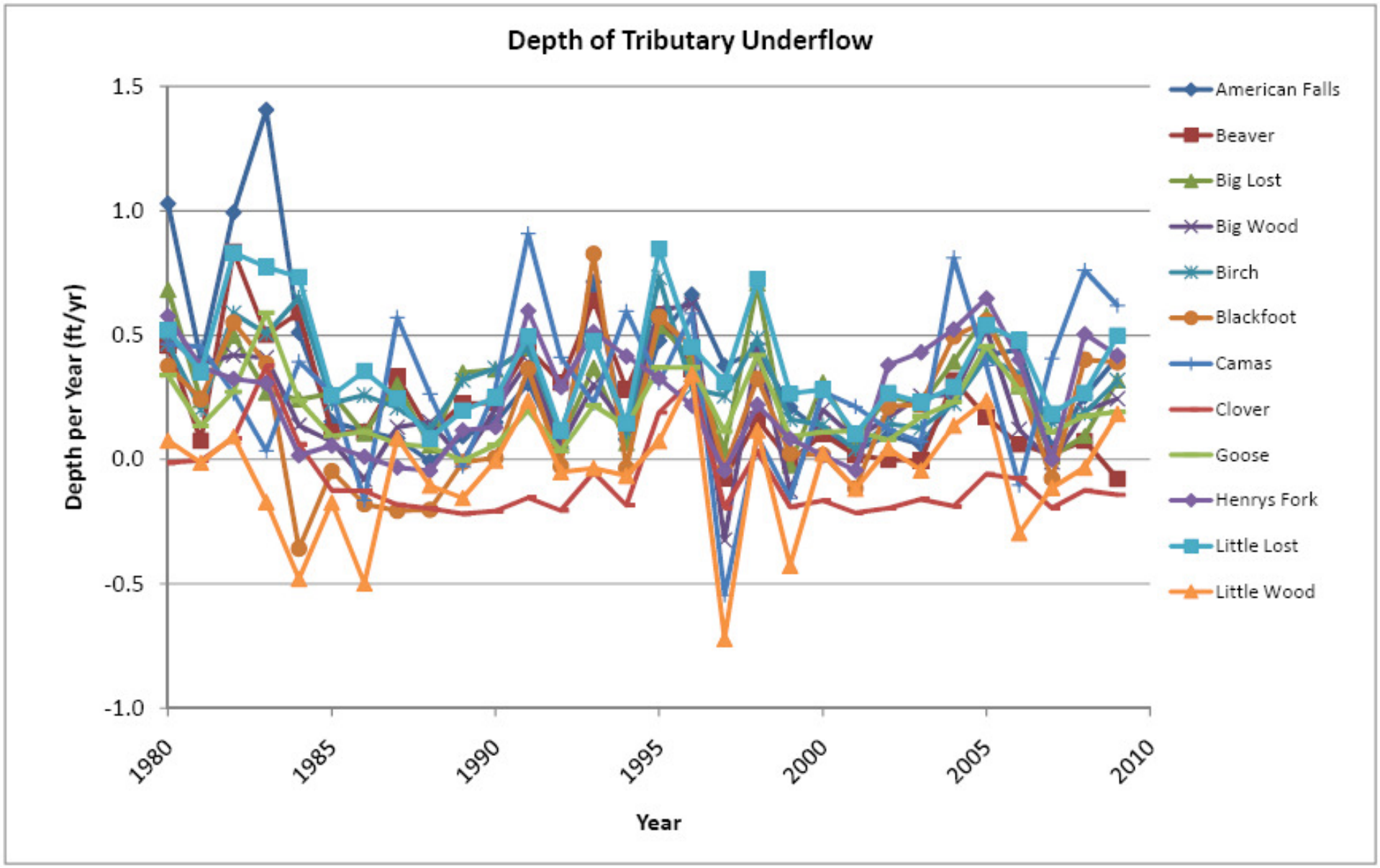


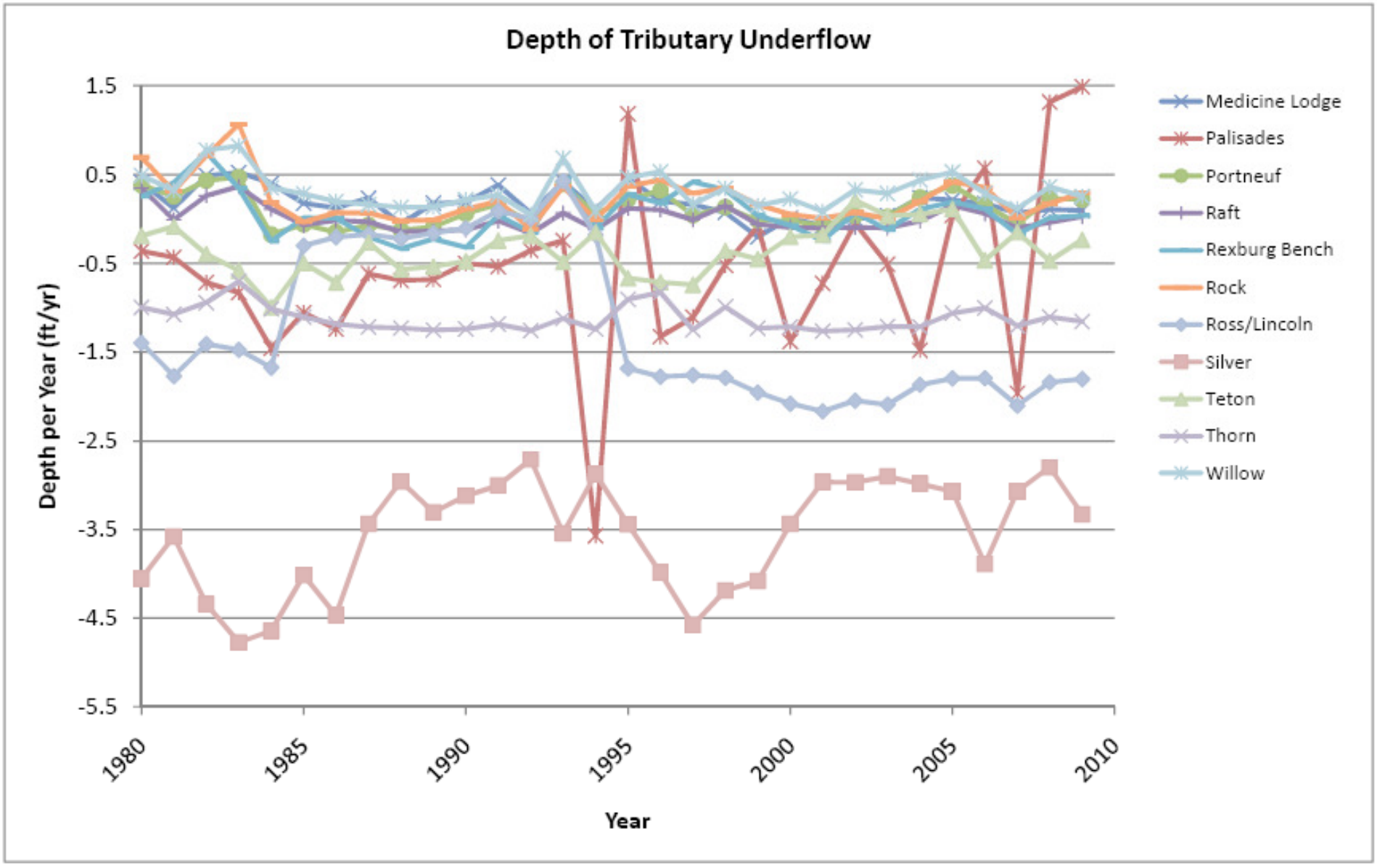
Note that the scale is different for this figure relative to previous


Relation between Elevation and Basin Yield for the Tributary Basins
Average Basin Yield Depth (ft)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Average Basin Elevation (ft)
American Falls
Beaver
Big Lost
Big Wood
Birch
Blackfoot
Camas
Clover
Goose
Henrys Fork
Little Lost
Little Wood
Medicine Lodge
Palisades
Portneuf
Raft
Rexburg Bench
Rock
Ross/Lincoln
Silver
Teton
Thorn
Willow
Tributary Basin of the Eastern Snake RIver Plain
Average Basin Yield (1980-2009)
Average Basin Elevation (ft)


Average Basin Yield Depth (feet)
Beaver
Camas
Medicine Lodge
Henrys Fork
Birch
Little Lost
Big Lost
Teton
Rexburg Bench
Eastern Snake River Plain
Little Wood
Big Wood
Palisades
Silver
Willow
Clover Thorn
Ross/Lincoln
Blackfoot
Portneuf
American Falls
Rock
Raft
Goose
0 15 30 60 Miles
Legend
Avg Basin Yield Depth (ft)
0.0 - 0.2
0.2 - 0.4
0.4 - 0.6
0.6 - 0.8
0.8 - 1.0
1.0 - 1.2
1.2 - 1.4
1.4 - 1.6

TRIBUTARY UNDERFLOW


Depth of Tributary Underflow
Depth per Year (ft/yr)
1.5
1.0
0.5
0.0
-0.5
-1.0
1980
1985
1990
1995
2000
2005
2010
Year
American Falls
Beaver
Big Lost
Big Wood
Birch
Blackfoot
Camas
Clover
Goose
Henrys Fork
Little Lost
Little Wood


Depth of Tributary Underflow
Depth per Year (ft/yr)
1.5
0.5
-0.5
-1.5
-2.5
-3.5
-4.5
-5.5
1980
1985
1990
1995
2000
2005
2010
Year
Medicine Lodge
Palisades
Portneuf
Raft
Rexburg Bench
Rock
Ross/Lincoln
Silver
Teton
Thorn
Willow

Why Negative Values?

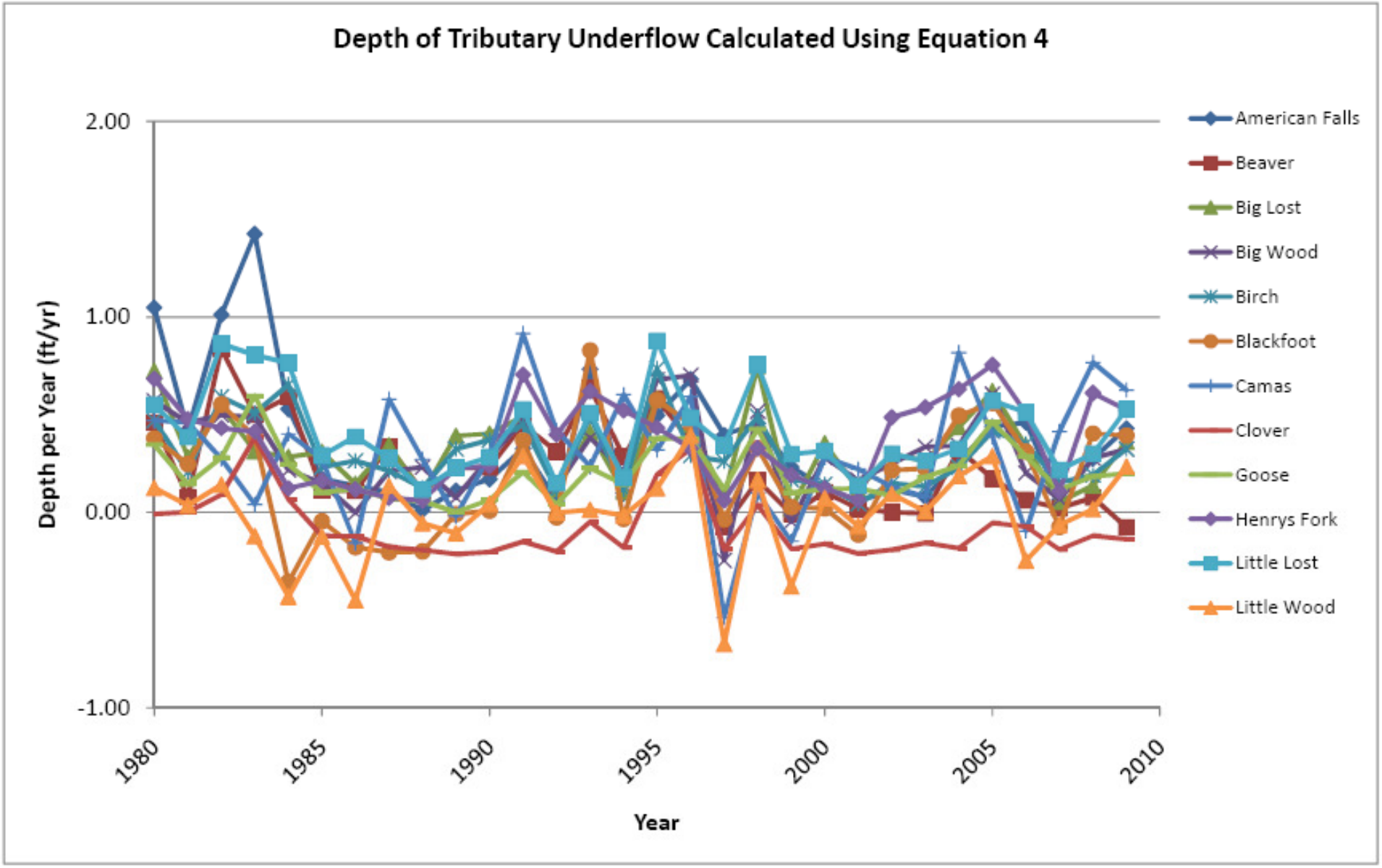
- Could be the result of error in any of the following:
  1. Streamflow
  2. Estimates of irrigated ET
  3. Langbein method
- Streamflow: some sites had poor gage data; estimates were applied
- Irrigated ET: possible overlap with potential ET; METRIC ET estimates were based on years 2000, 2002, 2006
- Langbein method: too simple; climatic variables (temp, precip) may not be enough of a representation of Water Yield
- Another possibility: in water short periods, groundwater from tributary valley aquifers sustains baseflow in streams, supporting irrigation and/or surface flows exiting the basin

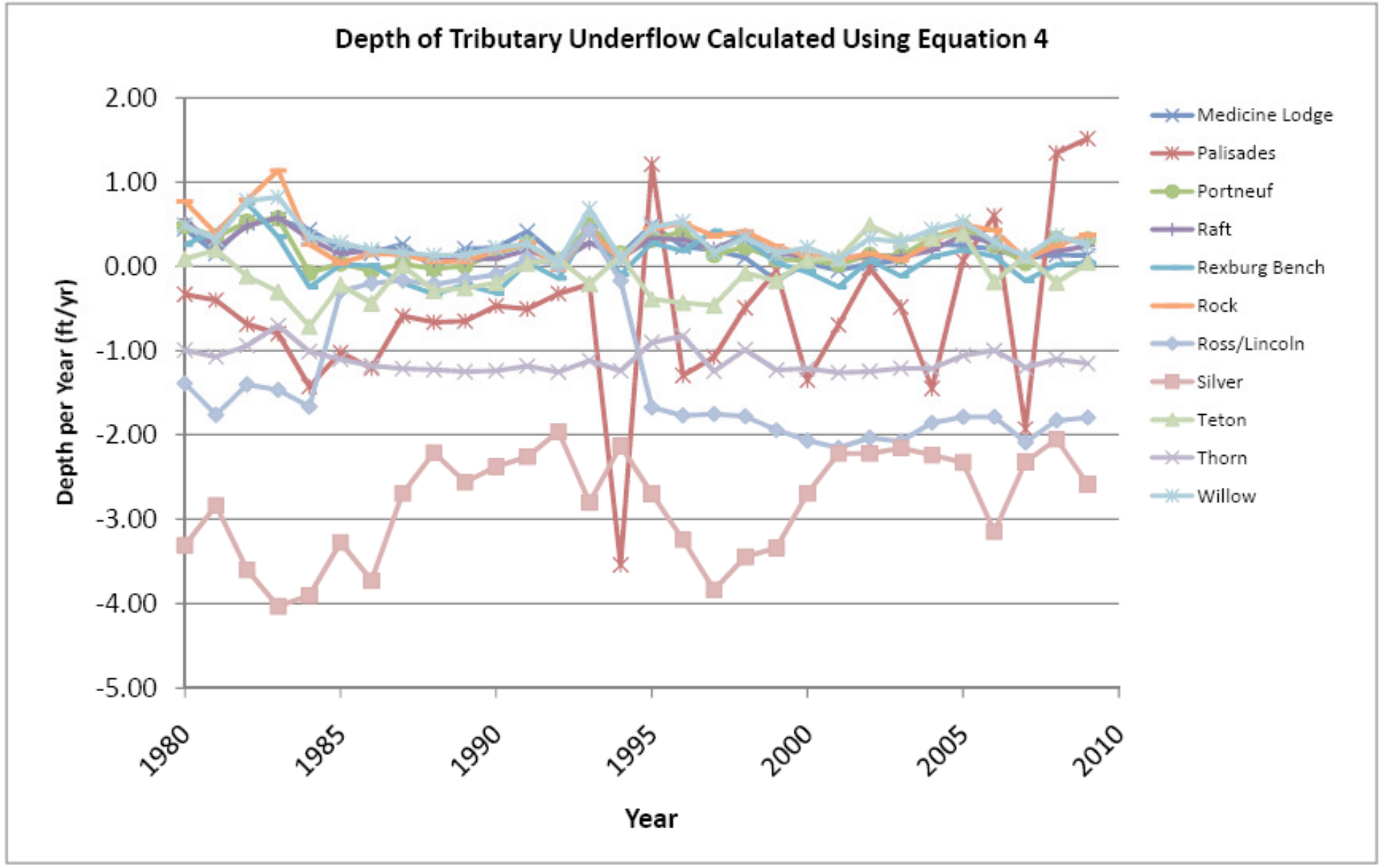
Tributary Underflow

Removal of METRIC ET:

Tributary Underflow = Water Yield – Surface Flow Exiting Basin

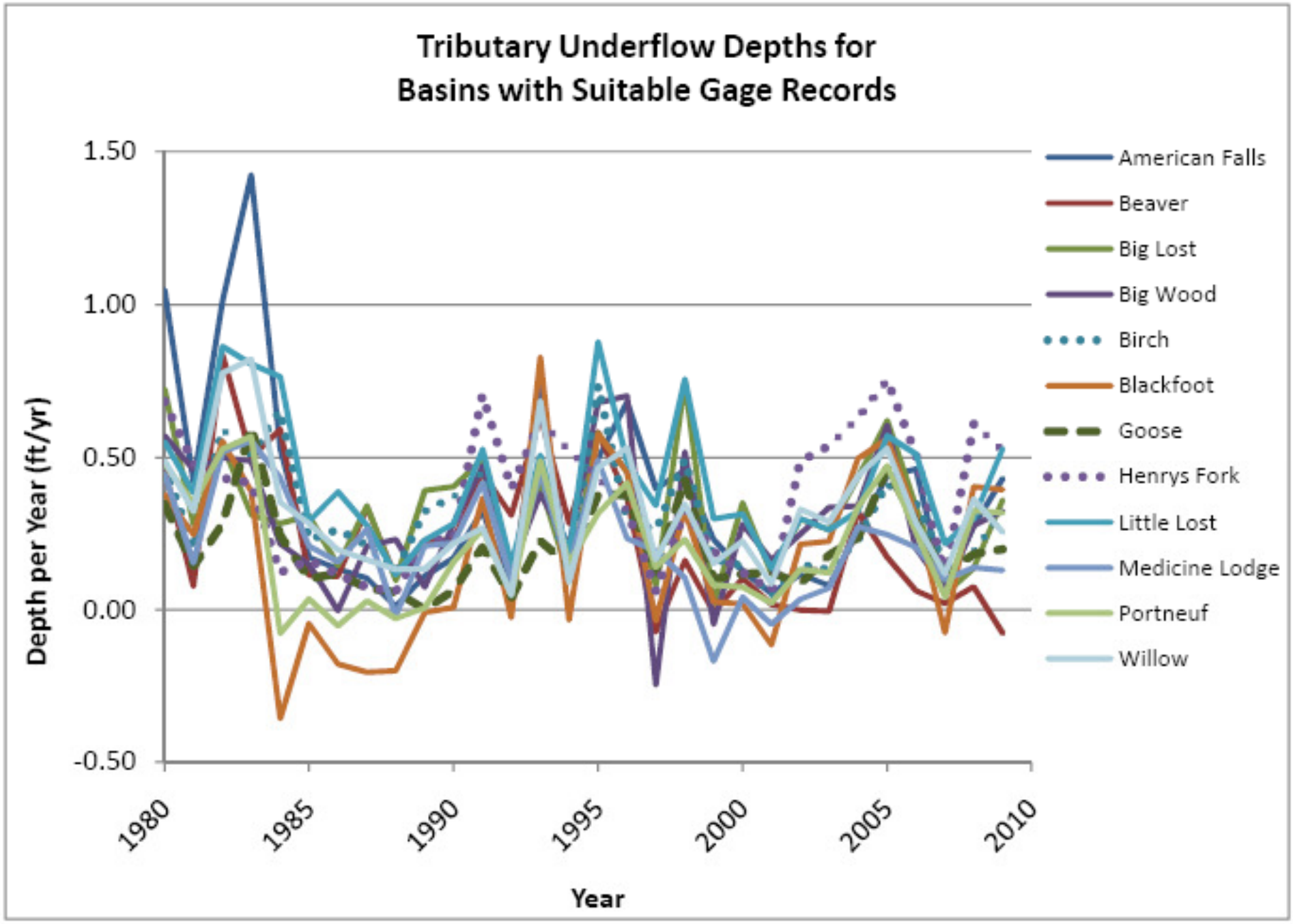
(Referred to as Equation 4 in the final USGS report)


Depth of Tributary Underflow Calculated Using Equation 4
Depth per Year (ft/yr)
2.00
1.00
0.00
-1.00
1980
1985
1990
1995
2000
2005
2010
Year
American Falls
Beaver
Big Lost
Big Wood
Birch
Blackfoot
Camas
Clover
Goose
Henrys Fork
Little Lost
Little Wood


Depth of Tributary Underflow Calculated Using Equation 4
Depth per Year (ft/yr)
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
1980
1985
1990
1995
2000
2005
2010
Year
Medicine Lodge
Palisades
Portneuf
Raft
Rexburg Bench
Rock
Ross/Lincoln
Silver
Teton
Thorn
Willow

Which Values are Acceptable?

- Removing METRIC ET didn't change the values enough to make a huge difference (negative values were still present)
- When quality streamflow data was available, tributary underflow values were more reasonable
  - Suitable gage sites were defined as those less than 8 miles from the model boundary and having no more than 5 years missing from the period of record


Tributary Underflow Depths for
Basins with Suitable Gage Records
1.50
1.00
0.50
0.00
-0.50
Depth per Year (ft/yr)
1980
1985
1990
1995
2000
2005
2010
Year
American Falls
Beaver
Big Lost
Big Wood
Birch
Blackfoot
Goose
Henrys Fork
Little Lost
Medicine Lodge
Portneuf
Willow

Conclusions

- Limited data available (streamflow, ET)
- Use of the Langbein method may not be suitable for this climate
- Each basin should be individually analyzed
- Final USGS report can be found at this link:

  http://www.iwrri.uidaho.edu/documents/TribUnd_USGS104b_022811_FINAL.pdf?pid=120274&doc=1

QUESTIONS OR COMMENTS?