

Hydrology of Closed-Basin Drainages

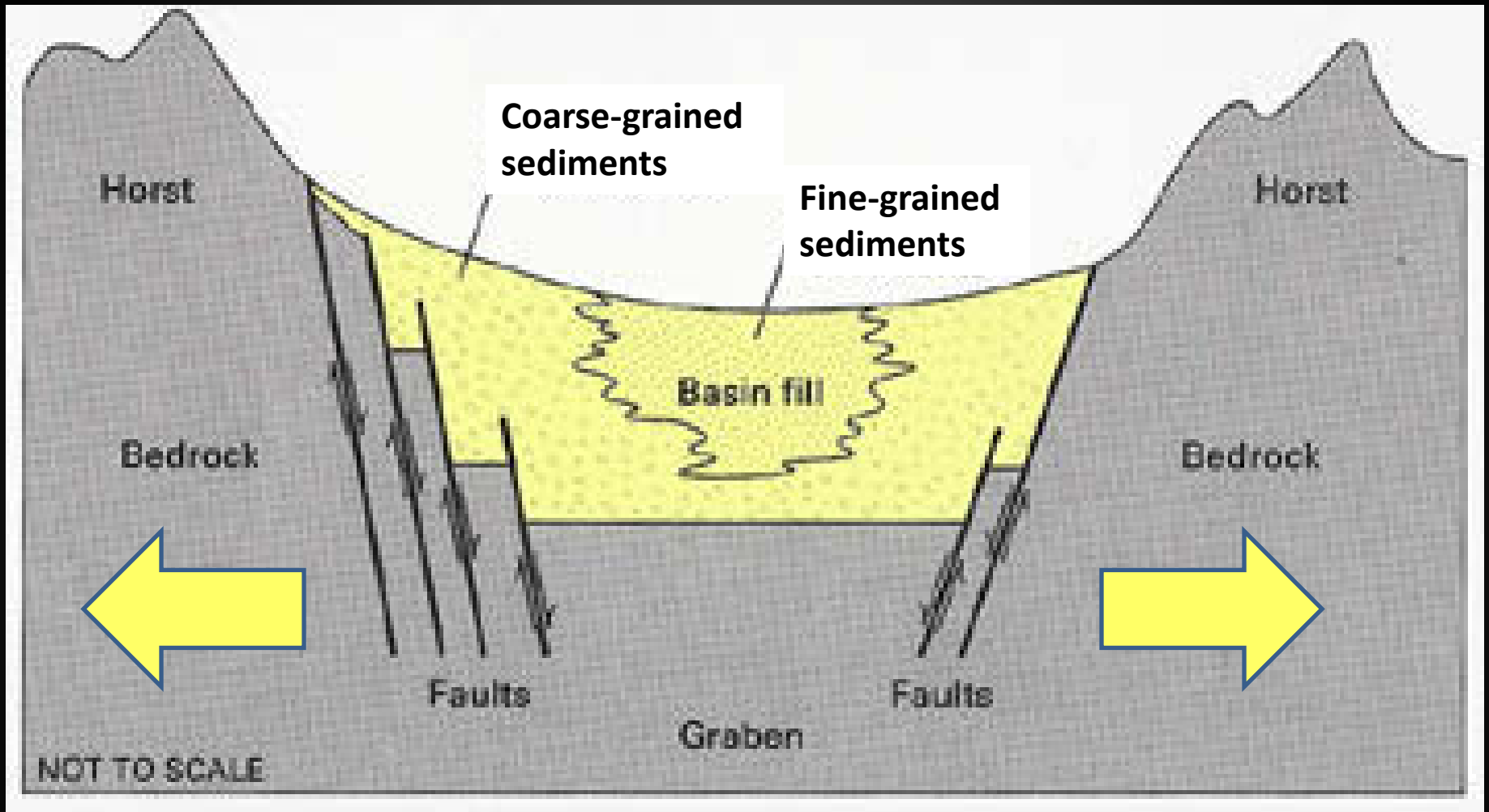
Harney Basin Study Advisory Committee
20 April 2017

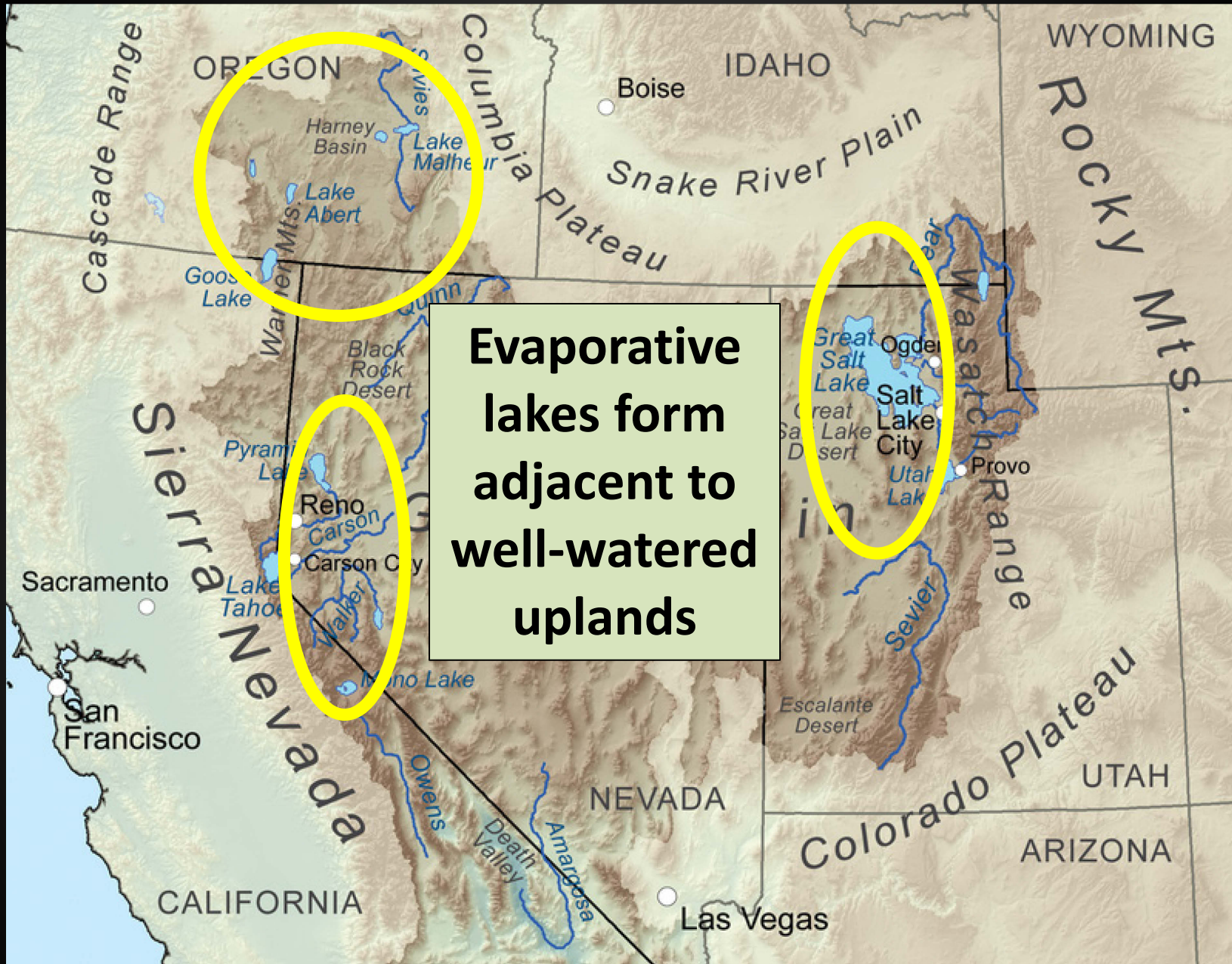
Hank Johnson, U.S. Geological Survey



Image credit:

By Kmusser - Own work, Elevation data from SRTM, all other features from the National Atlas. Rand McNally, The New International Atlas, 1993 used as reference., CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=12079426>



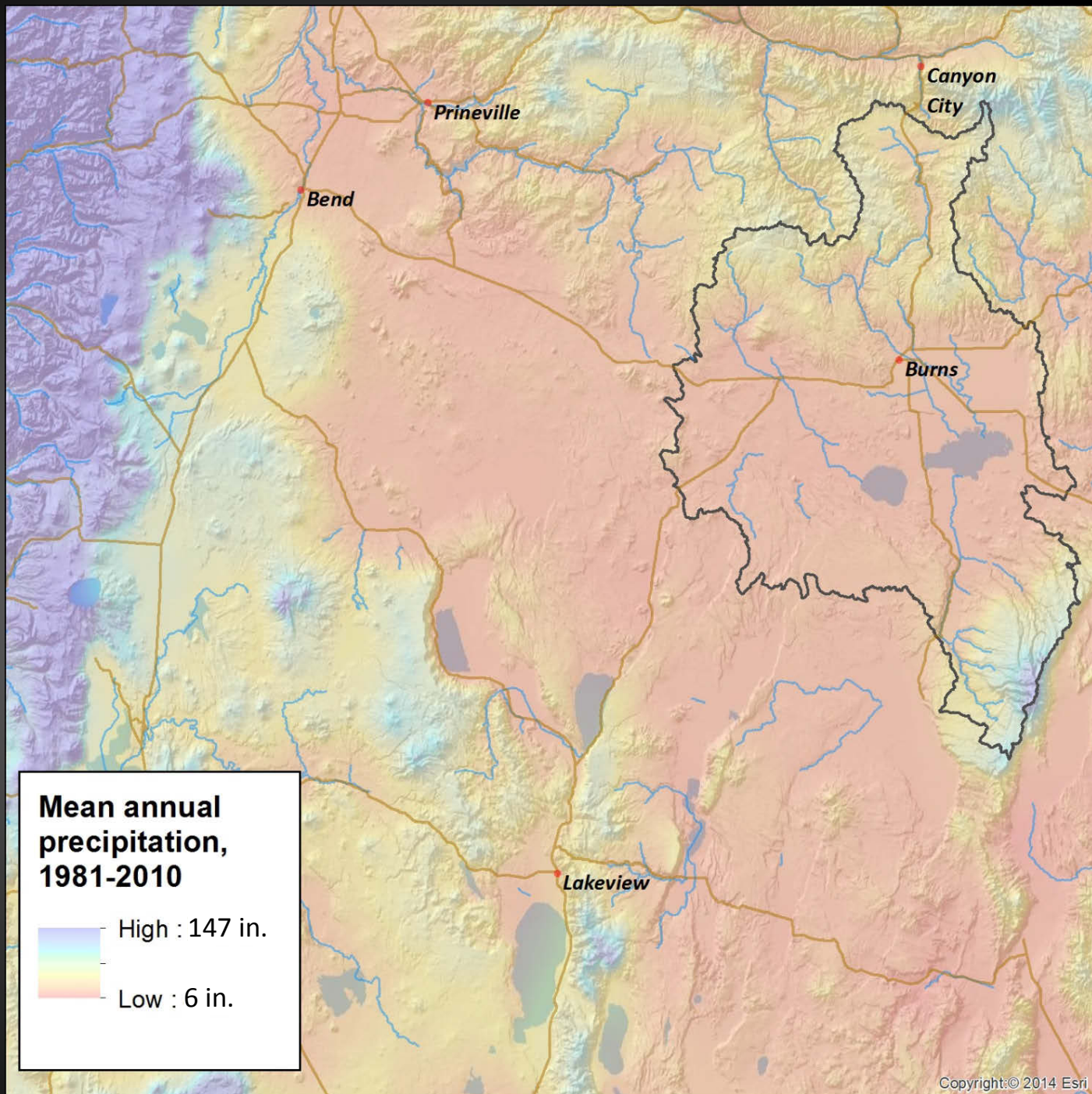


**Evaporative
lakes form
adjacent to
well-watered
uplands**

Image credit:

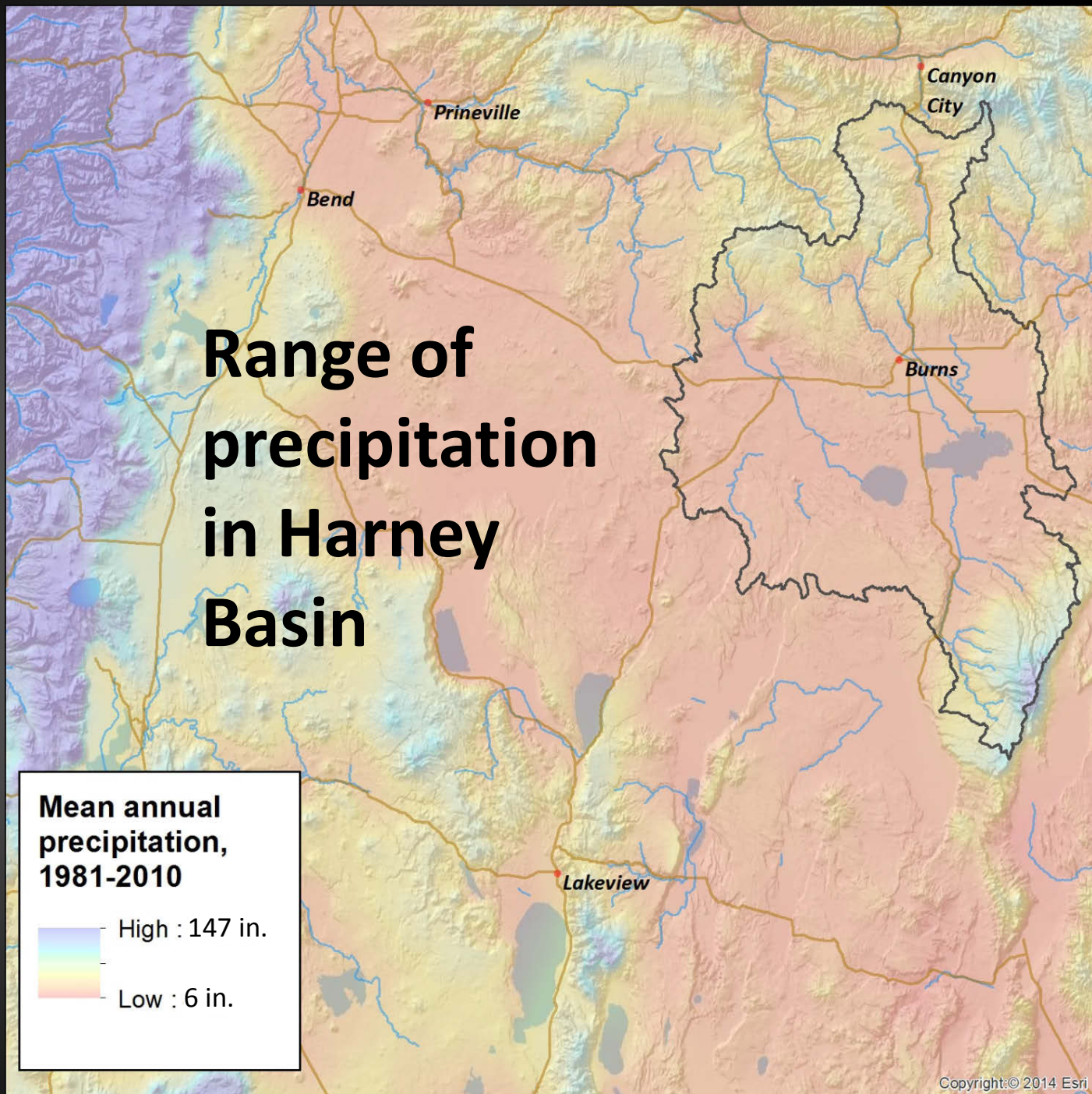
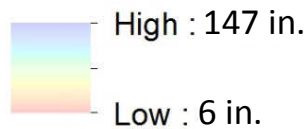
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Arid with islands of moisture



Range of precipitation in Harney Basin

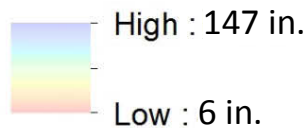
Mean annual precipitation, 1981-2010

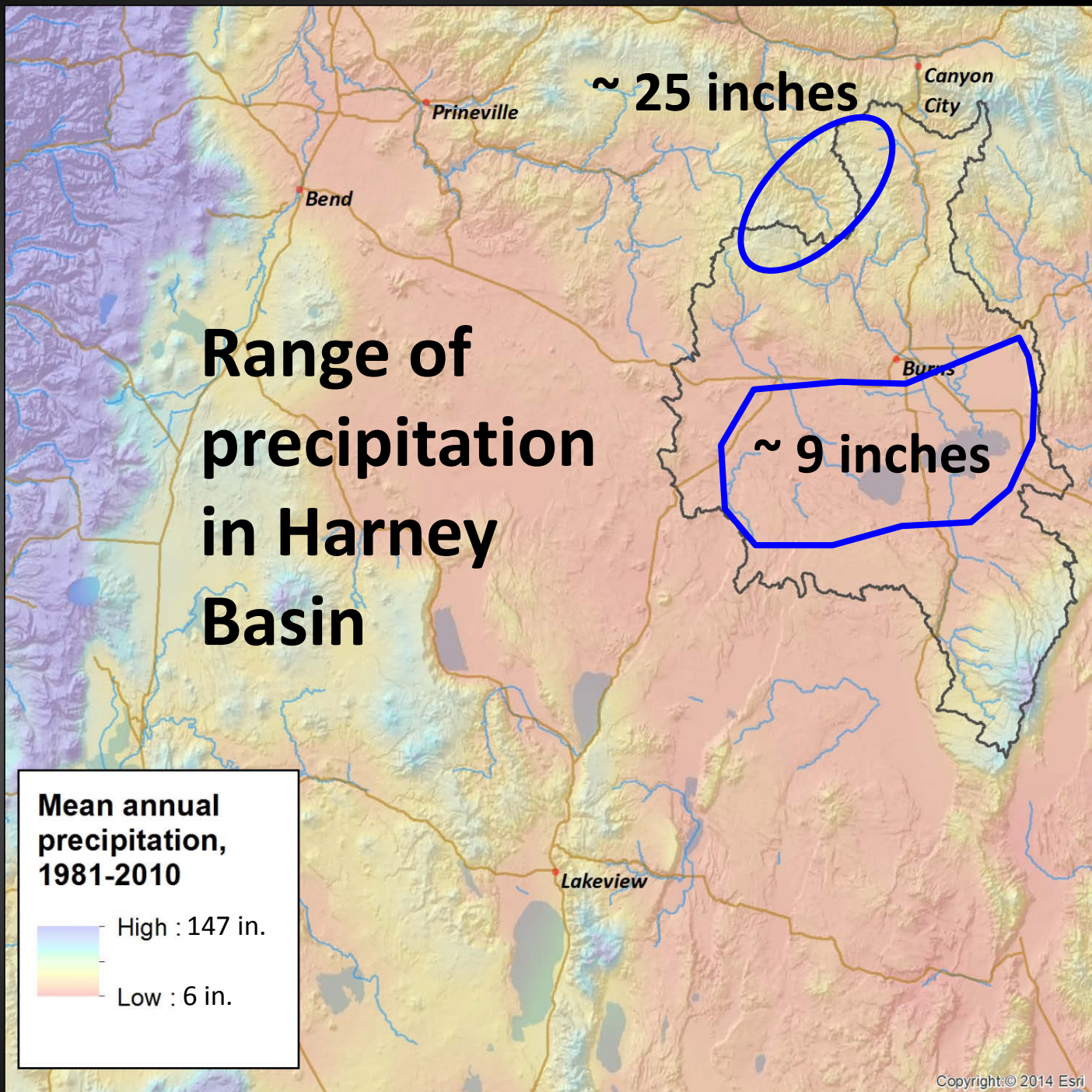


Range of precipitation in Harney Basin

~ 9 inches

Mean annual precipitation, 1981-2010





Range of precipitation in Harney Basin

Mean annual precipitation, 1981-2010



~ 25 inches

~ 9 inches

~ 50 inches

Prineville

Bend

Canyon City

Burns

Lakeview



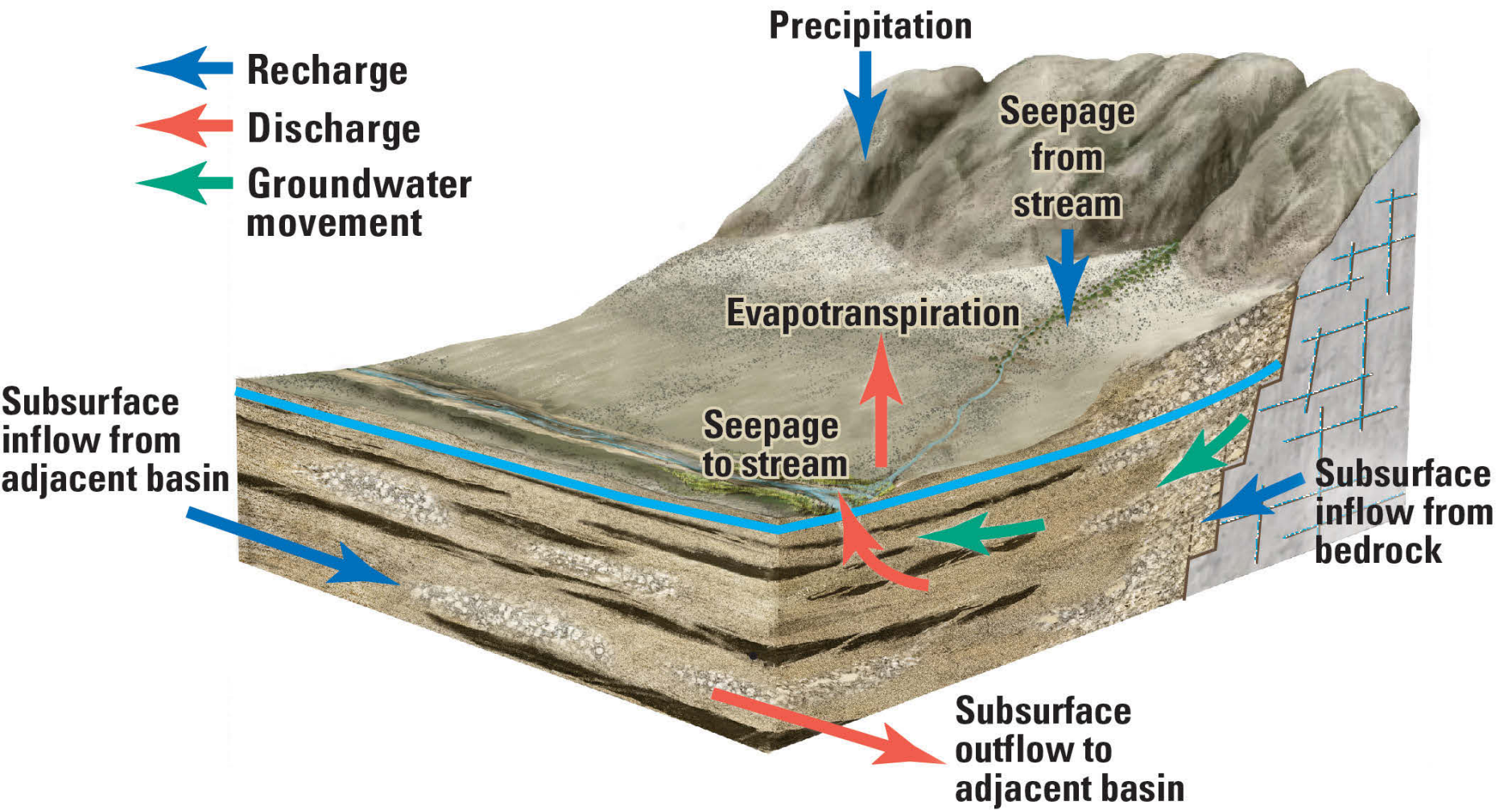
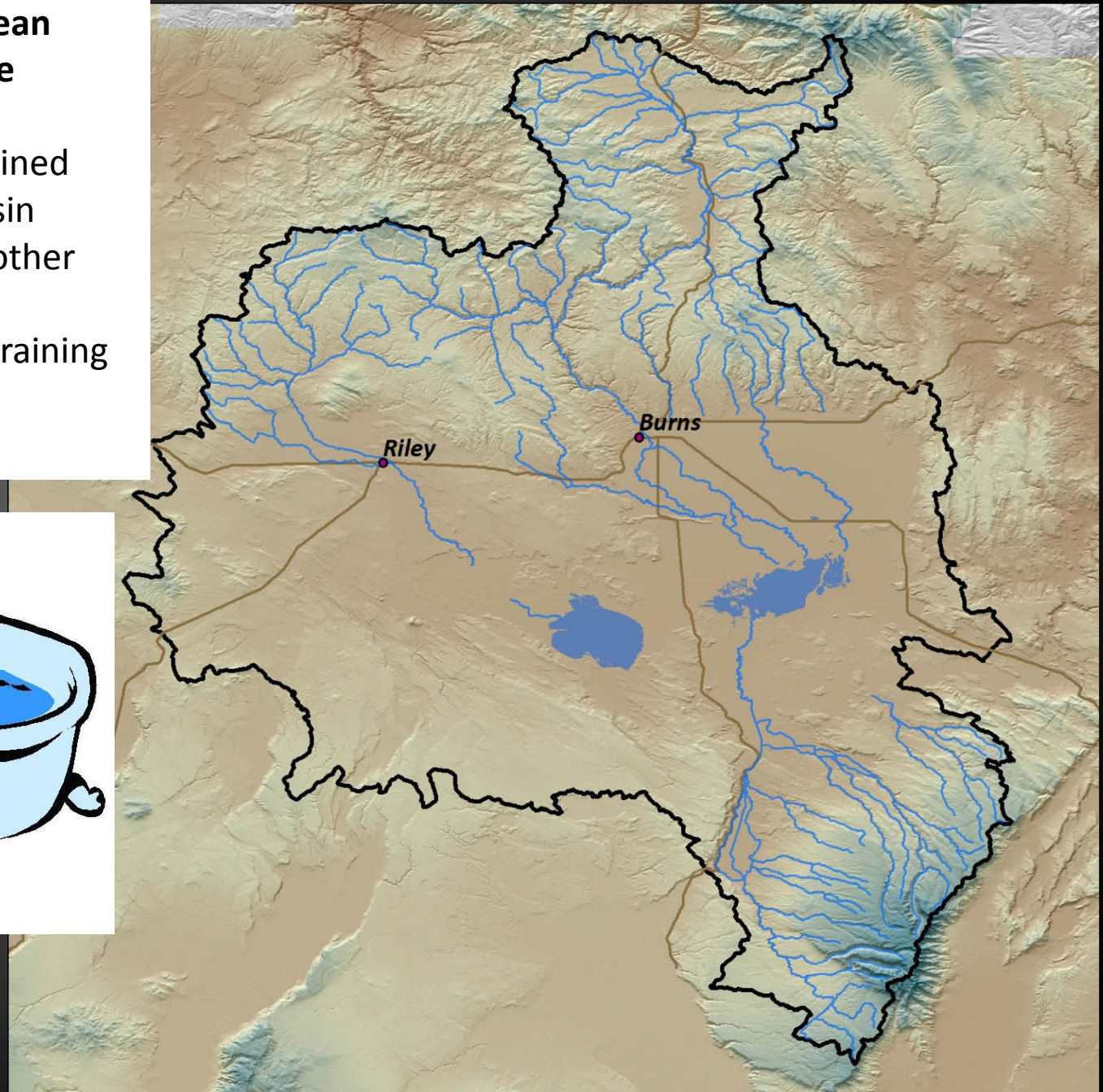
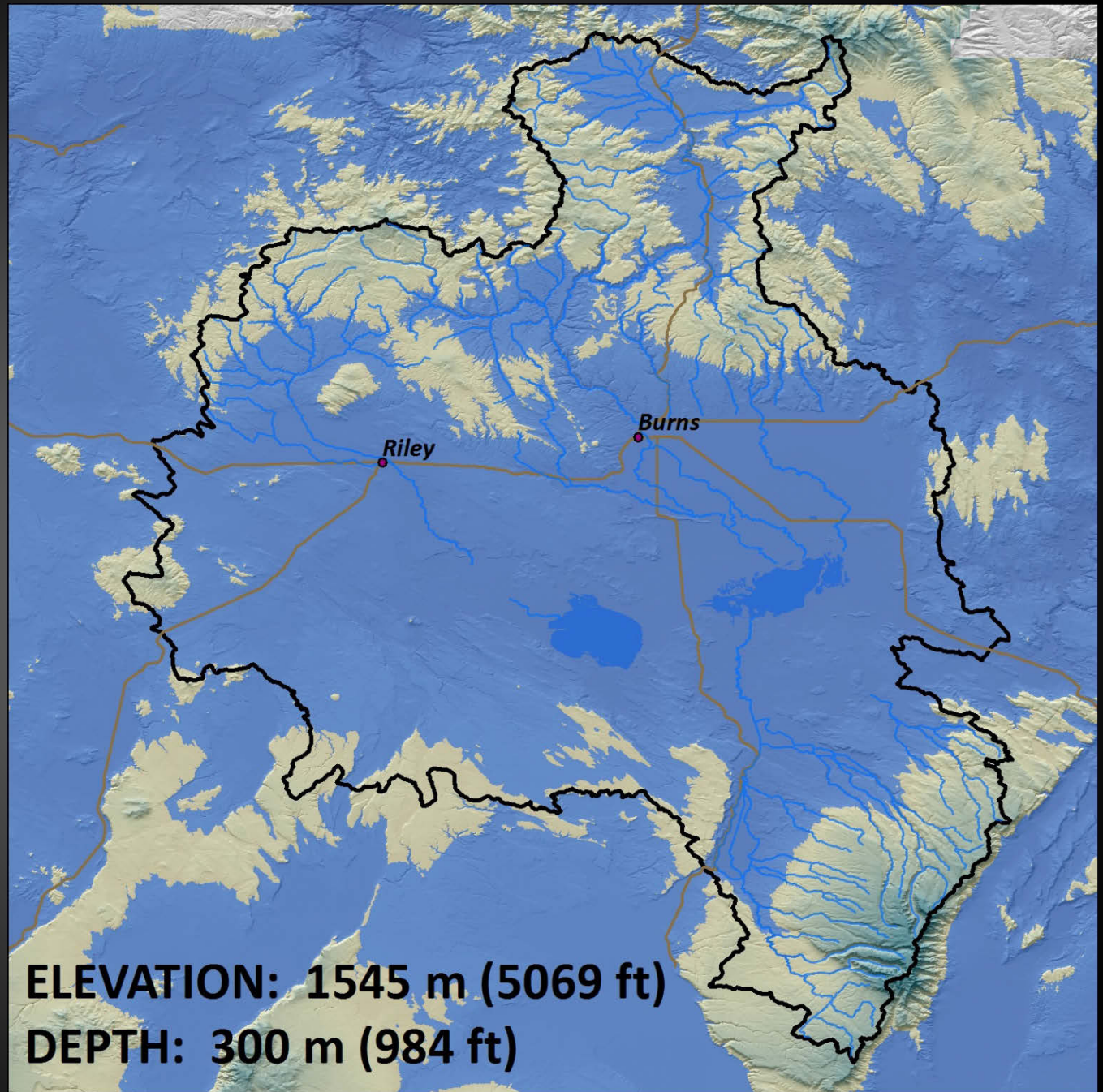


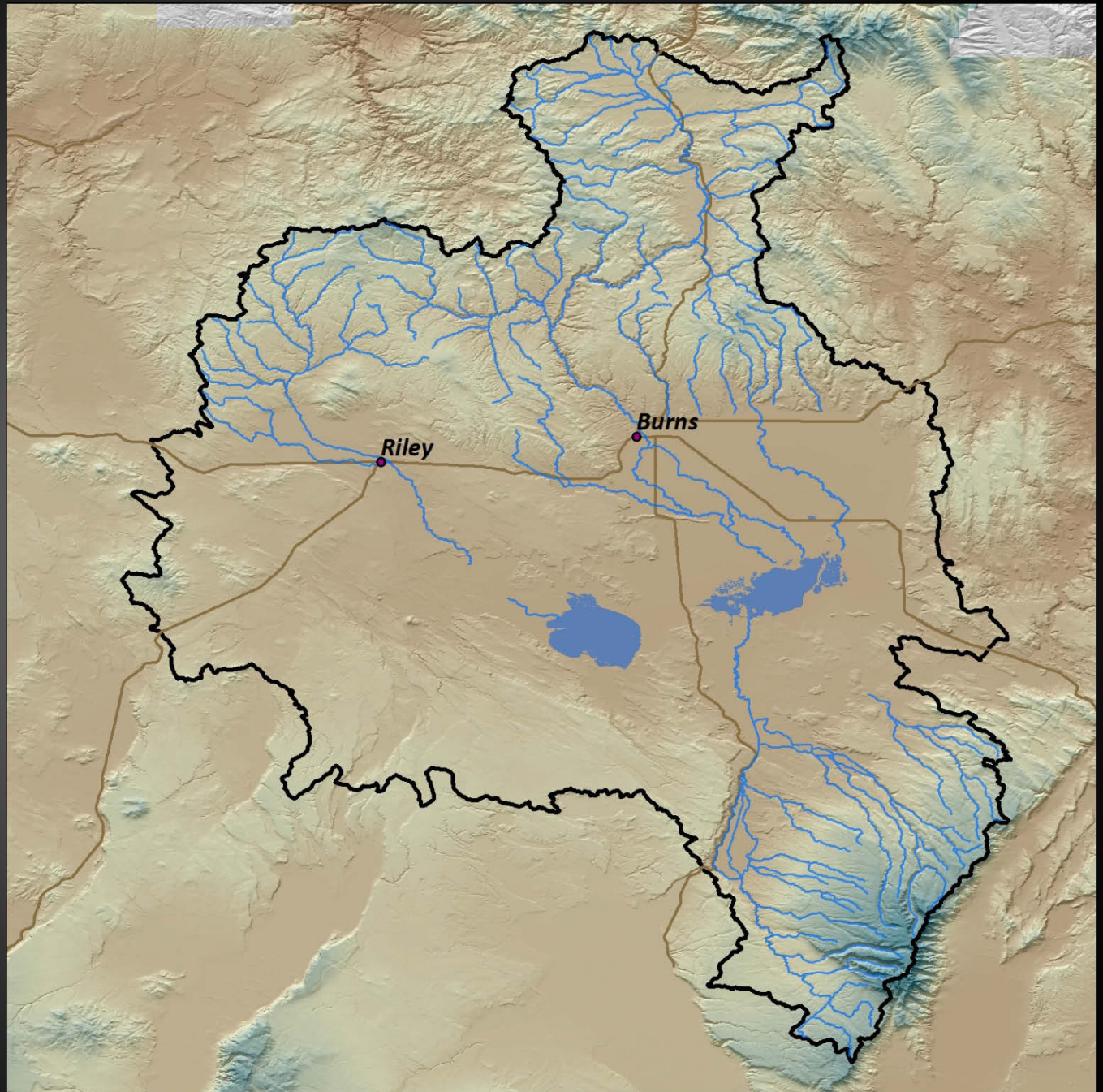
Figure modified from: Thiros, S.A., Paul, A.P., Bexfield, L.M., and Anning, D.W., 2014, *The quality of our Nation's waters: Water quality in basin-fill aquifers of the southwestern United States: Arizona, California, Colorado, Nevada, New Mexico, and Utah, 1993-2009*: U.S. Geological Survey Circular 1358, 113 p.

What do hydrologists mean when they talk about the Harney Basin?

- Topographically contained
- Water outside the basin boundary flows in another direction
- Can be visualized as draining a bathtub







Hydrologic Budget



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IN

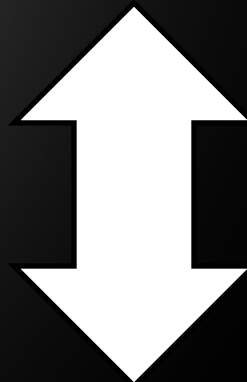


OUT



Image sources: Microsoft PowerPoint Clip Art Gallery
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NET CHANGE
IN ACCOUNT



Hydrologic Budget

IN = OUT ± CHANGE
IN
STORAGE



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Hydrologic Budget

$$IN = OUT \pm \text{CHANGE IN STORAGE}$$

IN

- Precipitation (Recharge)
- Interbasin groundwater flow
- Interbasin transfer of water

OUT

- Streamflow
- Evapotranspiration (ET)
- Interbasin groundwater flow
- Interbasin transfer of water
- Commodity export

Hydrologic Budget

$$IN = OUT \pm \text{CHANGE IN STORAGE}$$

IN

- Precipitation (Recharge)
- Interbasin groundwater flow
- ~~• Interbasin transfer of water~~

OUT

- ~~• Streamflow~~
- Evapotranspiration (ET)
- Interbasin groundwater flow
- ~~• Interbasin transfer of water~~
- ~~• Commodity export~~

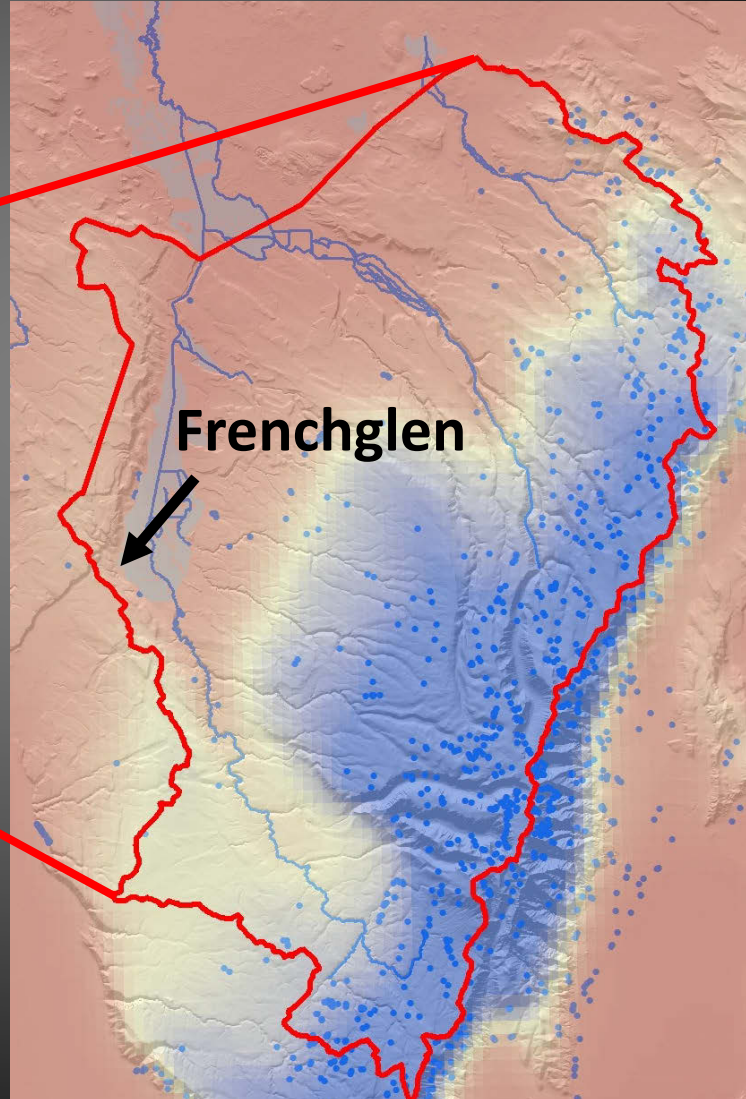
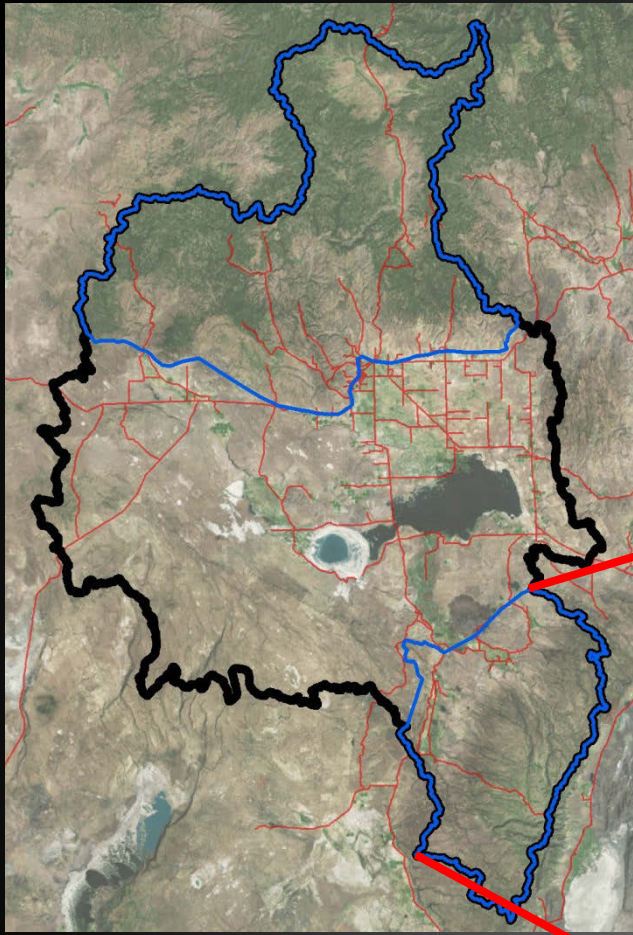
A
VERY PRELIMINARY

Water Budget for the
Blue Mountains
and
Steens Mountain
Recharge Areas

BLUE MOUNTAINS RECHARGE AREA



STEENS MOUNTAIN RECHARGE AREA



IN = OUT ± CHANGE IN STORAGE

	– PROVISIONAL DATA – SUBJECT TO REVISION	Blue Mountains	Steens Mountain
IN	Precipitation		
OUT	Evapotranspiration (ET)		
	Streamflow		
	DIFFERENCE		

IN = OUT ± CHANGE IN STORAGE

	– PROVISIONAL DATA – SUBJECT TO REVISION	Blue Mountains	Steens Mountain
IN	Precipitation	18"	
OUT	Evapotranspiration (ET)	5"	
	Streamflow	2"	
	DIFFERENCE	11"	

IN = OUT ± CHANGE IN STORAGE

	– PROVISIONAL DATA – SUBJECT TO REVISION	Blue Mountains	Steens Mountain
IN	Precipitation	18"	22"
OUT	Evapotranspiration (ET)	5"	2"
	Streamflow	2"	4"
	DIFFERENCE	11"	16"

IN = OUT ± CHANGE IN STORAGE

	– PROVISIONAL DATA – SUBJECT TO REVISION	Blue Mountains	Steens Mountain
IN	Precipitation	18"	22"
OUT	Evapotranspiration (ET)	5"	2"
	Streamflow	2"	4"
	DIFFERENCE	11"	16"



Groundwater recharge
Sublimation of snow
Error

“Recharge” as Percent of Precipitation

Preliminary Calculations for Harney Basin

Blue Mountains

61%

Steens Mountains

73%

Other Studies

Upper Umatilla Basin

36%

Herrera and other, in press

Klamath Basin

20%

Gannett and others, 2009

Deschutes Basin

35-40%

Gannett and others, 2001

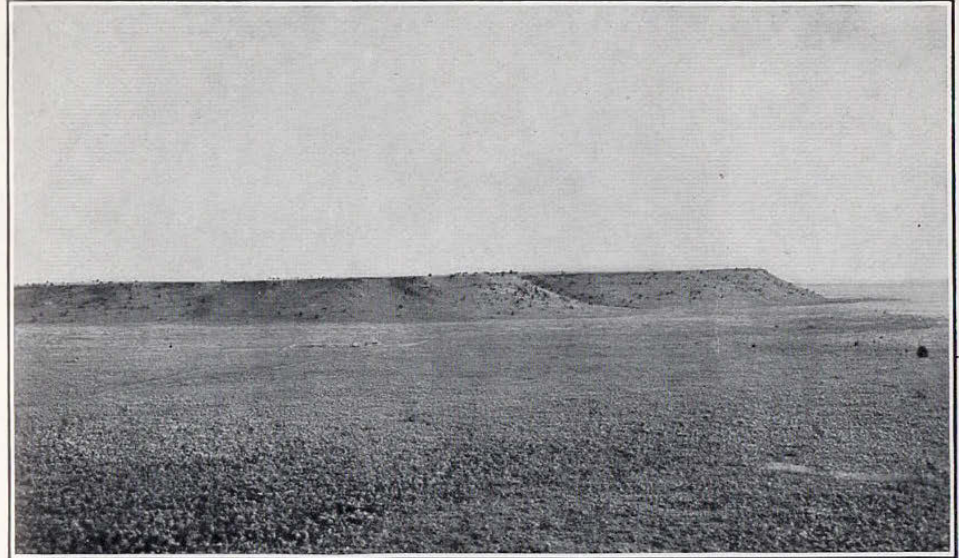
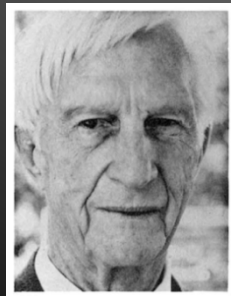
Underestimate of ET is the likely culprit



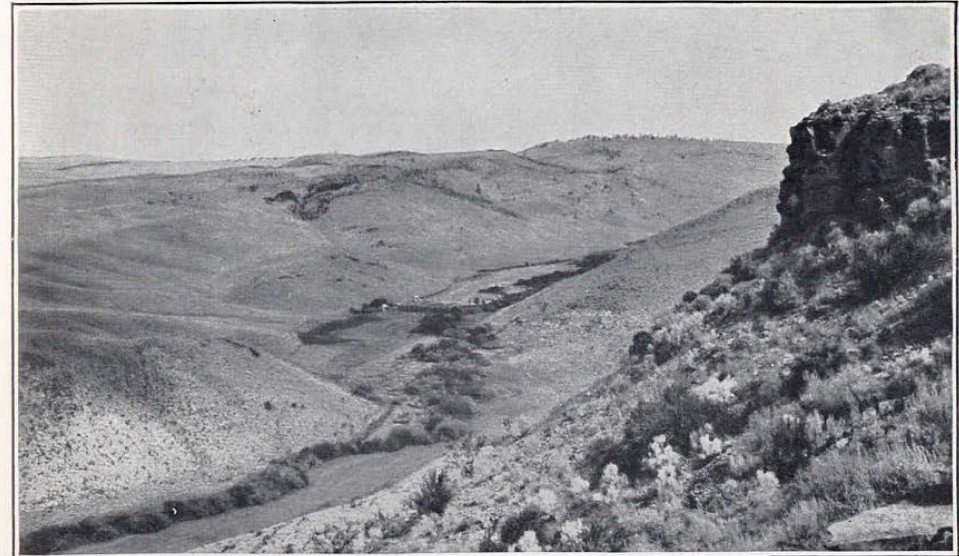
Pre-Development

- LOTS of variability – annual, decadal, even centuries
- On average, the water budget was balanced

Quasi-Equilibrium



A. CHARACTERISTIC SCARP AT WEST EDGE OF HARNEY VALLEY.



B. VALLEY OF RATTLESNAKE CREEK ABOVE HARNEY.

Surface water diversion and irrigation

- Some effect on ET

Groundwater development

- Large increases in ET
- Depletion of storage = declining GW levels



Hydrologic Budget

$$IN = OUT \pm \text{CHANGE IN STORAGE}$$

IN

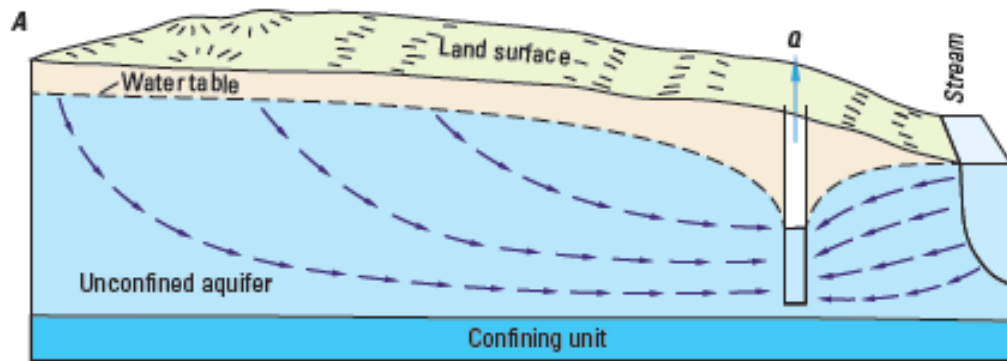
- Precipitation (Recharge)
- Interbasin groundwater flow
- ~~• Interbasin transfer of water (e.g. canal)~~

OUT

- ~~• Streamflow~~
- Evapotranspiration
- Interbasin groundwater flow
- ~~• Interbasin transfer of water~~
- ~~• Commodity export~~

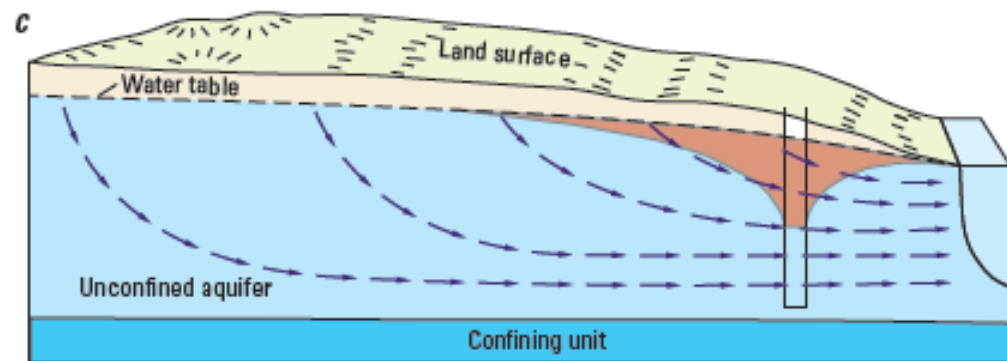
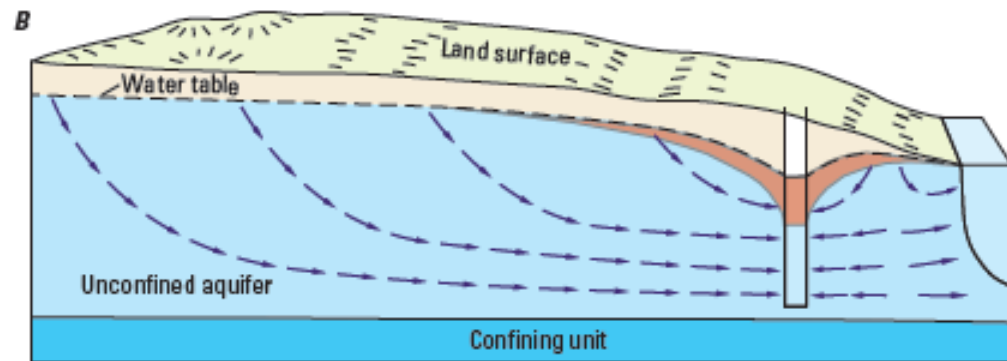
Toward a New Quasi-Equilibrium

- Lower water levels in aquifers
- Reduction or loss of streamflow
- Reduction or loss of spring flow
- Decreasing groundwater quality
- Lower lake levels and smaller areal extent



EXPLANATION

 Volume of cone of depression refilled since pumping stopped



Investigation of the Groundwater System of the Harney Basin, Oregon

Stephen B. Gingerich

**For the
Greater Harney Valley Groundwater Study
Advisory Committee
April 20, 2017**

Burns, OR

Some questions to be addressed

- How much water enters the Harney Basin (recharge)?
- How much water leaves the Harney Basin (discharge)?
- How might water-level declines progress in the future?
- How can water-level declines be managed?
- How does pumping affect surface-water discharge?
- To what degree are different parts of the basin hydrologically connected?

Study Approach

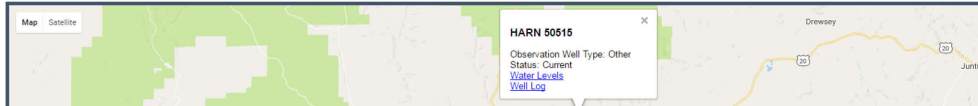
- Compile, review, and analyze existing hydrologic data
- Develop an understanding of the groundwater-flow system
- Collect additional hydrologic data in areas with gaps
- Develop hydrologic budget to estimate water flow in and out of the system
- Develop a numerical groundwater flow model to test our understanding of the flow system and evaluate management options

Compile existing hydrologic data

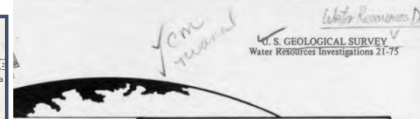
Oregon Water Resources Department
Harney County Observation Wells

Return to Search Page

- State Observation Wells
- HARN 9
- HARN 10
- HARN 75
- HARN 107
- HARN 130
- HARN 147



Hydrology of Malheur Lake, Harney County, southeastern Oregon



USGS and OWRD databases

Published hydrology reports

Driller's reports

Private data

PERMIT CONDITION WATER-LEVEL REPORTING FORM

Well owner: Name, Address, City/State/Zip, Phone/Fax/Cell, Email, Application: Permit, Certificate, Usual, Transfer

Your water right requires periodic static water-level measurements in your wells. Complete your permit or certificate to determine when measurements should be made, when reports are due, and who is allowed to make the measurements. Keep copies of all measurement reports for your records. All wells that have been contracted must be measured regardless of whether they are being used. Please contact the Department if you are no longer the holder of the right or no longer have an interest in it.

Other water rights that list this well: Complete one form for each well.

Application number(s), Permit number(s), Certificate number(s)

Identification of measured well (Provide as much information as possible): Water Resources Well Log ID, Well ID (Well Tag) on Well Log, Well ID (Well Tag) on Well Log-L, Start Card # on Well Log, Date drilled, Owner on well log, Casing diameter (inches), Date drilled, Owner on well log.

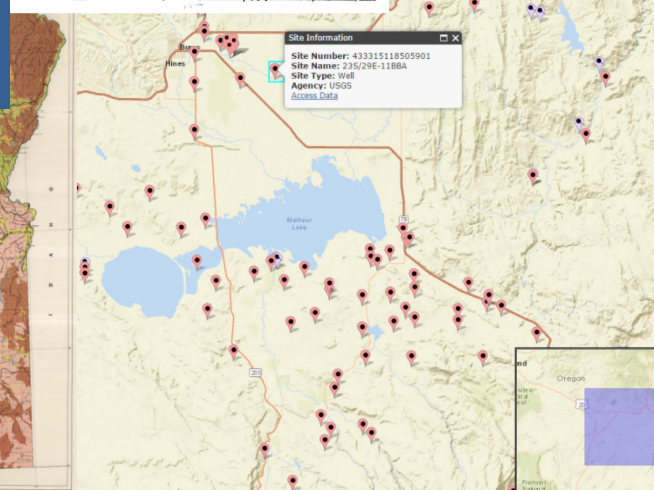
Well-Log Measurement: Date of measurement, Measurements should be made to at least the nearest tenth of a foot (0.1), the nearest inch (1/8") or the nearest percent of a foot or a pipe. Depth to water below measuring point, Measuring point height above/below land surface, Depth to water below land surface, Measurement Station, State, Pumping, Measurement Method, E-tape, Artesian, Other, Length of time well was idle prior to measurement, Measuring point description.

When did water use begin for this well under this permit? Month, Year

I hereby certify that the information on this report is accurate and represents the static water level in the well at the time of measurement.

Person making measurement (print): Department of measurement, Licensed number (include license type: CWRE, RG, PL, WWC, Pump Installer), Day-time phone number, E-mail address.

If you have any questions about this notice, please call the Measurement & Reporting Section of the Department at 503-986-8822. Before this Form for OWRD, Water & Ript Section, 729 Rosemary St., NE, Salem, OR 97304 is filed or issued as an application for a permit or certificate, it must be accompanied by the fee for the permit or certificate as set forth in ORS 473.005.



UN

GEOLO

OR



UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1939

HARNEY VALLEY,
HARNEY COUNTY, OREGON

BY
A. R. LEONARD
U.S. GEOLOGICAL SURVEY

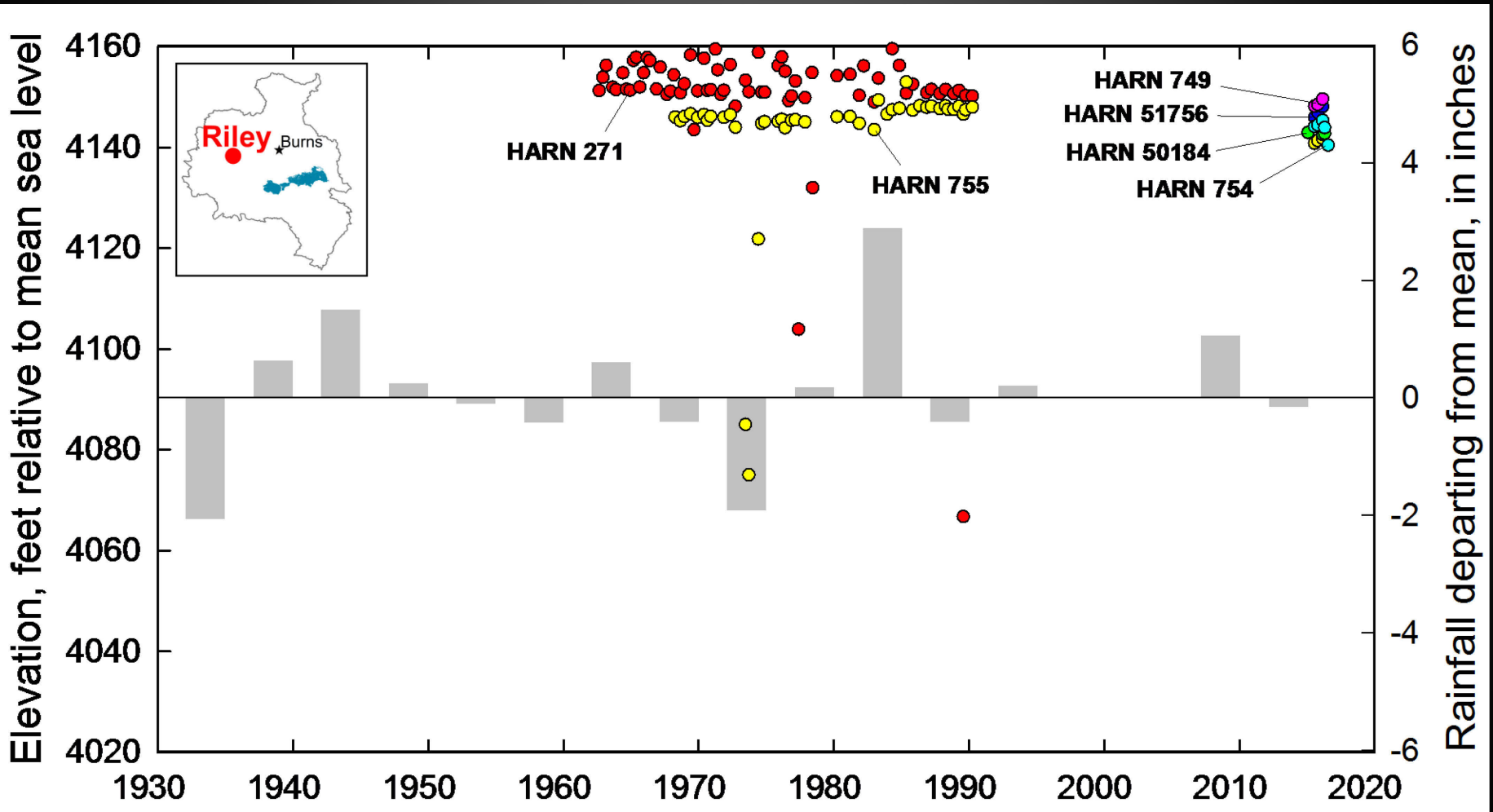


PREPARED IN COOPERATION WITH
THE UNITED STATES DEPARTMENT OF THE INTERIOR
AND HARNEY COUNTY COURT

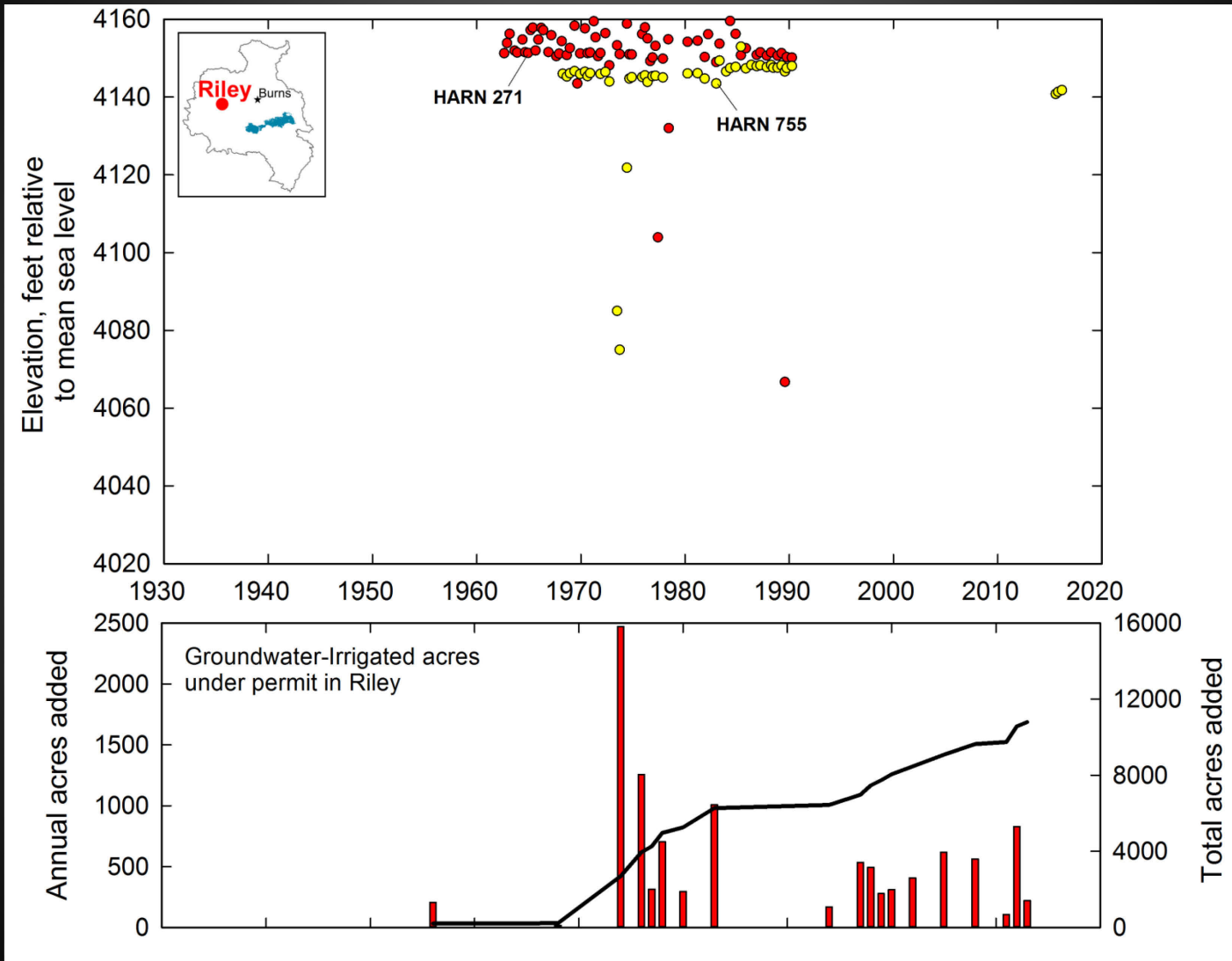
NOVEMBER, 1970



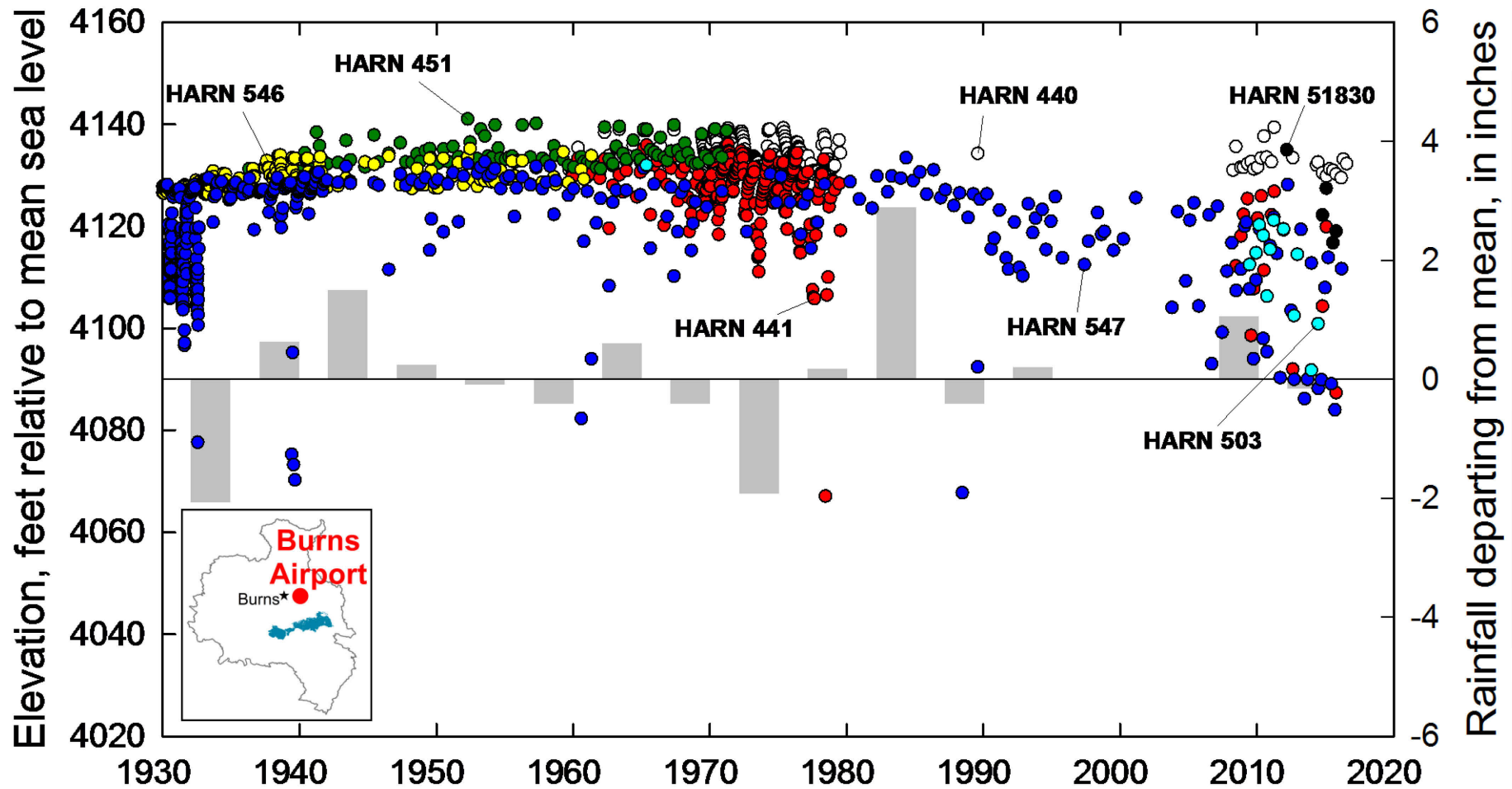
Harney Basin water levels



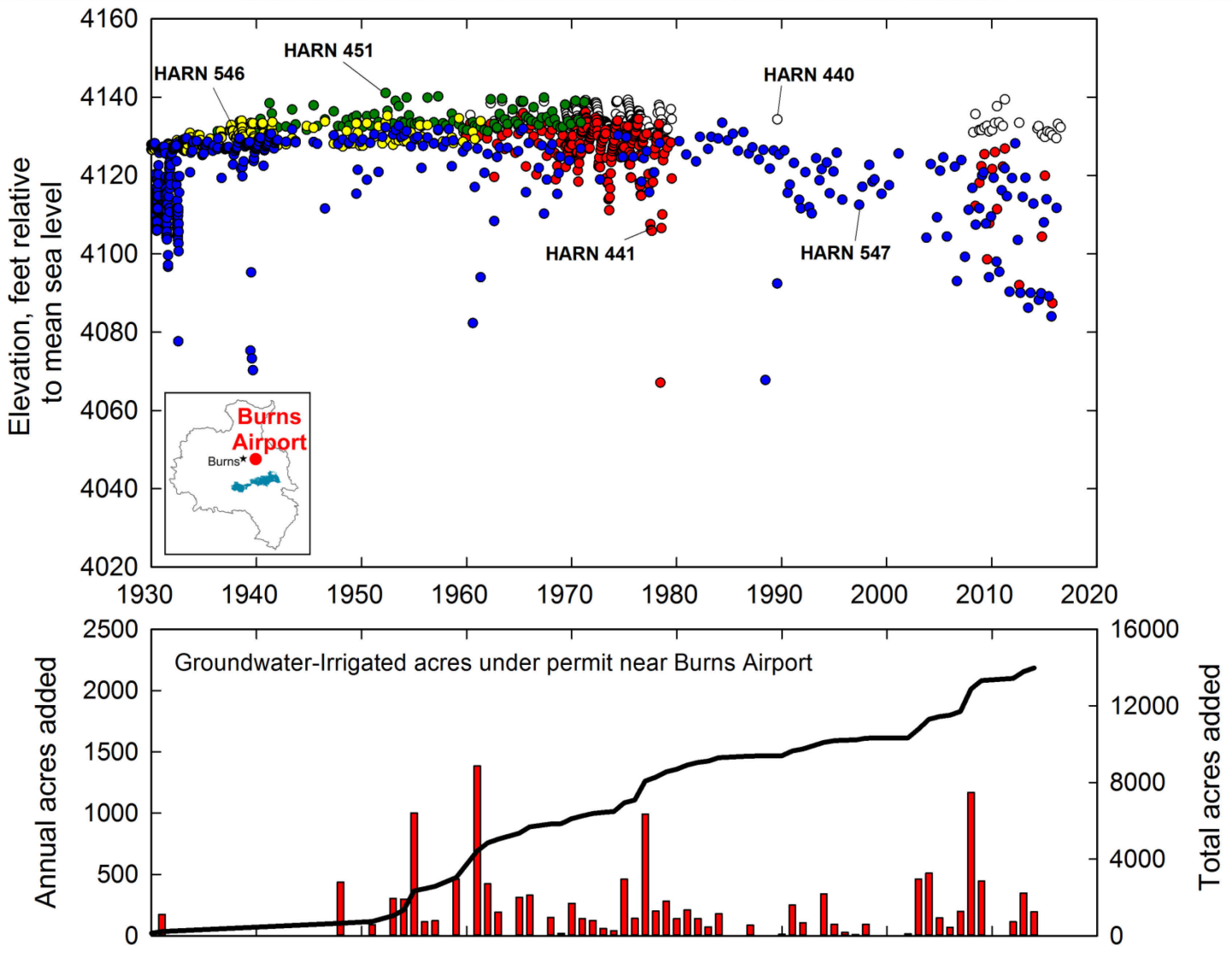
Harney Basin water levels



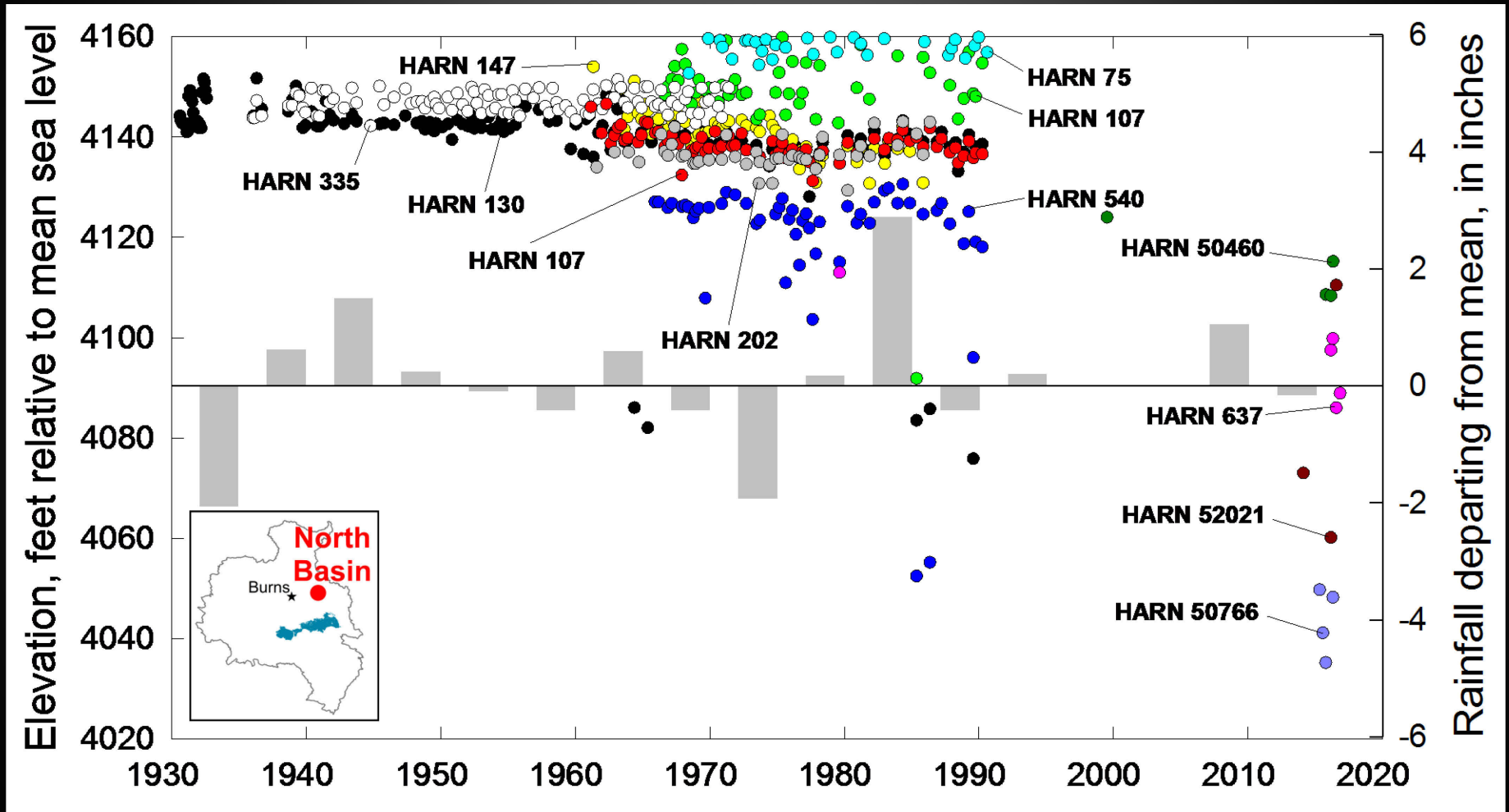
Harney Basin water levels



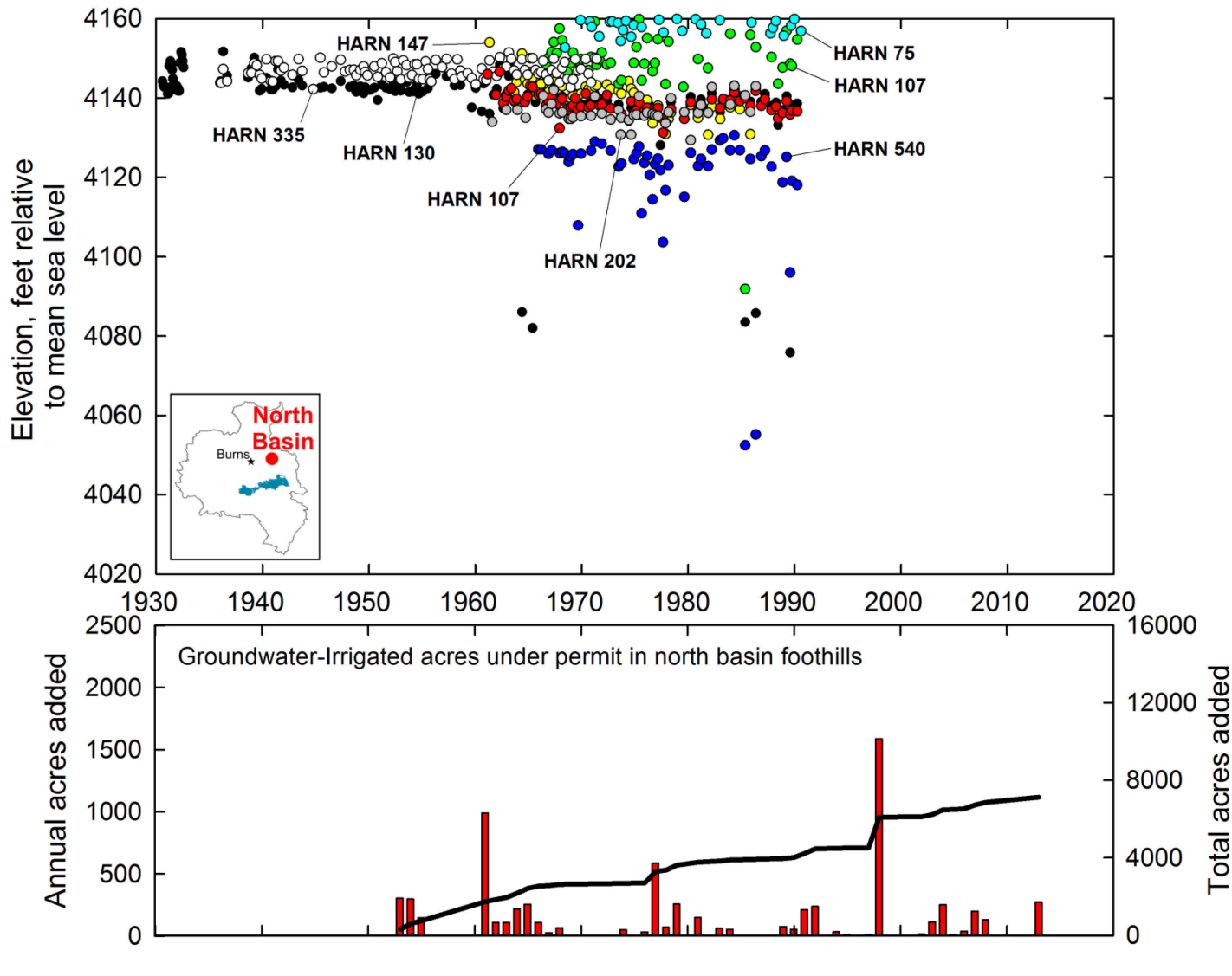
Harney Basin water levels



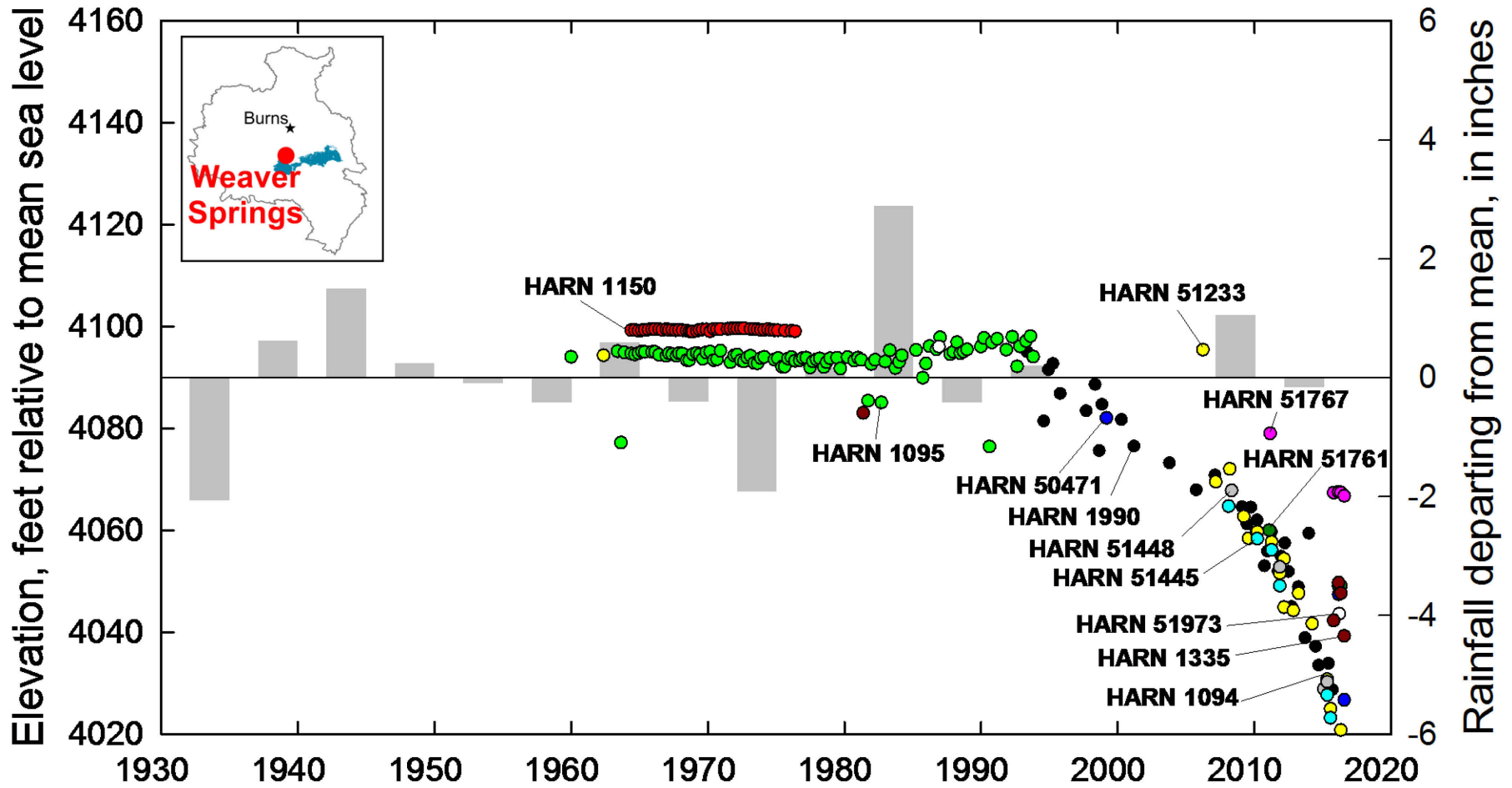
Harney Basin water levels



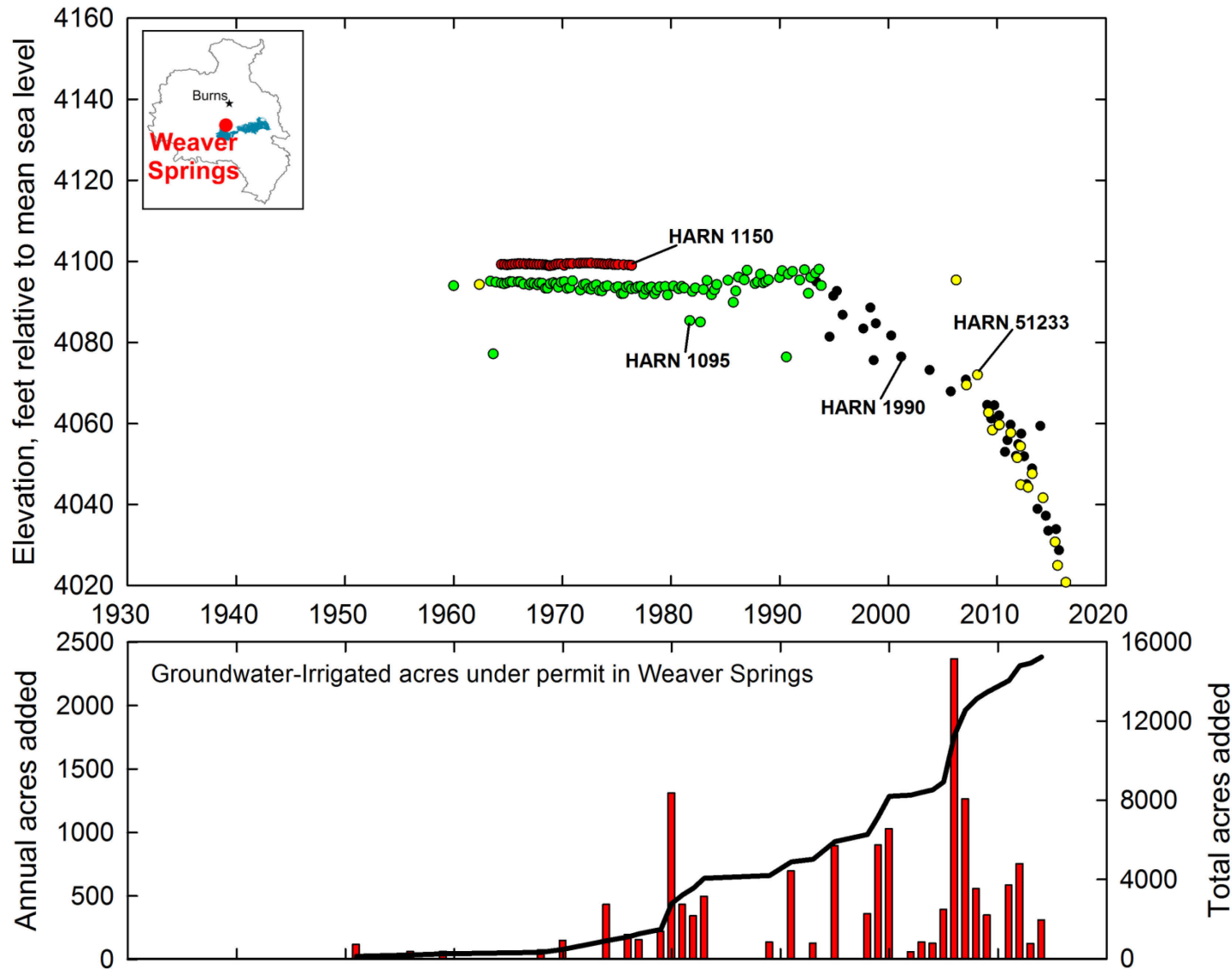
Harney Basin water levels



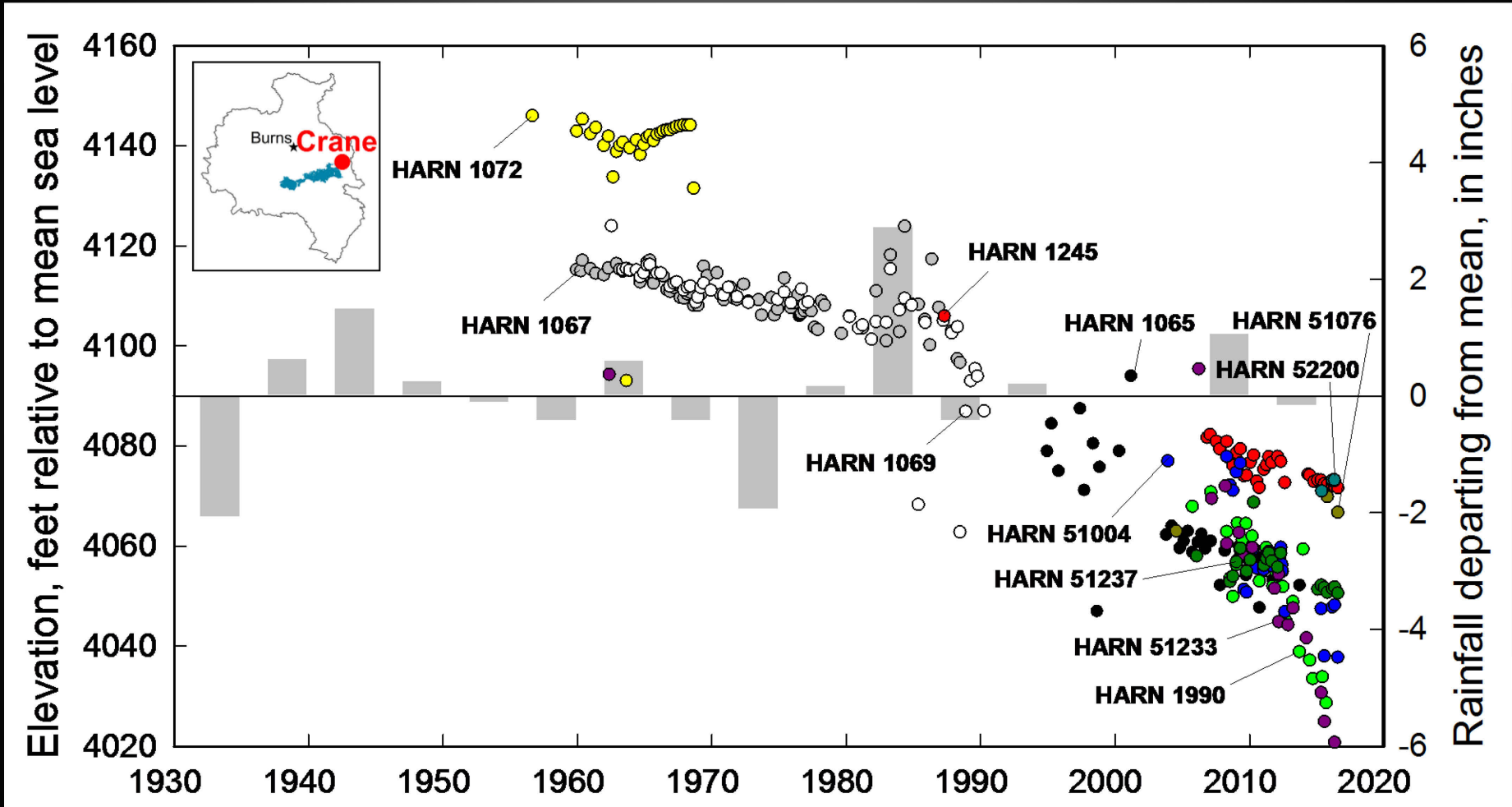
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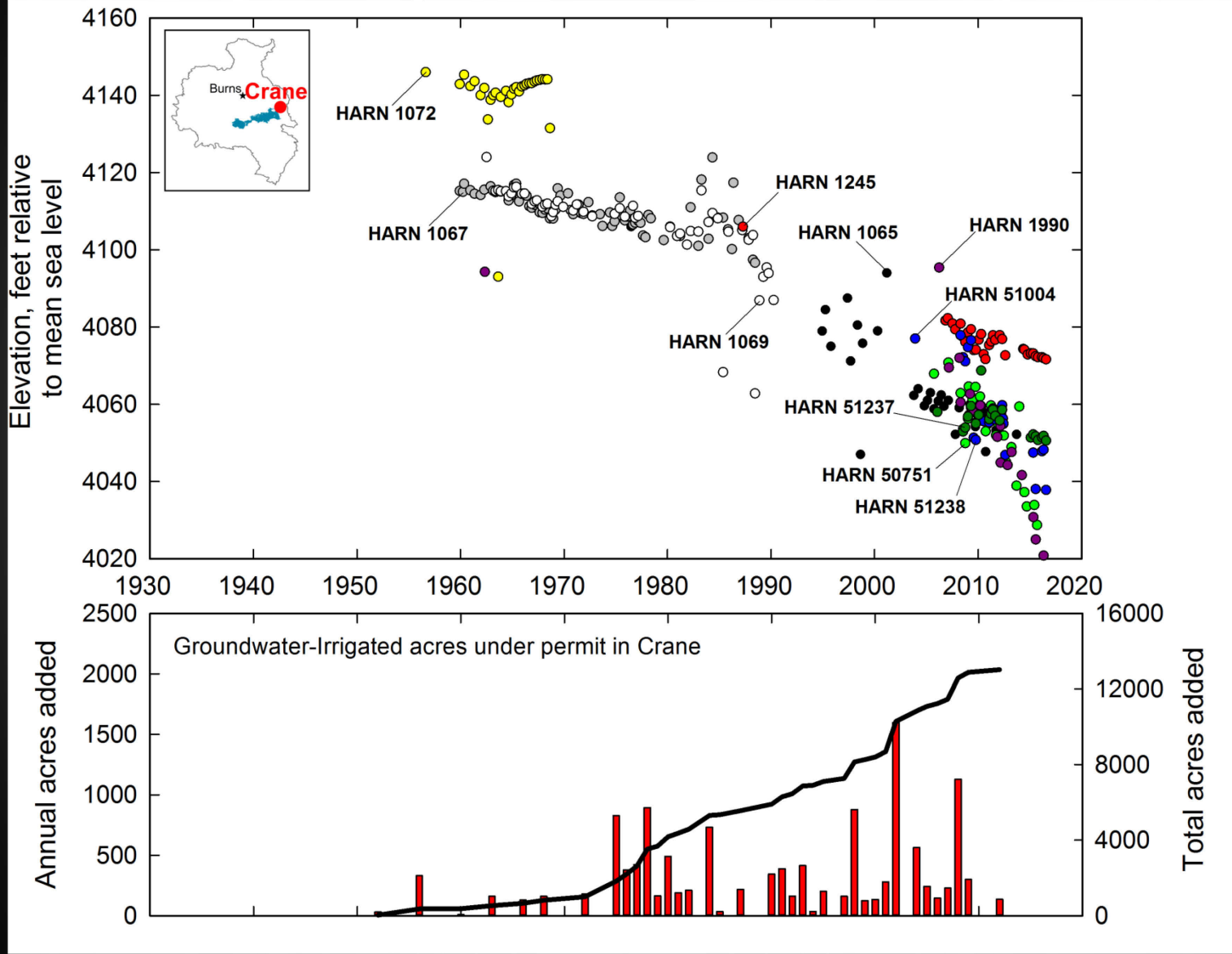
Harney Basin water levels



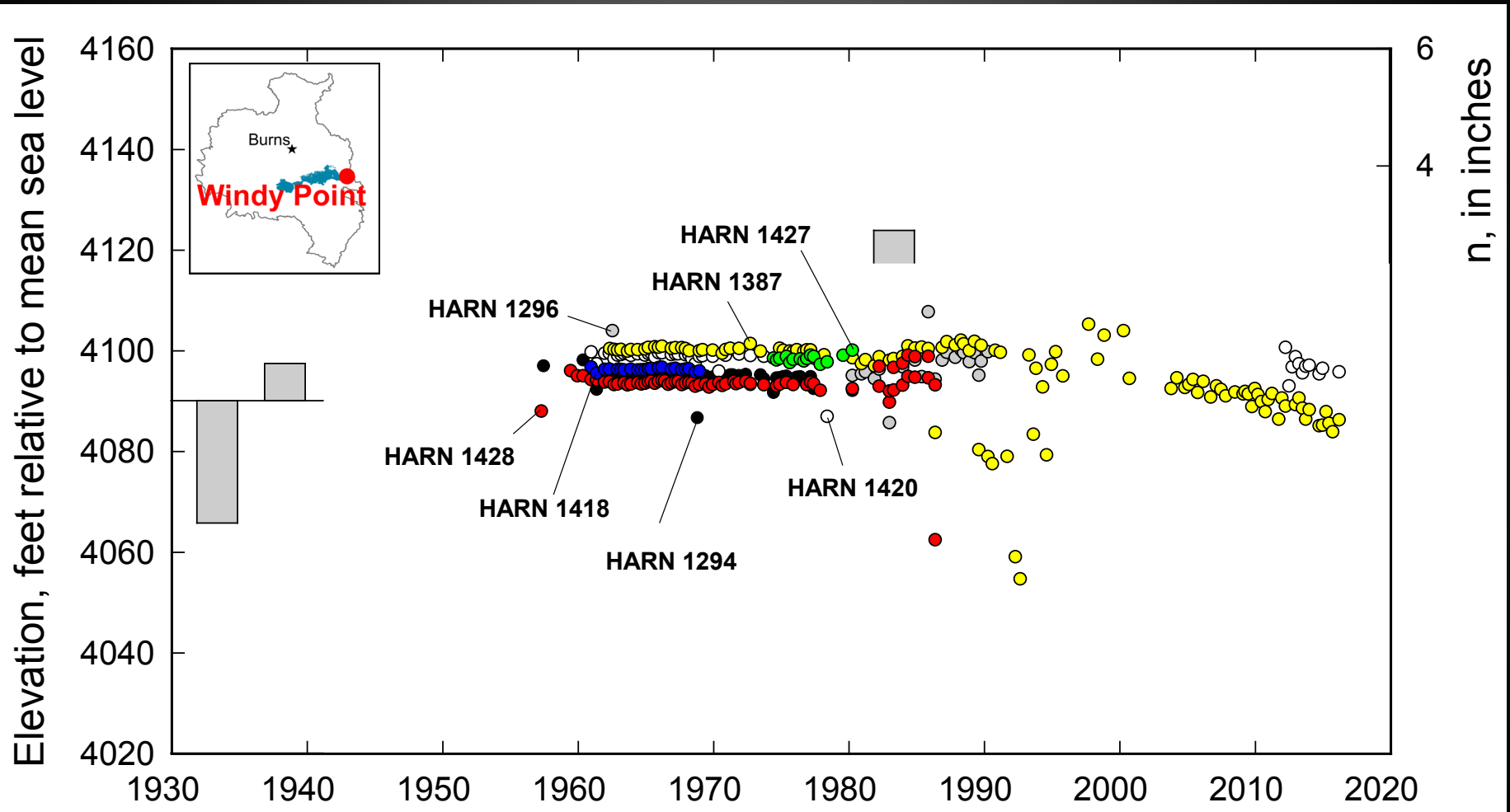
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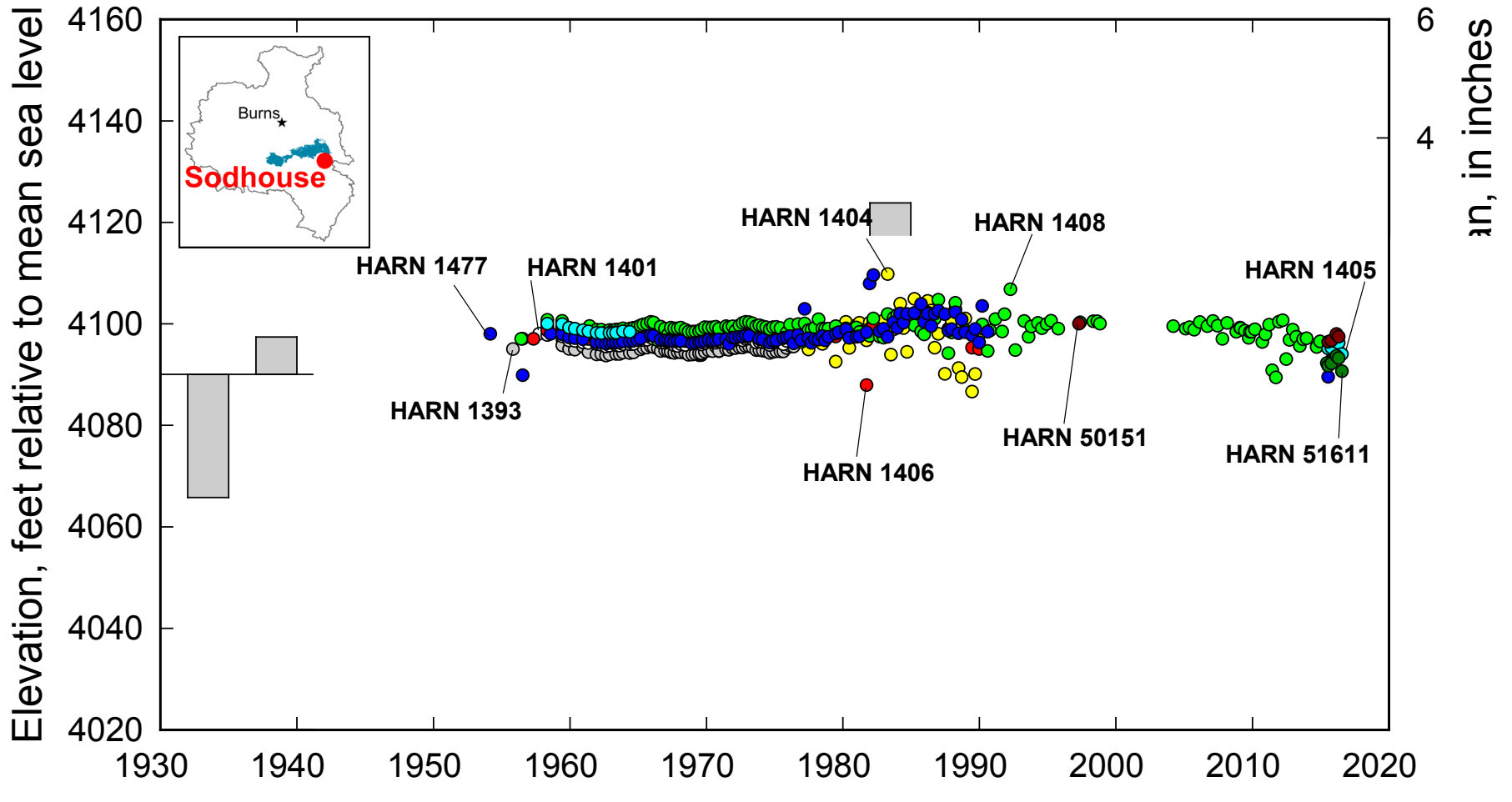
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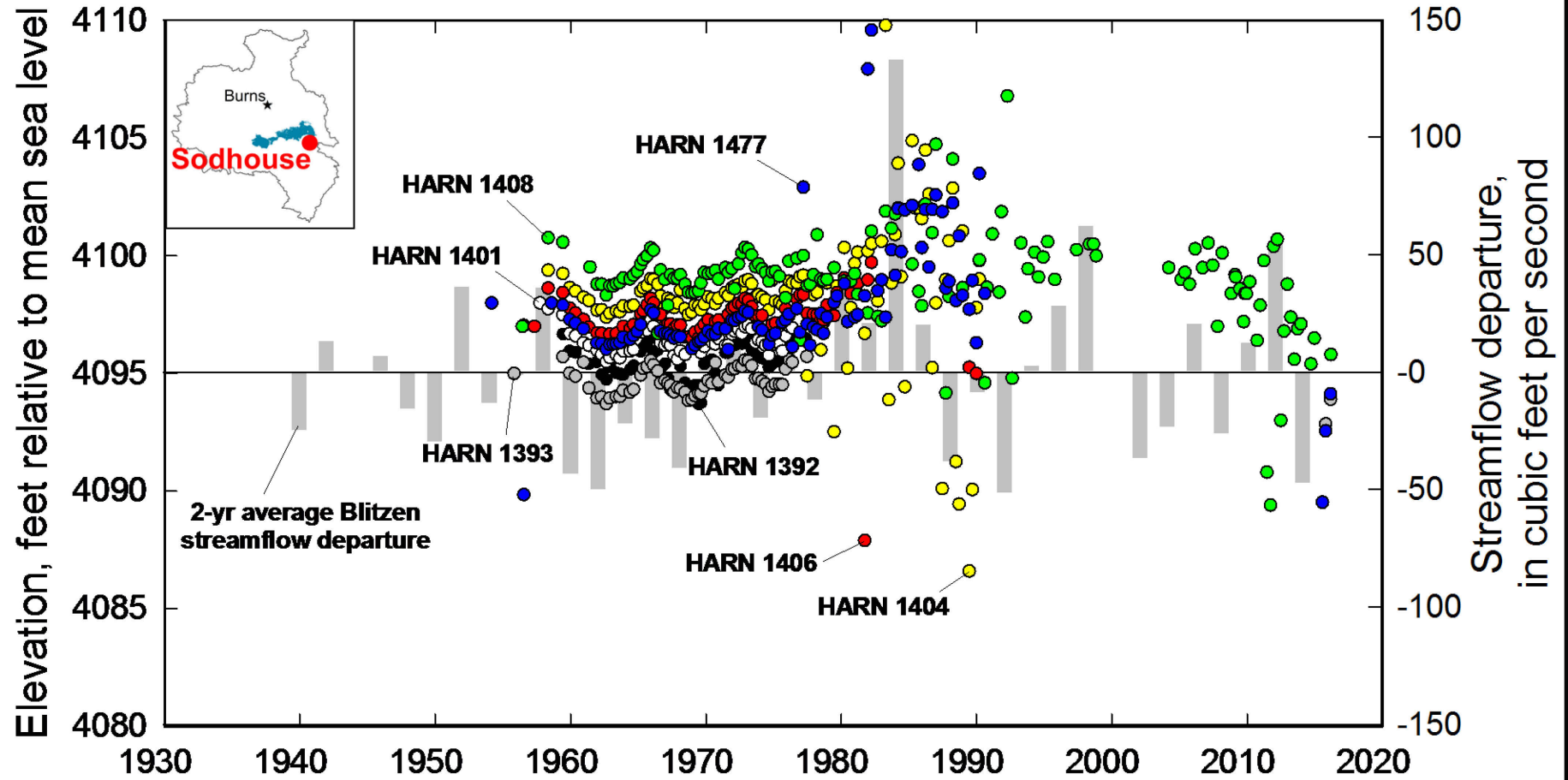
Harney Basin water levels



Harney Basin water levels



Harney Basin water levels



Next steps

- Continue developing hydrogeologic framework
- Develop and assemble water-budget components

End of Presentation