

Idaho Geological Survey Big Lost River Basin Groundwater budget (2000 -19)

Big Lost Modeling Technical Advisory Committee
Mackay, Idaho
May 17, 2023

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www.idahogeology.org

Big Lost River Basin— Hydrogeologic investigation publications

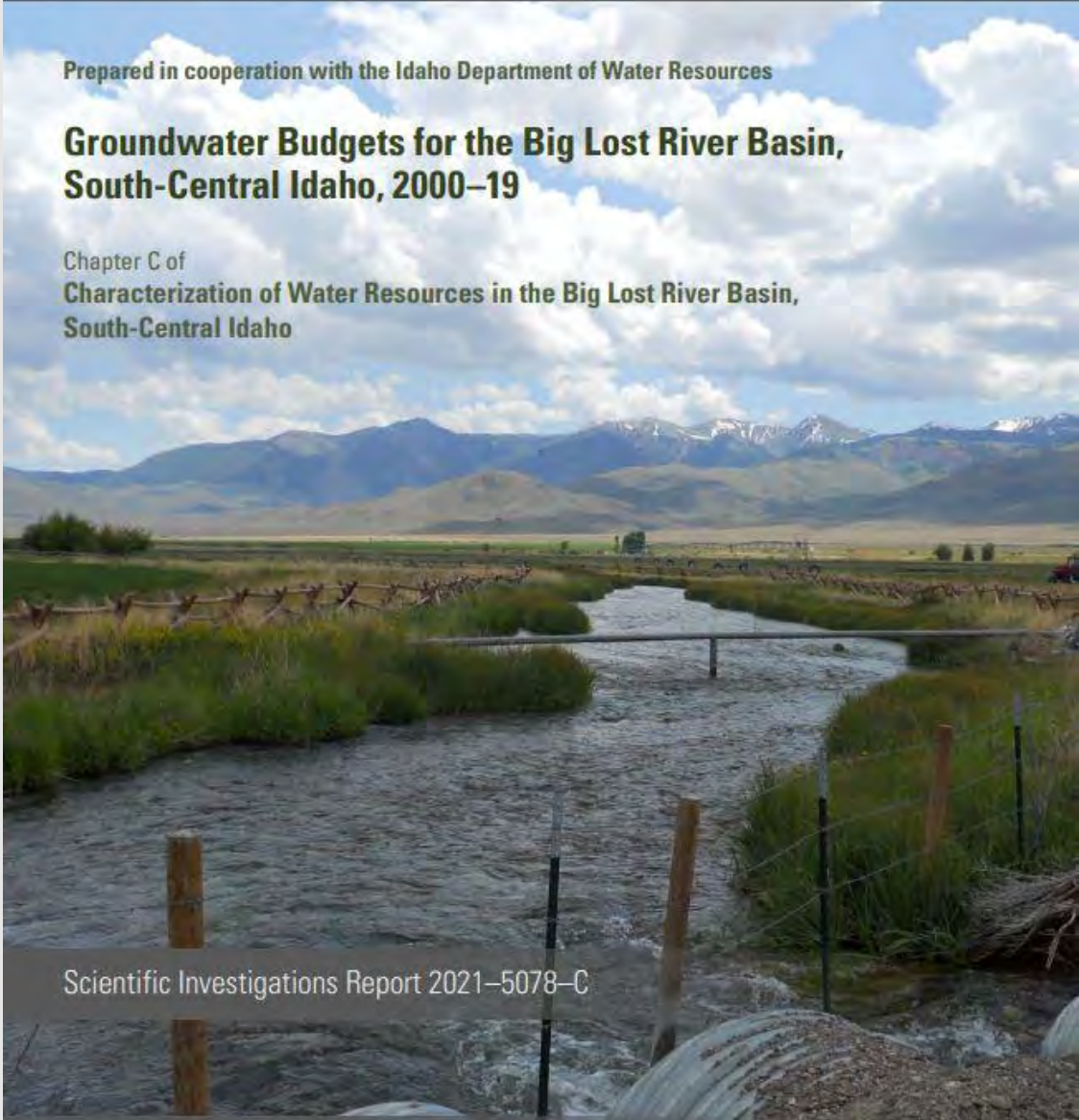
Report links

- USGS hydrogeologic framework:
<https://pubs.er.usgs.gov/publication/sir20215078A>
- USGS seepage study:
<https://pubs.er.usgs.gov/publication/sir20215078B>
- IGS groundwater budget:
<https://pubs.er.usgs.gov/publication/sir20215078C>
- IDWR reports:
<https://idwr.idaho.gov/water-data/projects/big-lost/hydrologic-investigation/>

Prepared in cooperation with the Idaho Department of Water Resources

Groundwater Budgets for the Big Lost River Basin, South-Central Idaho, 2000–19

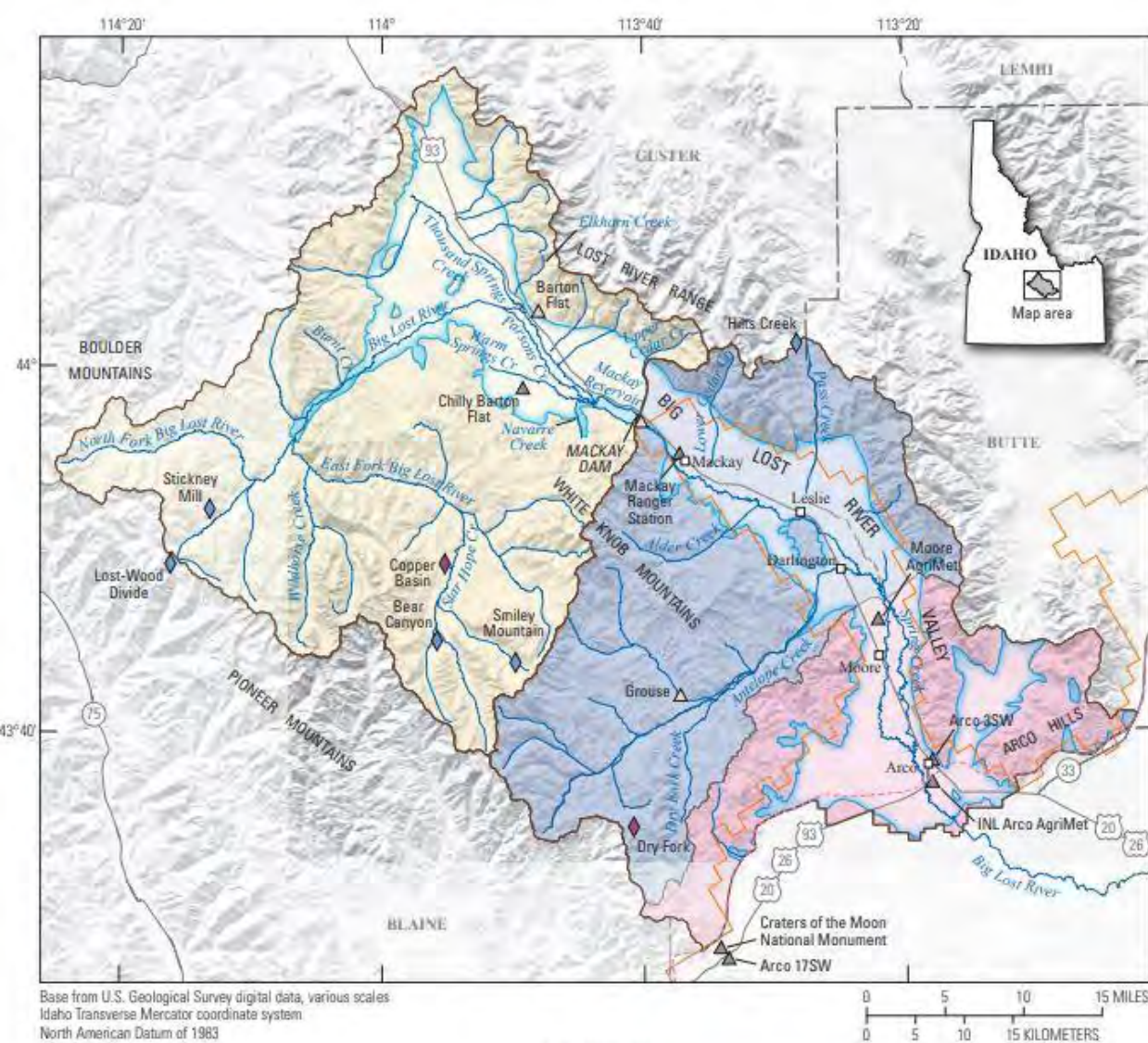
Chapter C of
**Characterization of Water Resources in the Big Lost River Basin,
South-Central Idaho**



Scientific Investigations Report 2021–5078–C

Groundwater budget considerations

- *Purpose:*
 - Provides a framework for subsequent numerical modeling
 - Supports decision making
- *Process:*
 - Identify predominant inflow and outflow components
 - Compile available datasets and quantify volumetric estimates
 - Evaluate the resulting budget adequacy
- *Limitations:*
 - Data gaps, requiring estimation
 - Neglects certain processes (i.e., sublimation, soil-moisture storage, transient stresses)
 - Results are not calibrated or verified

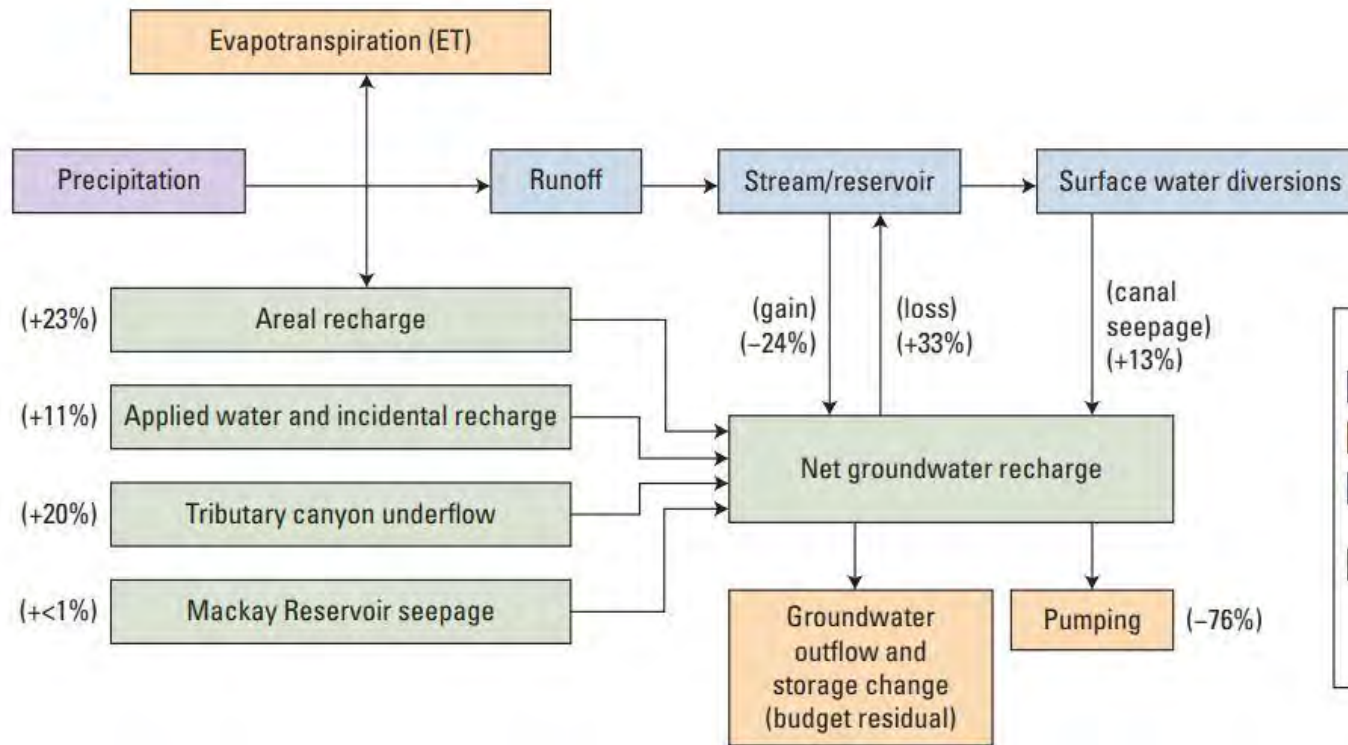


EXPLANATION

- Big Lost River Basin study boundary
- Subbasin**
 - Upper subbasin
 - Middle subbasin
 - Lower subbasin
- Eastern Snake River Plain aquifer (ESPA) numerical groundwater model boundary (IDWR, 2013a)
- - - Numerical groundwater model of INL (northern model boundary; Fisher and others, 2012)
- Groundwater budget aquifer extent derived for the study (from Lewis and others, 2012)
- Weather site (Bureau of Reclamation, 2016; Western Regional Climatic Center, 2020; National Oceanic and Atmospheric Administration, 2020)
- ▲ Arco 17SW Active
- ▲ Grouse Inactive
- ◆ SNOTEL site (Natural Resources Conservation Service, 2020)
- ◆ Dry Fork Snow course site (Natural Resources Conservation Service, 2020)

- Watershed scale – separate budgets above and below Mackay Dam
- 3 subbasins considered:
 - Upper (509,800 acres)
 - Middle (335,930 acres)
 - Lower (183,600 acres)
- 20-year groundwater budget (2000-19)
- Emphasis on dry (2014), wet (2017), and average annual conditions

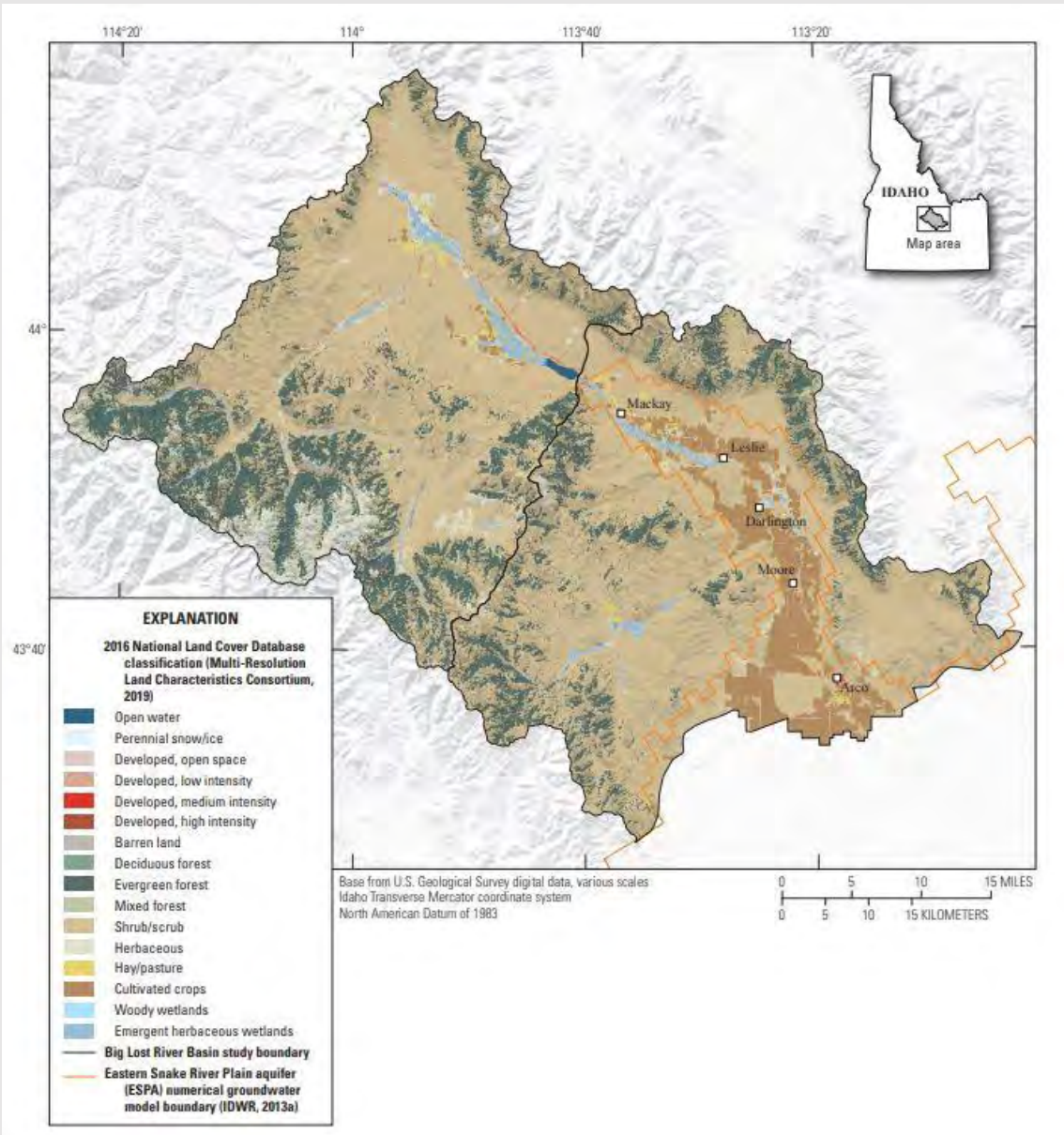
Groundwater budget components



EXPLANATION

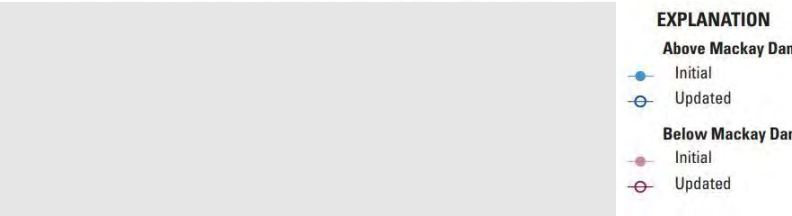
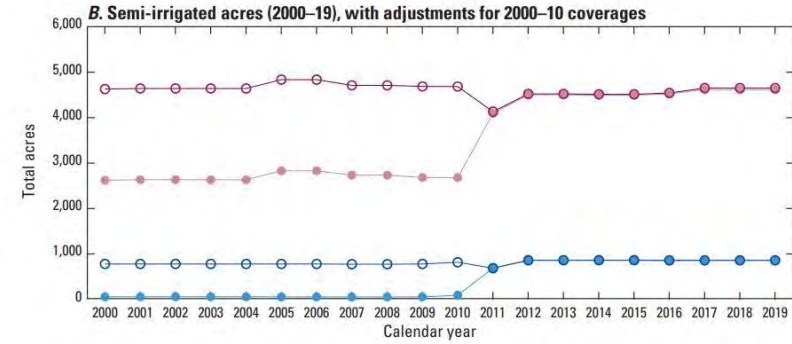
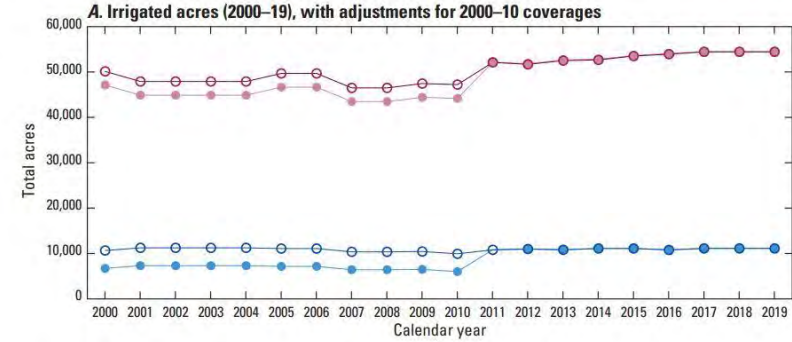
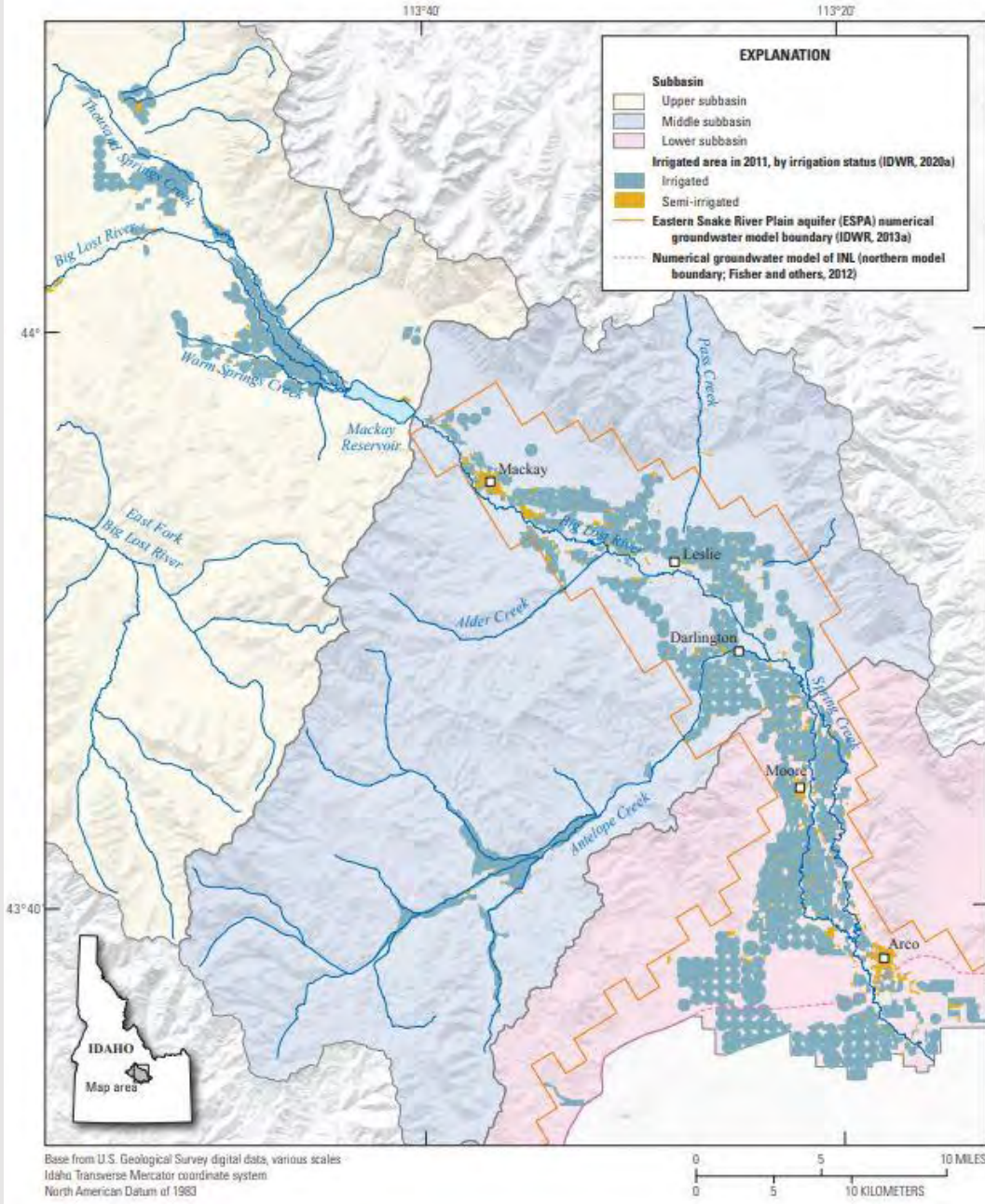
- Precipitation inflow term**
- Outflow terms**
- Surface water, including interaction with groundwater**
- Inflow components**
- < **Less than**
- % **Percent**

Land coverage



- *Data sources:*
 - NLCD – National Land Cover Database
 - CDL – CropScape Data Layer
- *Applications:*
 - Evapotranspiration
 - Areal recharge
 - Irrigation recharge
- *Limitations:*
 - Missing years
 - Assumed translation to ETIdaho categories

Irrigated lands



Precipitation

PRISM CLIMATE GROUP

Northwest Alliance for Computational Science and Engineering

Home Normals Comparisons This Month Prior 6 Months Recent Years Historical Past Projects Explorer FAQ

PRISM Climate Data

Website Update: Daily Map Graphics Generator

Our new web-based [Daily Map Graphics Generator](#) has been released. This tool allows users to generate up to a month's worth of daily map graphics at a time, on-the-fly, for any PRISM climate variable from 1981 to present. The graphics are always generated from the most up-to-date PRISM datasets. The tool also provides the option of including an animation (MP4 format) of the generated map graphics.

The PRISM Climate Group gathers climate observations from a wide range of monitoring networks, applies sophisticated quality control measures, and develops spatial climate datasets to reveal short- and long-term climate patterns. The resulting datasets incorporate a variety of modeling techniques and are available at multiple spatial/temporal resolutions, covering the period from 1895 to the present. Whenever possible, we offer these datasets to the public, either free of charge or for a fee (depending on dataset size/complexity and funding available for the activity).

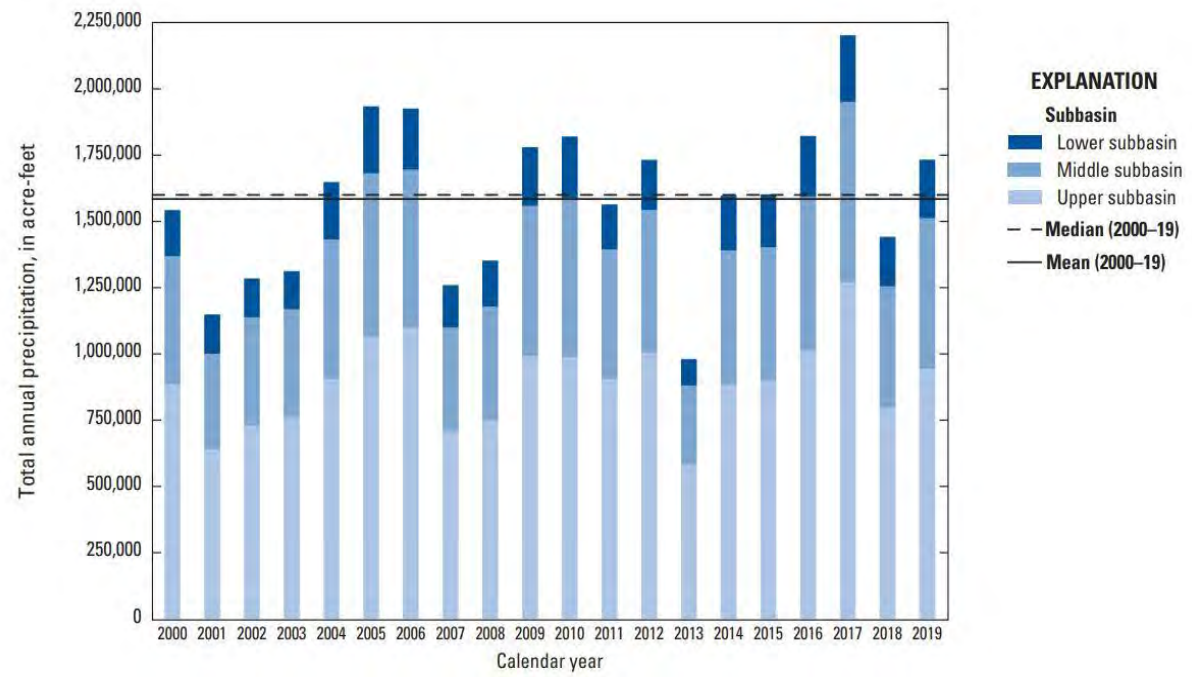
- Methods used by the [PRISM model](#)
- Descriptions of the [PRISM datasets](#)
- [How we developed the PRISM model](#)
- [Publications](#) about PRISM
- Calendar of PRISM [dataset updates](#)
- [What's new](#) at PRISM
- [PRISM-Updates mailing list](#)
- Help [improve PRISM data](#) as a citizen scientist
- [Daily map graphics generator](#)

Journal articles describing how we developed our daily precipitation grids and solar radiation normals are [now available!](#)

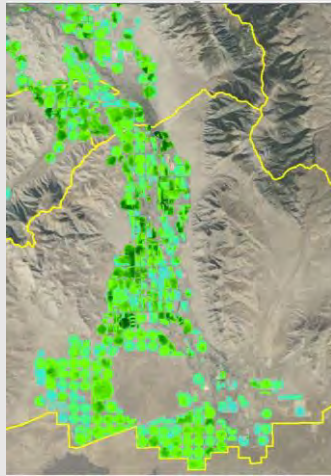
High Resolution Data Available

The native grid resolution of the PRISM datasets is 800m, but they have been filtered to 4km resolution for easier downloading and manipulation on this website. The 800m versions of all PRISM datasets, which contain 25x more information, are available to users for a fee. Details on availability, pricing, and ordering are found [here](#).

- *Data sources:*
 - Weather station datasets
 - PRISM Climate Group (4 km)
 - ETIdaho stations (areal recharge)
- *PRISM Results:*
 - Upper subbasin - highest precip
 - Lower subbasin – lowest precip
 - 2017 – highest year
 - 2013 – lowest year
- *Limitations:*
 - Neglects sublimation
 - Unmeasured precipitation (interpolated, estimated)



Evapotranspiration



University of Idaho
Kimberly Research and Extension Center

Water Resources Program
ETIdaho 2017
Evapotranspiration and Consumptive Irrigation Water Requirements for Idaho

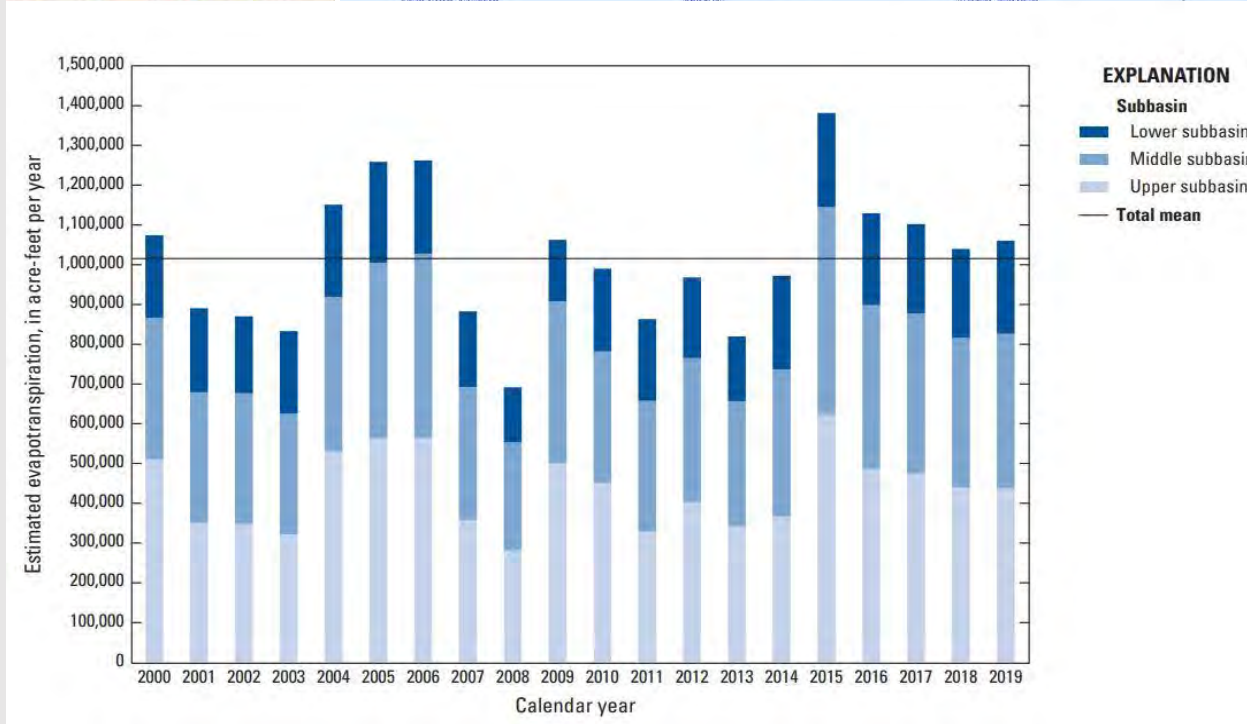
base send suggestions for improving this site to robbison at uidaho dot edu

2023-04-09 10:41

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Mackay RS

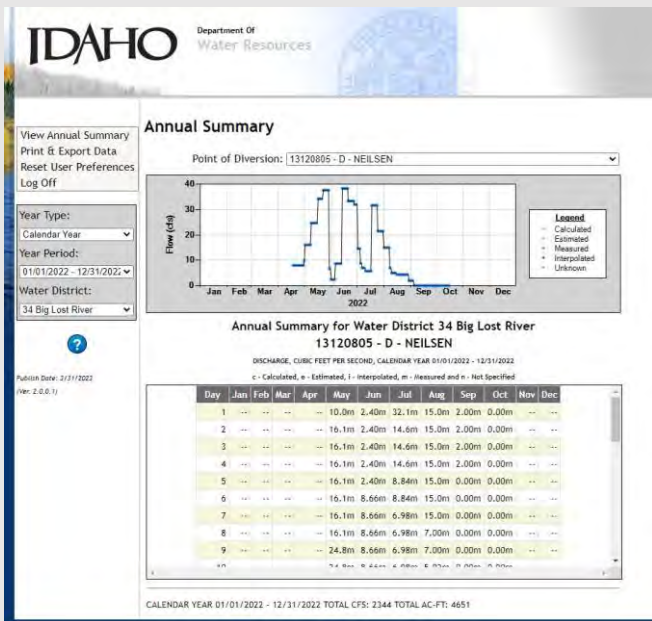
Station Type: NWS	Station Identifier: USCO095462	County: Goshute
Latitude: 43° 55' North	Longitude: 113° 37' West	Elevation: 5910
Start: Jan 1909	Stop: Dec 2016	Years with data: 92
Statistical summaries based on thirty year normal spans 1983 to 2016		
Wind Characterization from Arco, ID		
Neighboring stations based on Thiessen polygons		
-NA-		
Remarks: None		
Special Data Summaries		
Alfalfa Reference ET	20 Day Mean Temperature	Gross Precipitation
Land Covers with Evapotranspiration Estimates		
Managed land covers (crops) are assumed to be irrigated for this station unless otherwise specified.		
Alfalfa - peak (no cutting effects)	Alfalfa - frequent cuttings	Alfalfa - less frequent cuttings
Grass Hay	Silage Corn - truncated season	Sweet Corn - early onset
Sweet Corn - late start	Soybean Grain - Irrigated	Soybean Grain - Rainfed
Winter Grain - Irrigated	Winter Grain - Rainfed	Grass Pasture - high management
Grass Pasture - low management	Grass - Turf (lawns) - Irrigated	Grass - Turf (lawns) - Rainfed
Sacred Vegetables - general	Potatoes - heavy harvest	Potatoes - late harvest
Safflower - irrigated	Safflower - Rainfed	Cashew
Asparagus	Rice Soil	Mulched soil (including grain stubble)
Dormant Turf (winter limit)	Berries Grapes - early/late season	Berries Grapes - late season
Rainier Grasses - Bromegrass	Bare Brush	Wetlands - knee stands



- **Data sources:**
 - METRIC (IDWR)
 - ETIdaho (UI)
- **Results:**
 - Mean 1,015,200 ac-ft
 - Lowest (in 2008) 692,000 ac-ft
 - Highest (in 2015) 1,381,700 ac-ft
 - 0.9 ac-ft/ac – upper basin
 - 1.1 ac-ft/ac – middle/lower basins
- **Limitations:**
 - Interpolation effects
 - Surrogate year assumptions
 - Assigned land category and crop type

Surface-water diversions and return surface-water flows

- Data sources:**
 - IDWR surface-water diversion database (115 locations)
 - WD34 (Pivotrac) surface-water return flows (East Side Ditch and Burnett Canal)
- Methods:**
 - Data compilation
 - Linear regression – unmeasured surface-water diversions
- Results:**
 - Higher utilization of surface water above Mackay Dam compared to below (90% in upper subbasin; 65% in middle subbasin; 55% in lower subbasin)
 - Highest diversions in wettest years*
- Limitations:**
 - No SW div records above Mackay Dam or Antelope Creek (2000-02)
 - Limited return flow datasets



Pivotrac Monitoring
(800) 244-2298

summary | map | oil | pumps | reports | my profile | farm notes | my profile | contact | rain page | logo

summary for Water District 34

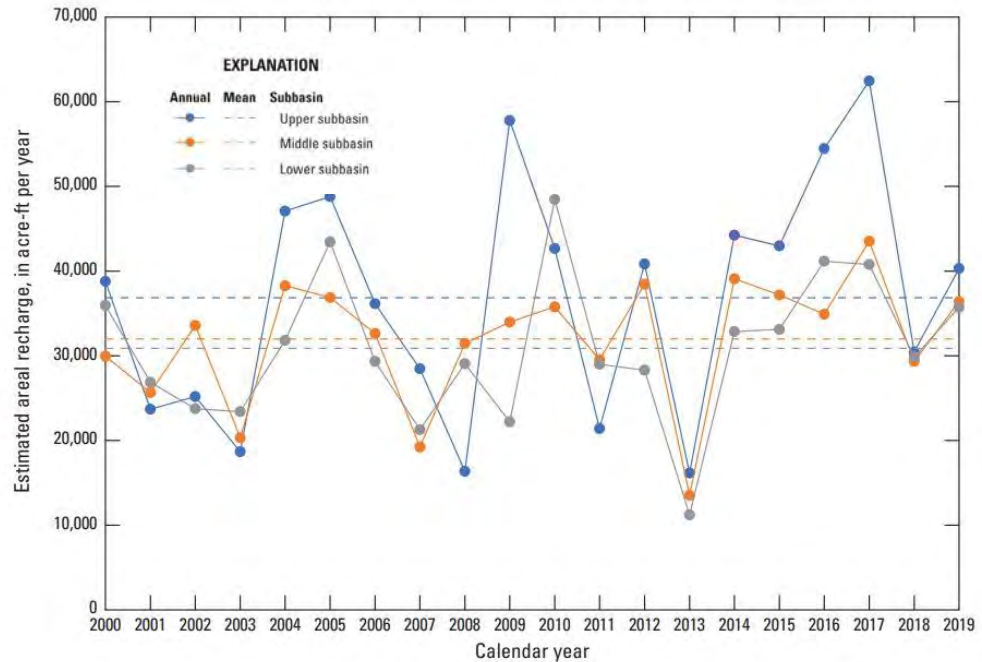
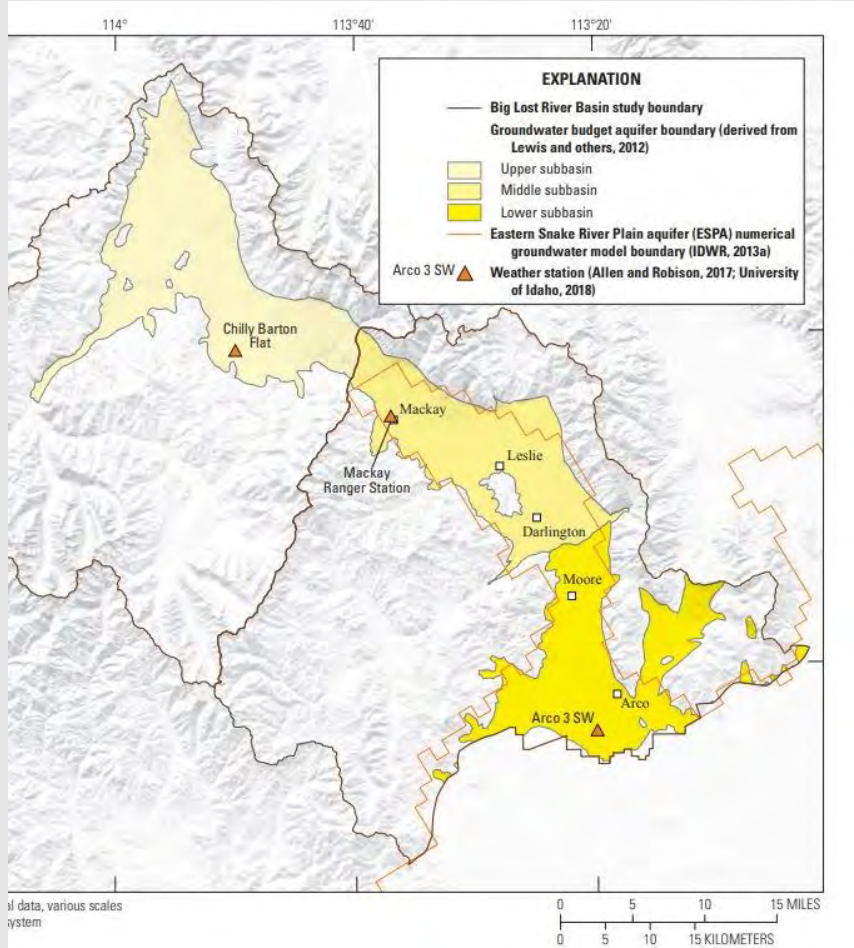
site	status	mode	level	CF/S	MCF Total	Avg CF/S Yesterday	Type
Antelope Hwy	normal	--	65.0	0.00	0.0	0.0	Rectangular Weir
Arco	normal	--	32.7	0.00	0.0	0.0	Rectangular Weir
Arco T.E.	high	--	--	--	--	--	Trapzoid Weir
Burnett	normal	6.22 ft	531.0	45.91	533.0	0.0	Trapzoid Weir
Burnett T.E.	normal	--	61.2	0.00	0.0	0.0	Cippolet Weir
Darlington T.E.	normal	2.27 ft	51.8	4.41	54.0	0.0	Rectangular Weir
East Side In	normal	--	424.5	36.28	1854.1	0.0	Trapzoid Weir
East Side Out	normal	--	138.5	0.00	0.0	0.0	Rectangular Weir
Moore-backup	normal	--	--	--	--	--	Rectangular Weir
Moore T.E.	normal	--	--	--	--	--	Rectangular Weir
Nelson	normal	0.0 ft	0.0	0.00	0.0	0.0	Rated Section
Hunsy	normal	1.70 ft	86.0	7.84	91.2	0.0	Rectangular Weir
Hunsy T.E.	normal	1.63 ft	32.5	2.79	40.0	0.0	Rectangular Weir
Sirvauger	normal	2.03 ft	62.7	3.35	56.7	0.0	Parshall Flume
Sirvauger T.E.	high	1.94 ft	23.6	2.04	23.4	0.0	Rectangular Weir
Sharp	normal	1.47 ft	37.0	3.20	37.2	0.0	Parshall Flume
Beck	normal	--	--	--	--	--	Rectangular Weir
Island	normal	--	48.4	0.00	0.0	0.0	Rectangular Weir
Chilly	normal	0.68 ft	28.9	2.64	38.9	0.0	Rectangular Weir
Felton	normal	--	12.6	0.00	0.0	0.0	Rectangular Weir
Jenson	normal	1.20 ft	29.6	2.69	31.3	0.0	Rectangular Weir
West Side Moore	normal	0.17 ft	2.9	7.97	238.5	0.0	Rectangular Weir
West Side W	normal	1.41 ft	34.6	3.76	45.7	0.0	Parshall Flume
West Side E	normal	1.62 ft	43.0	3.72	42.3	0.0	Parshall Flume
Coburn Spgs	normal	--	2.2	0.00	0.0	0.0	Parshall Flume
Moore	high	1.60 ft	--	--	--	--	Rectangular Weir
Darlington A	normal	7.6	0.00	0.0	0.0	0.0	Trapzoid Weir
manual override	low	--	--	--	--	--	Trapzoid Weir

site	function	last value	units	lowest value	highest value	role
Moore D.W.	Static Water Level	47.51	Feet	47.51	47.51	0.00
Chilly D.W.	Static Water Level	51.89	Feet	50.67	52.14	0.03
E. Mackay	Static Water Level	-340289200000000000014192072600942972764160.00	Feet	77.08	85.61	0.00
W. Mackay	Static Water Level	12.77	Feet	10.69	12.70	0.00



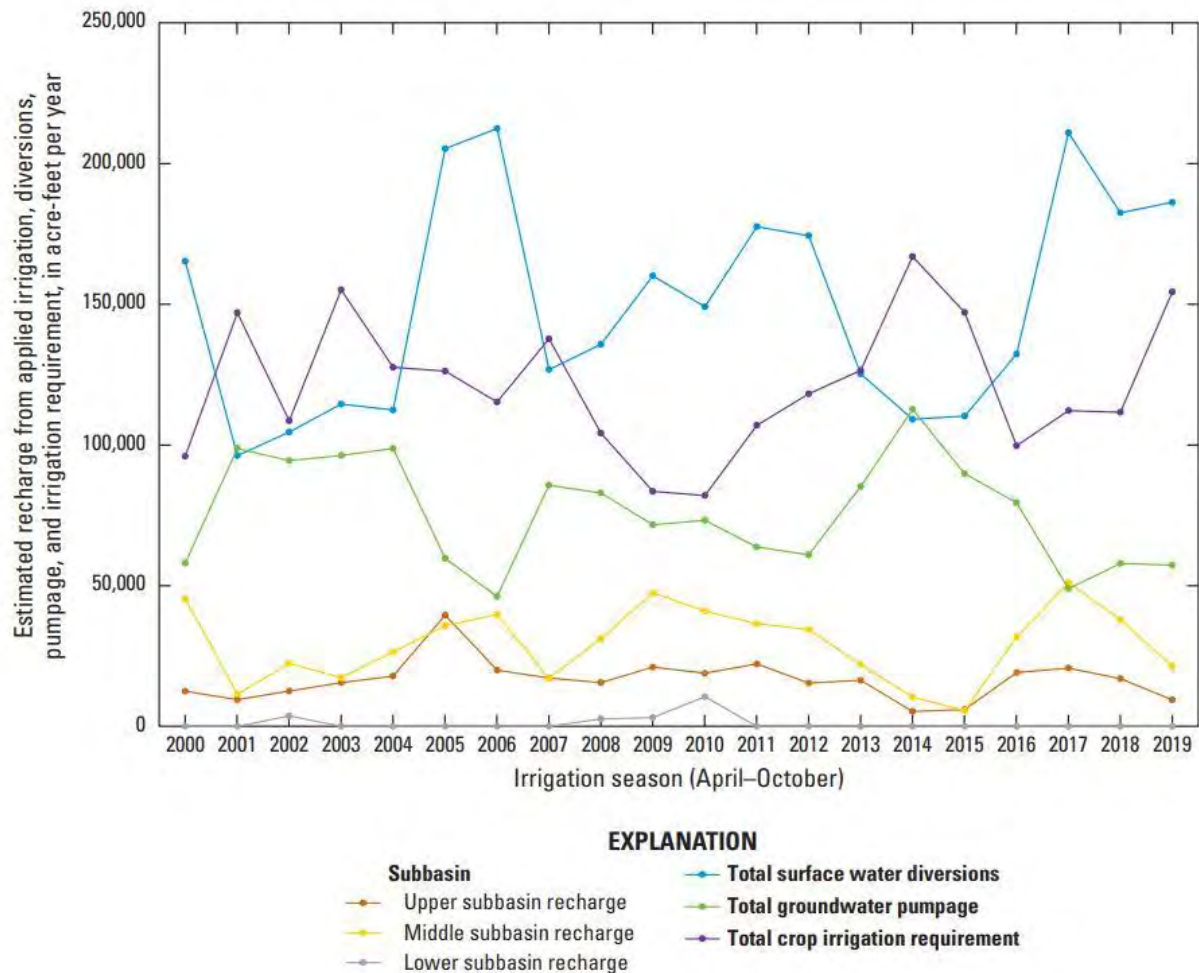
Sharp Canal (IGS, 2019)

Inflow – Areal recharge



- *Data sources: ETIdaho (UI), modified aquifer extent (IGS)*
- *Methods: (Precip) – (ET) – (Surface runoff)*
- *Results:*
 - *~ 100,000 acre-ft/yr (2000-19)*
 - *4.4 in/yr above Mackay Dam; 4.9 in/yr below Mackay Dam*
- *Limitations: 2017- 2019 terms estimated from linear regression; neglects soil moisture*

Inflow – Applied irrigation recharge

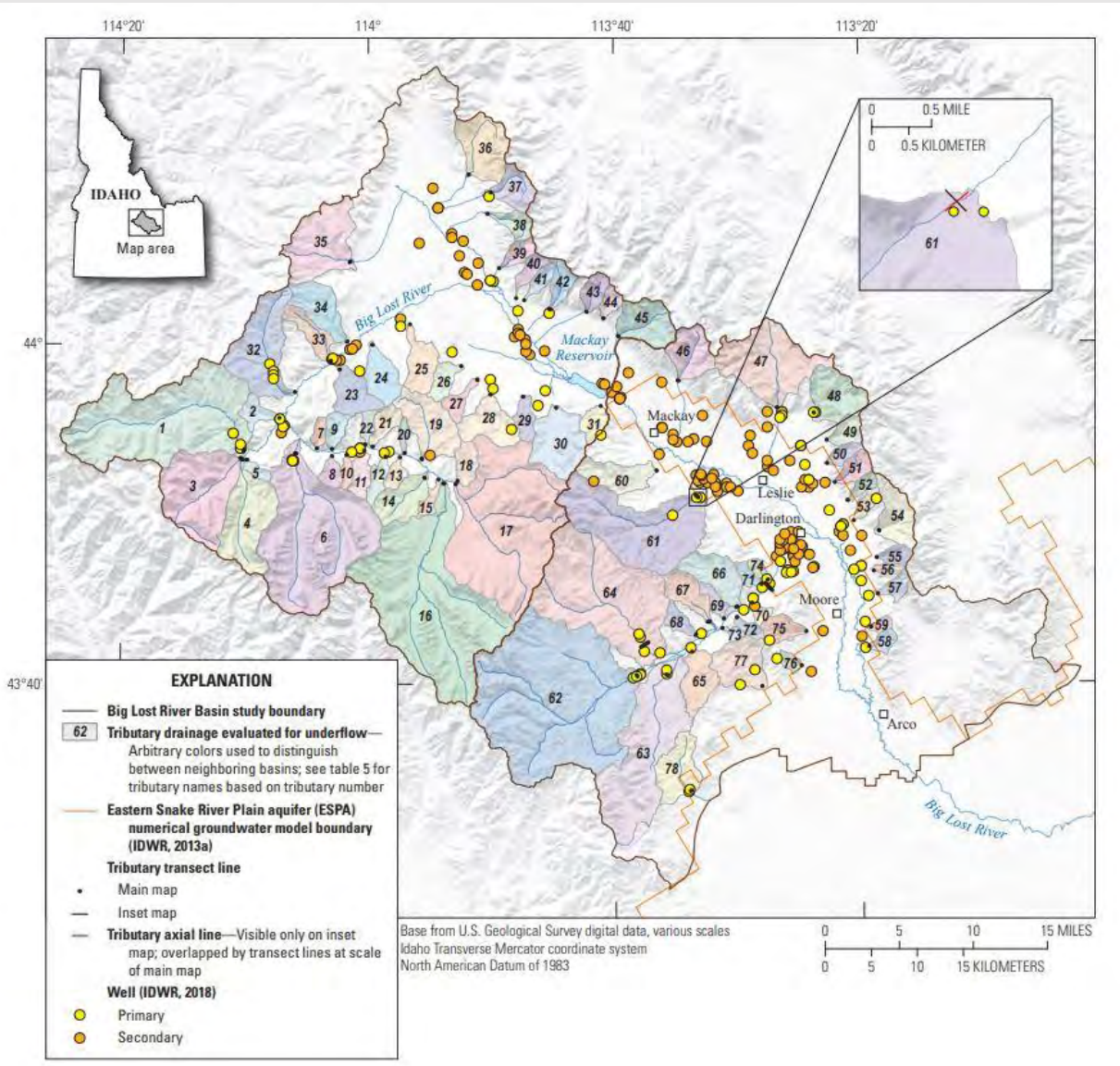


- **Data sources:**
 - IDWR: (Divsw, GW pumpage, irrigated lands, METRIC, ditch rider logs, storage balance spreadsheets)
 - UI: ETIdaho
 - Pivotrac: return flows
 - PRISM Climate Group: precip
- **Methods:**

$$Q = \text{Divsw} + \text{Divgw} - \text{Retsw} - \text{Canalseep} - \text{CIR}$$

[Irr and semi-irr lands]
(Apr – Oct)
- **Results:**
 - 16,600 ac-ft/yr (above Dam)
 - 30,300 ac-ft/yr (below Dam)
- **Limitations:**
 - Uncertainty due to unmeasured parameters

Inflow – Tributary canyon underflow



• Data sources:

- Tributary delineation (USGS StreamStats)
- Precipitation (PRISM)
- Well lithology (IDWR)
- 1 aquifer test (USGS)

• Methods:

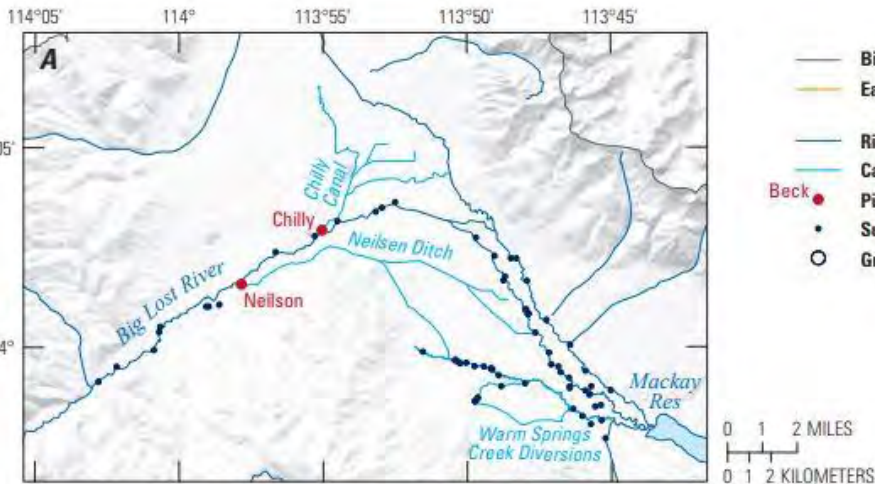
- Tributary delineation
- Darcy's Law ($Q = KA \frac{dh}{dz}$)
- Annual precipitation adjustment (all canyons)
- Small canyon scaling-factor adjustment

• Results (mean annual, acre-ft/yr):

- Upper = 50,900
- Middle = 34,700
- Lower = 3,000

• Limitations:

- Results highly sensitive to estimated input terms

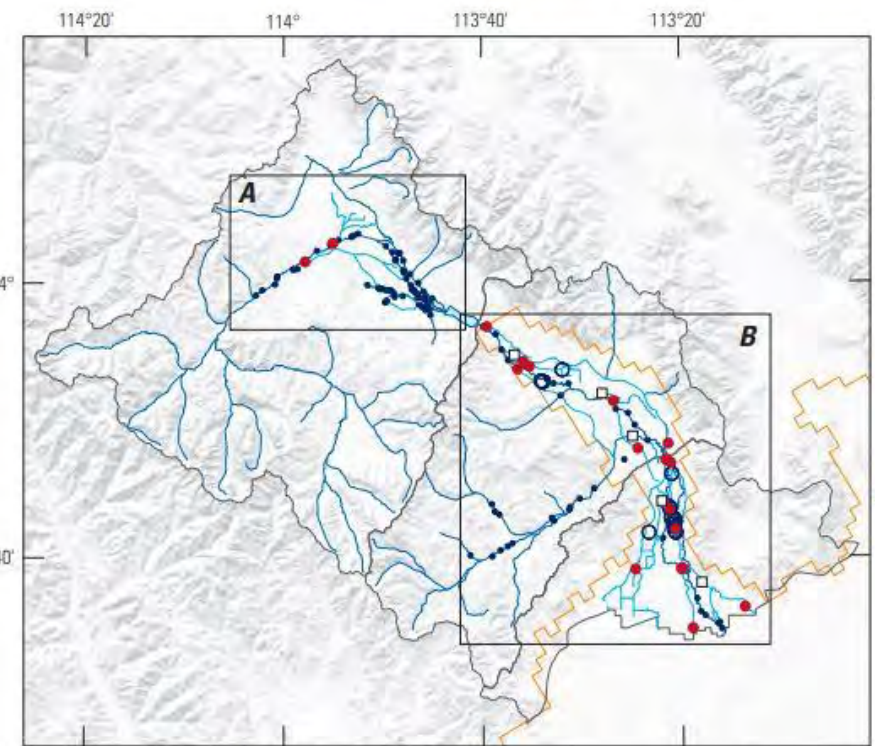


EXPLANATION

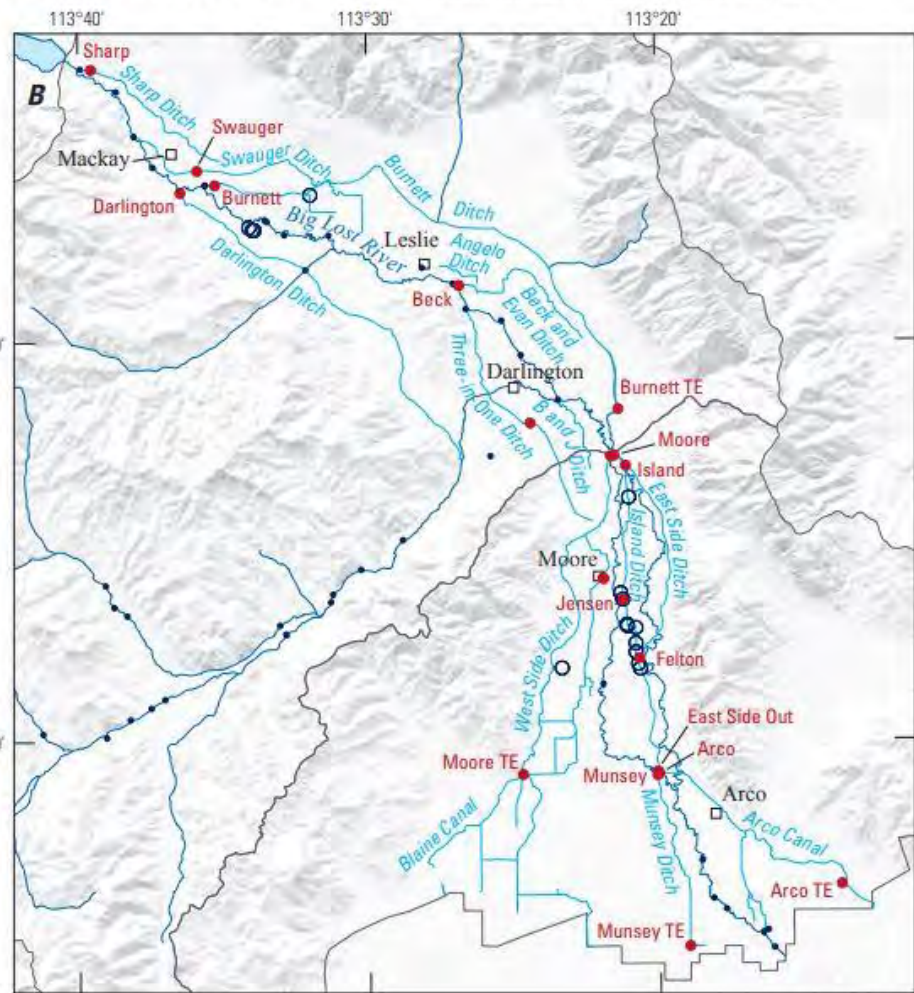
- Big Lost River Basin study subarea
- Eastern Snake River Plain aquifer (ESPA) numerical groundwater model boundary (IDWR, 2013a)
- River
- Canal
- Beck Pivotracs site (location approximate)
- Surface-water diversion (IDWR, 2022a)
- Groundwater well (pumpage to canals; IDWR, 2020d)

Pivotracs Monitoring, <http://www.pivotrac.com/>, contracted to Water District 34, unpub. data, 2021—data available upon request from Water District 34 watermaster, Lucas Yockey, at 208-589-3138

GIS coverage for some canals, not included on the U.S. Geological Survey base, is from D. Hoekema, IDWR, unpub. data, 2018—data available upon request from IDWR, Idaho Water Center, Boise, Idaho, at <https://idwr.idaho.gov/contact-us/> or 208-287-4800.

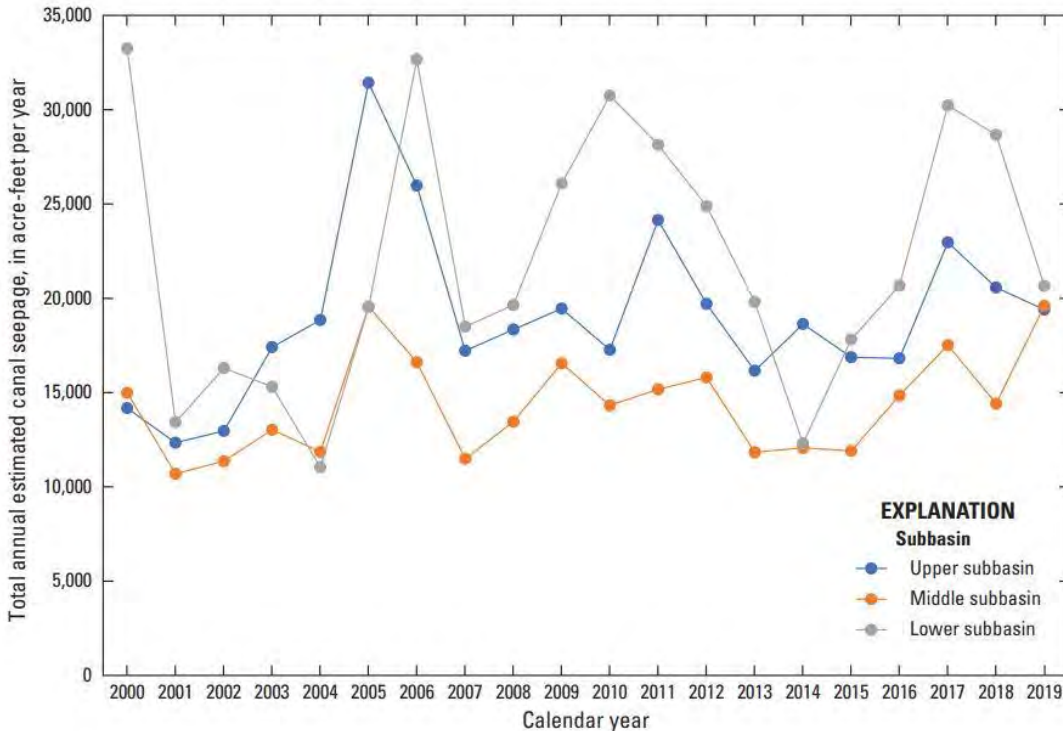


Base from U.S. Geological Survey digital data, various scales
Idaho Transverse Mercator coordinate system
North American Datum of 1983

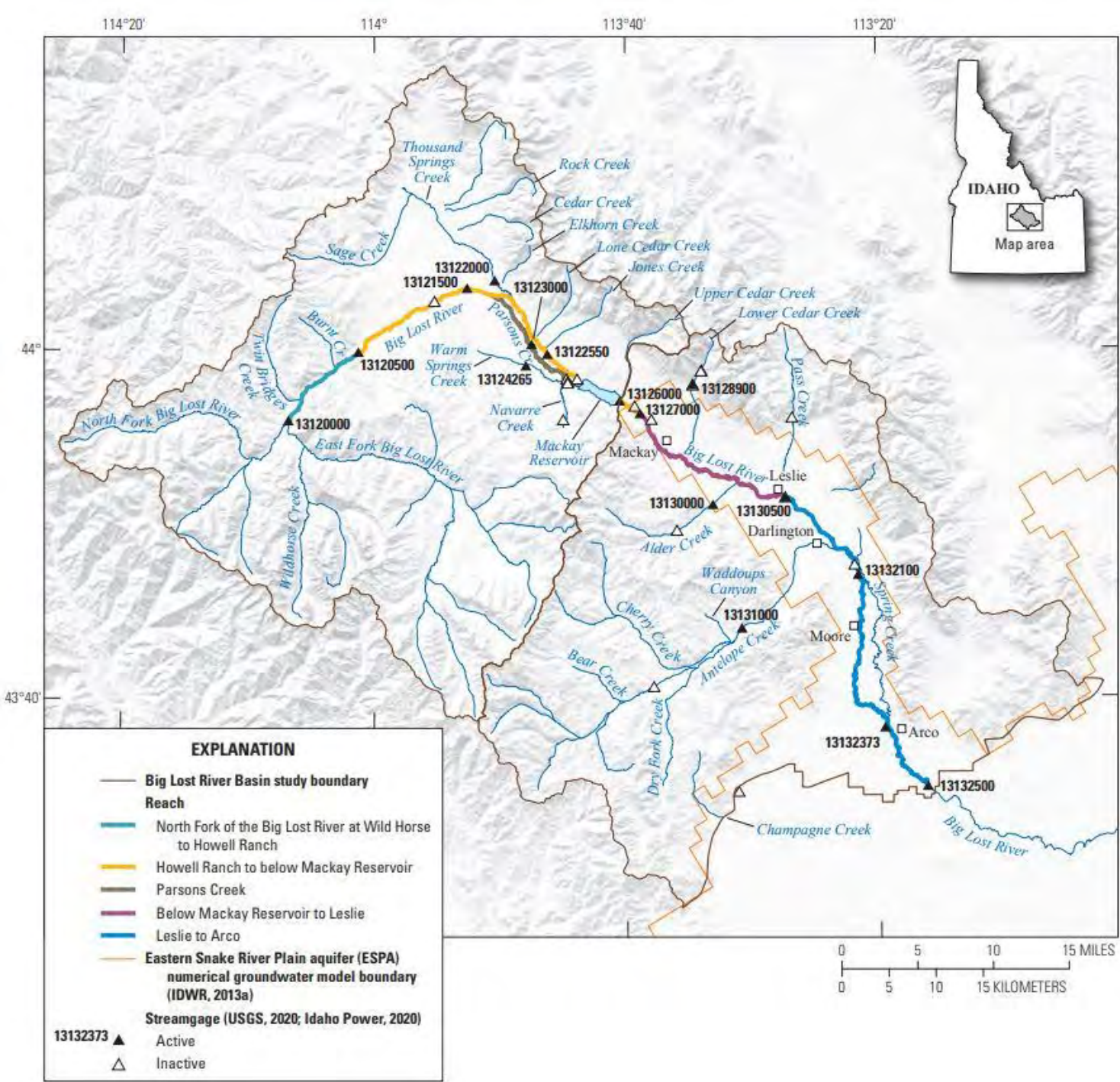


0 1 2 MILES
0 1 2 KILOMETERS

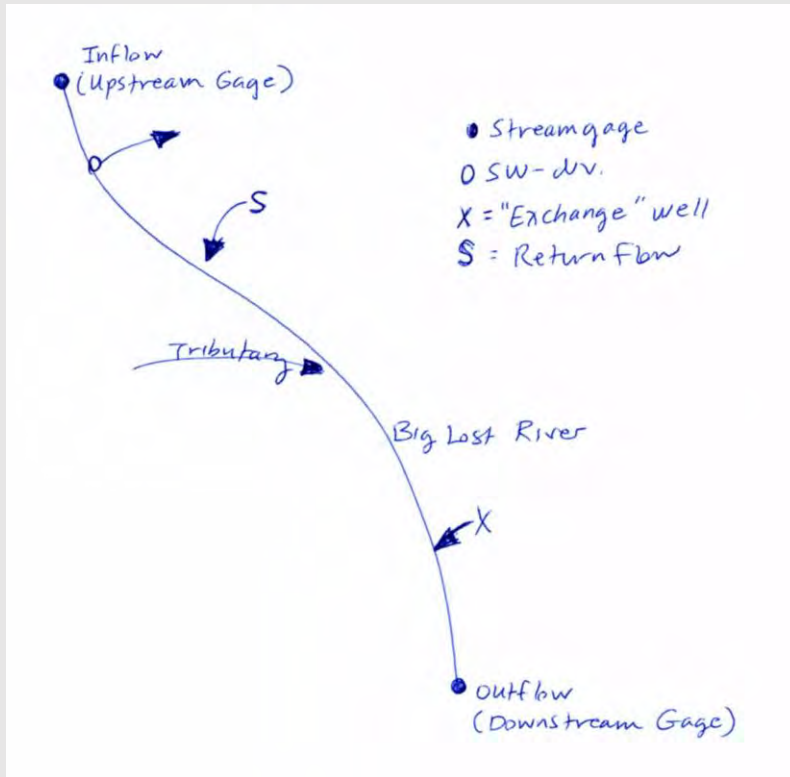
Inflow – Canal seepage



- **Data sources:**
 - *WD34: Ditch rider logs*
 - *IDWR: Storage balance (2015-19); surface-water diversion database*
- **Methods:**
 - **Delivery factors (DF)**
 - Diversion volume / Headgate volume
 - Seepage volume = $(1-DF) * S_{wdiv} \text{ volume}$
 - Below Mackay Dam
 - 2015-19: DF (0.73-0.77)
 - 2000-14: Linear regression DF (0.71, Middle; 0.62 Lower)
 - Above Mackay Dam, assumed DF (0.6)
 - Unmeasured canal diversions above Mackay Dam: linear regression with diversion volumes below Dam
- **Results (mean, acre-ft/yr):**
 - 19,000 (Upper); 14,400 (Middle); 22,000 (Lower)
- **Limitations:**
 - Assumed DF above Mackay Dam
 - Estimated surface-water diversions (2000-02) above Dam
 - Extrapolating 2015-19 DF to prior years below Mackay Dam

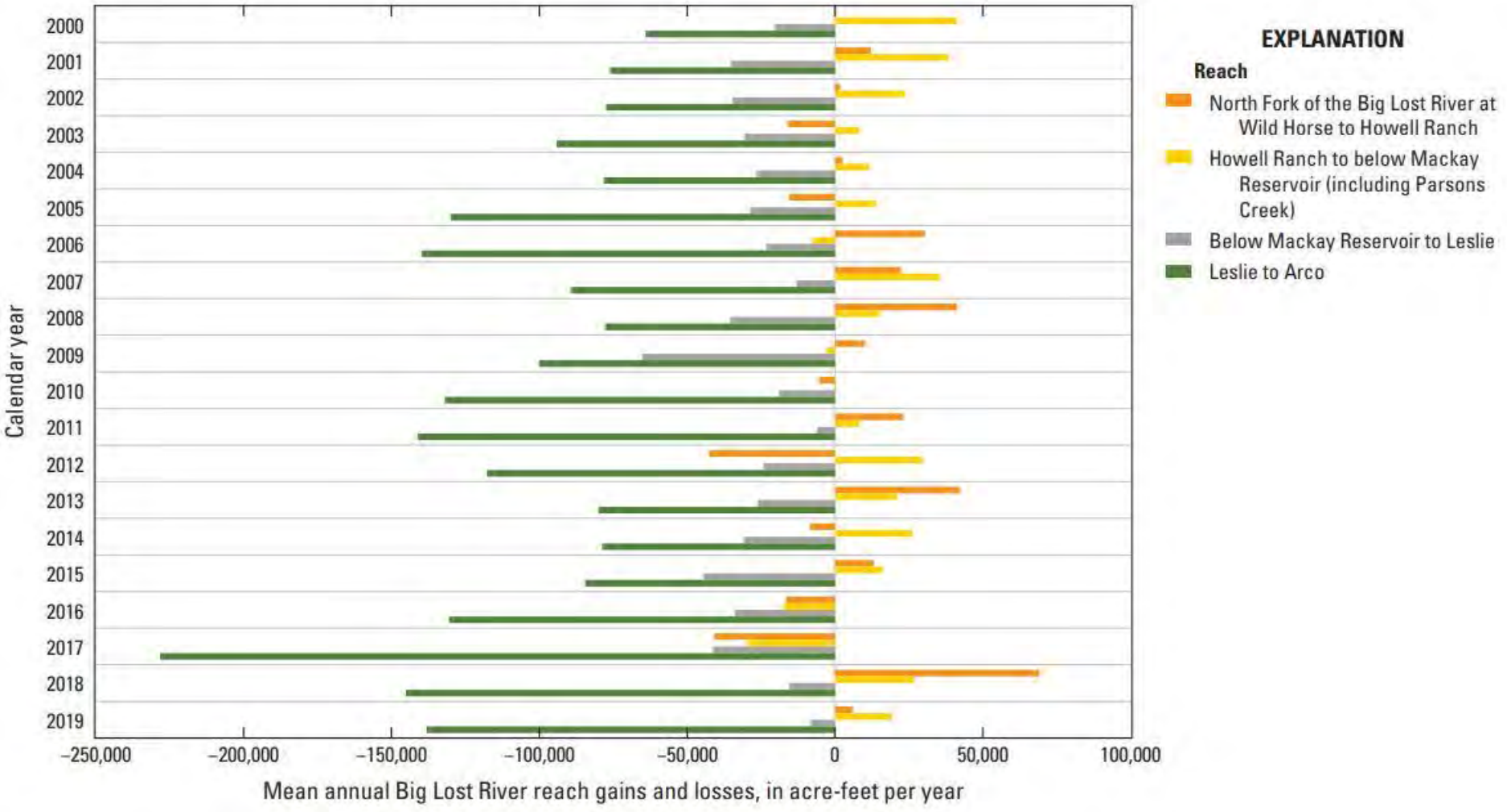


Inflow and outflow – Big Lost River gains and losses



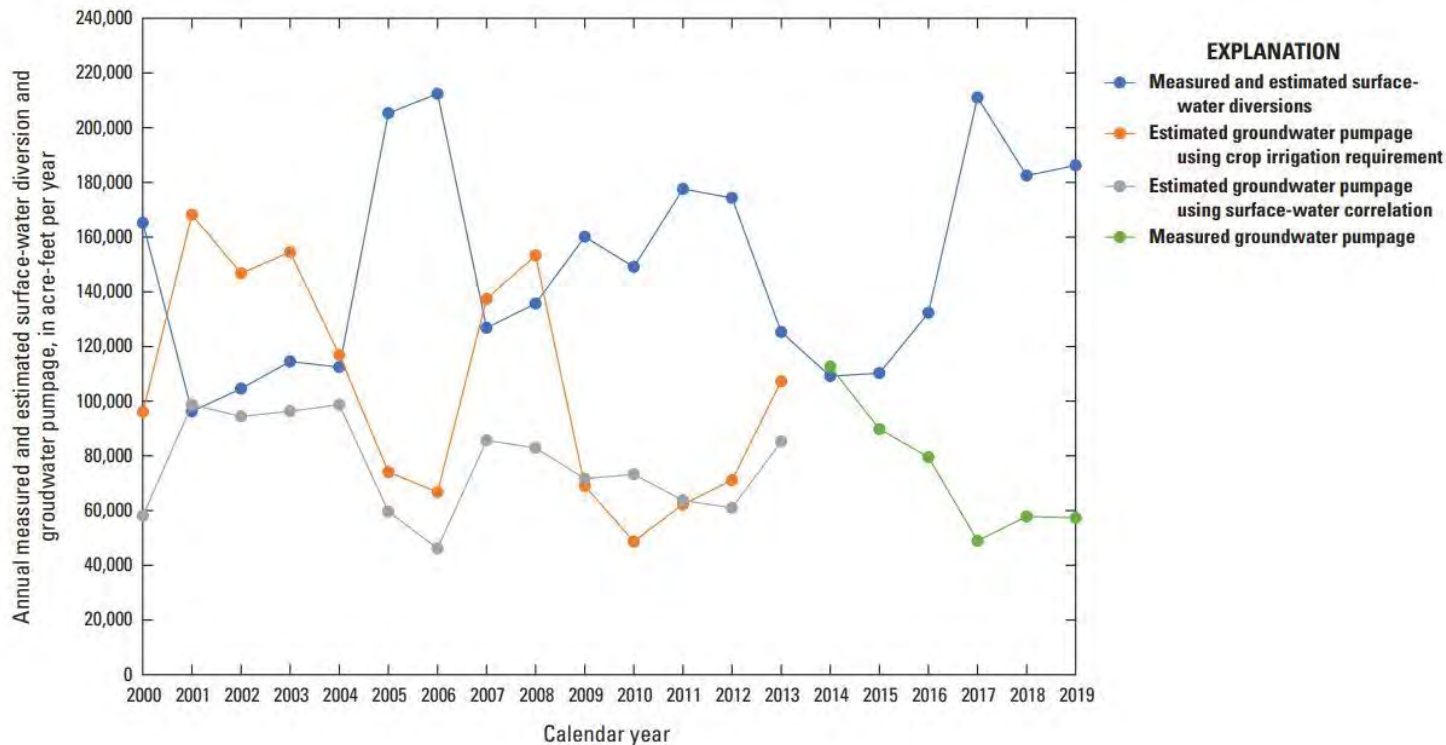
- **Data sources:**
 - IDWR: surface-water diversion database, including groundwater pumpage to canals ("exchange wells")
 - USGS: streamgage mean annual streamflow
 - Pivotrac: return surface water flows
- **Methods:**
 - $\text{Gain/loss} = \text{Outflow} - \text{Inflow} - \text{Tributary inflow} + \text{Swdiv} - \text{Gwpump to canals} - \text{Return flow}$
- **Results:** Next slide
- **Limitations:**
 - Tributary stream seepage neglected
 - Unmeasured tributary streamflow

Inflow and outflow – Big Lost River gains (outflow) and losses (inflow)

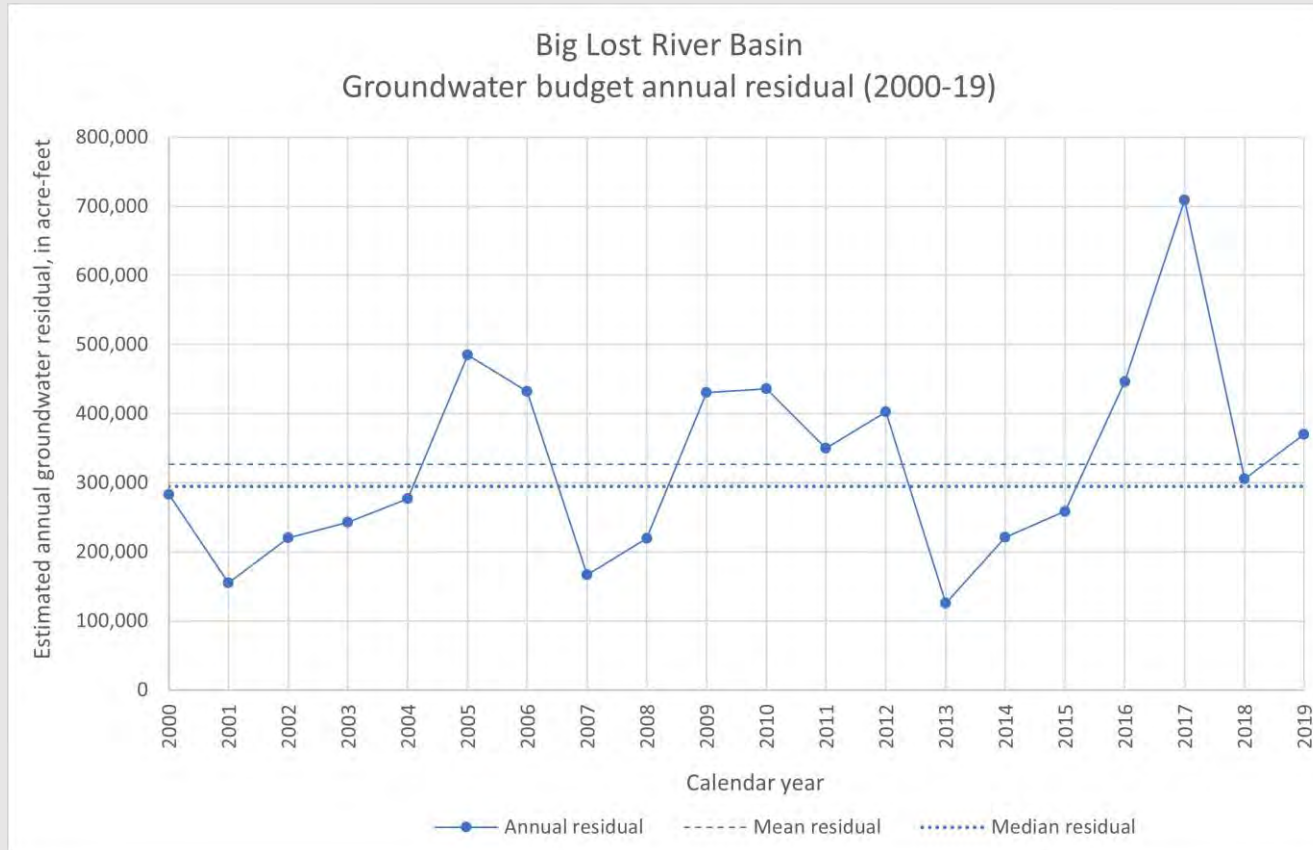


Outflow – Groundwater pumpage

- **Data sources:**
 - IDWR: WMIS database annual flowmeter records (2014-19) and power consumption records (2010-13)
 - IDWR: surface-water diversion database
- **Methods:**
 - Unmeasured pumpage (2000-13): Linear regression with annual surface-water diversion volumes (2014-19)
- **Results (mean annual in ac-ft/yr):**
 - Irrigation: Upper subbasin (4,250); Middle subbasin (34,000); Lower subbasin (37,800)
- **Limitations:**
 - Unmeasured pumpage estimates (2000-13)

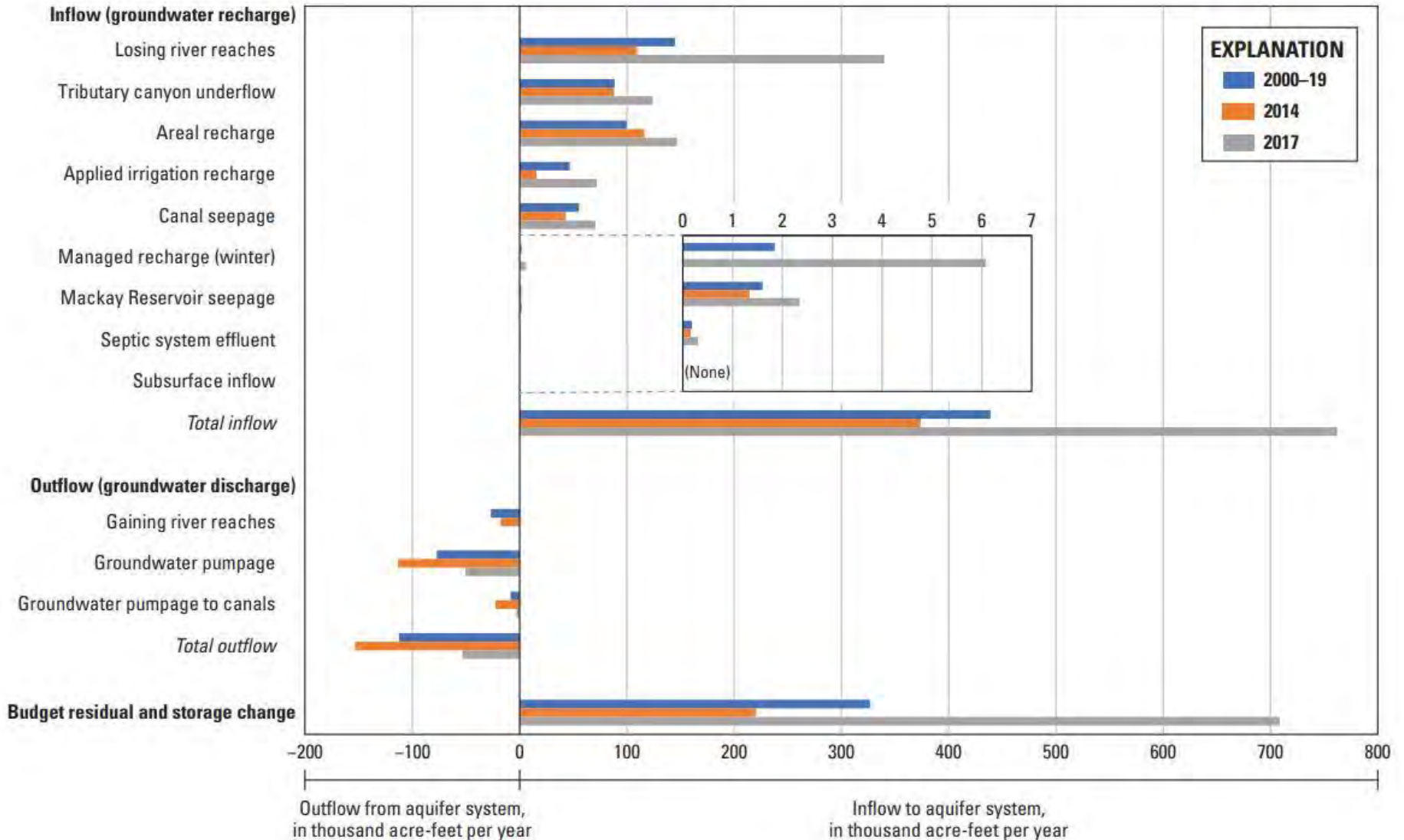


Groundwater budget residuals



- Groundwater underflow leaving the basin
- Annual changes in aquifer storage
- Errors

Groundwater budget results



Prior groundwater budgets

Source	Time period of study	Study extent	Basin discharge (acre-ft/yr)	Comments
Stearns and others, 1938	¹ 1920–27	Above and below Mackay Dam	226,000	Groundwater
Mundorff and others, 1964	1921–50	Above Mackay Dam	280,000	Surface water and groundwater
		Below Mackay Dam	60,000	
Crosthwaite and others, 1970a	1944–68	Above and below Mackay Dam	307,700	Groundwater underflow above gauge near Arco
Said and others, 2005	2000	Above and below Mackay Dam	267,000	Surface water and groundwater
Sukow, 2017	1985–2010	ESPA model below Mackay Dam	204,000	Groundwater
Ackerman and others, 2010	1966-90	INL site northern model boundary	261,400	Steady state numerical groundwater-flow model input

¹Water years (October 1–September 30)

Clark, 2022	2000 - 19	Above and below Mackay Dam	326,700	Groundwater (underflow and storage change)
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Groundwater budget key findings

- Above Mackay Dam

- Combined surface water and groundwater provide for irrigation needs and Mackay Reservoir storage
- Higher precipitation due to snowmelt provides for appreciable tributary canyon underflow and areal recharge
- Additional recharge to the aquifer from applied irrigation and canal seepage
- Overall positive groundwater residual above Mackay Dam

- Below Mackay Dam

- Highest recharge sources include losing river reaches and groundwater inflow from above Mackay Dam
- Less additional recharge provided from areal recharge, tributary canyon underflow, canal seepage, and applied irrigation
- Surface-water diversions and groundwater pumping account for most of the net withdrawals of water
- More variable surface-water and groundwater supplies due to less precipitation and less flow in the Big Lost River

Questions?

Thank you!

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Big Lost River Basin project field trip (IGS, 2018)