

Bill Williams Groundwater Basin Profile



Basin Summary Statistics

Size¹: 3,350 square miles

Elevation²: Range: 450-7,379 ft; Median: 3,023 ft

Top 3 land cover types by area³: Shrub/Scrub (90%), Evergreen Forest (7.2%), Grassland Herbaceous (1.1%)

Major surface watershed(s)⁴: Santa Maria River, Burro Creek, Big Sandy River, Bill Williams River

Groundwater subbasins¹: Santa Maria, Burro Creek, Alamo Reservoir, Skull Valley, Clara Peak

Groundwater-derived streamflow fraction⁵:

0.45 (Moderate)



Mean Annual Hydrologic Cycle Components (1980-2020)
BILL WILLIAMS

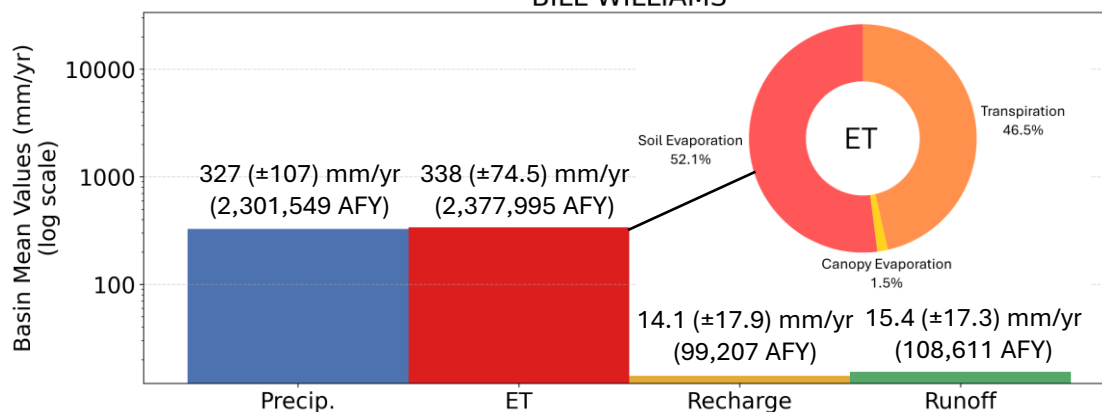


Figure 1 (above). Bar chart showing Noah-MP modeling results of the historical mean annual hydrologic cycle components (precipitation [P], evapotranspiration [ET], natural recharge, and runoff) in the basin from 1980-2020.⁶ ET is partitioned into soil evaporation, canopy evaporation, and transpiration. It is possible for ET to be greater than P when there are other sources such as groundwater, surface water, or water in storage.

Mean Monthly Hydrologic Cycle Components (1980-2020)
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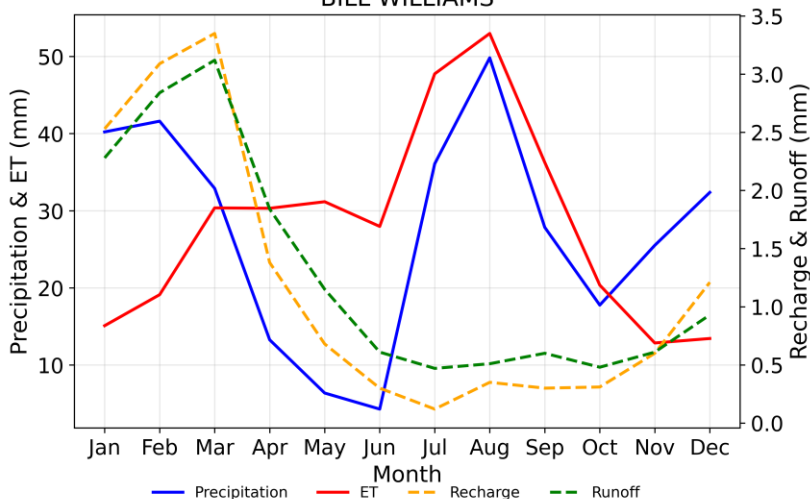


Figure 2. Graph showing monthly mean precipitation, ET, recharge, and runoff for the groundwater basin (1980-2020) from Noah-MP modeling results.⁶

Precipitation (P) in the Bill Williams basin is affected by the North American Monsoon during the summer months and large frontal systems during the winter. On annual timescales, evapotranspiration (ET) is greater than P; however, P exceeds ET in the cooler seasons from mid-October to March. Soil evaporation makes up 52.1% of total ET in the basin, while transpiration comprises 46.5% and canopy evaporation accounts for the remainder (1.5%). Natural recharge (14.1 mm/yr) and runoff (15.4 mm/yr) peak in March due to springtime snowmelt. Groundwater supplies an estimated 45% of total streamflow in the Bill Williams basin.



Figure 3 (below). Gridded depiction of mean annual water fluxes across the groundwater basin from Noah-MP modeling (1980-2020): (a) precipitation, (b) evapotranspiration, (c) recharge, (d) runoff.⁶ Major cities/towns⁷ and Native American Reservation boundaries⁸ are shown (as applicable) to help orient the reader.

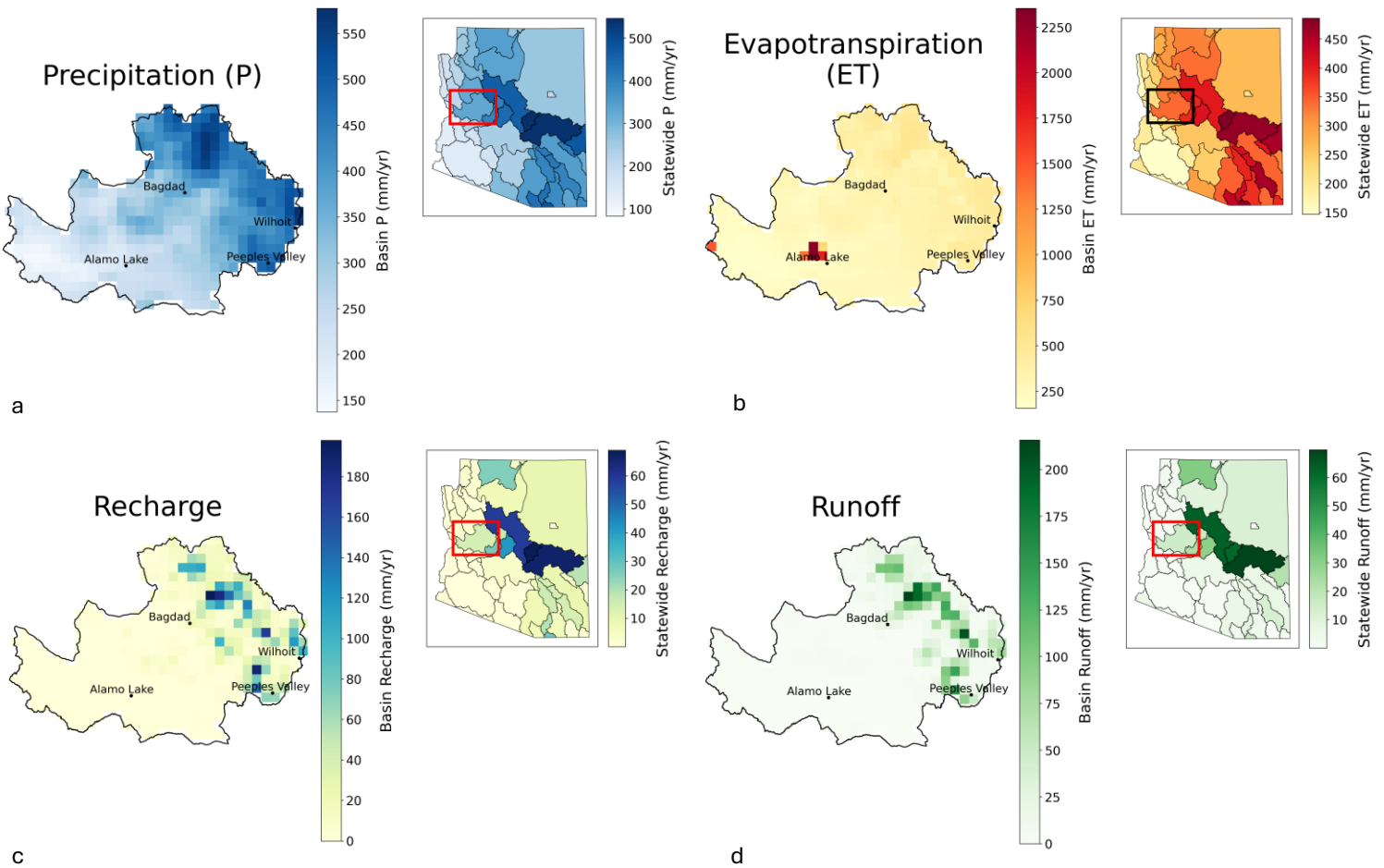
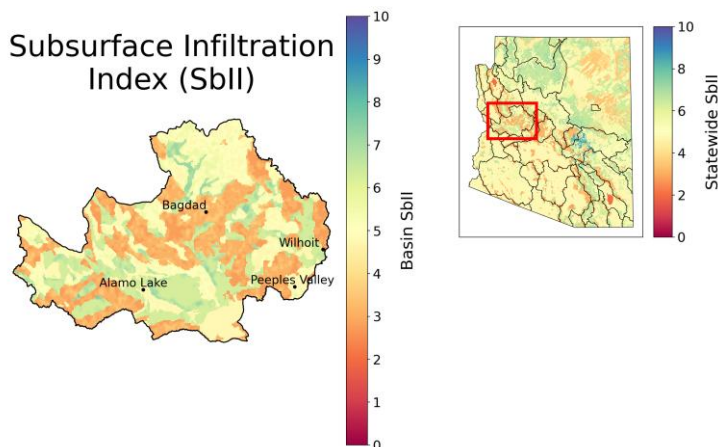


Figure 4 (below). Subsurface infiltration index (SbII) showing infiltration potential of the subsurface across the groundwater basin on a scale of 1-10 based on geologic features.⁹



Precipitation (P) in the Bill Williams basin is greatest at the higher elevations in the eastern portion of the basin, where P can exceed 500 mm/yr on average. Natural recharge (~160 mm/yr) and runoff (~175 mm/yr) are also highest in this region. ET (~2,000 mm/yr) is highest over the open water of Alamo Lake. Infiltration potential varies across the basin, with the areas of highest potential along alluvial deposits and drainages throughout the basin.



Climate Change Projections: Changes in Temperature, Precipitation, ET, Recharge, and Runoff (2060-2099 vs. 1981-2020)

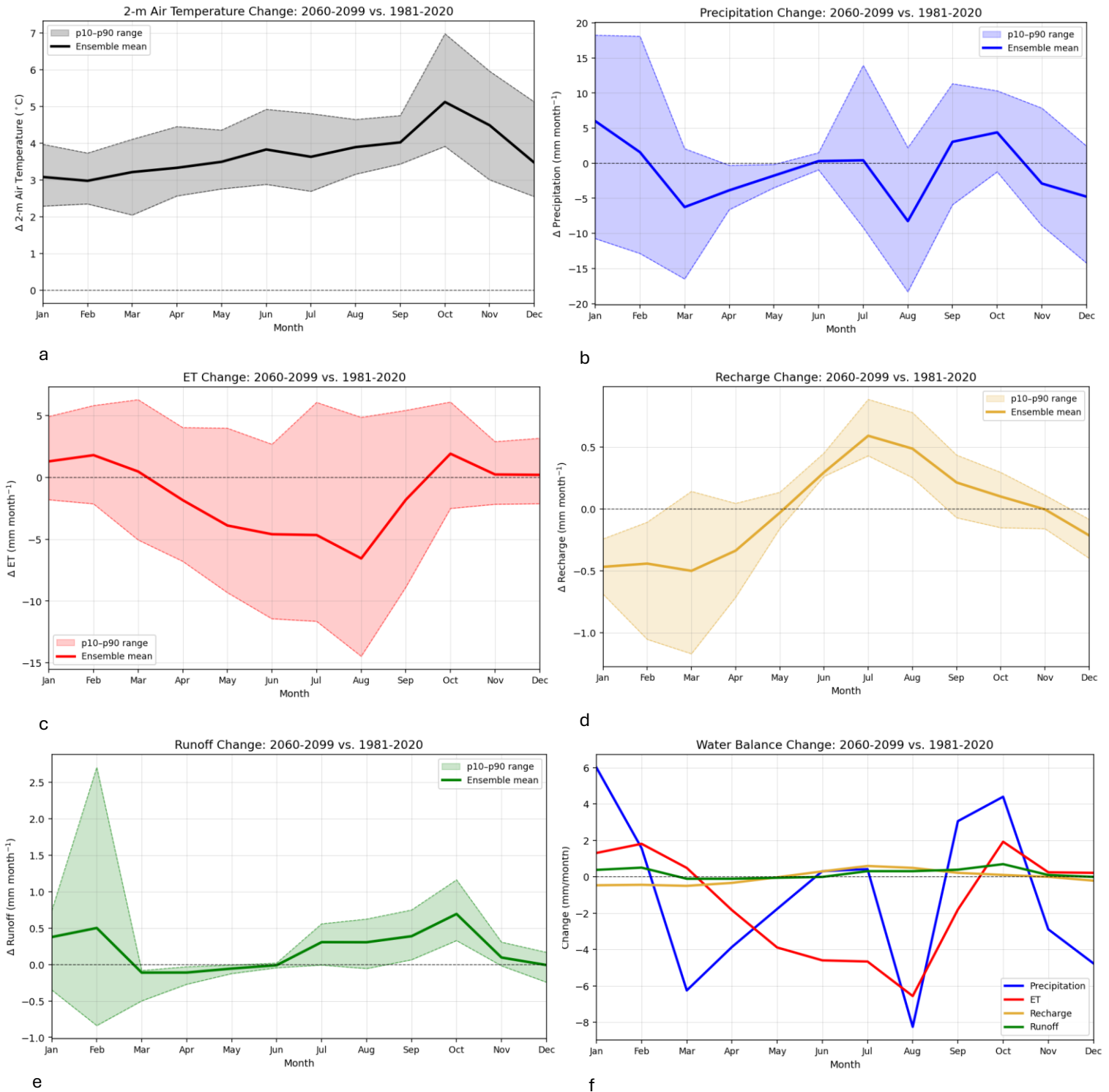


Figure 5. Plots (a)-(e) show projected changes in (a) temperature, (b) precipitation, (c) evapotranspiration (ET), (d) natural recharge, and (e) runoff statewide, comparing end of the 21st century to the historical record from 1981-2020 under the IPCC Scenario SSP3-7.0.¹⁰ Plot (f) shows the change in the water balance components (P, ET, recharge, and runoff) on a single graph for direct comparison. The analysis uses 14 dynamically downscaled global climate models (GCM) at 9-km resolution and the Noah-MP land surface model. The ensemble mean of the 14 GCMs is shown in bold for each component of the hydrologic cycle, with the 10-90th percentile shaded to show model projection uncertainty.



Climate change projections across the Bill Williams basin show drier springs (18-32% drier March through May), and a drier August (16%), November (13%), and December (14%). September and October are projected to be 11-22% (3.0-4.5 mm/month) wetter on average by the end of the century, which is consistent with a projected increase in extreme events associated with hurricane and tropical cyclone activity. The months with the highest natural recharge (January-April) are projected to have declines of 45-95% (-0.34 to -0.52 mm/month). Despite showing less water loss from the system (i.e., a positive increase in Figure 8(d)), recharge projections are slightly negative from June through December (-0.14 to -0.41 mm/month).^{*} While runoff is projected to remain below 1.0 mm/month, minor increases of 0.36-0.44 mm/month are projected for January-February, while increases of 0.31-0.71 mm/month are projected for July-October. Projected increases in temperature range from approximately 3.0 °C in February to 5.2 °C in October. Higher temperatures and greater water availability from precipitation lead to a projected 10% (1.9 mm) increase in evapotranspiration (ET) in October and 8% (1.3-1.7 mm) in January-February compared to the baseline period, while less water availability in August leads to a projected decline in ET (13% or -6.5 mm).

^{*}Projected negative recharge values are attributed to increased capillary rise from the aquifer through the vadose zone due to climate factors, resulting in water loss from the system. Because the Noah-MP model does not include groundwater pumping, this indicates that climate-driven factors play a significant role in groundwater storage decline in Arizona.

References

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