

Validation of CalSimHydro 2.0 Runoff Simulation for Small Watersheds

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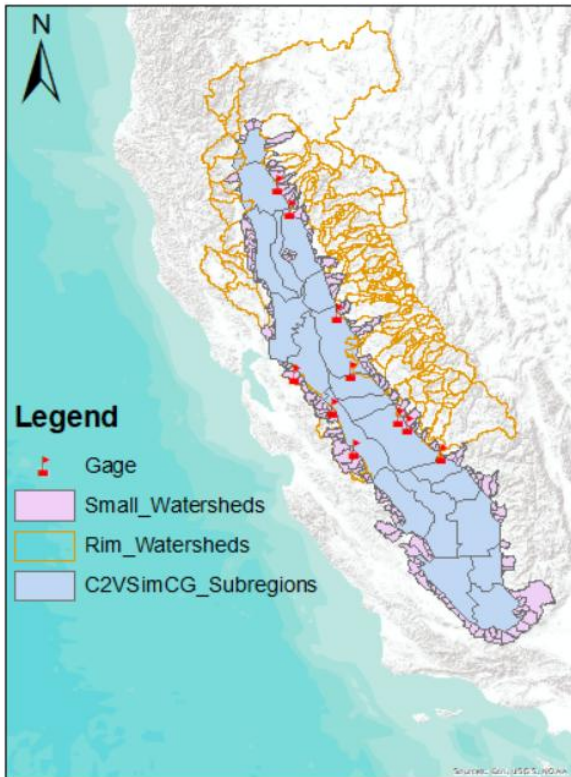
Outline

- Background
- Objective and Validation Methods
- Overall Performance of Simulation
- Several Issues and Possible Solutions: Case Studies
- Summary and Future Work

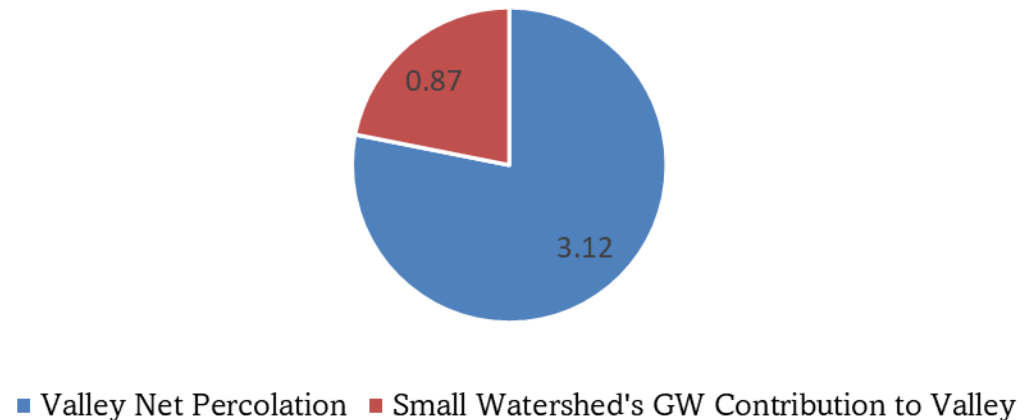


Background

- Why Use Small Watersheds in CalSimhydro 2.0 ?
 - 151 small watersheds used for simulating lateral groundwater flow
 - SWs has small or intermittent streams and provides 5% of the inflows to Central Valley
 - Lateral groundwater flow in foothills is essential to the Valley Floor groundwater simulation in CalSimhydro 2.0:

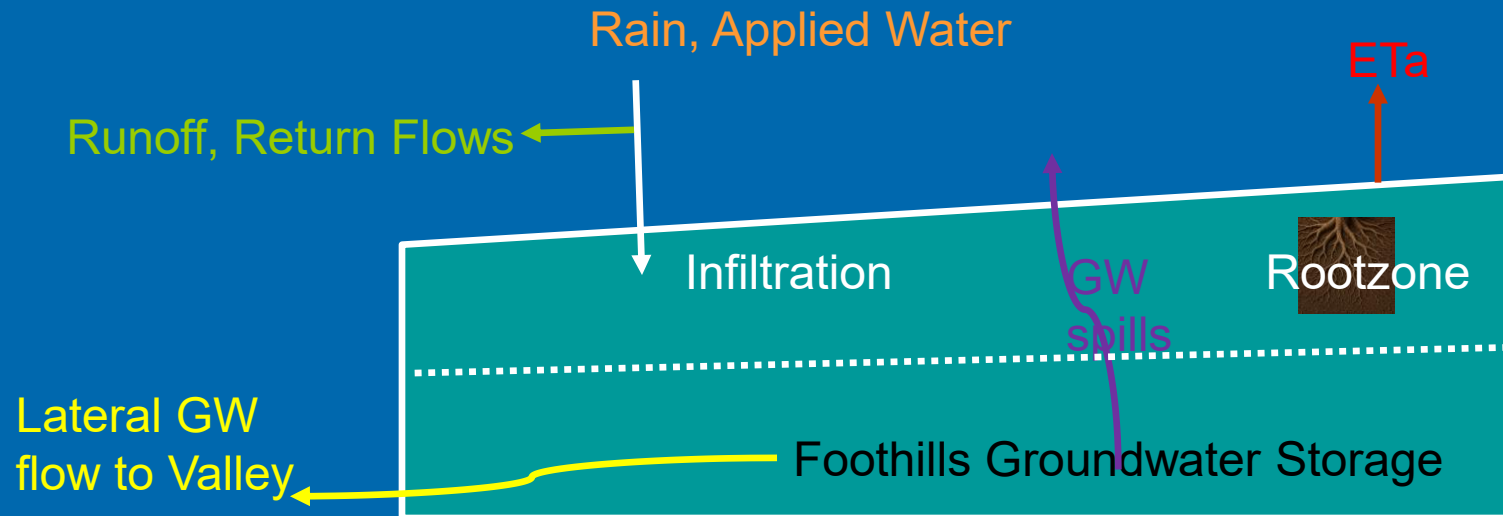


Sources of Valley Floor GW



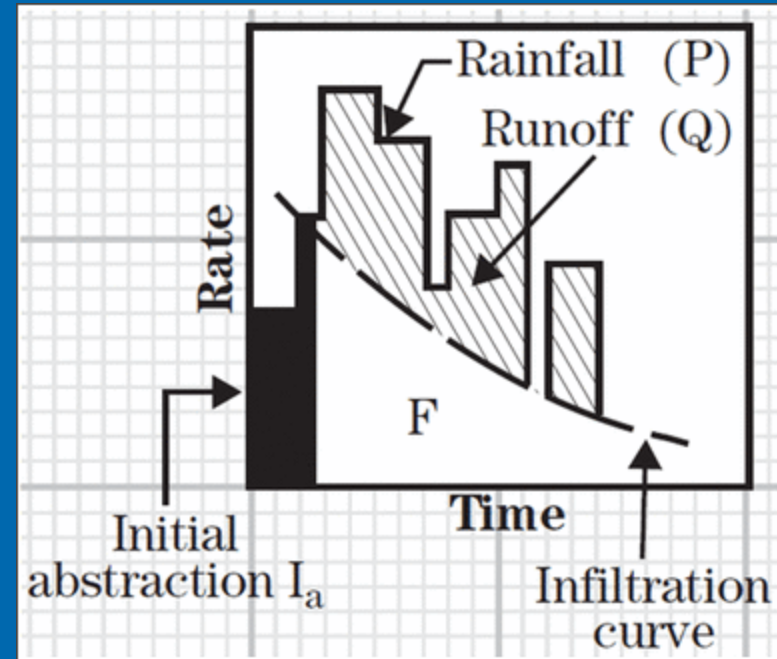
Objectives

- Improve representation of lateral groundwater flow (How?)
- A bucket GW model for SWs
 - $\text{Precip/Applied Water} = \text{Infiltration} + \text{runoff/return flow} + \text{ETa}$
 - $\text{Lateral GW Flow} = \text{recession coefficient} * \text{storage of GW in SW}$
- Ensure realistic runoff simulation in foothills' SWs
- 25 SWs overlap with rim inflow watersheds
- Among 25, 11 SWs have gage data available for validation



Small Watershed Runoff Simulation

- Rainfall Runoff estimated using NRCS Curve Number (CN) method
- Baseflow from groundwater return
- Agricultural return flows
- CN =88 for all SWs



$$Q = \frac{(P - I_a)^2}{(P - I_a + S)}$$

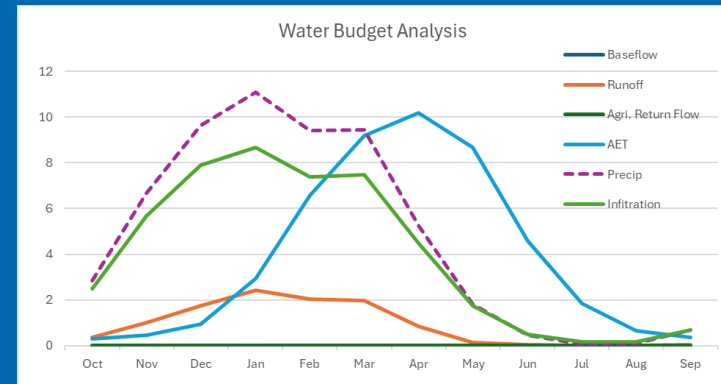
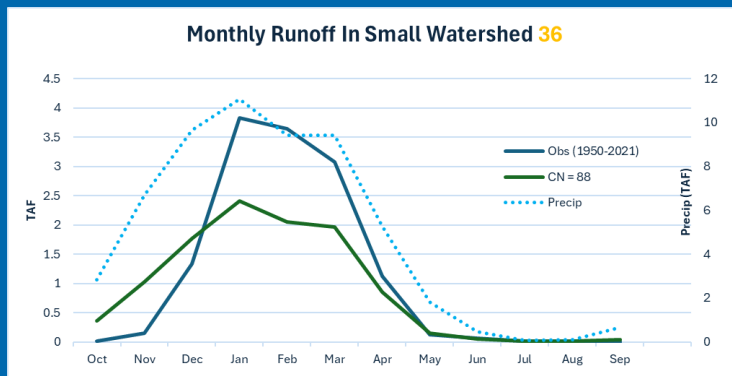
$$I_a = r S$$

$$S_{max} = \frac{1000}{CN} - 10$$

$$S = \begin{cases} S_{max} \left[1 - \frac{\theta^t - \frac{\theta_f}{2}}{\theta_T - \frac{\theta_f}{2}} \right] & \text{for } \theta^t > \frac{\theta_f}{2} \\ S_{max} & \text{for } \theta^t \leq \frac{\theta_f}{2} \end{cases}$$

Validation Approach

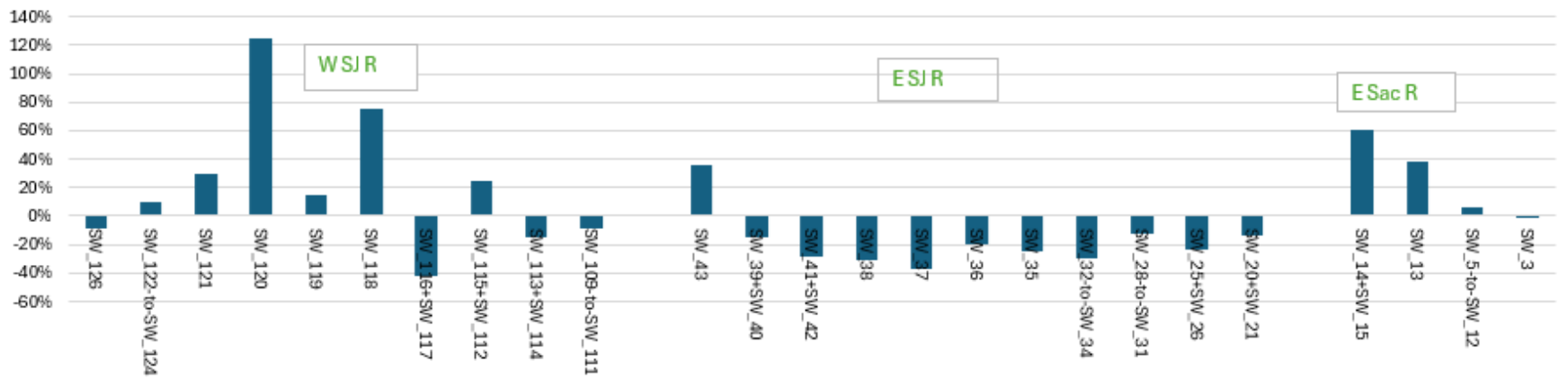
- Compare simulated vs observed annual runoff and evaluate mean bias (%)
- Compare mean monthly runoff patterns especially peak flow timing
- Compare time series and compute NSE score and R^2
- Perform water budget analysis to find source of biases



Key Findings

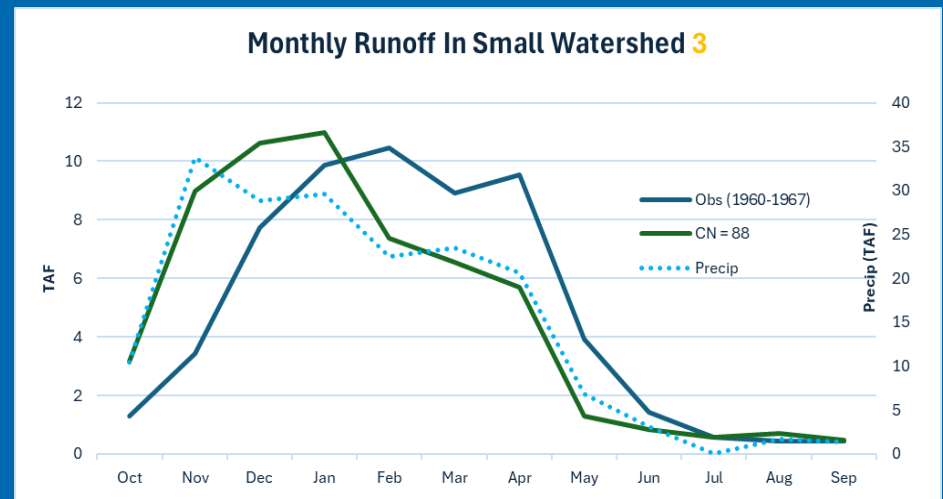
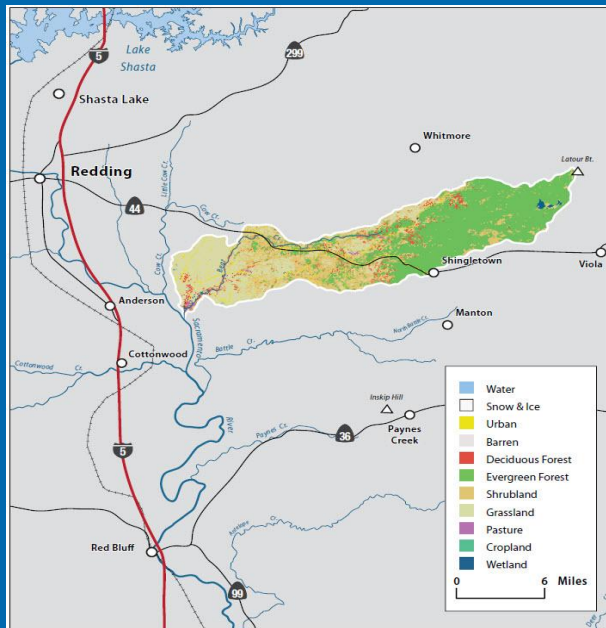
- Simulated Runoff Mean Bias: -43% to 124% among 25 SWs. Need Calibration!!!
- SWs along E Sac River tends to be oversimulated, E San Joaquin River underestimated, W SJR overestimated mostly
- Earlier flow peak occurs 1-2 months earlier than gage data in snowfall-rainfall mixed SWs
- Flow peak occurs 1 month later than gage data in some SWs at West Bank of SJ River

Mean Bias for Small Watershed Runoff Simulation



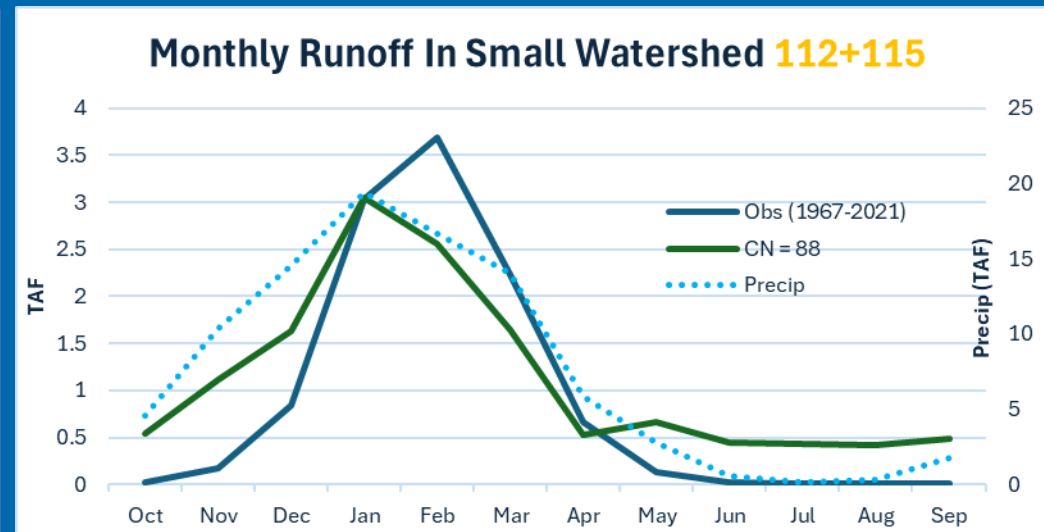
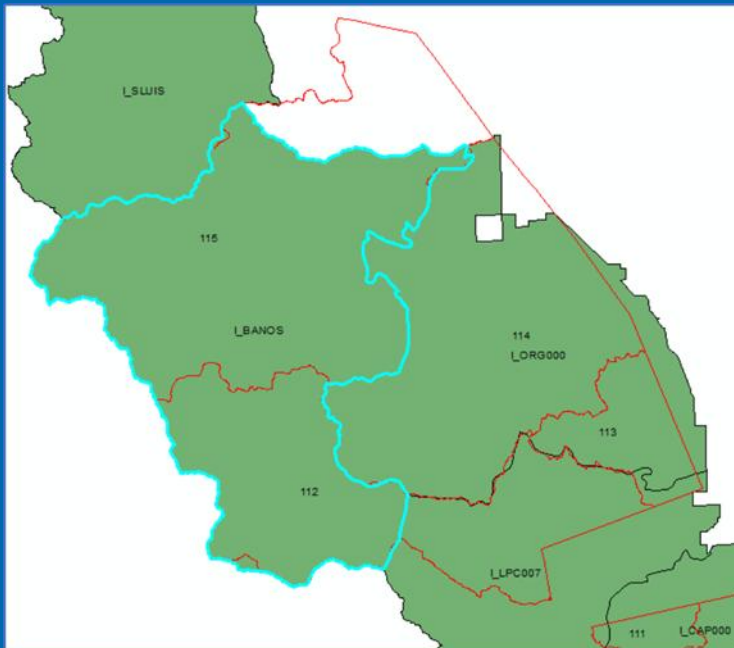
Case Study 1: Biases from Snowmelt

- Annual flow matches with the observed (1960 —1967)
- Flow pattern mismatches with the observed
- Snowfall and snowmelt in the upper part (6367 ft mt. peak).
- Shallow groundwater, in the form of springs and seeps, provides base flow
- CN method does not simulate snowmelt
- Irrigation diversions and groundwater pumping contribute to the summer low-flow with AG return flow



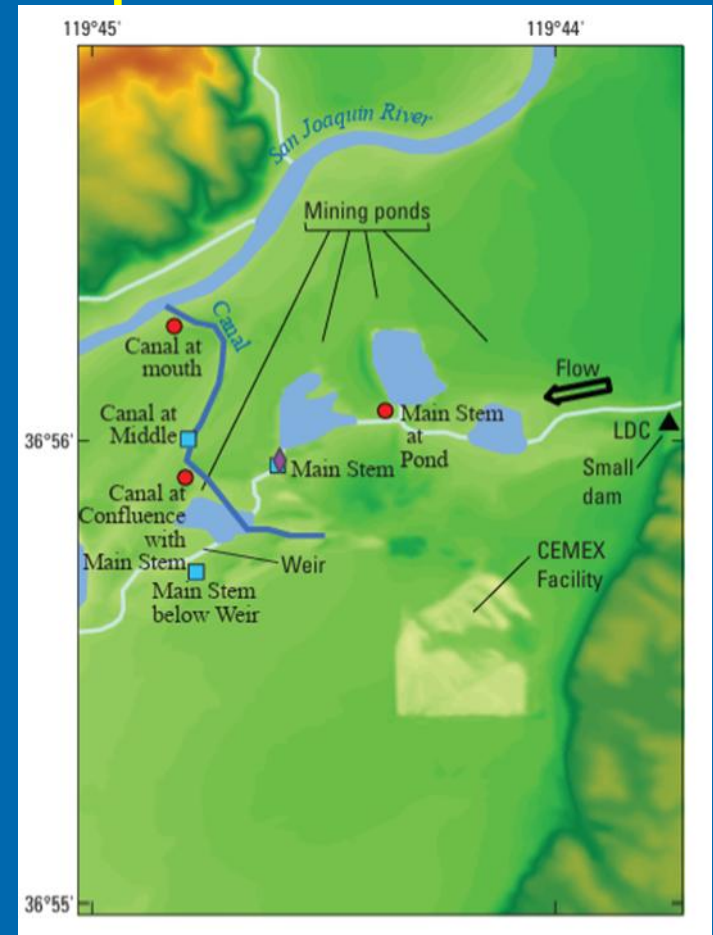
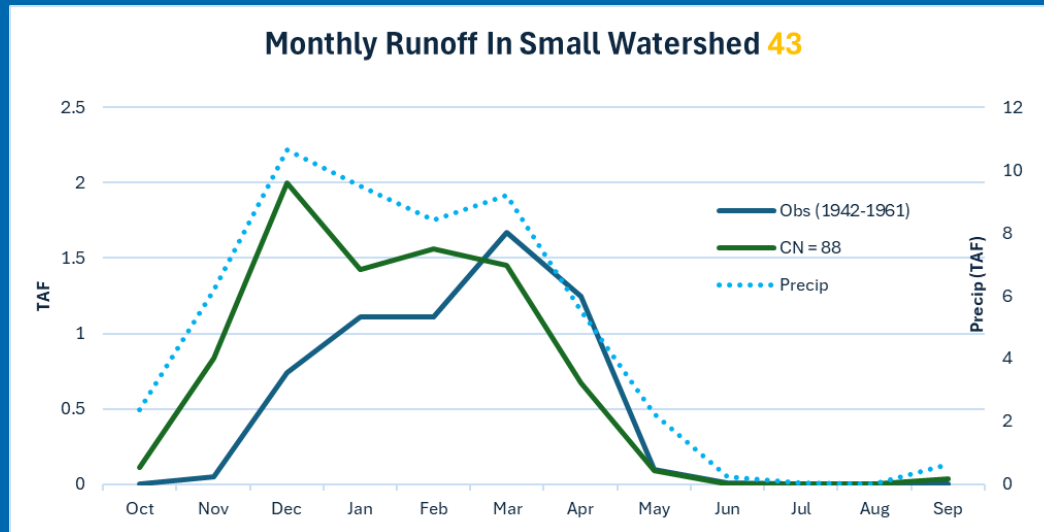
Case Study 2 : Biases from Shallow GW

- Annual flow overpredicted by 24%
- One month lag the observed peak
- Shallow groundwater is active in SW 112 and 115
- The model does not simulate shallow GW well
- Too much return flow from AG in summer



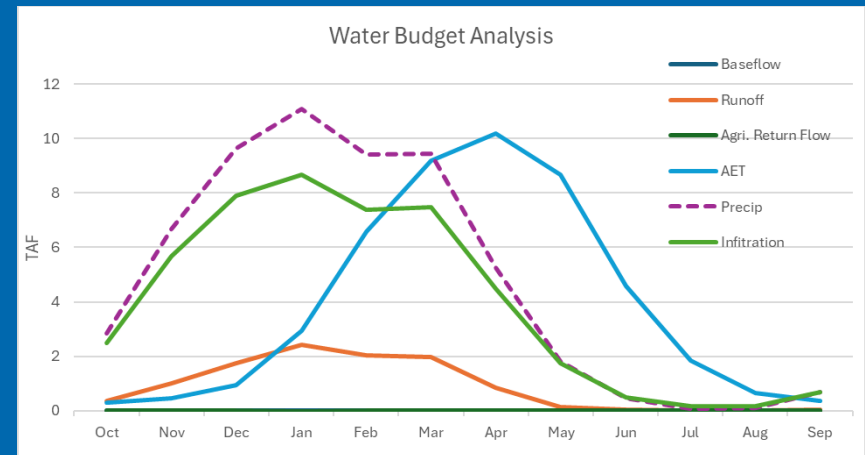
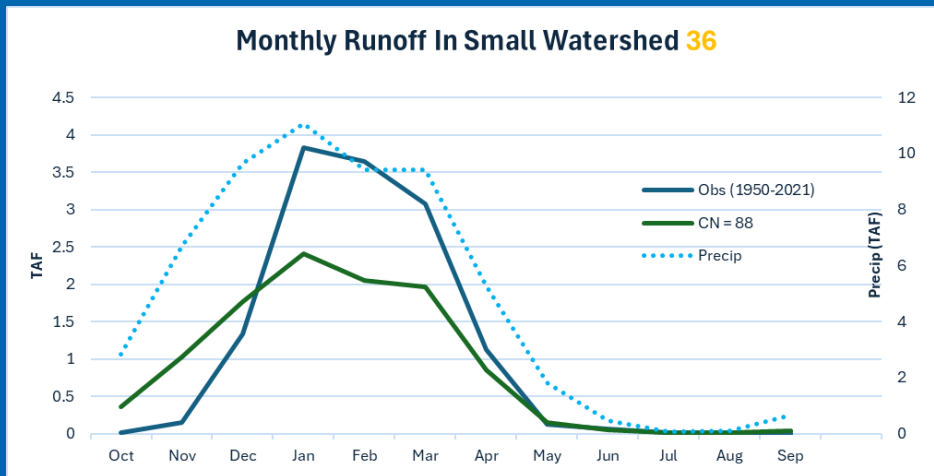
Case Study 3 : Biases from Impaired Flow

- Annual flow overpredicted by 35%
- Three months ahead of the observed peak
- Mining activities impair flow in LDC in SW 43
- CN approach simulates natural flow



Budget Analysis in SW 36

- Underestimate of annual runoff was related to too much infiltration. Increase CN!!!
- Too much flow in fall and earlies winter months possibly due to too less ETa or too less infiltration.
- Curve numbers need be adjusted based on the Antecedent Moisture Condition (AMC) for these months or increase ETo



Summary and Future Work

- One curve number can not fit all SWs
 - Snow-influenced basins: systematic early peak bias
 - Early-season runoff overestimation is common
 - Shallow groundwater simulation needs more work
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- Calibrate small watershed module by PEST
 - Incorporate snowmelt processes
 - Incorporate routing process
 - Expand validation dataset

Question?