

Hydrological Modeling of the Semi-arid Santa Cruz Basin

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REWATI NIRLA¹, Thomas Meixner², Laura M. Norman³

¹ Graduate student, Hydrology and Water Resources, University of Arizona, Tucson, AZ

² Associate Professor, Hydrology and Water Resources, University of Arizona, Tucson, AZ

³ Research Physical Scientist, USGS, Tucson, AZ

Background:

Upper Santa Cruz River:

- Cultural, historical, and ecological value
- Supports a huge diversity of plants and animals
- Sustains people residing in the watershed by replenishing the groundwater aquifer, a primary regional water source

Continuous discharge of treated water ($\sim 56024 \text{ m}^3/\text{day}$) from Nogales International Wastewater Treatment Plant (NIWTP):

- Perennial flow in the segment ($\sim 40 \text{ km}$ downstream of NIWTP)
- $\sim 2.8 \text{ km}$ of the Santa Cruz River flow through the Tumacácori National Historical Park (Tumacácori Mission unit): primary water source in the park
- Support the riparian vegetation (1.6 km of endangered Southwest Cottonwood - Willow riparian habitat) and habitat for a number of rare or federally listed animals (eg. Yellow-billed cuckoo and SW Willow-flycatcher)

Los Alisos plant:

- under construction , ~32 km south of Nogales
- Allow Mexico to treat the waste water and discharge back to Los Alisos Basin
- Huge hydrological implications on the Santa Cruz River

Analyzing the impact of various anticipated scenarios of effluent reduction :

- Important for management perspective

Application of watershed models: Feasible Methods

Soil and Water Assessment Tool (SWAT):

- A process-based, semi-distributed, continuous watershed model
- Developed to predict the impact of management practices on water, sediment and agricultural chemicals in complex watershed over long periods of time
- GIS interface: ArcSWAT

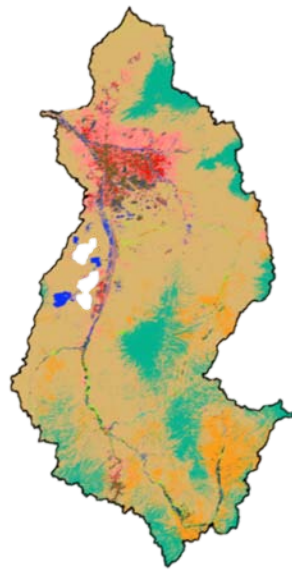




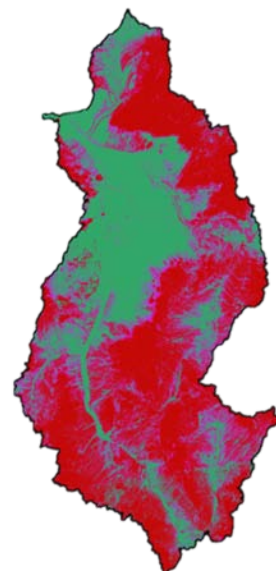
Digital Elevation
Model (DEM)
Elevation:610-
2884m



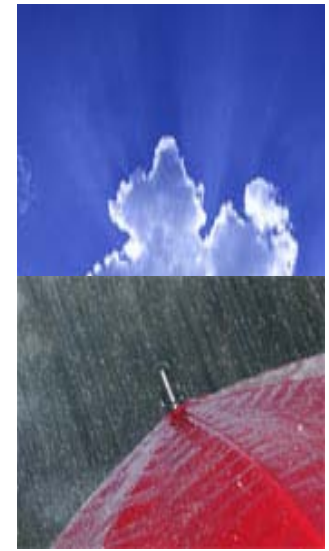
Soil Data
25 soil types



Land use/ cover
14 land use types



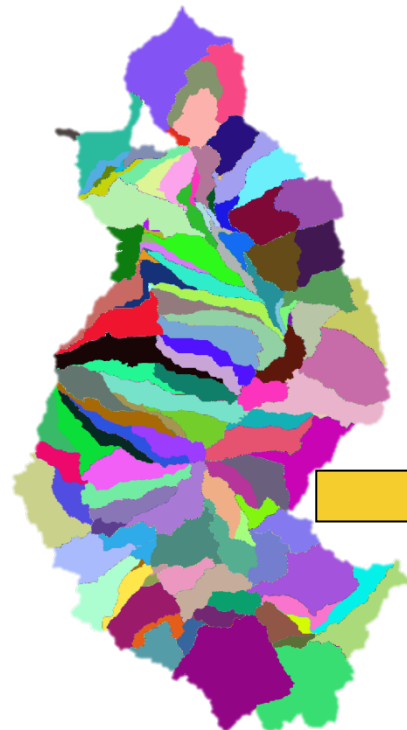
Slope
3 slope types



Climate
Daily P & T (1960-
2007)



SWAT
Model



Outputs:

- Flow
- Sediment
- Nutrient
- Pesticide
- Bacteria

Modeling the Santa Cruz:

131 Sub-watersheds

2583 Hydrological Response Units (HRUs)

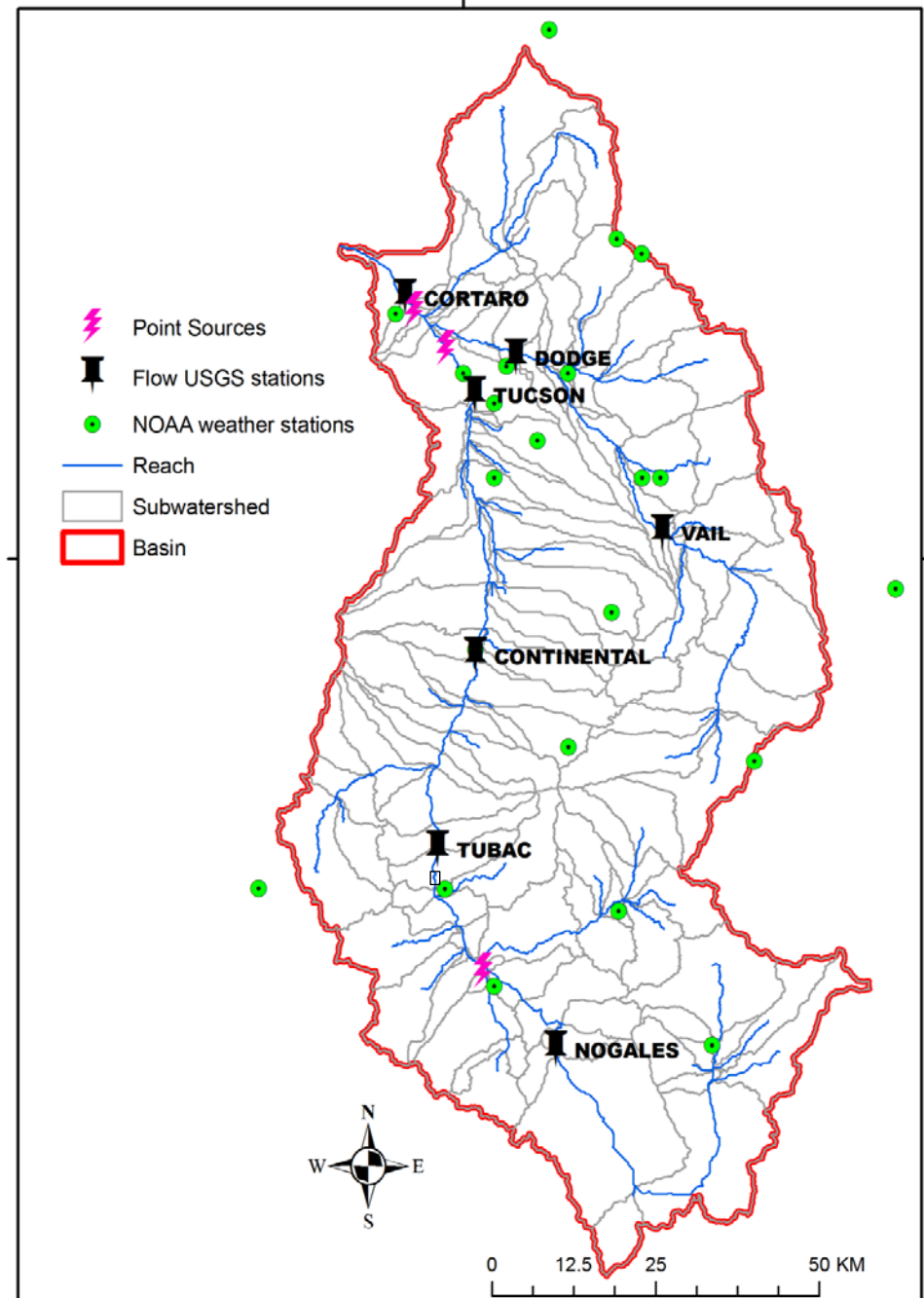
Effluent: 3 WWTPs @ Ina, Rogers and Nogales

22 climate stations

Model Calibration:

Model calibration: Altering model parameters within acceptable ranges of values to better match predicted model values with observed values (e.g. stream discharge) of the system

- **Outlet Calibration:** Adjusting parameters for the whole watershed to match observed data at outlet
- **Spatial (Fine) Calibration:** Adjusting parameter values based on observed data at various locations within the watershed sequentially starting from upstream and moving towards the downstream watershed outlet



Model Results:

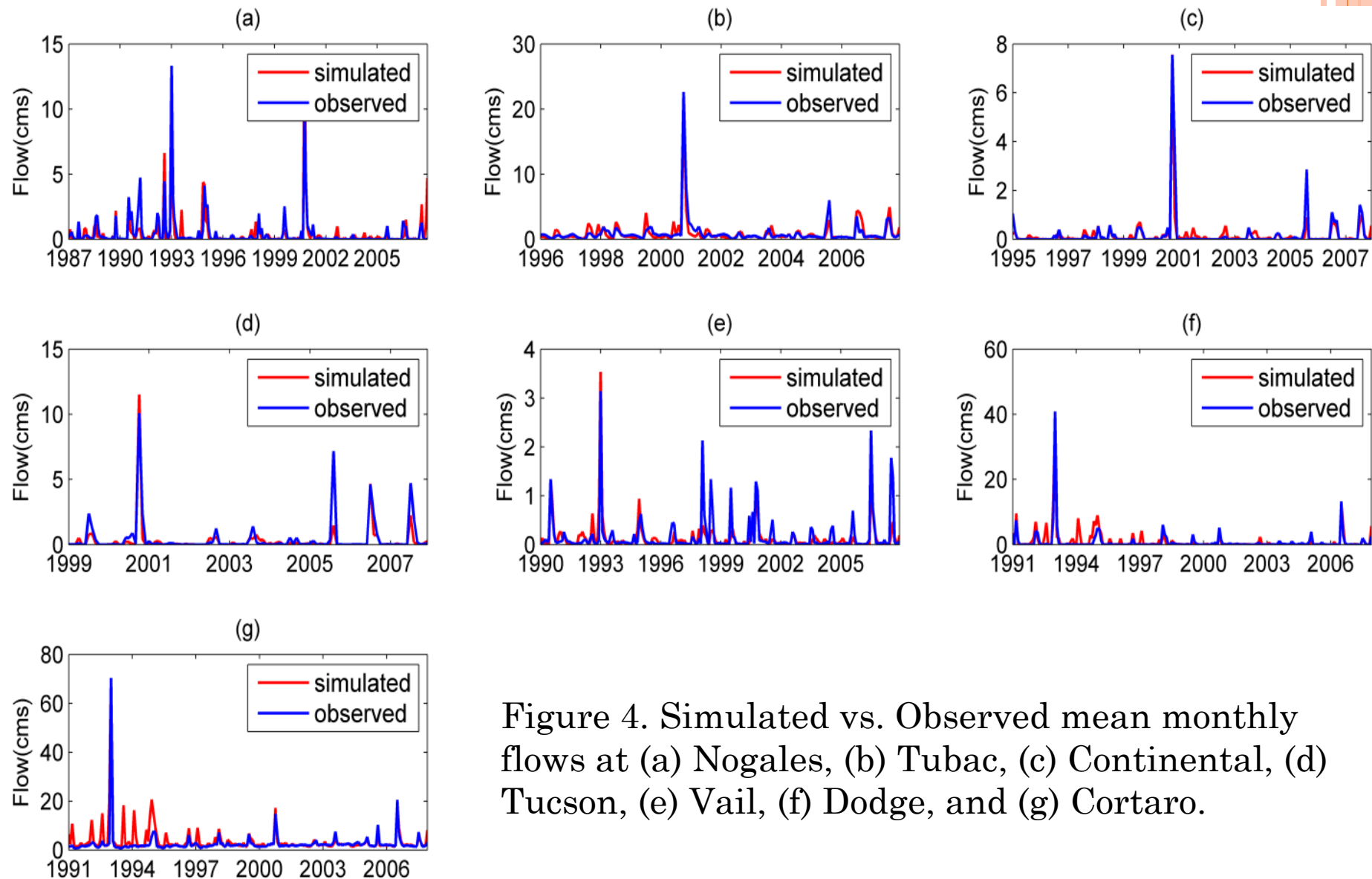
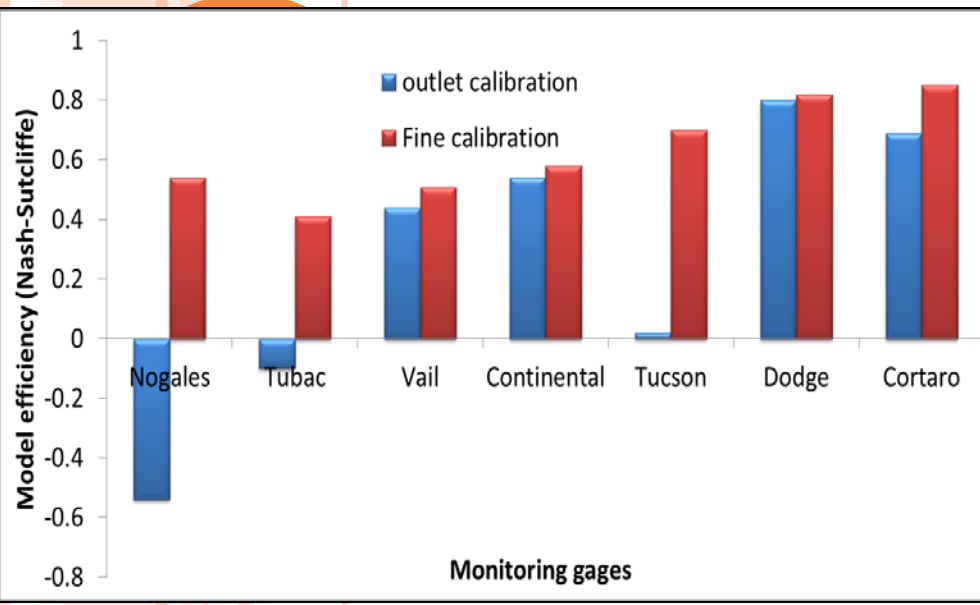
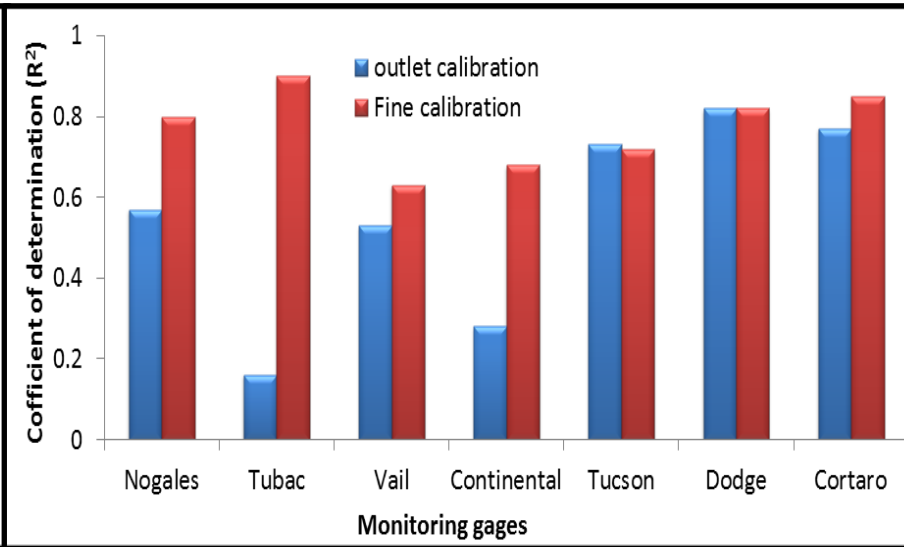
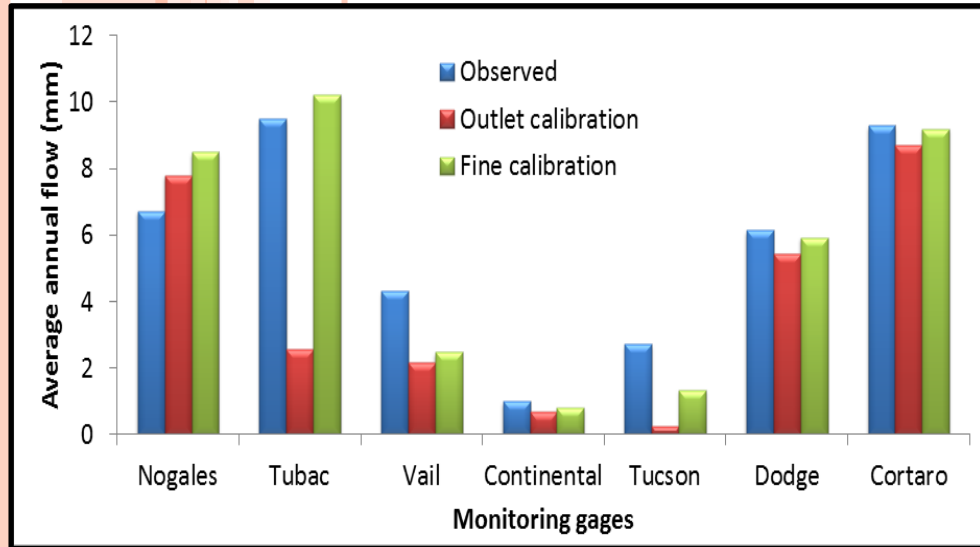


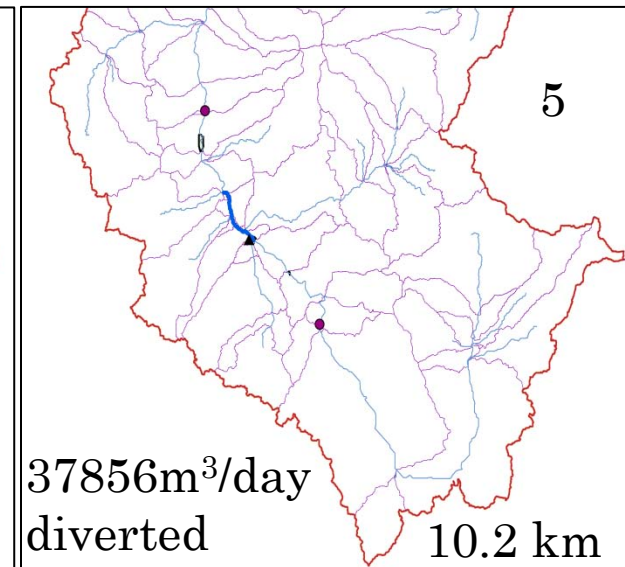
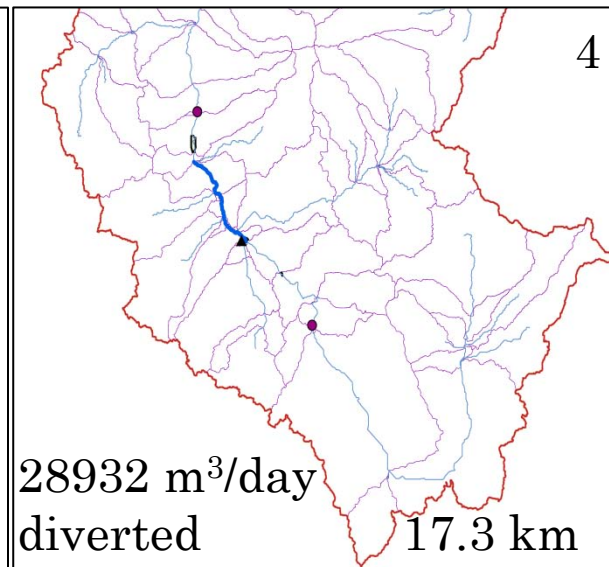
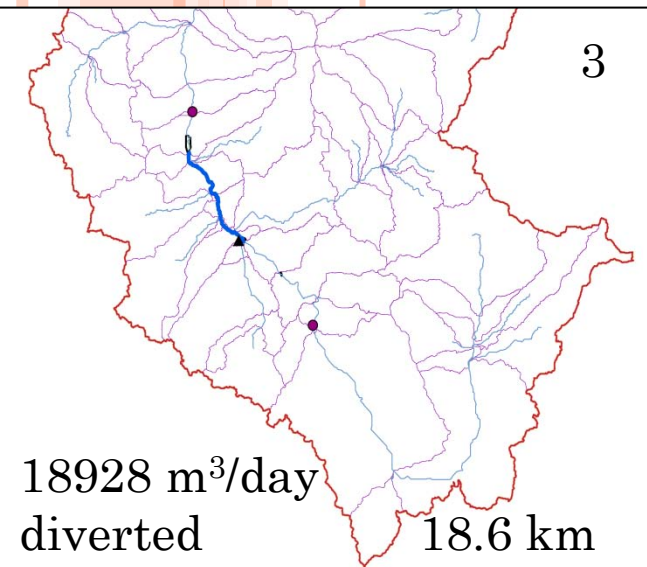
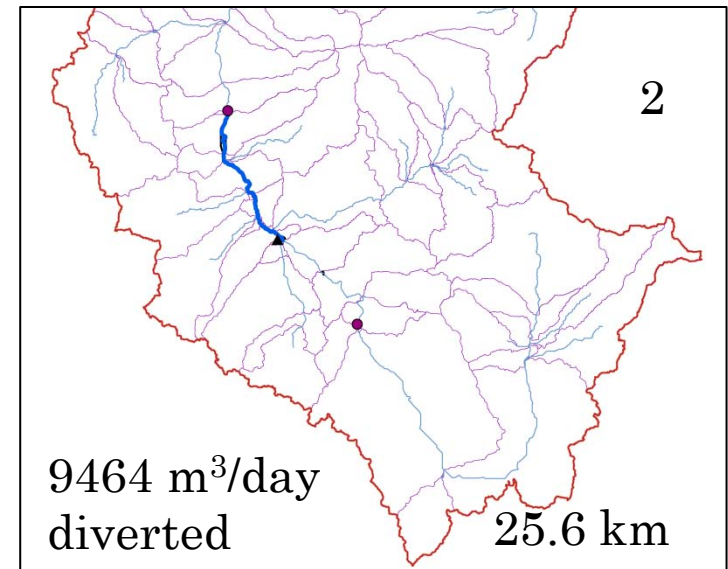
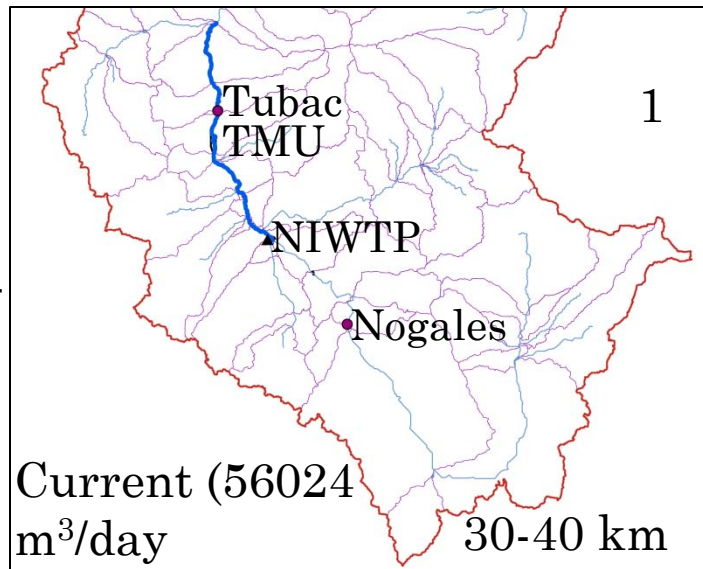
Figure 4. Simulated vs. Observed mean monthly flows at (a) Nogales, (b) Tubac, (c) Continental, (d) Tucson, (e) Vail, (f) Dodge, and (g) Cortaro.

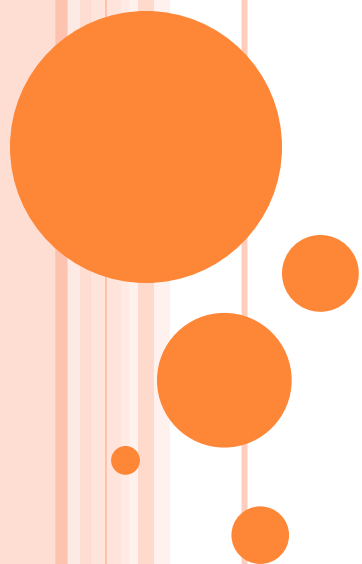
Model Performance:



NSE for validation period		
	Single outlet calibration	Spatial/Fine calibration
Nogales	-0.54	0.54
Tubac	-0.1	0.41
Continental	0.53	0.58
Tucson	0.02	0.52
Vail	0.44	0.51
Dodge	0.8	0.82
Cortaro	0.69	0.85

Model Prediction of Perennial Reaches





Conclusions:

- Model prediction improves with spatial calibration compared to single outlet calibration.
- The river at Tubac will be on longer perennial as soon as the Los Alisos Plant starts operating and diverting 18168 m³/day during the first phase.
- The impact might not be obvious at Tumacácori Mission unit until more than 27632 m³/day is diverted.
- The real problem occurs at TMU if all the waste water coming from Mexico is diverted to the new plant and discharged into Los Alisos Basin- no more perennial.
- The perennial segment of the Santa Cruz River could shrink from current ~40 km to ~10.8 km if all the waste water coming from Mexico is diverted.
- This will pose a significant threat in protecting the riparian vegetation and associated biodiversity at Tumacácori National Park area.



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Thank You

Questions?



Less Pollution



Less Oasis