

Natural Flow Regime of the Rio Grande/Bravo

Ramon Saiz-Rodriguez
rsaiz@ucdavis.edu

Introduction

The Rio Bravo/Grande basin (RGB) is a transboundary watershed shared by the United States (US) and Mexico that extends over three states in the US (Colorado, New Mexico, and Texas) and five Mexican states (Durango, Chihuahua, Coahuila, Nuevo León, and Tamaulipas). The RGB main river (Rio Grande in the US and Rio Bravo in Mexico) delimits the border between the two countries (Figure 1) and is the major water supply of border communities. Water use for municipal and agriculture is expected to significant increase in the next fifty years (Vaughan, 2012).

The basin characterized by having an extreme climate condition and highly diverted water destined to agriculture, industry and municipal use. As a result of the rapidly grow in population and the implementation of water infrastructure to allocate water for different use the streamflow's had change in timing, magnitude and quality. The pollutants due the low flow and low carrying sediment has affected the ecosystem and the organisms living in the riparian habitat of the rivers and creeks.

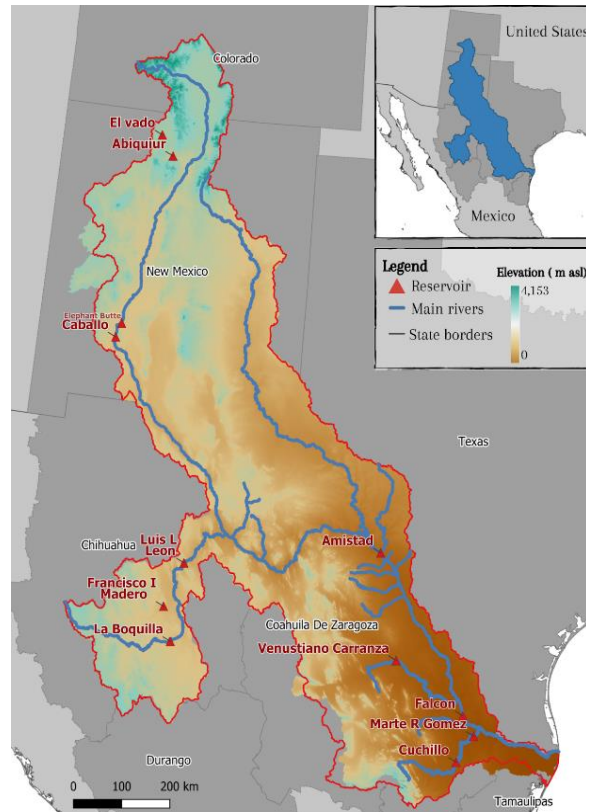


Figure 1. Rio Grande/Bravo basin

Objectives

The main objective of this report is to determine the natural flow regime from 1900 to 2021 of the Rio Grande/Bravo basin to understand the natural flow regime variability.

Specific objective

- Estimate the natural flow of the RGB Below Rio Conchos Near Ojinaga
- Estimate the natural flow regime of the Pecos River [In progress]

Natural streamflow: flows that would have occurred in the absence of human activities.

Regulated streamflow: flows altered by human intervention (dams, diversions, etc.).

Naturalized streamflow: estimated natural flow, reconstructed with records of regulated flows.

Methods

The RGB Below Rio Conchos, Near Ojinaga to Amistad was divided in 4 control points: RGB Below Ojinaga, Johnson Ranch, Foster Ranch and Amistad (see Figure 2). The historical record for the streamflow's acquisition was obtained from the IBWC gage stations.

Pecos River was divided in 9 control points as shown in figure 3. The historical record from the points was obtained from the USGS Water Watch. The streamflow data was obtained in a daily step format, as well as precipitation and temperature data obtained from the PRISM Climate Data from the Oregon State University. Climate Data was used to estimate the water deviation and returns from agricultural fields.

The natural flows were obtained using a simple mass balance $\Delta S = Inflows_t + Outflows_t$; where $Inflows_t$ corresponds to the input water upstream (on the control point upstream) and $Outflows_t$ the discharge downstream (on the next control point or downstream of the section analyzed). The flowchart process for considering Incremental flows or not is shown in figure 4.

Historical record and filling data gaps

Historical records dates for RGB Below Ojinaga starts from 1901 to 2010. Gaps are found in Johnson Ranch from 1901 to 1936 to and from 1901 to 1961 for Foster Ranch. In order to fill those gaps a QPPQ method was used between Johnson Ranch and Foster Ranch. The QPPQ uses the flow duration curves at gages with missing data to estimate the probability of occurrence based on gaged stream flow data. The gages must be relatively close and the streamflow for both locations has to be similar and unaltered by diversions.



Figure 2. RGB Below Conchos Near Ojinaga,



Figure 3. Pecos River control points

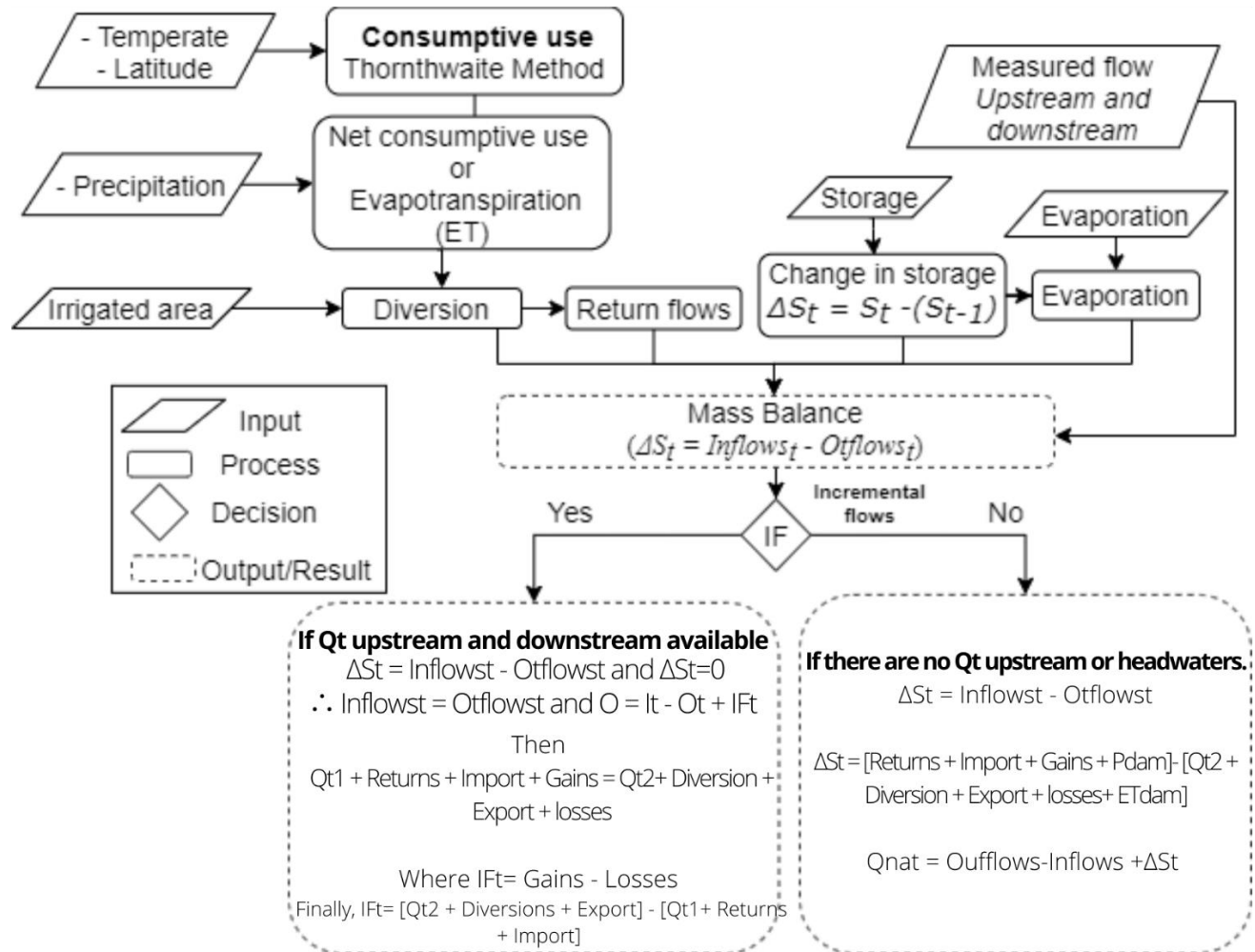


Figure 4. Model reference (Gonzalez-Escorcia, 2017)

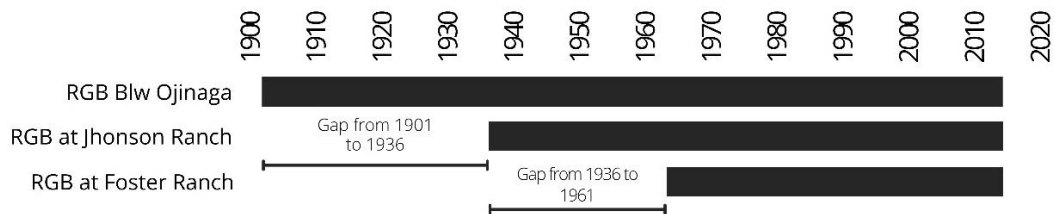


Figure 5. Historical record for control points in the RGB Below Ojinaga to Amistad section

Once obtained the missing gap between Johnson Ranch and Foster Ranch (figure 4), the natural flow regime was estimated using the equation above. The gap from 1901 to 1931 from RGB below Ojinaga to Foster Ranch was obtained by determine the linear relation between both gage stations and extrapolated the missing values (Figure 7). Same procedure was used to estimate from Johnson Ranch to fill the missing data at Foster Ranch. The procedure to obtain the relation between the stations was by using a linear regression that fitted the best both gages.

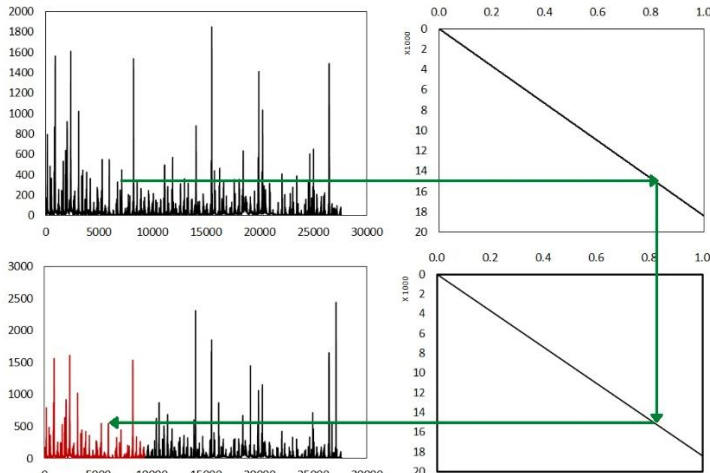


Figure 6. Filling data missing using QPPQ using Foster Ranch to complete Johnson Ranch

Historical record from Alamito Creek was also obtained as an input for the control point 1 (From Below Ojinaga to Foster Ranch). The historical data was used to estimate the natural flow regime between the selected gage stations as follows:

- Input (Historical data) = Rio Conchos, RGB Above Ojinaga and Alamito Creek
- Output= RGB Below Ojinaga

$$IF_t = RGB\ Below\ Ojinaga - (Rio\ Conchos + RGB\ Above\ Ojinaga + Alamito), \text{ Finally the } RGB\ Below\ Ojinaga\ (Natural\ Flow) = Rio\ Conchos\ Nat + RGB\ Above\ Ojinaga + Alamito + IF_t$$

Estimations of Natural Flow Regime for the RGB in the Northern branch of the RGB Basin were previously estimated and were used as an input for the next control point. Once obtained the Natural Flow Regime Below Ojinaga (RGB_BlwO_Nat) the same procedure was used for the remaining control points: RGB_BlwO to Johnson Ranch, Johnson Ranch to Foster Ranch and Foster Ranch to Amistad International Reservoir.

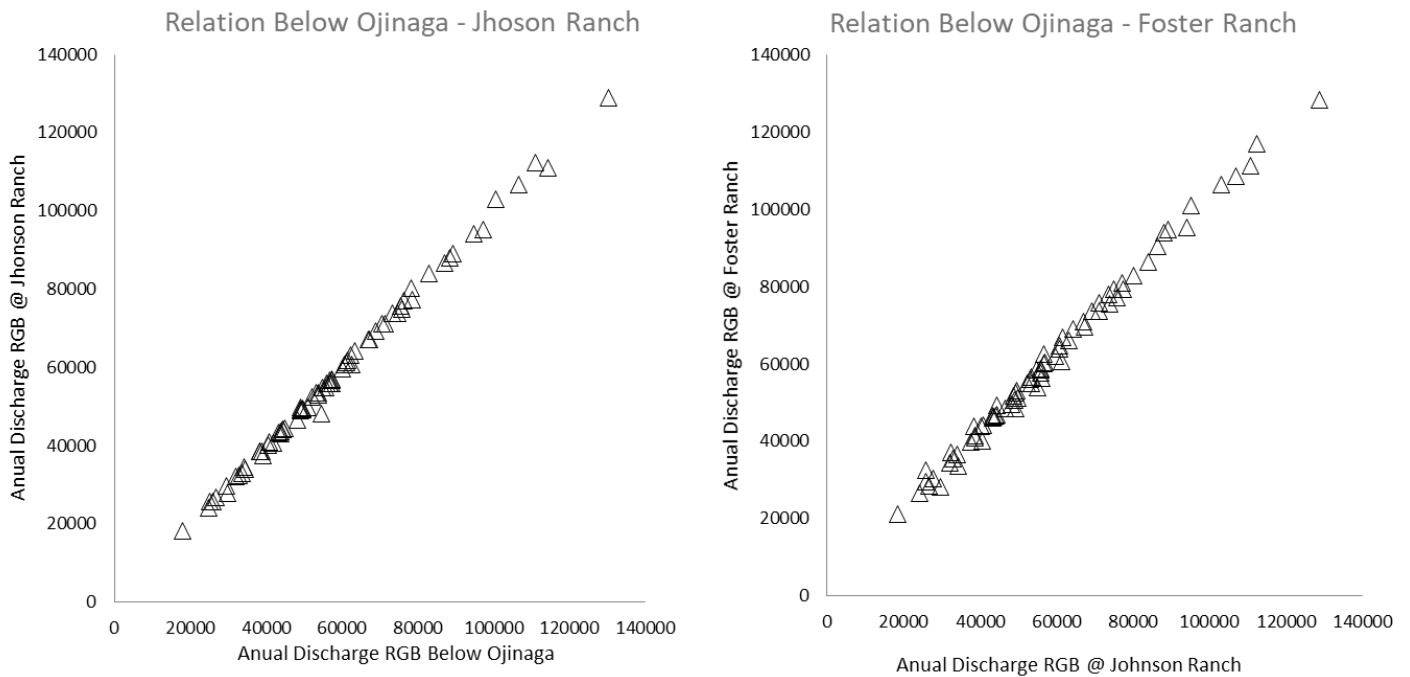
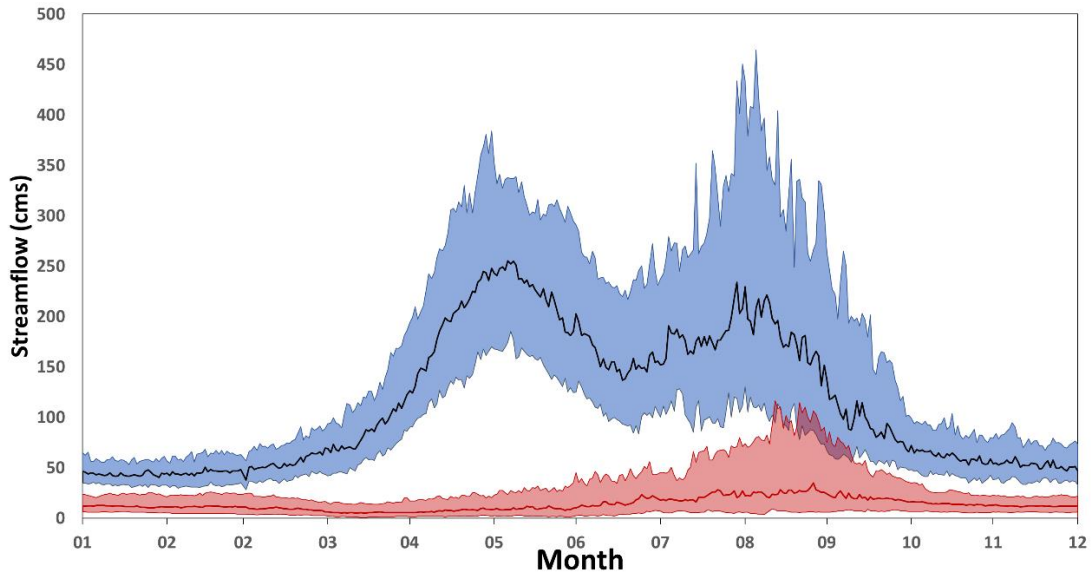


Figure 7. Linear relation between Below Ojinaga and Johnson Ranch, and Below Ojinaga and Foster Ranch.

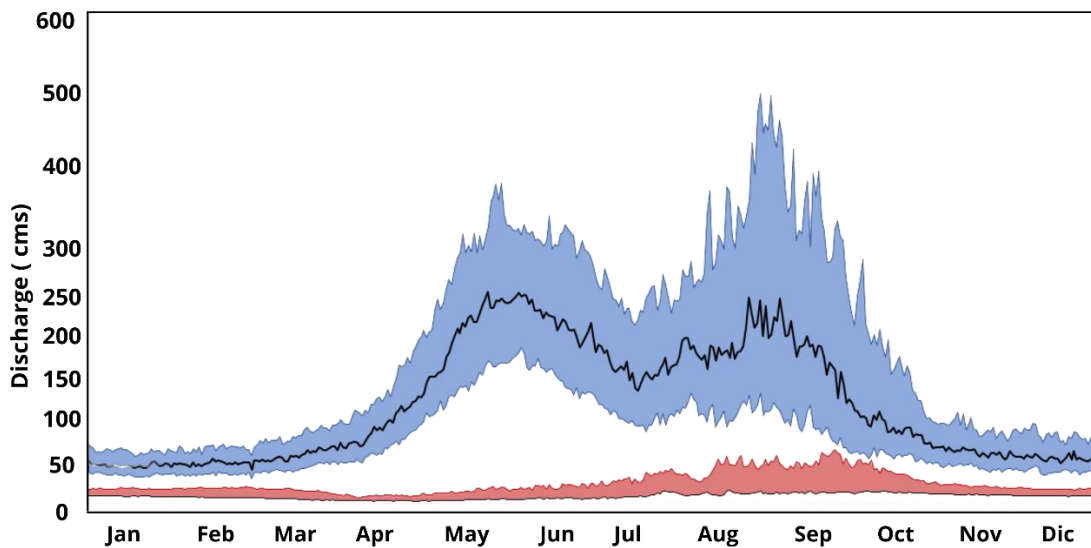
Preliminary Results

The result obtained were the Natural Flow regime for the control points of the Rio Bravo Below Ojinaga, Johnson Ranch and Foster Ranch. Figure 8 shows in blue the natural flow regime, the upper boundary represents the 75 percentiles, the lower boundary the 25 percentile and the black line the median of occurrence. Same is shown the historical records with the 75 percentile and 25 percentiles with the upper and lower boundary respectably and in the red line the median.

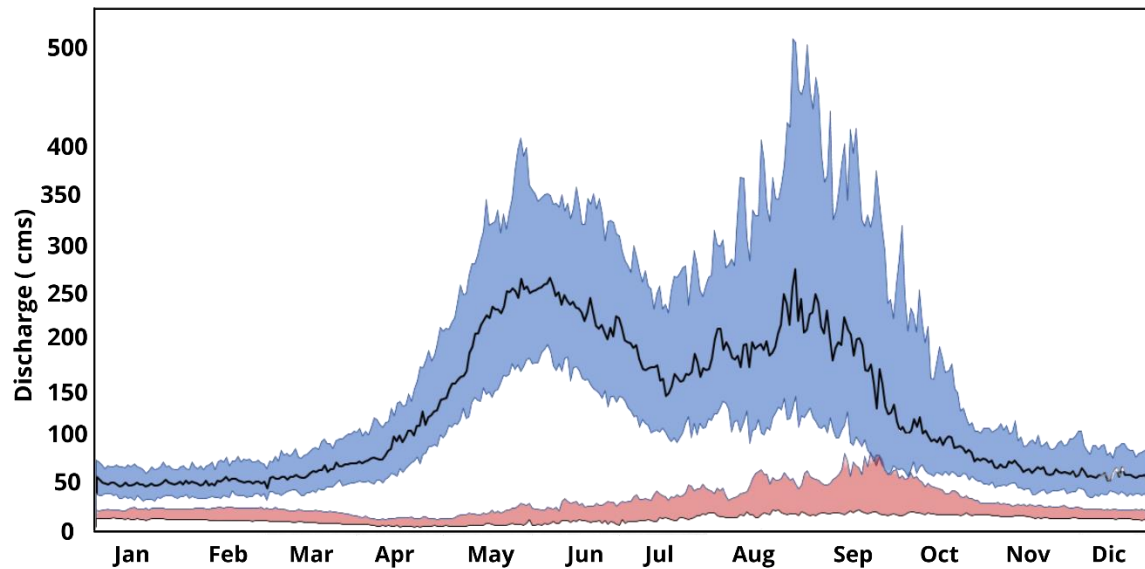
Rio Bravo/Grande Below Ojinaga Natural flow



Rio Bravo/Grande at Johnson Ranch



Rio Bravo/Grande at Foster Ranch



Conclusion and next steps

The natural flow regime is possible to estimate by using historical record and statistical data filling methods for missing data in the gages. The preliminary results show the highly flow degradation in the basin. The results shown in this report are the first step for an environmental flow analysis in the basin.

The next steps are to estimate the Natural Flow regime in the Pecos River using the same methodology as above. The Pecos River has more diversion due the agricultural crop fields that will need to estimate the conjunctive use as well as evaporation and storage from the reservoirs along the river. With the Pecos Natural flow and the RGB above Amistad natural flow the natural flow for below Amistad International reservoir will be calculated. Pecos River natural flow is still in progress and so far the control points were assigned and the data acquisition was completed. Next steps also include the characterization of the flows based in their ecological function and ecosystem services of the flow regimes and a comparison of the historical records with the natural flows. Future work includes the estimation of the natural flow regime of the whole RGB basin from upstream to downstream at the outlet of the Rio Bravo Grande at the Golf of Mexico.

References

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