ECOLOGICAL FLOW DETERMINATION OF MEZCALAPA RIVER BASED ON MEXICAN STANDARD WITH HYDRAULIC AND HYDROLOGIC CONSIDERATIONS

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1.- BACKGROUND:

The importance of the natural regime of a river for sustaining biodiversity and ecological integrity is well established. Ecological and environmental flows have similar characteristics to that of the natural regime as far as quantity, quality and duration. These latter characteristics are necessary to support the species and assure the functions and resilience of freshwater ecosystems. The existence of human communities are dependent on healthy ecosystems. (Poff et al., 2010; Dyson, et al., 2003; TNC, 2011 and Brisbane, 2007).

Furthermore, the consideration in rivers of their ecological flow allows an integrated and sustainable management of water resources. In addition to methodologies oriented to the determination of environmental flow, the current international trend is to regulate administration of watersheds by rules and regulations.

In the case of Mexico, it was on September 20th, of 2012 that the Official Journal of the Federation published the Declaration of Mexican Standard Validity NMX-AA-159-SCFI-2012 (hereinafter "the norm"), which "establishes the procedure for the determination of ecological flow in watersheds".

The present study was performed on the Mezcalapa river in the state of Tabasco, located in the south-east of Mexico (see figure 1). It includes the segment going from Peñitas dam to the bifurcation in the river to create "Samaria" and "Carrizal"(see figure 2). In order to analyze the hydrologic alteration in this basin, we have proposed an ecological flow, using two distinct methodologies: MSM and IHA (Mexican Standard Methodology and Indicators of Hydrologic Alteration).

The natural regime, the altered regime and the proposed ecological flow were modeled with the HEC-RAS software. The main objective has been to analyze changes in hydraulic variables that affect the environment, taking as main indicators the flood area, the depth of flow and the velocity.

Fig 1. Geographical location.

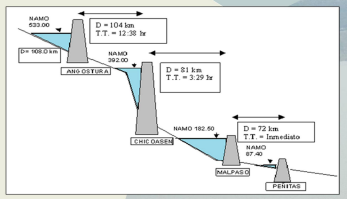


Fig 2. Grijalva Hydroelectric Complex.

2.- METHODS:

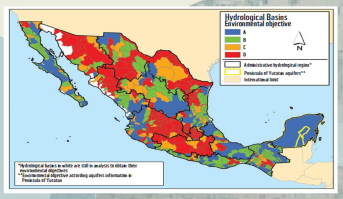


Fig 3. Conceptual model, criteria matrix and environmental objectives map.

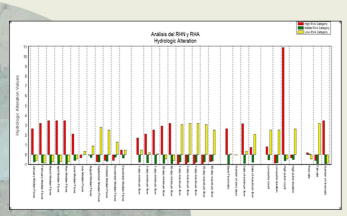


Fig 6. Hydrologic Alteration (Range of Variability Approach).

Fig 4. Grijalva Hydroelectric Complex.

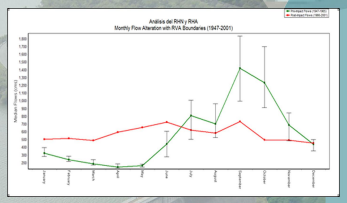
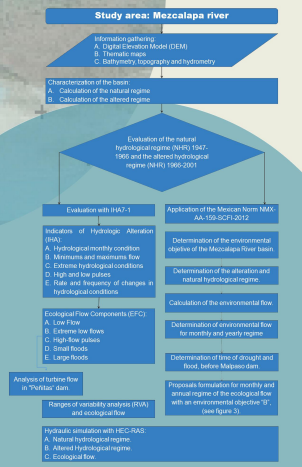


Fig 5. The interannual variation flow.



3.- RESULTS:

The multiplicity of streams helps in maintaining connectivity the flow in the basin, which has important ecological implications. The watershed under study is considered well drained and is classified as a level 10.

Over the course of a year the basin´s monthly flow was recorded at the "30015 hydrometric station". Data showed that the station's flow had changed (see figure 5). The typical annual variation of the riverbed was disrupted due to alterations caused by the dam. Nowadays the regime is practically constant throughout the year. In comparison to the natural regime, the minimum and maximum flows of the basin have been reversed. The moment of minimum flow for the NHR was from April to October and now it occurs from October to March, whereas the typical period of maximum flow was happening from October to March and now happening from April to October (NHR).

The minimal flows for Mezcalapa River ranges between 125.6 m3/s and 178.1 m3/s, for NHR's condition. In the condition AHR the minimal flows are between 162 m3/s and 408.2 m3/s. The maximum flow of one day is of 4426.0 m3/s for the NHR and of 1539.0 m3/s in the altered hydrological regime (AHR). The minimal flow for 90 days is 1486.0 m3/s in NHR and 886.8 m3/s for AHR. The maximum flows of the AHR are much less than those of the NHR. This pattern becomes more evident for very short periods, such as 1, 3 and 7 days. (see figure 6)

The Mexican standard NMX-AA-159-SCFI-2012 was used to identify the alteration of the natural regime in the basin and to determine the ecological flow.

In order to have a complete analysis of variability in the different regimes, HEC-RAS was used to obtain velocity, depth and flood maps for the driest and most humid months (April and October, respectively).

Fig 7. Flood map of April. Station 39+100.00 km to 34+700.00 km.

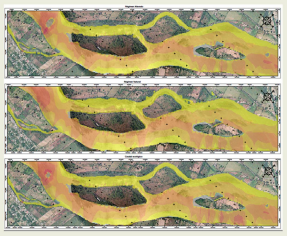


Fig 8. Speed map of October. Station 39+100.00 km to 34+700.00 km.

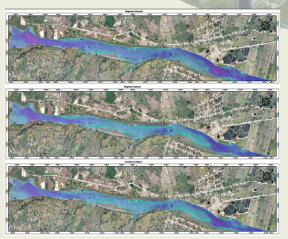


Fig 9. Depth map of October. Station 73+181.00 km to 68+900.00 km.

The first is altered regime flow. The second is natural regime flow. The last is Ecological flow proposal.

4.- CONCLUSIONS:

A series of information was used with periods of record of 19 years for RHN and 35 years for RHA, consequently one can conclude that the obtained results are reliable.

The IHA7.1 is very powerful; it executes parametric and non-parametric analysis, providing spreadsheets and a series of graphs for a complete and comparative interpretation.

The hydrological methods are the base for the determination of environmental flow; nevertheless, the proposed government norm is not considered to be the best, because it does not take into account qualitative environmental characteristics.

In summary, for October the hydraulic variables of the AHR and the proposed environmental flow behave in similar ways. The NHR presents flows that are very high in comparison to the AHR regime and the proposed environmental flow. The in-depth analysis allowed to obtain the hydraulic profiles of the riverbed at various times. The results show a similar pattern in April for NHR and the proposed ecological flow (see figure 10).

For the basin of Mezcalapa River with presence of aquatic interconnected ecosystems, with a low pressure on the water, numerous development hydraulic projects and many important water utilization projects for consumption and generation of energy, it turns out to be relevant to rely on a strategy of minimum flow that should support a sound management of the basin harmonizing the conservation of the ecosystems and its environmental services, as well as the current and social awaited benefits.

Hydraulic modeling of AHR, NHR and of the proposed ecological flow permits to visualize the effects of alterations in the study area, the natural conditions prevailing more than 50 years ago and how the river would behave with the proposed ecological flow.

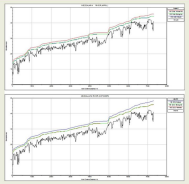


Fig 10. Hydraulic profiles, April and October.

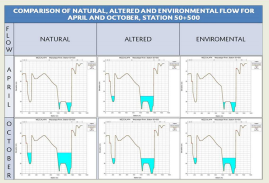


Fig 11. Hydraulic sections.