THE INSTREAM FLOW STATE OF THE ART, IN BRAZIL AND IN THE WORLD

(Short Version)

Reference: Edit n. 05 of the year 2006, PROJETO 704BRA2041 of the United Nations Organization for the Education, the Science and the Culture - UNESCO

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I - INTRODUCTION

This report, named “The State of the Art about Instream Flow, in Brazil and in the World”, was elaborated to attend the Contract relative to the Edital n.05 of the year 2006, PROJETO 704BRA2041 of the United Nations Organization for Education, the Science and the Culture – UNESCO. It is a short version of the portuguese text.

The consultant attributions are: a) to participate in meetings of the CBHSF (São Francisco River Watershed Committee) Technical Plans, Program and Projects Commission to define the working plan, the methodologies and others instruments that would be necessaries, b) to develop study on instream flow state of the art, in Brazil and in the world. Beyond the complete portuguese version, this study must have an synthetic English version, c) to participate in the workshop “Instream Flow Applied to São Francisco River”, d) to elaborate a Reference Term (TDR), based on the workshop propositions, aiming the development of future studies in São Francisco Watershed.

This document was elaborated to attend item b.

The report development observed what is established in the Work Plan presented to UNESCO according to the Edital already cited. Beyond that, it utilized information of the Instream Flow Workshop: São Francisco River Watershed occurred on 24-25 of November of 2006, in the town of Maceió realized by CBHSF.

The conflict involving aquatic organism habitat protection and the crescent water requirements for water derivation in the rivers, for different uses, is a management water resources problem. Today the competition for water derivation and the aquatic fauna requirements is a reality. The methods to determine instream flow are used to minimize the impact of these water derivations in the aquatic resources.

The studies complexity of instream flow is dependent upon the objectives and the resources needing protection, as well as the project magnitude. The existence of several methods to the knowledge of this flow complicates this process. The methods have classified in many categories, reflecting the complexity variation in their application. In addition, is to be considered the results disparity presented for different methodologies actually utilized, making difficulty the instream flow determination.

The São Francisco River has water resources that sustain productive aquatic ecosystems and many uses by human being (i.e. fishing, electric energy generation, irrigation, potable water supply, industry uses, recreation, navigation, etc). The knowledge of its instream flow for its water resources management, is one of the aims of the CBHSF, together ANA and UNESCO.

The report includes: I – this introduction, II – instream flow terminology, III – regulation in Brazil, IV - state of the art in the world and in Brazil, V – the actual scenery in the use of methodologies to determine instream flow, VI – the instream flow in São Francisco River context, VII – the references.

The management of this work was done by Dr. Flávia Gomes de Barros responsible for the ANA Water Management Resources Office, Dr. Yvonilde Medeiros Executive Secretary of the CBHSF, and José Carlos de Queiroz and Wilde Cardoso Gontijo Júnior (ANA), who also helped in the review, to whom the author is grateful for this.

II – INSTREAM FLOW – TERMINOLOGY

There are several terminologies for the instream flow concept, (J. Gondim, 2006), as for instance:
a) <u>instream flow(s):</u>
- is the water flowing in the river (IFC 2004);
- is the water required to be in the river to maintain and for conservation of natural aquatic ecosystems, scenery aspects for others scientific and cultural interests (J.M. Bernardo, 1996, em J. Gondim, 2006);
b)-<u>also named environmental</u>, residuals, or remaining- water quantity that remains in the rivers bed after the withdraws to attend external uses as public water supply, industrial, irrigation, animal needs, electric energy, etc (Bennetti, A.D.,2003, em J. Gondim, 2006);
c)-<u>minimum residual flow</u>, it is a reference value that must be maintained in the river reach downstream of a dam or water derivation (Collischonn & Gusmão Angra, 2004, em J. Gondim, 2006);
d) <u>minimum ecologic flow</u>: it is the flow to guarantee downstream of dams or water derivation, to maintain the river natural ecological conditions, em J. Gondim, 2006;
e)-<u>environment preservation flow</u>- it is the flow necessary to maintain the ecosystem functions that are in the river, in its bed. In others words, it is a value (or values) that preserves the hydrologic pulse conditions, sediments transport and nutrients, synchronicity with the wilderness species cycle life, of the fauna and vegetation and the necessaries perturbations to the renovation and the functioning of the water body associated ecosystems (Jussara Cruz, em J. Gondim, 2006);
f)- <u>environmental flows</u>:
- water regimens to be maintained in the river, in the humid areas and in the coastal areas in order to preserve the ecosystems and their benefits where exists water uses competition and where the flows are regulated (Technical Note C1 – "Concepts and Methods" World Bank, in J. Gondim, 2006);
- the water quantity that must be maintained in the river, or that is disposal in it, to attend the specific aim management of this ecosystem (Technical Note C1 – "Concepts and Methods" World Bank, in J. Gondim, 2006);
g)- <u>reference flow</u>: "water body flow to be used as a base for the management process, having in mind the water multiple use and the necessary articulation among instances of the SISNAMA- Environment National System and the SINGREH – Water Resources Management National System (CONAMA n. 357/2005 Resolution);
h)-"Instream Flow Requirements –IFRS": flows required to maintain fishes (Technical Note C1- "Concepts and Methods" World Bank, in J. Gondim, 2006);
i)- "Maintainance IFR": hydrologic regimen required to maintain all fluvial ecosystems functions, and to guarantee the plants and animals reproduction in the major part of the time (Technical Note C1- "Concepts and Methods" World Bank, in J. Gondim, 2006);
j)- "Drought IFR": a hydrologic regimen drastically reduced applicable in years of drought, in order to guarantee the survive of species, but without provisions for their reproduction (Technical Note C1- "Concepts and Methods" World Bank, in J. Gondim, 2006);
k)- "Minimum Flow": generic term utilized to describe the required flows to maintain certain ecosystem characteristic . This concept was born in USA as a remaining flow to limit water derivations during drought periods, having or not relevance for the arid regions (Technical Note C1- "Concepts and Methods" World Bank, in J. Gondim, 2006).

In this report all terms above described and existents in the searched literature are treated in equivalent form of the instream flow, because all of them have the same central aim to protect the nature, in a direct or indirect way.

III – REGULATION IN BRAZIL

In general, the fixation of instream flows in Brazil has been made principally through the legislation in the state and federal levels, mainly for environment licensing administrative procedures water right concession and dam construction.

The environment and water resources country legislation does not point explicitly who is the competence to define the instream flow (Da Silva, Luciano Meneses C. et al, 2005).

The Water Code, Decree n. 24.643/1934, in the Article 143, establishes that all hydraulic electric energy projects will must satisfy the requirements of all general interests: a) of the feeding and necessities of the river marginal populations, b) of the public salubrity, d) of the irrigation, e) of the floods protection, f) of the fish conservation and free circulation, g) of the water flowing and rejection.

For the case of small hydroelectric the Norm n. 4, fixes that the flow downstream of the dam can not be less than the monthly average flow calculated on the basis of the annual observations in the local for the dam (MORTARI, 1977).

The Norms to Present Studies and projects for projects and exploration of water resources to generate electric energy, of the extinct DNAEE – National Water and Electric Energy Department (1984), specifically the Norma n. 2 and 3- Norm to Approve Projects of Electric Generation for the Public and Private Use establishes a residual flow in the water body downstream to the dam higher than 80% of the monthly average flow, characterized with base in the hydrological flow time series having at least 10 years(MORTARI, 1977).

The Resolution CONAMA n. 05/1988, specifies that it is under licensing, any water supply system construction which value for water derivation will be more than 20% above the minimum flow of the water body and or that modify the physical conditions e or the water body biotic.

The 1988 Federal Constitution brought several innovations related to the environment protection, being distinguished by the fact to be the first Brazilian Constitution to dedicate a chapter to the theme. However, only with the law 6.938/81 (Environment National Politics), is that truly has the beginning the environment protection as such in Brazil (Benjamim, 1999).

In Ceará State, the Decree n. 23.067/1994, presents in its article 19 that: the water availability will be a function of the local hydro geologic characteristics or of the watershed that the permit is for, observing too the following: I- when it deals with superficial water; a) the minimum natural flow will be zero; b) the reference value will be the regularized annual discharge having 90% guarantee. II – when it deals with ground water, the quantitative reference can consist of: a) in the nominal well test, or, b) in the aquifer recharge capacity.

In the State of Bahia, in consonance with the Law n. 6.855/1995, and state Decree n. 6.296/1997, the reference flow (for water resources permit) will be: 1- 80% of water body reference flow, estimated with base on the up to 90% of duration to the dairy level, when there are no dams 2- 80% of regularized flows with 90% guarantee, of the natural lakes or dams build in perennial water bodies; 3 – 95% of regularized flows with 90% guarantee, of the natural lakes or dams build in intermittent water bodies; 4 – in the cases of human water supply, the limits of 1 and 2 can be up to 95%; 5 – in the 2 case, the 20% remaining flow of the natural flows with 90% guarantee must flow to downstream, bottom discharge or by other mechanism that does not include lift pumps; 6 – no users, individually, will have permit above 20% of a water body reference flow (Article 14, Decree n. 6.296/1997).

The Parana State (Portaria n^{o}. 06/96) regulations determine that the allowable water volume to be derived directly must be less than 50% of $\mathbf{Q_{7,10}}$, or that the downstream flow be higher than 50% of $\mathbf{Q_{7,10}}$.

In Rio Grande do Norte State, the Decree n. 13.282/1997, indicates in the article 13 that: the water availability will be evaluated as a function of the hydro geologic and hydrologic characteristics of the superficial or underground watershed where the permit is for, observing still, the following: I – when it is superficial water; a) the minimum natural flow will be zero or established in specific legislation, based on hydrologic study; b) the reference value will be the annual regularized discharge having 90% guarantee. II – when it is groundwater, the quantitative reference must take in account: a) the aquifer recharge capacity, foreseen in legislation used on specific hydro geologic study; b) the interference due to surrounding wells.

The Law n. 9.433/1997, that deals with the Water Resources National Politics, purposes in its articles 2 and 3 the water resources rational utilization, its systematic management without dissociation of the quantity and quality aspects, as well as to adequate this management to the physical, biotic, demographic, economic, social, and cultural diversities of the different country regions.

In São Paulo, the Decree n. 43.284/1998 (regulating Cabreuva and Jundiaí municipal APA – Environmental Protection Area) defines that must be used the flow reference $\mathbf{Q_{7,10}}$.

The Minas Gerais legislation (Port. n. 010/98 and 007/99) to be used in the water use permit utilizes the reference flow $\mathbf{Q_{7,10}}$ as specified below:

- till that are established the watershed reference flows, it will be adopted $\mathbf{Q_{7,10}}$, for each watershed.

- it is fixed 30% of $\mathbf{Q_{7,10}}$, for the maximum consumptive water uses for water permit in the watershed portion limited for each cross section considered, in natural conditions, remaining downstream of each derivation, minimum residuals fluxes equivalents to 70% of $\mathbf{Q_{7,10}}$.

-when the water body is regularized by the interested or by others users, the permit limit can be more than 30% of $\mathbf{Q_{7,10}}$, taking in account the perennial or regularization potential, since it is maintained a downstream minimum residual flux, equivalent to 70% of $\mathbf{Q_{7,10}}$.

In Espírito Santo State the Environment Secretary – SEAMA, its Decree n. 4.489/1999, specifies that the dam downstream flow must be at least equal to smaller value comparative between $\mathbf{Q_{7,10}}$ and the minimum flow measured in the drought period, calculated for that water body cross section, that must be in the technical project, guaranteeing downstream multiple use and the aquatic ecosystem maintenance. The Normative Instruction n. 019/2005 also defines the flow reference for administrative procedures and technical criteria for the right to water resources use.

The MMA (Ministry of the Environment) in the Normative Instruction n. 004/2000, Annex I, Article 2, which approve the administrative procedures to water right concession, in Federal water bodies, defines instream flow as being the minimum flow necessary to guarantee the preservation of the aquatic ecosystems natural equilibrium and the sustainability.

The CNRH (The National Water Resources Council) Resolution N. 16/2001 in the Article 21, item III, presents the minimum flow as being that necessary to prevent environment degradation, to maintain aquatic ecosystems and to maintain adequate conditions to the aquatic transport, when possible among others uses.

The Rio de Janeiro legislation (Port. SERLA n. 307/2002) specify general criteria and technical and administrative procedures, to water resource use permit emission, in its article 5 determines that for flow reference will be utilized $\mathbf{Q_{7,10}}$.

In Mato Grosso State, the Water Resources Council Resolution n. 3/2003, in its article 1, establishes: to the effect of this resolution are adopted the following definitions: (X) ecologic or remaining flow; minimum flow that must be maintained in dam downstream, established in the permit process; (XI) restriction flow: flow that establishes limits to attend multiple water resources uses or that guides the reservoir operation when occurring flooding or floods.

In 2004, it was developed the São Francisco River Watershed Water Resources Plan by the CBHSF, ANA, GEF – Environment World Fund, PNUMA and OEA.

The CBHSF Deliberation N. 08/2004, defines hydro responsibility, potable water maximum flow, the remaining average and minimum instream flow in the mouth as integrant part of the São Francisco Watershed Water Resources Plan, and specifies that:

Art.4 – to adopt, provisory, 1,300 m^3/s the daily average flow, as the minimum ecologic flow in the mouth, until that to have the revision or the confirmation of this value in the next Plan edition.
§1^0 – the minimum ecologic flow must guarantee the ecosystem maintenance and to preserve the aquatic biodiversity and will not be practiced continuously.

Art. 5^o- The remaining flows in the watershed Rivers, after water allocations for consumptive uses, must be higher than minimum flows necessaries to maintain aquatic biota in each river reach.

§1^0 – To adopt, provisory, 1,500 m^3/s the mean annual average flow, as the remaining flow in the São Francisco River Mouth.

§2^0 – It is indicated as priority the immediate study development to the knowledge not only of the minimum ecologic flow, but also on the possibility of establishment of a regimen of ecologic flows that makes possible seasonal flow variations, both necessaries to maintain the biodiversity and the dynamic environmental equilibrium in all São Francisco reach and tributaries that will receive hydroelectric reservoirs, and still in its mouth and in the adjacent costal zone. These studies will contemplate strategies for the maintenance of nutrients flow, from upstream to downstream, affected by large hydroelectric.

The CBHSF Deliberation N. 13/2004, presents basics recommendations to implement integrated inspection proposed by the São Francisco Watershed Plan, and in the Art. 6 establishes the studies promotion to implement a basic network to develop a methodology to determine criteria and instream flow values for the tributaries of São Francisco watershed rivers.

The Resolution CONAMA 357/2005, defines reference flow as “water body flow utilized as base for the management process, having in mind the water multiple use and the necessary articulation of the SISNAMA instances and of the SINGREH”.

The CBHSF Deliberation n. 21/2005, determines in the Art. 3,I – To viable studies and necessaries actions to elaborate and constructing water pact and Water Plan partial revision, in a time of 01 year, including: b) studies realization to establish the São Francisco instream flow.

The State of Espirito Santo IEMA Normative Instruction N. 019/2005 also defines reference flow for water rights concessions administrative procedures.

IV – THE STATE OF THE ART

There are about 207 methodologies distributed in 44 countries for instream flow evaluation here classified in four types: hydrologic, hydraulics, habitat and holistic.

The first type is hydrologic methodology that utilizes hydrologic data (time series of diary or monthly flows). In general, they fix a percentage or proportion of the natural flow to represent the instream flow.

The hydraulics methodologies, second type, consider the changes in simple hydraulics variables as wetted perimeter or maximum depth, measured in one river cross section. The instream flows are obtained through a graphic in which is represented by the study variable and the flow.

The third type comprehend the methodologies that make use of the habitat, that aims to evaluate the instream flow taking in account the available physical habitat for the species under analysis. These methodologies are a process of instream flow policy development that incorporates variables or multiple rules, for use in negotiation with basis in the flow to attend the aquatic ecosystem needs, considering water supply demands and other water uses. They usually implicates in the determination of a relation flow-habitat to compare inflow alternatives in long term.

The holistic methodologies, fourth type, identify the flow critical events as a function of the established criteria for the flow variability, for some or principal components or river ecosystem parameters. They are basically ways to organize and using flow data and knowledge, being able, to include some methods here described. It is a methodology that utilizes distinct procedures to produce results that none other procedure and/or method would produce alone.

Several studies were realized throughout out the time about methodologies to determine instream flow including Mohardt (1986), Sarmento, R. et al (1999), Tharme, R.E. (2003), IUCN – International Union for Conservation of Nature and Natural Resources (2003), The World Bank (2003) and Annear,T. (2004, IFC-Instream Flow Council (2004).

In this report the term reference flow, residual flow and remainder flow are treated as equivalent to the term instream flow, because all of them have as central aim to protect the nature, in a direct or indirect way.

IV.1- METHODOLOGIES IN THE WORLD

IV.1.1- HYDROLOGIC METHODOLOGIES

One of the first methods developed with intention to evaluate the value of the ecological outflow of rivers is known as **“One Flow Method - OFM”** (Sams and Pearson, 1963, cited per Morhardt, 1986). The gotten equation aims at on the basis of to determine an excellent outflow for the position of fish (Salmons) using air photographs of the segment of the river in study

In 1975 the **Method of Tennant or Montana** was developed, which bases only on simple hydrologic variables (Tennant, 1976; Morhardt, 1986). Tennant defined the fluvial ecosystem as function of the outflow, expressed in percentage, with regard to the annual average outflow of the river, calculated for the place of the hydraulics exploitation. The Method recommends an established ecological outflow in a set of percentages in relation to the annual average outflow, calculated for the place of the hydraulics exploitation, utilizing different percentages for the periods from October to March and April to September. The Tennant method has had several modifications that aim to better adapt the calculated instream flow regimens to the natural flow regimen in many regions different from that for which the method was developed. Its major limitation is that it can be applied to water bodies morphologically similar to that from which the technique was developed, being more suitable to rivers of large dimension, that show a small flow variation during the year.

In the year of 1976 was elaborated the **$Q_{7,10}$ Method,** which recommends instream flows based on flow time series, more specifically the minimum flow that is observed during seven days consecutives, having return period of ten years (Chiang and Johnson, 1976, cited by Loar and Sale, 1981). It has been utilized mainly in the East and Southeast of the USA, beyond to be the most employed method in Brazil. Its instream flow recommendation has no ecologic basis, because does not consider the ecosystem specifications and ignore the ictiofauna natural dynamics and the necessary time for its recuperation when submitted to long reduced flow period.

The **State of Texas** utilizes actually two hydrologic methods to define the instream flow; one is the **Lyons method** and the other for water planning **"Consensus Criteria for Environmental Flow Needs, CCEFN".** The Lyons method was developed by Barry W. Lyons, 1979, Texas Parks and Wildlife biologist. The methodology uses percentages of diary men flows as parameter to determine the instream flow in Texas Rivers. The CCEFN is the second method, which is a part of the Texas Water Plan in elaboration by "TWDB-Texas Water Development Board". The adopted criteria are the natural flow – the estimated flow that would be in the river without the impacts generated by human interference its watershed. While Lyons method uses measured data for the flow value, CCEFN uses natural flow percentiles values in the water derivation and remaining flow. However, the two methods yield instream flow different values for the same river in Texas.

In 1980 was developed the **"Aquatic Base Flow" (ABF)** for the New England region in the USA (Larsen, 1980, cited by Morhardt, 1986). The ABF has aims to create flow adequate conditions to maintain the water body aquatic organisms. The ABF basic hypothesis is that the average flows or recommended are sufficient for the fishes species. The ABF flow recommendations, are made having base in a flow time series, from which is calculated the mean for the year driest month. The precision level of the method is low. According to Russel (1990), cited by Alves (1993), comparative studies with others methods suggests that the results obtained through this method are more conservatives, that is, the recommended flows are higher than those obtained with other methods.

A more sophisticated hydrologic model is the **"RVA – Range of Variability Approach"**, Richter et al, 1997. The RVA purpose is to give a structure for the rivers management to restore or to maintain the natural variability of the hydrologic regimens to aquatic ecosystem restore/conservation. In the method application the diary flows are characterized for a period register reflecting natural hydrologic regimens (not altered by anthrop effects) utilizing 32 hydrologic alteration indicators obtained by the IHA – Hydrologic Alteration Indicators method, considered in continuity. It is selected an extension of these parameters to formulate initials instream flow targets for the river management. The instream flows targets are utilized for strategic management (i.e., reservoirs operations and water derivations) and adequate refined as indicated by the ecologic monitoring in long term and as required by the aquatic ecosystem conservation. The RVA has been applied in more than 30 instream flow studies in USA and Canada, and the South Africa. Some researchers consider RVA as holistic methodology.

Jenq Tzong Shiau (2004), utilized RVA to determine instream flow after a lateral weir construction named Taitung in the Peinan River in Taiwan. The goal was to make the postdiversion flows attain the target ranges at the same frequency as that which occurred in the postdiversion flows

In 2001 The Nature Conservancy, utilized the **Hydrologic Alteration Indicators (IHA)** to obtain hydrologic regimen characteristics, aiming to analyze the changes in these characteristics throughout the time. A hydrologic evaluation using this method is to obtain an series of hydrologic attributes relevant biologically that characterizes the annual variation of the water conditions as basis for comparison with past hydrologic regimens, and after the system has been altered by human actions. The method calculates a hydrologic characteristics set, or indicators, to evaluate hydrologic alteration. It includes four steps: define data series for ecosystem interest; calculates the hydrologic attributes values; calculates intra –annual statistics; calculates hydrologic alteration indicators values. The method can be utilized to compare the system condition with itself throughout the time (before and after the impact); to compare the system condition with other system, or to compare actual conditions with model simulations of the future modifications. The Nature Conservancy has a tool (IHA) for parameter calculation for five different types of the hydrologic flow components, that is, minimum flows, extreme minimum flows, high flow pulses, small floods, and large floods. This flows scenery must be maintained to guarantee the river ecologic integrity.

The Duration Flow Curve method is based in the hydrologic flow registers. The great restriction to the method is that it requires much research to establish and to verify the relations of the biology with the hydrologic parameters in proposition for use.

IV.1.2- HYDRAULICS METHODOLOGIES

The “**Toe-Width Method**” was developed by the “Department of Fisheries”, “The Department of Game”, and the U.S. Geological Survey (USGS) in the 1970 decade to determine the minimum instream flow for fishes. The results of nine years of river depth and velocity measurements were utilized to calculate the habitat per area unit, for each measured flow. A toe-width is the distance between the river branches measured in the stream bed. This width is used in the form of an equation to determine the necessary flow to allow the Salmon reproduction.

In 1974 was elaborated the **Washington Method** for the Washington Department of Fisheries (Collins, 1974, cited by Alves, 1993). The method involves the cartography of the river reach to determine spawning areas and growing of the considered species. In the method are selected at least three places of interest, in which are defined, in each area, four cross sections. In each cross section, and if possible between them, are made velocity and water depth measurements considering at least five values of flow. It is important that the flow values of interest are within of the interval of the interest. The values obtained allow defining the water depth and velocity.

For each flow, are build topographic maps, for spawning and growth that show different combinations of velocity and water depth. From this map area are measured with adequate combinations of velocity and water depth, from which are elaborated area curves for spawning and growth as a flow function. The recommended flow correspond to the curves peaks, being the instream flow defined as that able to maintain 75% of the maximum area for spawning or growth. The great advantage of this method is its graphic form, not being necessary to use hydraulic simulation.

In the year of 1983 was developed the **Wetted Perimeter Method –MPM**. This method (Annear and Conder, 1984) admits the existence of a relation between the wetted perimeter and habitat availability for the ictiofauna. In the method application are define cross sections where is supposed to have a great variation of the wetted perimeter as flow changes, generally places with high velocities and low water depths. Next are made velocity and water depth measurements, considering at least three flows, if needed hydraulics simulation can be used. Then, it is defined a graphic that relates wetted perimeter with the flow. It is identified the inflexion point in the curve, from which the wetted perimeter has small increase and represents deterioration of the habitat. The flow referred to the inflexion point, is the recommended flow.

Liu et Al, 2007, defines the concepts of ecological flow velocity as well as ecological hydraulic radius which considers both the watercourse information (including hydraulic radius, roughness coefficient and hydraulic gradient) and the required stream velocity necessary for maintenance of certain ecological functions all together. This concept was used in the estimation of ecological water requirement of Zhuba

Hydrological Station watercourse in Niqu branch of the Yalong River in China as an example. The results obtained were compared to the results presented by Tennant methodology.

IV.1.3- HABITAT METHODOLOGIES

The Instream Flow Incremental Methodology – IFIM was developed in 1982 (Bovee, et al., 1998), actually Aquatic Systems Branch of the National Ecology Research Center, USFWS, in Fort Collins, USA.
IFIM is based on the principia that the longitudinal and lateral distribution of the aquatic organisms is determined, among other factors, by the hydraulics, structure and morphologic characteristics of the water bodies. Each organism tends to select in the water body the better conditions to live, corresponding to each variable of the microhabitat (velocity, water depth, substrate and cover) a reference degree that is proportional to the aptitude of the variable value for the specie (Alves, 1996). According to Bovee et al (1998), the river area that has favorable environmental conditions to maintain a fish population can be quantified as a flow function. IFIM is made off by a series of theory and computer procedures linked that describes time and space characteristics of the habitat as consequence of a given alteration alternative of the rivers flow regimen. The incremental characteristic of the method becomes from the fact that each problem is faced, allowing that the solution will be found from the flow variations, beginning from an initial value considering several alternatives, becoming adequate to the resolution of conflicts among may water users.
IFIM can be implemented in five phases sequential: (i) diagnostic and identification of the problem, (ii) study management, (iii) study implementation, (iv) alternative analysis and (v) problem resolution. The decision variable generated by IFIM is the available habitat area for the species, determined as a function of the flow. The recommended instream flow corresponds to the highest value from a set of flows calculated for several species and that, for this, will be sufficient to maintain the existent populations. The IFIM can applied not only to study instream flows, but also to environmental impact studies decurrently from any perturbation type that occur in the water body.

In 1993, Nestler et al used the **RCHARC – The Riverine Community Habitat Assessment and Restoration Concept** to study flow alteration effects on the aquatic biota in channel projects. It is a method to evaluate river habitat under low flow conditions. It combines conceptual elements of the Index of Biotic Integrity (IBI) and of the system PHABSIM-Physical Habitat Simulation (software utilized to quantify adequate hydraulics attributes against not adequate hydraulics attributes of the selected species habitat and life stages as a flow function. Basically it is utilized for river recuperation projects under reference conditions. It involves the following hypothesis: each specific flow is guaranteed by a distribution of water depth and velocities; and, the aquatic community structure is closed related to the hydraulics diversity, as described by water depth and velocity frequency distributions. The method has the following characteristics: does not make quantitative comparisons between river reaches (the evaluations are qualitative); makes links between field observations, research results, and understanding the habitat diversity; does not utilize the criteria of species adequacy to calculate habitat; requires data of river geometry, hydrology, levels of water, water depth decreasing, and data on microhabitat as sediment transport, dissolved oxygen and water temperature.

The empiric method **Plunge Pool,** developed by the Washington Department of Fish and Wildlife and Department of Ecology, 1996, was projected to establish minimum standards of flows and flow operational regimens for rivers with trout having higher gradient, pebbles stream bed and falls.

In 1998, the **Pennsylvania Environmental Protection** Department, the Susquehanna River Watershed Commission, the Pennsylvania Fishing Commission, the U.S. Army Corps of engineers, the Maryland Environmental Department and the U.S. Geological Survey Biologic Resources Division developed a study to evaluate the instream flow needs. The study objective was to develop a procedure to determine the levels for instream flow that: 1- considered the fishing protection; 2- would be applicable to Pennsylvania rivers; 3- not requires high cost studies; 4- would be ease to use in the water permit process. The components of the physic habitat of the IFIM methodology- Instream Flow Incremental Methodology were applied to specific places in Pennsylvania and Maryland. A computer program was developed to estimate the water derivation effects on the physic microhabitat and the available water for use. This program evaluates impact statistics foe several water derivations alternatives for any project in the study region. Also, the program realized several combinations of species, and water derivations to evaluate the resultant annual habitat reduction for each combination. As study result were obtained curves that relates species habitat with water derivation, to determine the limits of water withdraw.

The **Tidal Distributary/Estuary Method,** Duke Engineering, 1999, is an incremental technique to provide flows to maintain the cannel refugee in the low tide and in the flooding areas in the high tides. The method purpose is to determine the flows that will maintain the estuary resources and processes. The technique employs a regression model that correlates the estuary water levels as a tide function and to establish habitat adequate to maintain the fishes and the estuary and the vegetation communities. One restriction is that the method does not take in an account the salinity, important factor in the estuaries. It supplies information, but no answers.

The Texas Water Development Board (TWDB), 2002, and the Texas Parks and Wildlife Department (TPWD) jointly established and currently maintain an analytical study program focused on determining the effects of and needs for freshwater inflows into the state's bay and estuary systems. Study elements include hydrographic surveys, hydrodynamic modeling of circulation and salinity patterns, sediment analysis, nutrient analysis, fisheries analysis, freshwater inflow optimization modeling, and verification of needs. For determining the needs, statistical regression models are developed among freshwater inflows, salinities, and coastal fisheries. Results from the models and analysis are placed into the Texas Estuarine Mathematical Programming (TxEMP) model, along with information on salinity viability limits, nutrient budgets, fishery biomass ratios and inflows bounds. The numerical relationships are solved within the constraints and limits, and optimized to meet state management objectives for maintenance of biological productivity and overall ecological health. Solution curves from the TxEMP model are verified by TWDB's hydrodynamic simulation of estuarine circulation and salinity structure, which is evaluated against TPWD's analysis of species abundance and distribution patterns in each bay and estuary system.

The **MesoHABSIM –** MesoHABitat SIMulator (2001, in IFC, 2004, is similar to PHABSIM integrant module of IFIM. It purposes is to give a mean to evaluate the habitat that can be utilized in rehabilitation sceneries including flows regimens alternatives, for the entire river or in one cross section.
MesoHABitat Simulator is similar to PHABSIM because both quantify habitat physical attributes, doing relation with those from adequate habitat requirements for the selected species and life stages as a flow function. While PHABSIM involves microhabitat detailed research within the selected sampling places, MesoHABSim utilizes mesohabitt mapping in all river cross sections under multiple flows conditions.

The method **Demonstration Flow Assessment – DFA, in IFC, 2004,** uses river habitat conditions direct observations to determine the instream flow for different flows, and a group of experts choose the flows alternatives. The DFA uses procedures that can be divided in two parts. The first part is general and deals with the decision analysis based on judgment. This part includes: 1- decision structure: approach an evaluation through its objectives and contours, 2- conceptual modeling; key processes identification and mechanisms by which the selected variable affects the studied resources, 3- measurable indicators definition based in the conceptual models, 4- observation how the measurements respond to the studied variables, and 5- results analysis and uncertainty to choose management alternatives. The second part is ecologic: habitat quantifying as a mean to evaluate the effects of the management alternatives. This part includes: 1- identification of specific habitat that will be wished due to specific reasons, 2- quantity estimate of these habitat types for each alternative, and 3- evaluation of the alternatives in how they will provide the wished quantities for each habitat type. The authors illustrate the use of procedures, including a study to evaluate the instream flow for Salmon reproduction in the Clakamos River in Oregon, USA. The subjectivity and uncertainty are the mains limitations in DFA use, because it does not use quantifying. It has been applied mainly in the hydroelectric permit process. DFA has same beddings as PHABSIM integrant of IFIM.

IV.1.4- HOLISTIC METHODOLOGIES

The **Holistic Methodology** (Arthington et al, 1992) was developed in Australia to study instream flow taking in account all river ecosystems, being able to include associated areas such as marshes, groundwater and estuaries. Additionally, it considers all species that are that are sensible to the flow, such as invertebrates, vegetation and animals, and contemplating all floods aspects, droughts, and water quality. It represents the conceptual basis and theories for the holistic methods majority to determine instream flow. In general, this methodology uses professional experts group and can involves interested parts, making that the process be holistic. The group makes judgments related to ecologic consequences for several river flows on quantitative and temporal aspects. One method disadvantage is its high cost in data acquisition.

King J. M. & Louw D. in 1998, employed the **BBM – Building Block Methodology in South Africa**. It was developed by local researchers and the DWF – South African Department of Water Affairs and Forestry. Basically, it has three phases: 1- workshop preparation, including, interested people consulting, office and field studies to local selection, river reach geomorphologic analysis, and social researches and river habitat integrity, establishing objectives for the river future condition, economic and ecologic importance river evaluation, hydraulics and hydrologic analysis, 2- multidisciplinary workshop to build to construct flow regime variation through instream flow characteristics identification essential in monthly terms, 3 – necessary instream flow linking to the phase of water resources engineering development, with scenery modeling and hydrologic analysis.
The method is applicable to regulated and non regulated rivers when dealing with flows restoration.

It was developed in Africa by Southern Waters and Metsi Consultants a holistic methodology with a social economic component (King et al. 2003), named **Downstream Response to Imposed Flow Transformations** (**DRIFT**). The DRIFT application comprehend four modules: 1 – biophysical module: used to describe the ecosystem present condition, to predict its flows alteration changes; 2 – sociological module: utilized to identify users subsistence risks due to flows alteration and to quantify its linking in terms of natural resources and healthy profiles; 3 – scenery development module: it links the first two modules through a data set, to obtain predictions of flows alterations consequences; 4 – economic module: it generates costs description to mitigate and compensate for each scenery. This methodology has limited application in South Africa region. The DRIFT, was utilized in the Lesotho Highlands Water Project (LHWP), World Bank, 2003. The DRIFT methodology contains a process to evaluate the social consequences for each flow scenery and others means to evaluate economic costs to regulate the flows, as a function of the effects on fishes and others natural resources or services realized by the communities.
Arthington, A.H., 2004, describes the holistic methods principal characteristics.

IV.2 – METHODOLOGIES IN BRAZIL

The Tennant method was employed in the elaboration of the water resources plan for Velhas and Paracatu rivers in the State of Minas Gerais, Froes, 2006.

Sarmento, et al, in 1999, presents the instream flow state of the art. One conclusion was that for Brazil the legislation and the methodologies dealing with instream flows were rare. Also, the existent methodologies in the States and Federal Brazilian organisms recommend residual flows (remaining project downstream flow) based only on hydraulics parameters, not considering the aquatic ecology, that is, it was utilized the $\mathbf{Q_{7,10}}$ method, practiced up to date.

Pelissari, 2000, realized the first formal instream flow research work, using the methods IFIM, Tennant, Wetted Perimeter, ABF and $\mathbf{Q_{7,10}}$ to determine instream flow in Timbuí River in Espirito Santo State.

Pelissari, et al, also developed the following studies: habitat preference indexes for fishes in the in the determination of instream flow for Tímbui River in Espirito Santo State- ES – (1999); instream flow study for Santa Maria River (2001); instream flow to be considered in the human water supply system environmental licensing (2001); instream flow for Santa Maria River, ES; Santa Marian River instream flow determination to characterize water availability for the Great Vitoria Region future (2004).

Bezerra, N.R., 2001, researched methodologies to define minimum flows for water bodies. The research results was the development of a methodological support for decision taking, that allowed to initiate collecting information relatives to the different methods and techniques to help in the process to define minimum flows values in water bodies. From this analysis, it was possible to develop a first version named Evaluation Theoretical Flowchart – FTA. This flowchart aimed to evaluate the nature and the limitations of different methods and techniques necessaries in the definition process for minimum flow values for water bodies, developing, from this analysis, a diagram to be used in decision taking to evaluate minimum flows.

Benneti et al, 2003, presented a review of methods used to define residuals flows grouping as: hydrologic, hydraulics, multiple regressions, habitats classification, holistic and not formals.

Gonçalves et al, 2003, made a review and application of some methods to determine the minimum flow to be in water bodies.

Marques et al, 2003, considered the methods influence in determining instream flow in the energy generating costs for hydroelectric projects.

Curado, L. C., 2003, presented reference minimum flows indicators for River Miranda watershed in the Mato Grosso State. The method objective was to apply methods for establishing this minimum flow, defined through numerical values that represent the water quantity that must remains in the river bed. The purposed methodology was applied preliminarily in a River Aquidauana cross section and afterwards repeated to comparison to other Miranda River cross section.

Collischonn et al, 2005, presents some reflections about utilized criteria to define remaining river flows, looking for to demonstrate the insufficiency of the traditional criteria to define instream flow as a unique value, valid for all years and for all year seasons.

Sarmento et al, 2005, developed the work entitled methodology to evaluate the Paraíba do Sul instream flow downstream of Hydroelectric Funil.

Sarmento et al, in the period 2004-2006, executed the ANEEL –Brazilian National Agency for Electricity – research and development project for FURNAS, to determine the instream flow downstream of Funil Hydroelectric, in the State of Rio de Janeiro. The research aims was habitat simulation, and as consequence the instream flow determination. The method used was IFIM.

ANA in 2004, as in Da Silva, L. M. C., 2006, led a technical and specialists group, together CBHSF and entities states managers, to execute the São Francisco Watershed Water Resources Plan. In this plan it was utilized Tennant method to define the instream flow for fish survival: minimum: 10% of long period mean flow; mean: 20% of long period mean flow; ideal: 30% of long period mean flow. The plan adopted provisionally the flow 1,300 m^3/s. as instream flow in the river mouth.

Luz, L. Dantas, 2004, considered river ecology aspects, emphasizing the importance of hydrologic and bio geochemical processes that occur longitudinally and transversally in the rivers marshes areas.

Luz, L. Dantas, 2006, used IHA model to analyze the alterations occurred in São Francisco River low reach due to the dams building to generate electricity in its mean and low reaches.

V – NOWADAYS SCENARIO ON THE USE OF THE METHODOLOGIES

Tharme, E.R., 2003, presents a world statistics and trends about the methodologies used to evaluate instream flows (**Table 1**). At least 207 methodologies were identified in 44 countries.

Table 1-World Methodologies

Methodology	Percentage of Global Existent Methodologies Number - %
Hydrologic	**29,5**
Hydraulics	**11,1**
Habitat	**28,0**
Holistic	**7,7**
Others&Combinations	**23,7**

The hydrologic methodology is the most used, 29.5%, followed by Habitat, with 28.0 %

Tennant is the hydrologic method more used, in 16 states or provinces of North America. At least 25 countries applied this method. The method application requires hydrologic time series data trustworthiness. Beyond that, the biologic data quality precision is important, as for instance, the fishes life regularity phase. Moreover, the annual mean flow worked by the method, many times does not reflects the hydrologic season aspect. It does not require necessarily field measurements, but would help in the method validation. The results obtained are relatively consistent when applied in rivers different regions.

IFIM has been considered by instream flow studies people, as the methodology that utilizes the habitat, it is the more scientific and defensible to evaluate this flow. It allows evaluating river habitat throughout time and spatial aspects as a consequence from water resources management purposes. The data collecting requires much time and can be difficult and danger in larger rivers. IFIM deals with experienced biologists.

Two researches were realized in 1981 and 1996 involving the instream flows practices in the States and Federal Agencies of USA and Canada. Forty six States and twelve Canadian Provinces answered the research. The results showed that the most commonly applied method (utilized in 38 States or Provinces) to evaluate the instream flow is Fish and Wildlife Service Instream Flow Incremental Methodology (IFIM), Reiser W. D., 1989.

RVA was employed in more than 30 instream flow studies in USA, Canada and South Africa. This method allows establishing provisory flow targets and river management strategies without ecological data of long period. The trustworthiness of hydrologic data availability limits the application of all IHA parameters, being able to generate uncertainties in the interpretation of parameters natural variation.

In the hydraulics (11.1%), the wetted perimeter method is the most utilized in the world and the third in North America in last decade. This method encloses only low flows and does not consider the inter-annual variability. Additionally, it does not consider the channel geomorphology, water quality, and it is not applicable for channels with well defined backwater. For channels with parabolic cross sections or in V shape, the relation wetted perimeter and flow does not present the inflexion point well defined. The method must not be applied in rivers having low gradient and with meanders. It is ease applicable to rivers without hydrologic measurements.

The methodologies trends, Tharme , E. R., 2003, considering the world divided in six regions (Australasia, rest of Asia, Africa, North America, South and Central Americas, Europe and Mean Orient), show that Europe and North America are the most that use hydrologic methodology with 38 and 26 % respectively. It has a few uses in Pacific Asia excluding Australia and New Zealand.

The hydraulics methodology is the most used in North America with 76% having also large use in Europe and Australasia.

Among all methodologies that utilize the habitat, the leader is USA with 51%, having few use in the others five regions.

The Australasia region leads the holistic methodology use with 65% within all methodologies, only in Australia. In second level in the use of this methodology is Africa with 29%. In Europe the use of this methodology only happened in United Kingdom.

All methodologies types are employed in Australia and Europe, being only two types, which are utilized for all regions (hydrologic and habitat methodologies), are practiced in Central and South Americas. New Zealand has make investment in the habitat and hydrologic methodologies, giving less attention to holistic methodology. USA and Canada has made few efforts to explorer holistic methodology, guiding researches for habitat methodology. The methodologies considered in USA, Australia and Canada are more guided for the state level. Portugal and Spain have made considerable effort in hydrologic methodology, France in Habitat methodology, and Italy in hydrologic. Brasil and Japan are in vanguard in the regional development to evaluate instream flow. Australia and South Africa appear more in holistic methodology, Tharme, E. R., 2003.

In Brazil instream flow was considered formally first time by Sarmento et al, in 1999.

In general, the instream flow fixation (flow: reference, residual, remaining, ecologic) has been made principally through legislation in state and federal levels, for use in the administrative procedures for water resources permit and dams construction. The procedures majority follows, indirectly, the hydrologic methodology utilizing the $\mathbf{Q_{7,10}}$ concepts. In second place is Tennant method with few applications. IHA method was once used by Luz et al, 2004, in São Francisco River.

The hydraulics methodology appears in some works through wetted perimeter.
The IFIM method was applied first time in Brazil in year 2000, in the rivers Tímbui and Santa Maria da Vitória in the State of Espirito Santo, and in the Paraiba do Sul River in 2004 in the State of Rio de Janeiro. These are the only IFIM applications that have register in the country.

In November 2006, it was realized in Maceió town by CBHSF the Instream Flow Workshop for São Francisco Watershed, aiming mainly to define guidelines for studies on instream flow in this watershed

In 2006, the CTAP – CNRH Project Analysis Technical Commission, realized a discussion about criteria to define ecologic flow, remaining flow or minimum flow, trough professionals representatives, entities representatives, considered as it follows.

In the 51[a] CTAP meeting, Joaquim Gondim of ANA presented the theme “Vazão Ecológica, Vazão Remanescente, Vazão Mínima”, in which treated with several definitions of instream flow. Moreover, suggested an integrated research edit on instream flow to be supported by CT-HIDRO, aiming a multidisciplinary (hydrology, ecology, socioeconomic and modeling) network research in representatives watersheds.

In the 52[a] CTAP meeting, IGAM – Minas Gerais Water Management Institute, Celia Froes made a presentation on minimum residual flow in the State of Minas Gerais. Also, in this meeting, this consultant presented the applications of IFIM in the Paraiba do Sul River in the State of Rio de Janeiro and the NEVE-Study Group on Instream Flow.

In the 53[a] CTAP meeting, Walter Collischonn and others of Rio Grande do Sul Federal University, presented the theme Searching for the Ecologic Hidrogram. In addition, The Bahia State Water Resources Secretary showed the criteria for instream flow in this State.

In the 54[a] CTAP meeting, the following presentations: "Vazão Ecológica no Espírito Santo (Gustavo A. B. da Rosa of IEMA); Abordagem legal relacionada à vazão mínima residual em cursos de água de domínio do Estado (Marco Vinicius Gonçalves do IEMA); Critérios para deefinição de vazão ecológica (José Luiz Scroccaro do SUDERSHA/Paraná). These presentations considered mainly the instream flow existent state legislation. Other presentation was made by D. Eng. Meneses C. da Silva, ANA water right manager, entitled "Vazão Ecológica – Implicações Legais e Institucionais sobre a Outorga". He concluded that, in practice, water right criteria has defined instream flows, or there is no scientific basis (environmental) in the water right concessions; based only in references flows (flow observed statistics: i.e. 80% Q90%.). Moreover, he pointed out which institution has competence to define instream flow, among others questions.

In the 55[a] CTAP meeting, Eldis Camargo (PGE/ANA) made the presentation named "Vazão Ecológica Contribuição Jurídica para Formatação do Conceito". Also, Ney Fukui (NOS – National Electric System Operator), presented "Influências dos Condicionantes Ambientais e de Restrições de Uso Múltiplo da Água na Operação do Sistema Interligado Nacional".

The CTAP presentations are available in the CNRH Internet site.

It is under analysis in the Technical Commission for Projects Analysis of the Brazilian Water Resources National Council (CNRH) - CTAP a resolution minute (version 01/10-11-2006) relative to guidelines for a remaining flow (minimum?), and the instream flow definition, among others things. The CTAP actual situation (55[a] meeting, 2007), is the discussion from the contributions during the meetings, to elaborate the basic document and the resolution purpose on instream flow.

The CNPq – Brazilian National Council for Scientific Development and Technology – in September of 2006 divulgated the first national project (Edit MCT/CNPq-CT-HIDRO No. 45/20060, with the objective to determine and to evaluate the instream flow in Brazilian watersheds, to compatible hydrologic aspects, limnology, ecologic and socioeconomics of the flows regimens, to subsidize strategies of water resources management instruments application, negotiated water allocation and reservoirs operation, that promote multiple water use, reduce relevant ecologic impacts in actual and projected water use, including reservoirs operation.

The CTPPP – CBHSF Technical Commission for Plans, Programs and Projects in 2006 detailed the professional profile for the consultant to develop instream flow studies for low region of São Francisco River, among others subjects. Also, it made a discussion to construct Reference Term related to instream flow.

In 2006 CBHSF promoted an "Instream Flow: São Francisco River Watershed" Workshop in Maceió town.

The **Table 2** presents methods characteristics to obtain instream flow.

Table 2-Methodologies Characteristics to Determine Instream Flow

METHODOLOGY	METHOD	ADVANTAGE	DISADVANTAGE	RESULTS RELATIVE TRUSTWORTHINESS	TIME FOR IMPLEMENTATION	USE	COST
HYDROLOGIC	**Tennant**	Relatively low cost, easy and fast implementation.	Developed for trout habitat management; valid for the region for which It was developed; It does not have biologic validation.	Low	Two weeks	Extensive in USA	medium
HYDRAULICS	**Wetted Perimeter**	Ease use and reduced data acquisition.	It Considers physical characteristics and not the river biotic necessities.	Low	2- 4 months	Extensive in USA	low
HABITAT	**IFIM**	Very well documented; deals with fishes.	Requires much field data; not ease use; requires good understanding of species study.	Low	2 – 5 years	Extensive in USA and UK	high
HOLISTIC	**Holistic**	Considers several ecosystem components	It does not have a structured procedures set for use; requires specialized training on the process.	Mean	6 – 18 months	Applied in many forms in Australia.	high
	BBM	Extensive documentation; deals with river ecosystem.	The judgment of its effectiveness requires time.	High	6 – 18 months	Applied in Australia, South Africa; adopted as South African standard for instream flow.	high
	DRIFT	Well documented; deals with river ecosystem; has strong social economic component aspects.	Limited consideration of synergetic interactions among different sceneries; limited inclusion of flow indicators to describe the system variability	High	1 – 3 years	Much limited; Leshoto, South Africa.	high

VI – THE INSTREAM FLOW IN SÃO FRANCISCO RIVER CONTEXT

The São Francisco River watershed, having drainage area of 634,781 Km^2 involves 503 municipalities and seven federation units: Bahia, Minas Gerais, Pernambuco, Alagoas, Sergipe, Goiás, and Distrito Federal. It is one of twelve hydrographic Brazil regions, according to the Brazilian National Water Resources Plan. The São Francisco Watershed can be divided in four physiographic regions for management purposes, that is, High, Mean, Sub-Mean and Low, and thirty four sub-watersheds. The watershed water main uses are: urban human 18%, rural human 3%, industry 10%, irrigation 64% and animal 5% (Geo Brasil, 2007).

"The São Francisco Watershed Water Resources Plan adopt provisory the daily average flow 1,300 m^3/s as minimum ecologic flow in the mouth, minimum restriction value actually already practiced downstream of Xingó by IBAMA determination, until it is made the revision or confirmation of this value in the next Plan edition.

The minimum ecologic flow must guarantee the ecosystem maintenance and aquatic biodiversity preservation and can not be practiced continuously.

In the public hearings, The Low São Francisco River Regional Advisory Chamber clamed that be established the value of 1,500 m^3/s as remaining flow in the São Francisco River mouth, value that allows to practice a seasonal flows regimen and not only uniform regimen during the year.

The Plan adopt provisory, the average annual flow 1,500 m^3/s, as the remaining flow in the São Francisco River mouth.

The Plan indicates as priority the immediate development of studies to search not only the minimum ecologic flow, but also the possibility to establish a flow regimen that allows seasons flows variations, both necessaries to maintain the biodiversity and the environment dynamic equilibrium for all São Francisco reach including principals tributaries that will receive hydroelectric reservoirs and also in its adjacent coastal zone, as manifested and required by the Technical Commissions and in the Plan discussions. These studies must contemplate strategies for maintenance of the flux of nutrients, from upstream to downstream, affected by larges hydroelectrics."

Only a few studies give attention to the knowledge of the São Francisco River instream flow. Existents studies were realized by Luz, C. Dantas et al, 2004 and 2006. In 2004, he made a discussion related to the rivers ecology suggesting a way to environmental recuperation of low São Francisco River. In 2006, he analyzed the occurred alterations in the fluvial regimen of low São Francisco River, due to the hydroelectric construction in the mean e low reaches.

As result of the Workshop on Instream Flow organized by CBHSF in Maceió, were defined points to be considered in the definition of the methodologies to study instream flow in São Francisco River, that is: 1)- flows regimens; 2)-biota amplitude that can be considered by the methodology; 3)- mouth dynamics-relation river – sea and saline edge behavior; 4) the marginal lakes dynamics by the nutrients contributions and consequently by the system primary productivity; 5)- instream flow- water quality relationship.

The state of the art, central aim of this study, shows that for the rivers instream flow determination, the methodologies having highest trustworthiness (see Table) are: IFIM – Instream Flow Incremental Methodology, BBM – Building Block Methodology and DRIFT – Downstream Response to Imposed Flow Transformations.

IFIM, habitat type, is capable to contemplate items 1, 2 and 5. The methodology was developed, and it is usually applied, for fish habitat. It is the most utilized, most known (IFC, 2004) and the oldest, originated in

1970 (World Bank, 2003). It has not been applied to studies that involve themes types the ones in items 3 and 4.

The BBM includes the physical components (hydrology, physical habitat, chemical water quality) and biologics (plants, fishes and macro invertebrates) of river ecosystem. Therefore, it is able to cover points 1, 2 and 5. There are no studies that show its application in studies involving themes like as in 3 and 4. It is a new methodology.

One of the newest methodologies for instream flow is DRIFT. DRIFT is very similar to IFIM (World Bank Technical Note C1, 2003). The points 1, 2 and 5 can be contemplated in this methodology. Also, there are no studies with DRIFT including themes as the ones in points 3 and 4.

All of these methodologies were not applied to studies including points 3 and 4.

Being IFIM the methodology most applied (including in Brazil), the most known, the oldest (about 37 years), classified as high trustworthiness, and that, "IFIM can be considered among the quantitatively structured methods the most advanced and complete" (Luz, Dantas, 2004), it is therefore, the most appropriate methodology to elaborate the Reference Term (TDR) for the studies to determine São Francisco River instream flow in its low region.

Having in mind that the existent methodologies for instream flow determination do not take in account item 3- mouth dynamics- river relation-the sea and saline edge behavior, it is recommended that its treatment be trough bi-tri mathematical modeling methodology based on the continuity, momentum and transport equations. This modeling type, from initial and contours conditions for estuary mouth, salinity, tides, winds, instream flow, and others parameters, allows the realization of different simulations to obtain future alterations for mouth form, tides, salinity and nutrients, etc. Also this modeling may be applied to item 4- lake dynamics and nutrients adding. The mathematical modeling application, requires the topography – bathimetry knowledge of the water bodies studied (river, lake, estuary). Additionally, the modeling requires its calibration and validation that needs field measurements for the studied parameters (tides, water depth, salinity, nutrients, sediments, etc) for specific sceneries. The future sceneries to be simulated in the modeling are the critical ones, i.e., floods and droughts. In the market there are available computer programs for this kind of modeling.

Also, the IFIM option is a function of the following.

The incremental methodologies are consecrated worldwide because define instream flow annual series, taking in account the aquatic biota, beyond the river geomorphologic, hydraulics and hydrologic characteristics. They are commonly utilized to evaluate environmental impact of hydroelectric operation, water derivation, watershed water transposition, or other development that interferes, in the water body hydraulics and biologic characteristics, as is the case of São Francisco River. Additionally, this methodologies have theoretical basis concise, being tested in many places, as USA, Europe and Africa countries. It is important to point out that incremental methodology has been already applied in Brazil with great success as cited here before.

This choice also attends the Water Resources Plan requirements for São Francisco River watershed. The Plan indicates as immediate priority the instream flows knowledge that considers aquatic biota, having in mind the ecosystem maintenance, taking in account river seasonality. In this case, the incremental methodology fully attends these needs.

Moreover, the incremental methodology is an excellent instrument for decision taking by the government, watershed committee and other interested parts, for watershed water resources management, because it makes possible to simulate several sceneries and/or future situations of watershed users interests.

Additionally, the incremental methodology has been applied largelly, as shown in the examples presented next.

In 1999, “Northern Shenandoah Valley Regional Commission, technical Committee; Virginia tech; United States Geological Survey –USGS; Virginia Department of Game and Inland Fisheries (VDGIF) and Virginia Department of Environmental Quality”, initiated a study with IFIM to evaluate the fish hydraulic and habitat response to the low flows conditions in the North Fork Shenandoah River watershed, Virginia, USA. The model results were utilized to identify aquatic conservation flows and to establish a process to implement conservation flows management.

The Washington State Department of Ecology and the Washington Department of Fish and Wildlife, 2001 and 2004, adopt IFIM in the instream flow studies. The method was applied to the rivers: Green (1989), Entiad and Mad (1955), Little Klickitat (1990), Methou (1992), Tucannon (1995), East Fork Lewis (1999), Kalama (1999), Biq Quilcene (1999), Washougal (1999), Wala Wala (2002) and Chehalis (2004). The studies results give the instream flows to be used by the fishes.

COST – European Cooperation in the Field of Scientific and technical Research is a cooperation inter-government among scientists and researchers in Europe, having the participation of 35 countries. One project in execution, three years, is the COST ACTION 626: European Aquatic Modelling Network (EAMN) involving Austria, Finland, France, Germany, Great Britain, Norway and Switzerland, that deals with the modeling to determine instream flows in watersheds in England and Wales. The method employed is IFIM.

Bullock, A. et al, 1991, applied IFIM to the rivers Gwash in Leicestershir/Lincolnshire and Blithe in Staffodshire in England, aiming to gain experience in the method, to access PHABSIM component of IFIM and to model the dam reservoir construction impact in the aquatic ecology, and to establish a research program in long term to recommend acceptable instream flows. The IFIM potential in the instream flows prescription was demonstrated in the study.

In the State of Espirito Santo, in the rivers Timbuí (Pelissari, 2000) e Santa Maria da Vitória (Pelissari e Sarmento, 2001) IFIM was used first time in Brazil, to known the instream flow of these rivers. Also, IFIM was applied in a “FURNAS Centrais Hidrelétricas and ANEEL” research and development project in 2004, coordinated by this consultant, in the Paraíba do Sul River to obtain the instream flows downstream of Funil hydroelectric, located in the proximities of Rezende City in the State of Rio de Janeiro. These uses, show the viability in using this method in the country.

The instream flow knowledge is a complex process that includes the science evolution, a public with diverse interests, and a set of institutional and legal aspects. To be more effective, the actors involved in the instream flow determination process, must consider a specific program to deal with the instream flow, managed by trained professionals, having as main function work with river watershed instream flow subjects, as recognized by IFC – Instream Flow Council, 2004, and IUCN – The World Conservation Union, 2003.

Therefore, it has to be considered to establish an Instream Flow Program for the São Francisco River watershed. The program will aim principally the development of appropriated methods, to collect right data and to train people for São Francisco River watershed instream flow knowledge.

The incremental methodology (type habitat) use here purposed to determine instream flow in the low reach of São Francisco River will be an integrant part and the beginning of this Instream Flow Program.

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