Western Nepal Environmental Flow Calculator (WENEFC)

User Guide - Draft

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1.0 Western Nepal Environmental Flow Calculator

Hydropower is an important source of electricity for Nepal and is considered a key parameter for the social and economic growth of the nation. As of now, 159 hydropower projects (HPPs) with a total installed capacity of about 3000 MW have been built and 258 HPPs with a total installed capacity of 8685 MW are under construction for fulfilling the demands of societal needs. In the operations of HPPs, river water is diverted to hydropower plants and releases very little water to the river channel downstream, leading to reduced water availability, deteriorating water quality, hindered sediment transport, blockage of fish migration, and negative impacts on downstream livelihoods. These changes may adversely affect the river's health particularly when the environmental flow requirement to sustain aquatic life and biodiversity of the river ecosystem downstream is not met. Therefore, environmental flow in the required quantity needs to be released to sustain biodiversity and riparian ecosystems, and preserve the social, cultural, and aesthetic water requirements of people living in the river basin.

Environmental flow, also known as in-stream flow, ecological flow, normative flow, etc., refers to flow maintained in developed rivers (rivers with hydroelectric projects, irrigation dams, etc.) to ensure a state of ecological health that meets acceptable environmental and societal values. Maintaining a healthy flow regime is important for retaining river channel morphology, regulating sediment transport, and allowing fish migration that sustains the ecological integrity of the river. In this regard, environmental flow assessment tools provide instruments to estimate acceptable levels of flow in the river that preserve biodiversity, maintain ecosystem services including social/cultural services and enhance socio-economic growth.

Although Nepal's policy landscape acknowledges the importance of environmental flows, its implementation faces numerous challenges. These obstacles include the absence of a comprehensive approach, limited capacity, and compliance issues. The country has endorsed the "Hydropower Policy, 2001" which explicitly states the release of a discharge of minimum flows of either the mean of the dry period or a quantum defined by an Environmental Impact Assessment (EIA) is mandatory during the operation of hydropower projects. The concept of Environmental Flows moves beyond "minimum flow" releases or "constant" flow releases by acknowledging that the health of river ecosystems depends on the availability of a variable flow regime, ideally following a pattern similar to that of "natural" or "unregulated" flow, although at a lower magnitude than "natural" flow.

1.1 Overview

The Western Nepal Environmental Flow Calculator is a software package for desktop assessment of Environmental Flows (EFs) in major rivers of Western Nepal, incorporating a built-in database of simulated flow time series at 157 locations.

Following topics are covered in detail in this document:

- Terminology and Methods
- Application Guide

2 Terminology and Methods

2.1 Environmental Flows (EF)

Environmental flows (EF) are defined as the "quantity, quality and timing of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems" (Arthington, 2018). It refers to a flow regime designed to maintain a river in some agreed ecological condition. All components of the natural hydrological regime have ecological significance. However, maintaining the full spectrum of naturally occurring flows in a river is normally impossible due to water resources development and catchment land-use changes. EF should therefore be seen as a compromise between river basin development on one hand and maintenance of river ecology on the other. Another useful way of thinking about EF is that of "environmental demand"- similar to crop water requirements, industrial or domestic water demand.

2.2 Types of Environmental Flow Assessment (EFA)

A number of Environmental Flow Assessment Methods have evolved in recent years. However, the assessment procedure and required input data for each method depend on its intended purpose. The EFA methods can be broadly categorised into two main types:

2.2.1 Detailed Assessment Methods

Detailed assessment methods usually require substantial amounts of field work, time and resources, even for a single river basin. Holistic methods and Habitat models are examples of such methods. Holistic methods adopt a whole-ecosystem view whereby ecologically and/or socially important flow events are identified, and an ecologically acceptable flow regime is defined by a multi-disciplinary panel of experts. Habitat models primarily focus on fish. They are used to assess the impacts of changing flow regime on physical habitat for key life stages of target fish species.

2.2.2 Desktop Assessment Methods

These are rapid assessment methods using primarily ecologically relevant hydrological characteristics (indices) or analysis of hydrological time series. The Tennant method, Range of Variability Approach (RVA), CAMS (Catchment Abstraction Management Strategies), the Desktop Reserve Model (DRM) and the method presented in this package are some examples of desktop assessment methods

2.3 Reference Hydrological Time Series

The minimum requirement for desktop Environmental Flow Assessment (EFA) application at any site in a river basin is sufficiently long (at least 20 years) monthly flow time series reflecting, as much as possible, the pattern of 'natural' flow variability. This flow time series is referred to as the reference hydrological time series. However, sites where EF are required are often either ungauged, or significantly impacted by upstream basin developments. Therefore representative 'unregulated' monthly flow time series, or corresponding aggregated measures of unregulated flow variability, like Flow Duration Curves (FDCs), have to be simulated or derived from available observed source records.

2.4 Flow Duration Curves (FDCs)

A Flow Duration Curve is a cumulative probability distribution function of flows. Any FDC can be represented by a table of flow values (percentiles) covering the entire range of probabilities of occurrence.

2.5 Environmental Management Classes (EMCs)

Environmental flows aim to maintain an ecosystem in, or upgrade it to, some prescribed or negotiated condition also referred to as 'desired future state', 'environmental management class' (EMC), 'ecological management category', 'level of environmental protection' etc (e.g. Acreman and Dunbar, 2004; DWAF, 1997). The higher the EMC, the more water will need to be allocated for ecosystem maintenance or conservation and more flow variability will need to be preserved.

Ideally, EMCs should be based on empirical relationships between flow and ecological status/conditions associated with clearly identifiable thresholds. However, at present the evidence for such thresholds is not sufficient and these categories are simply a management concept, which has been developed and used in the world because of a need to make decisions under conditions of limited lucid knowledge. Placing a river into a certain EMC is often accomplished by expert judgment using a scoring system (DWAF, 1997; Environment Agency, 2001). Alternatively, the EMCs may be used as default 'scenarios' of environmental protection and corresponding EFs - as 'scenarios' of environmental water demand.

2.6 Estimation of EF in Western Nepal EF Calculator

2.6.1 Selection of Reference Hydrological Time series

The Western Nepal Environmental Flow Calculator presents three options for selecting a reference hydrological time series as described below:

Default (built-in) Simulated Data - Hydrological Method

The default simulated flow time series data that are provided under this option in the Western Nepal Environmental Flow Calculator are "naturalized" simulated data at 157 different locations on Karnali-Mohana and Mahakali rivers of Western Nepal. The flow data at these locations have been simulated by using Soil and Water Assessment (SWAT) models of the rivers. Environmental Flows are calculated at these locations by shifting the original "natural" Flow Duration Curve to construct six other Environmental Flow Duration Curves as explained in Sections 2.6.2 to 2.6.5.

Default (built-in) Simulated Data - Holistic Method

The default simulated flow time series data that are provided under this option in the Western Nepal Environmental Flow Calculator are "naturalized" simulated data at 14 different locations on Karnali-Mohana and Mahakali rivers of Western Nepal. The flow data at these locations have been simulated by using Soil and Water Assessment (SWAT) models of the rivers. Environmental Flows are calculated at these locations by shifting the original Flow Duration Curve to set thresholds of abstraction at approximately 30% of the mean annual runoff and 80% of the mean annual runoff. These two thresholds define two environmental management classes, the higher one at a nearly pristine condition and the lower one at a substantially modified condition. The lower threshold accommodates the minimum social flow requirements too and is regarded as the bottom cutoff threshold. Flow in the river is expected to be above this level at all times.

User Defined Data

Other than the default (built-in) simulated flow time series a simulated or measured flow record supplied by the user in a user-defined file may also be used as the reference hydrological time series. Environmental flows can be estimated by using both the Hydrological method and the Holistic method under this option too. Guidelines for preparing the input flow file are provided under the section 3.0 Application Guide.

Observed Flow

This option enables the user to make use of observed "natural" flow time series from unregulated rivers or streams. However, this option is currently unavailable in the WENEFC.

2.6.2 Construction of the Reference/Natural Flow Duration Curve (Reference/Natural FDC)

The Reference/Natural Flow Duration Curve (FDC) may be constructed starting from either Default Simulated, User Defined or Observed Flow (unavailable at present) time series. This happens automatically within the WENEFC, once a reference hydrological time series is selected.

All FDCs in the WENEFC are represented by a table of flows corresponding to the 17 fixed percentage points: 0.01, 0.1, 1, 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, 95, 99, 99.9 and 99.99%. These points i) ensure that the entire range of flows is adequately covered and ii) facilitate the estimation of Environmental FDCs as explained in Section 2.6.4.

2.6.3 Define / Select Environmental Management Class (EMC)

Hydrological Method

Six EMCs are used in the Western Nepal Environmental Flow Calculator under this method, and six corresponding default levels of Environmental Flows (EFs) may be defined. The set of EMCs (Table 2.1) is similar to the one described in DWAF (1997).

Rivers in classes A and B represent unmodified and largely natural conditions, where no or limited modification is present or should be allowed from the management perspective. In moderately modified river ecosystems (class C rivers), the modifications are such that they generally have not (or will not - from the management perspective) affect the ecosystem integrity. Largely modified ecosystems (class D rivers) correspond to considerable modification from the natural state where the sensitive biota is reduced in numbers and extent. Seriously and critically modified ecosystems (classes E and F) are normally in poor conditions where most of the ecosystem functions and services are lost. Rivers which fall into classes C to F would normally be present in densely populated areas with multiple man-induced impacts. Poor ecosystem conditions (classes E or F) are sometimes not considered acceptable from a management perspective and the management intention is always to "move" such rivers up to the least acceptable class D through river rehabilitation measures. This restriction is not however applied in the Western Nepal Environmental Flow Calculator, primarily because the meaning of every EMC is somewhat arbitrary and needs to be filled with more ecological substance in the future. Some studies use transitional EMCs (e.g. A/B, B/C etc.) to allow for more flexibility in EF determinations (Hughes and Munster, 2000). It can be noted, however, that ecosystems in class F are likely to be those which have been modified beyond rehabilitation to anything approaching a natural condition. In the Western Nepal Environmental Flow Calculator, it is possible to estimate EFs corresponding to all or any of the above EMCs and then consider which one is best suited / feasible for the river in question, given existing and future basin developments. It is also possible to use expert judgment and available ecological information in order to place a river into the most probable / achievable EMC. An Example of the use of such a scoring system is presented in Smakhtin et al. (2007).

Table 2.1 Environmental Management Classes (EMCs)

EMC	Description	Management perspective
A	Natural rivers with minor modification of in-stream and riparian habitat.	Protected rivers and basins. Reserves and national parks. No new water projects (dams, diversions etc.) allowed.
B	Slightly modified and/or ecologically important rivers with largely intact biodiversity and habitats despite water resources development and/or basin modifications.	Water supply schemes or irrigation development present and / or allowed.
C	The habitats and dynamics of the biota have been disturbed, but basic ecosystem functions are still intact. Some sensitive species are lost and/or reduced in extent. Alien species present.	Multiple disturbances associated with the need for socio-economic development, e.g. dams, diversions, habitat modification and reduced water quality
D	Large changes in natural habitat, biota and basic ecosystem functions have occurred. A clearly lower than expected species richness. Much lowered presence of intolerant species. Alien species prevail	Significant and clearly visible disturbances associated with basin and water resources development, including dams, diversions, transfers, habitat modification and water quality degradation
E	Habitat diversity and availability have declined. A strikingly lower than expected species richness. Only tolerant species remain. Indigenous species can no longer breed. Alien species have invaded the ecosystem.	High human population density and extensive water resources exploitation. Generally, this status should not be acceptable as a management goal. Management interventions are necessary to restore flow pattern and to "move" a river to a higher management category.
F	Modifications have reached a critical level and ecosystem has been completely modified with almost total loss of natural habitat and biota. In the worst case, the basic ecosystem functions have been destroyed and the changes are irreversible	This status is not acceptable from the management perspective. Management interventions are necessary to restore flow pattern, river habitats etc (if still possible / feasible). - to "move" a river to a higher management category.

Holistic Method

The Holistic Method considers ecological and socio-cultural requirements in addition to hydrological considerations.

Ecological Considerations

Based on analysis of macro-invertebrate samples collected from upstream reaches of Karnali-Mohana and Mahakali rivers two flow thresholds affecting the richness and abundance of the indicator species Trichoptera were identified. The flow thresholds and the rationale for their identification are detailed below.

1. River abstraction < 30% of Mean Annual River flow (MAR) – Abundance of the indicator species is not affected if water abstractions are less than 30% of MAR, i.e., annual river flow is more than 70% of MAR
2. 30% of MAR < River abstraction < 80% of MAR - Abundance of the indicator species declines, but the impact is tolerable up to an abstraction level of 80% of the MAR, i.e., annual river flow is between 70% of MAR and 20% of MAR
3. River abstraction > 20% of MAR - Abundance of the indicator species declines rapidly when water abstractions become larger than 80% of the MAR, i.e., annual river flow is less than 20% of MAR.

Flow Duration Curves corresponding to the two thresholds of 70% of MAR and 20% of MAR are developed within the calculator. The Flow Duration Curve for the 20% threshold is adjusted to incorporate social/cultural requirements as detailed in the section on Social Considerations

Social/Cultural Considerations

Social/cultural requirements of riparian communities were assessed through a survey conducted among six communities living along the rivers of Western Nepal (Details are provided in Table 2). Water level requirements for each of their needs were identified during the survey under three categories as “Ideal”, “Acceptable” and “Poor” and are shown in Table 2.2. Noting that the minimum water level requirement is for irrigation, this requirement of 0.10 m was converted to a discharge value using corresponding river cross sections acquired during the ecological survey. The Flow Duration Curve for the 20% threshold was then adjusted to accommodate this minimum requirement during the low flow season. This resulted in two final Flow Duration Curves, which were provisionally named as Class A and Class B in the context of the Holistic Method (Figure 2.2). The idea is to define environmental flows in such a way as to maintain river flows always above the Class B level, in order to maintain the health of the river ecosystems. However, application of the Holistic Method is currently limited to upstream reaches of Karnali-Mohana and Mahakali rivers – where ecological sampling was performed, and identified sites similar to the sampled locations.

Table 2.2 Water level requirements to satisfy different needs of riparian communities.

	Ideal Level (m)	Acceptable Level (m)	Poor Level (m)
Irrigation	0.97	0.54	< = 0.10
	The recommended ideal level allows all families in their village settlements to collect or divert sufficient water through canals for irrigation. This could reverse the impacts on adverse crop production and satiate household needs for consumption.	The proposed acceptable level allows families who wish to irrigate to continue to do so and should ideally reduce their reliance on rainwater. Families in the Terai who grow crops on a commercial scale can continue to do so.	Levels below 0.10 meters could result in a negative rate of return for farmers, forcing even more of the population out of their villages in search for alternate sources of income. Additionally, water pumps and engines are most likely to not function or get damaged. Families who currently practice commercial farming may have to become fully reliant on underground water resources or find alternate sources of income.
Fishing	1.52	0.97	< = 0.30
	The proposed ideal level allows ample water for locals to find fish in, provided the water quality is acceptable. Nets, traditional *balchis* and fishing rods will all successfully work. This amount of water should provide enough space for the larger species of fish that locals say are no longer available.	The acceptable level still allows enough space for a variety of fish to comfortably swim in, allowing current fishing activity levels to be maintained. All popular fishing methods can still be practiced.	The poor level would not satisfy the current fishing activity, negatively affecting the livelihoods of the communities. Nets that require to be submerged in the water may no longer be as efficient. High levels of suspended sedimentation can also become more apparent with lower water levels and negatively affect aquatic habitat.
Socio-cultural and spiritual	1.21	0.96	< = 0.50
	The suggested ideal level is necessary to satisfy spiritual needs during various festivals. The additional water allows locals to fully immerse in the river to take part in cleansing and bathing rituals. Furthermore, the continuous flow of the river is very important in order to successfully complete the *Dahasanskar* ceremony.	The acceptable level leaves enough water to be able to submerge below the waist, in the river. A consistent flow is still very necessary. Additionally, there will be enough water in the river for all members of society to partake in their customs and practices. Marginalized communities will not have to find alternate solutions for the *Dahasanskar* ceremony.	The poor level does not allow locals to fully submerge and bathe in the water, nor does it guarantee the uninterrupted flow of the river to wash away the ceremonial blessings and offerings. At most, families can collect water in buckets to shower if they wish. Families may choose to bury their dead instead, affecting their traditional and cultural practices.
	1.22	0.74	< = 0.40

Household activities	The recommended ideal level guarantees that the remaining local water mills will function safely and well. Beyond this, there will still be enough water in the river for all community members' household activities.	The suggested acceptable level supports functioning of a water mill. It will provide families with enough water to carry out household activities.	Levels below 0.40 will not support water mills, as is the current condition in the Hills and lead to widespread closures. There will not be sufficient water to sustain an entire village's livelihoods activities without turning to other water sources. Taking care of livestock and showering larger cattle in the river may no longer be possible.
Tourism and recreation	3.00	2.00	<= 1.5
	The suggested ideal level will sustain the biodiversity, particularly of the endangered dolphins and the crocodiles present in the Karnali Basin. The flow of the water is also very important for activities such as rafting. to the local and neighboring communities. Certain parts of the river will remain safe for swimming activities.	The proposed acceptable level allows dolphins to comfortably swim and crocodiles to navigate the rivers. The environment by the river banks, where most of the mentioned picnic spots are located, will continue to be cherished and visited for recreational purposes.	The poor level does not support the endangered dolphin livelihoods and will likely drive them into the deeper rivers of India or harm them. Crocodiles may also migrate due to insufficient water levels. Water transport is no longer possible. Water levels so low may also reveal pollution and trash on the riverbanks, making picnic spots no longer appealing

2.6.4 Establishing Environmental Flow Duration Curves (FDCs) from Reference Condition.

<u>Hydrological Method</u>

The Western Nepal Environmental Flow Calculator uses a simple approach which has been proposed by Smakhtin and Anputhas (2006) to determine the default FDC representing a summary of Environmental Flows (EFs) for each Environmental Management Class (EMC). These curves are determined by the lateral shift of the original reference FDC - to the left, along the probability axis. The mentioned 17 percentage points on the probability axis: 0.01, 0.1, 1, 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, 95, 99, 99.9 and 99.99% are used as steps in this shifting procedure. A FDC shift by one step means that a flow which was exceeded, 99.99% of the time in the original FDC will now be exceeded 99.9% of the time, the flow at 99.9% becomes the flow at 99%, the flow at 99% becomes the flow at 95%, etc. The procedure is graphically illustrated in Figure 2.1. A linear extrapolation is used to define the "new low flows" at the lower tail of a shifted curve.

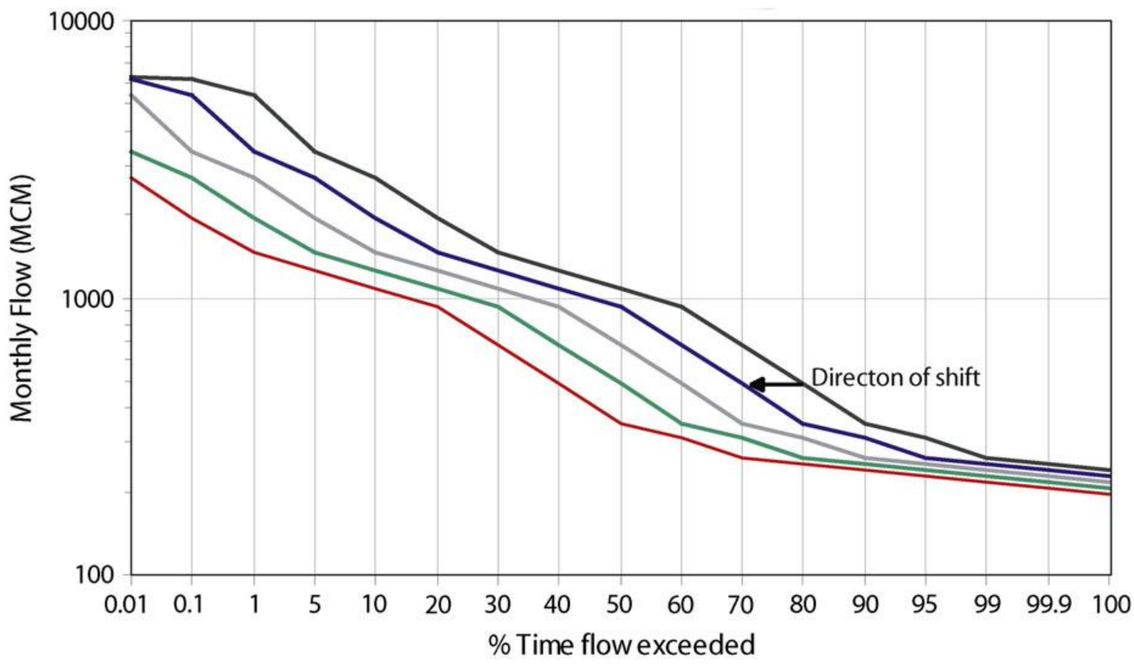

Figure 2.1 Procedure of shifting the natural flow duration curve to the left.

The default shift of the reference FDC for different EMCs is set to be one percentage category. In other words, a minimum lateral shift of one step (a distance between two adjacent percentage categories in the FDC table) is used. This means that for a Class A river the default environmental FDC is determined by the original reference FDC shifted one step to the left along the probability axis. For a Class B river the default environmental FDC is determined by the original reference FDC shifted two steps to the left along the probability axis from its original position, etc. Any shift of a FDC to the left means that:

(a) the general pattern of flow variability is preserved although with every shift, part of variability is 'lost';

(b) this loss is due to the reduced assurance of monthly flows, i.e. the same flow will be occurring less frequently;

(c) the total amount of EFs, expressed as the mean annual environmental flow is reduced.

<u>Holistic Method</u>

The Holistic Method considers ecological and socio cultural requirements in addition to hydrological considerations. Flow Duration Curves corresponding to the two thresholds of 70% of MAR and 20% of MAR are developed within the calculator. The Flow Duration Curve for the 20% threshold is adjusted to incorporate social/cultural requirements as detailed in the section on Social Considerations in 2.6.3 (Figure 2.2). The idea is to define environmental flows in such a way as to maintain river flows always above the Class B level, in order to maintain the health of the river ecosystems.

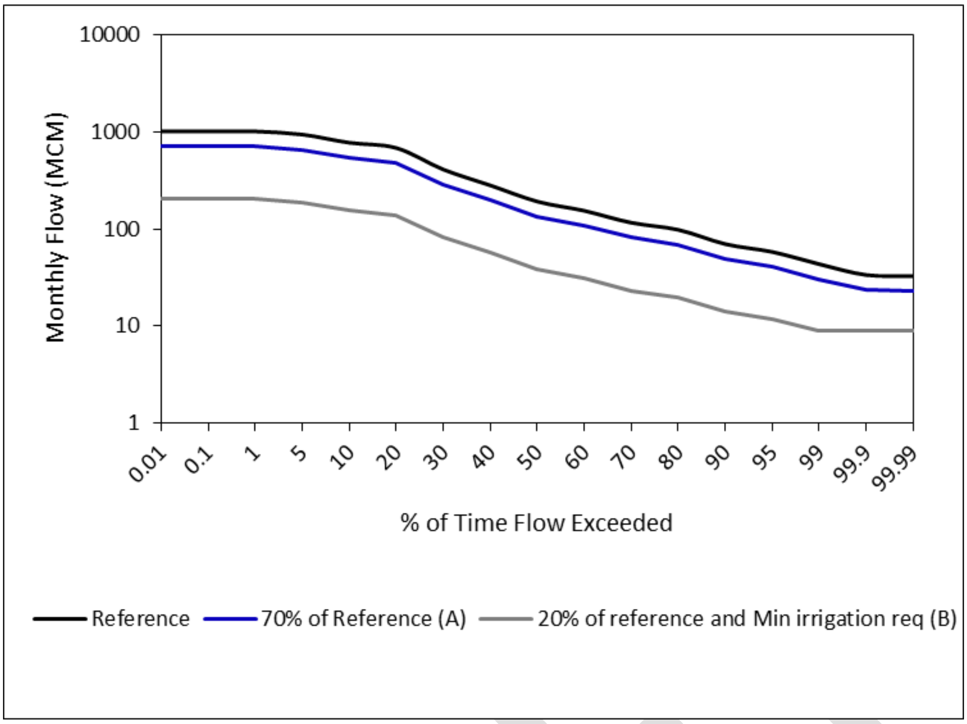

Figure 2.2 Procedure for shifting the Natural Flow Duration Curve to generate Environmental Flow Duration curves for classes A and B under the Holistic Method

2.6.5 Simulating Continuous Monthly Time Series of Environmental Flows (EF)

Once an Environmental Flow Duration Curve for an Environmental Management Class (EMC) is determined, it is also possible to convert it into the actual environmental monthly flow time series. The spatial interpolation procedure described in detail by Hughes and Smakhtin (1996) is used for this purpose. The underlying principle in this technique is that flows occurring simultaneously at sites in reasonably close proximity to each other correspond to similar percentage points on their respective Flow Duration Curves (FDCs). The site at which streamflow time series is generated is called a destination site. The site with available time series, which is used for generation, is called a source site. In essence, the procedure is to transfer the streamflow time series from the location where the data are available to the destination site. In the context of the Western Nepal Environmental Flow Calculator, the destination FDC is the one representing the EF sequence to be generated, while the source FDC and time series are those representing the reference natural flow regime. For each month, the procedure: i) identifies the percentage point position of the source site's streamflow on the source site's period-of-record FDC and ii) reads off the monthly flow value for the equivalent percentage point from the destination site's FDC (Figure 2.3). The generation of EF time series completes the desktop EF estimation for a site. The output is therefore presented in two forms - an environmental FDC and a corresponding environmental monthly flow time series.

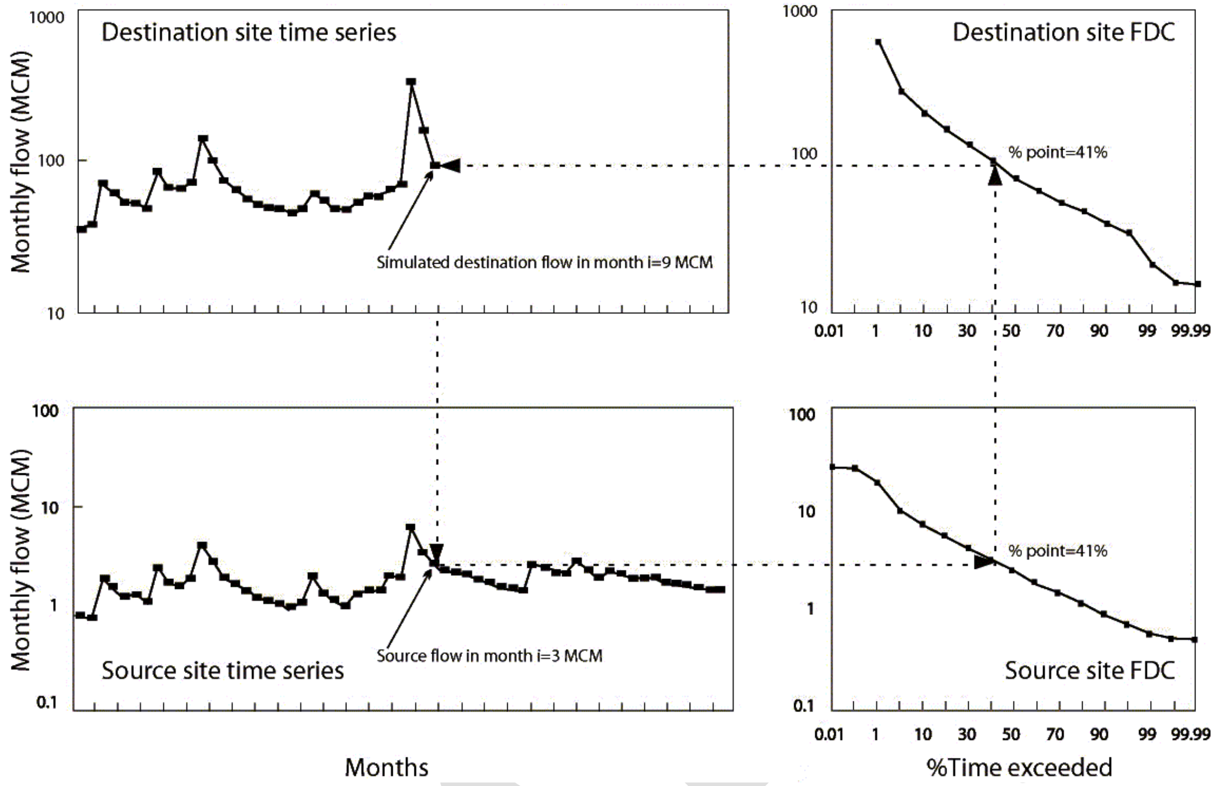

Figure 2.3 The illustration of the spatial Interpolation procedure to generate a complete monthly time series of EF from the established environmental FDC

2.7 Bibliography

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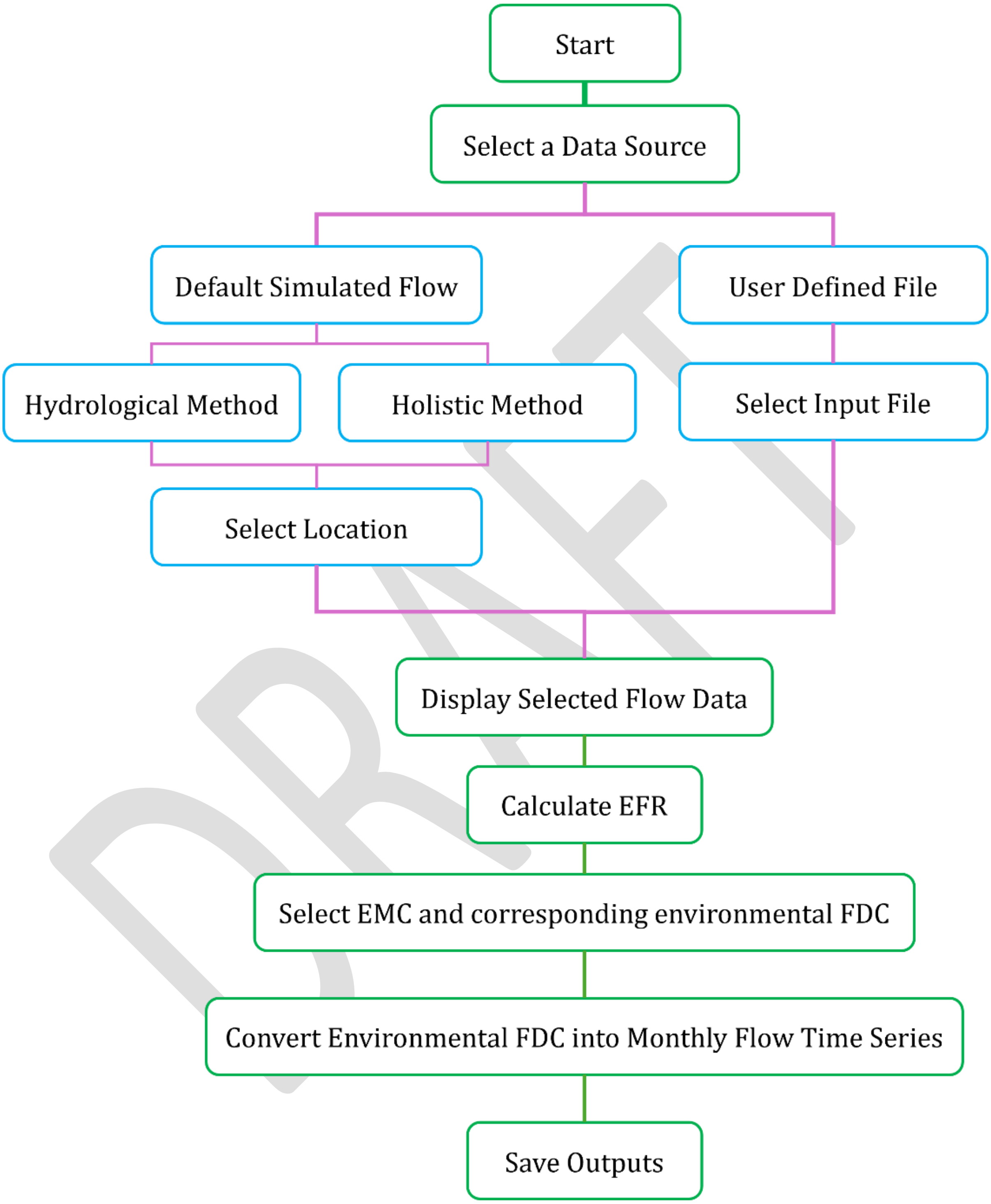

Figure 3.1 Flow chart showing calculation procedure

3.1 Select a data source

1. Select the Data tab on the Main Menu of the Western Nepal Environmental Flow Calculator.
2. Select one of the two data source options available: Default Simulated Flow or User Defined File. The Observed Flow option is currently unavailable.

3.1.1 Default Simulated Flow Option

Provides access to the built-in simulated "natural" flow data at different locations of Karnali-Mohana and Mahakali basins. The user will be prompted to select either the "Hydrological Method" or the "Holistic Method option".

3.1.1.1 Hydrological Method

This is the first of two analysis options available under the Default Simulated Flow Option. A user friendly, interactive map of Western Nepal will be loaded onto the screen once this option is selected (Figure 3.2). The locations where "naturalized" simulated flow data is available are shown in red on the map. "Naturalized" simulated monthly flow data for any of these locations may be retrieved by clicking on the point of interest.

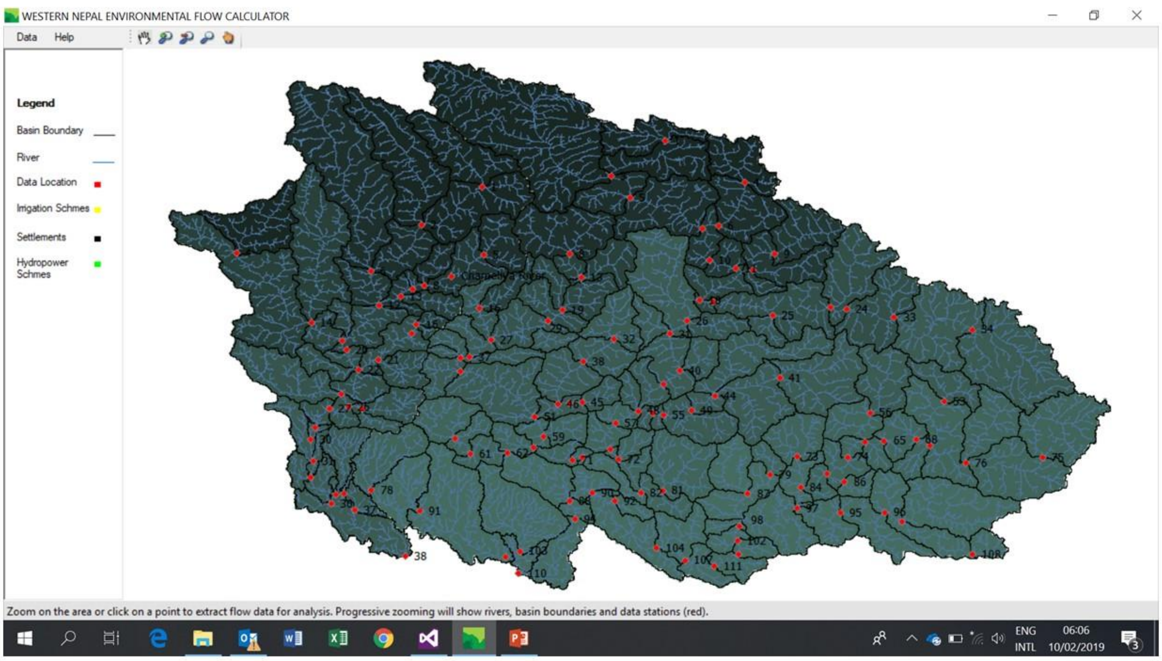

Figure 3.2 Locations (red circles) where estimates based on the Hydrological Method can be made shown on the Interactive map of the WENEFC.

Interacting with the Map

Use the Pan and Zoom tools on the toolbar for panning and zooming on the map. Progressive zooming will expose individual data points (in red) and several layers of GIS shape files. The GIS layers include:

- Basin Boundaries
- Sub Basin Boundaries
- Stream Network

Geographic coordinates of locations where simulated data is available are indicated on a tooltip as the cursor moves on the screen. The extent of details exposed on the map depends on the current zoom level.

Selecting Points on the Map

1. Click on Select a Point on the Toolbar on the Main Screen

2. Select the point of interest on any river basin and click on it.

3.1.1.2 Holistic Method

This is the second of two analysis options available under the Default Simulated Flow Option. A user friendly, interactive map of Western Nepal will be loaded onto the screen once this option is selected. The locations where simulated flow data is available and where estimates can be made under this method are shown in red (Figure 3.3).

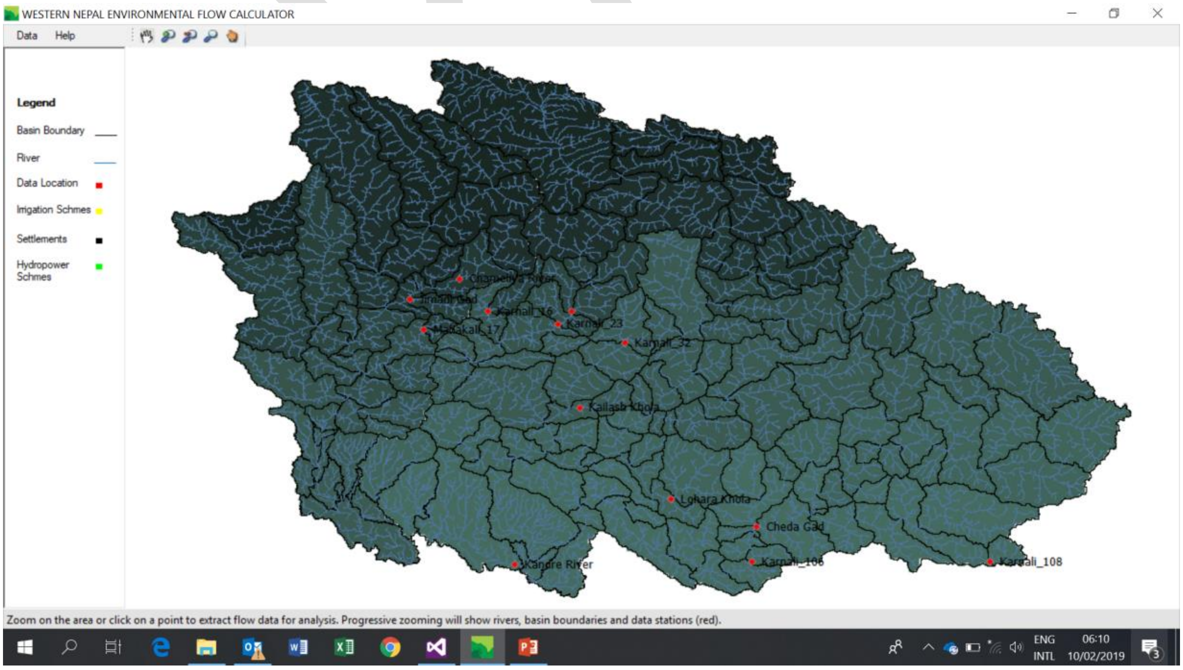

Figure 3.3 Locations (red circles) where estimates based on the Holistic Method can be made shown on the Interactive map of the WENEFC.

Interacting with Map

Use the Pan and Zoom tools on the toolbar for panning and zooming on the map. Progressive zooming will expose individual data points (in red) and several layers of GIS shape files. The GIS layers include:

- Basin Boundaries
- Sub Basin Boundaries
- Stream Network

Geographic coordinates of locations where simulated data is available are indicated on a tooltip as the cursor moves on the screen. The extent of details exposed on the map depends on the current zoom level.

Selecting Points on Map

1. Click on Select a Point on the Toolbar on the Main Screen

2. Select the point of interest on any river basin and click on it.

3.1.2 User Defined File Option

Provides the user the facility to carry out EF calculations for his/her own time series data. The data have to be stored in a text file in the format shown below. The first line contains the start date (mm/yyyy) of the time series, while the rest of the lines contain monthly discharges in m3/s. Include three decimal places with flow data values. Any missing data may be indicated with -9.999.

01/1901
38.900
30.290
31.430
110.000
21.120
1513.000
-9.999
-9.999
145.800
29.430
434.900
891.100

3.1.2.1 Accessing a "User Define File"

1. Click on User Defined File option on the Main Menu

2. Choose the input data file via the file open dialog.

The hydrological characteristics of the selected data are then displayed in a new screen.

Figure 3.4 shows different options for generating the input natural flow time series for gauged and ungauged sites.

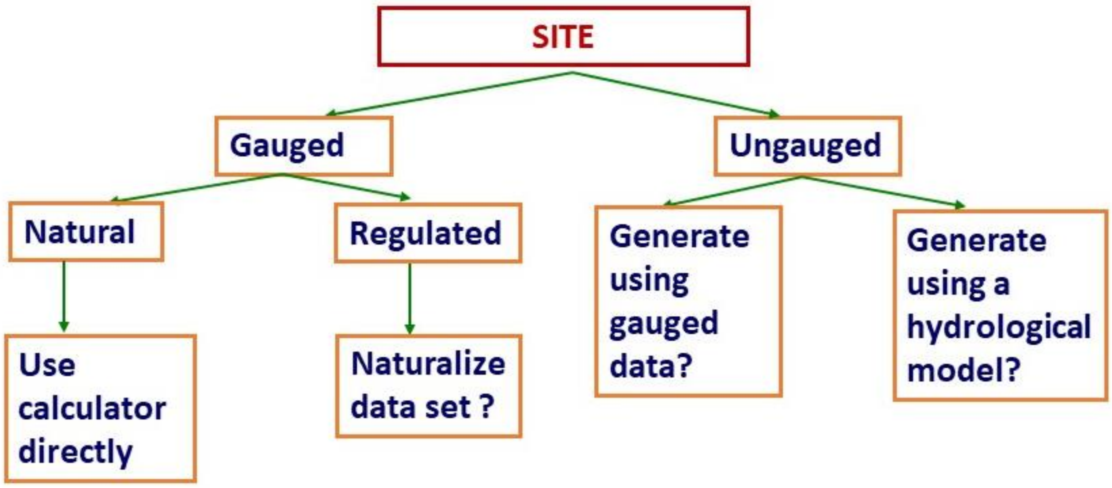

Figure 3.4 Different options for generating the input natural flow time series.

3.2 Display Hydrological Characteristics

This screen is automatically loaded once a source flow time series is selected either from the Default Simulated Flow database or from a user-defined file. The displayed hydrological characteristics include (Figure 3.5)

(a) Monthly (source) time series (top graph)

(b) Annual Time Series (second row left)

(c) Seasonal flow distribution for mean, wettest and driest year of record (second row right)

(d) Period of record flow duration curve (FDC) (bottom left)

(e) Basic statistics of the source data

Individual data points on each graph are displayed on a tooltip as the cursor moves along them.

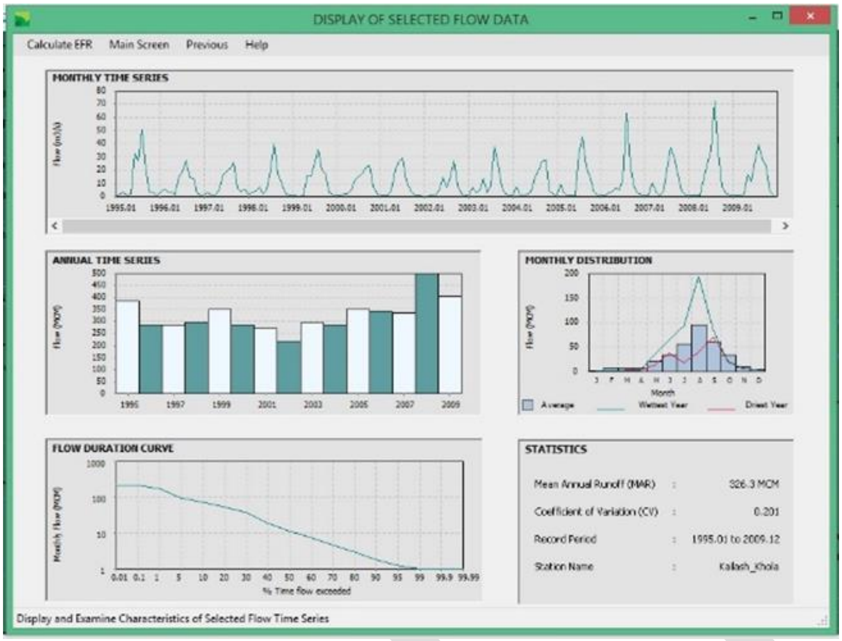

Figure 3.5 Display of Hydrological Characteristics

3.3 Calculate Environmental Flows and Select Default Environmental Management Class

1. Select the “Calculate EFR” tab on the main menu of the flow data display screen.

The environmental flow requirements (EFR) for the different Environmental Management Classes (EMCs) are calculated and presented as Flow Duration Curves (FDCs) in the next screen (Figure 3.6)

2. Select the appropriate Environmental Management Class for the river in question.

The selected graph and the respective column in table will be highlighted once an EMC is selected

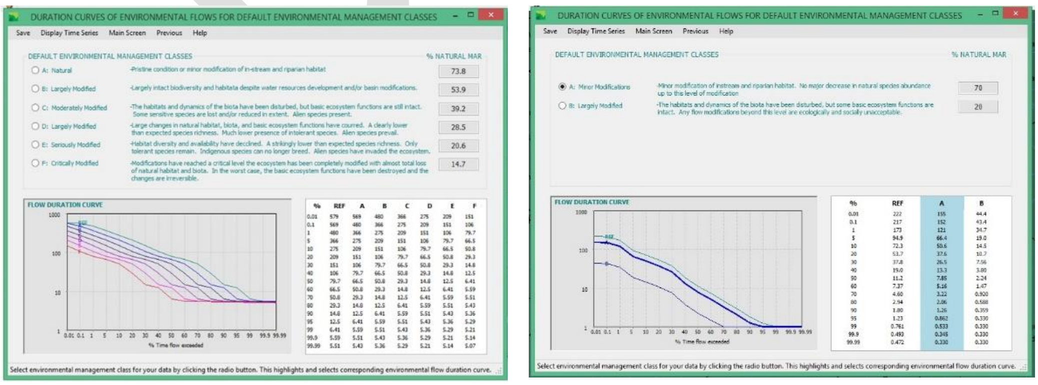

Figure 3.6 Selection of most probable EMC and Environmental Flow Duration Curve

3.4 Save Calculated Flow Tables

It is possible to save the calculated flow tables in text files.

<u>Option 1</u>: <u>Save the Entire Flow Table</u>

1. Click on Save tab on Environmental Management Class (EMC) Selection Screen.

2. Select the Save All option.

3. Enter the desired text file name in the Save File Dialog Box.

The saved file will have the format shown in Figure 3.7. The first column contains the 17 percentage points while the rest of the columns contain reference (natural) and environmental flows(EFs) corresponding to the 17 percentage points. The flows are given in MCM per month.

%	REF	A	B	C	D	E	F
0.01	7249	6429	4885	3754	3127	2472	1939
0.1	6429	4885	3754	3127	2472	1939	1412
1	4885	3754	3127	2472	1939	1412	1026
5	3754	3127	2472	1939	1412	1026	687
10	3127	2472	1939	1412	1026	687	456
20	2472	1939	1412	1026	687	456	306
30	1939	1412	1026	687	456	306	188
40	1412	1026	687	456	306	188	126
50	1026	687	456	306	188	126	49.1
60	687	456	306	188	126	49.1	18.2
70	456	306	188	126	49.1	18.2	13.7
80	306	188	126	49.1	18.2	13.7	13.3
90	188	126	49.1	18.2	13.7	13.3	13.3
95	126	49.1	18.2	13.7	13.3	13.3	13.3
99	49.1	18.2	13.7	13.3	13.3	13.3	13.3
99.9	18.2	13.7	13.3	13.3	13.3	13.3	13.3
99.99	13.7	13.3	13.3	13.3	13.3	13.3	13.3

Figure 3.7 Format of saved file in "Save All" option

<u>Option 2</u>: <u>Save only the Selected Flow Column</u>

1. Click on Save tab on Environmental Management Class (EMC) Selection screen.

2. Select the Save Selection option.

3. Enter the desired text file name in the Save File Dialog Box.

The saved file will have the format shown in Figure 3.8. The first column contains the 17 percentage points while the second column contains the environmental flows(EFs) corresponding to the 17 percentage points and the selected Environmental Management Class(EMC). The flows are given in MCM per month.

%	C
0.01	3754
0.1	3127
1	2472
5	1939
10	1412
20	1026
30	687
40	456
50	306
60	188
70	126
80	49.1
90	18.2
95	13.7
99	13.3
99.9	13.3
99.99	13.3

Figure 3.8 Format of saved file in "Save Selection" option

3.5 Display Estimated Reference and Environmental Monthly Flow Time Series

1. Click on Display Time Series tab on Environmental Management Class (EMC) Selection screen.

2. Use the zoom and pan tools provided to examine the displayed graphs more closely (Figure 3.9).

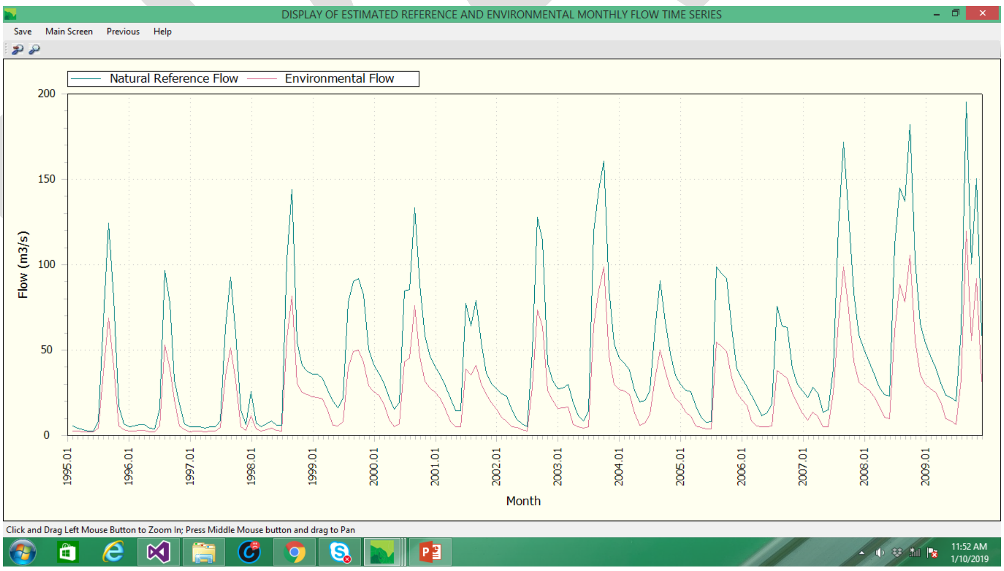

Figure 3.9 Display of Reference and Environmental Flow Time Series

3.6 Save Estimated Environmental Monthly Flow Time Series into a Text File

1. Click on Save tab on graphs (Reference and Environmental Flow Time Series) display screen.

2. Enter the desired text file name in the Save File Dialog Box.

The format of the saved file is shown below. The first line contains start date (mm/yyyy) of the time series, while the rest of the lines contain monthly discharges in m3/s.

01/1901
202.2
131.0
101.4
274.4
5515
6816
3147
2021
1123
1083
440.1
289.7
216.8
145.7
103.0
181.2
7144
8685