MODULE – 3: Inflow Estimation

3.1 Inflow Estimation Table for Different Rate of Rise

The basic purpose of the present module is to prepare the inflow estimation table for different rates of rise and at different elevations. The only data required for this purpose is the elevation-area-capacity (EAC) table and information about the release from the dam, if any. The output is presented in the form of a table. Inflow rates (in cumec) at different elevations are computed for different values of rate of rise. Knowing the initial reservoir elevation, rate of rise in reservoir level and the outflow rate, inflow rate to the reservoir can be picked up from the table.

3.1.1 Data Checks

Some of the checks performed by the module include:

a) EAC table of reservoir is checked. If the area (or storage capacity) at any reservoir level decreases with rising elevation, the program aborts and flags the line number in the EAC table for correction.

b) The storage capacity at each level in EAC table above the lowest level is checked by using the prismoidal formula. If the difference in the computed and specified capacity is greater than 10%, a message is flagged at the screen and in the result file after the presentation of Elevation-Area-Capacity Table in the Input Data section. The program does not abort in this case.

3.1.2 Input Data Description

The file extensions for input file, output file, and graphical files are ***.iti, .ito,*** and ***.itg*** respectively. Various items that are input to the program are described below:

Title of the analysis

Specify the title of the data file containing general details of the analysis for remembrance at a later date (not more than 100 characters).

Number of data points in EAC table

Specify the number of elevations for which corresponding water spread areas and cumulative storage capacity are available in the EAC table. Based on the entered value, the form for entry of EAC table will automatically generate the specified number of empty rows for input of EAC values.

It is important to mention that the accuracy of inflow computations depend on the accuracy of specifying the EAC table and it is desirable to have the EAC values at closer elevation interval (say, 0.5 m or so).

Initial reservoir level (m)

Specify the lowest starting reservoir elevation (m) at which inflows corresponding to different rates of rise are computed. This is the starting reservoir elevation in the output table.

Incremental level (m)

Specify the difference between successive reservoir elevations (in m, say 0.5 m) at which inflows are to be computed for different rates of rise in reservoir level.

Initial rate of rise (m/hr)

Specify the lowest initial rate of rise of reservoir level (in m/hr, say 0.1 m/hr) corresponding to which inflows are to be computed at different reservoir levels.

Incremental rate of rise (m/hr)

Specify the difference between successive rates of rise of reservoir level (in m/hr, say 0.1 m/hr) for which inflows are to be computed at different reservoir levels.

Discharge from the reservoir (cumec)

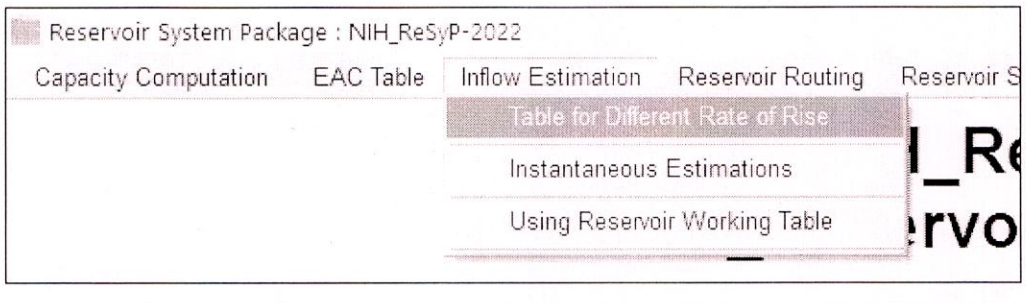
Specify the constant value of discharge or outflow (in cumec) that is being released from the reservoir during the period of measurement of rate of rise in reservoir level. Outflow or discharge affect the rate of reservoir level rise and are added directly to the inflow (in cumec) computed from the rate of reservoir level rise.

A table for entry of elevation, area, and storage capacity of a reservoir automatically opens in the general form. The number of rows in the table depend on the data specified in the cell corresponding to number of data points in EAC table.

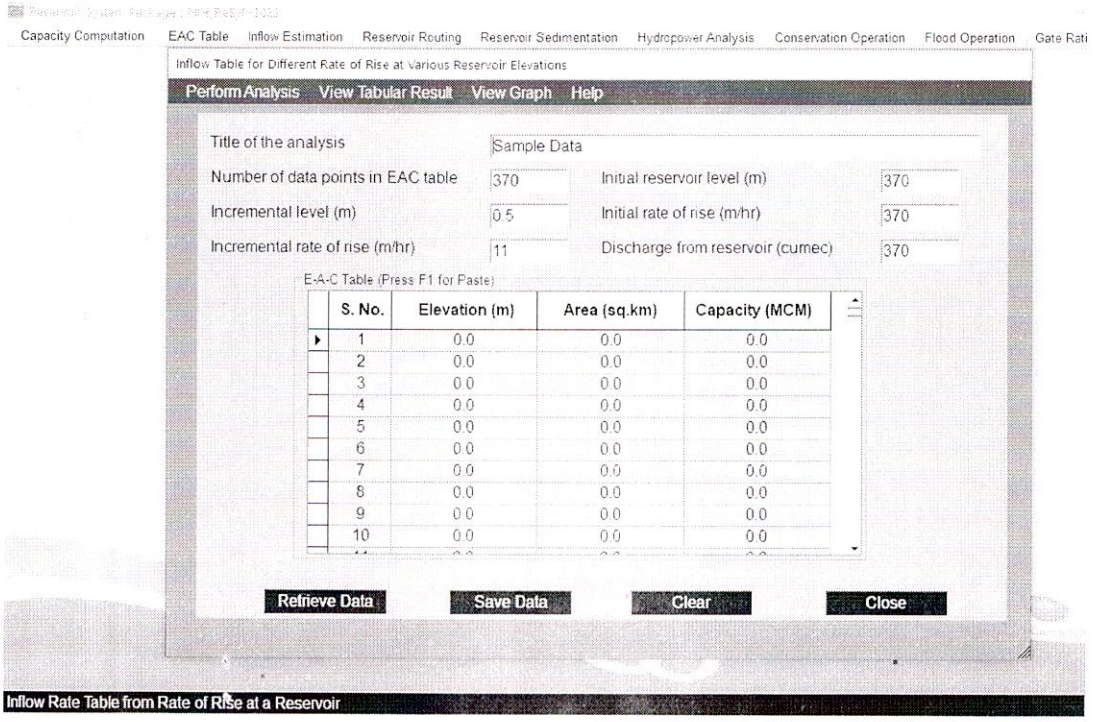
3.1.3 Steps of Analysis

The following are the steps for using the inflow estimation module:

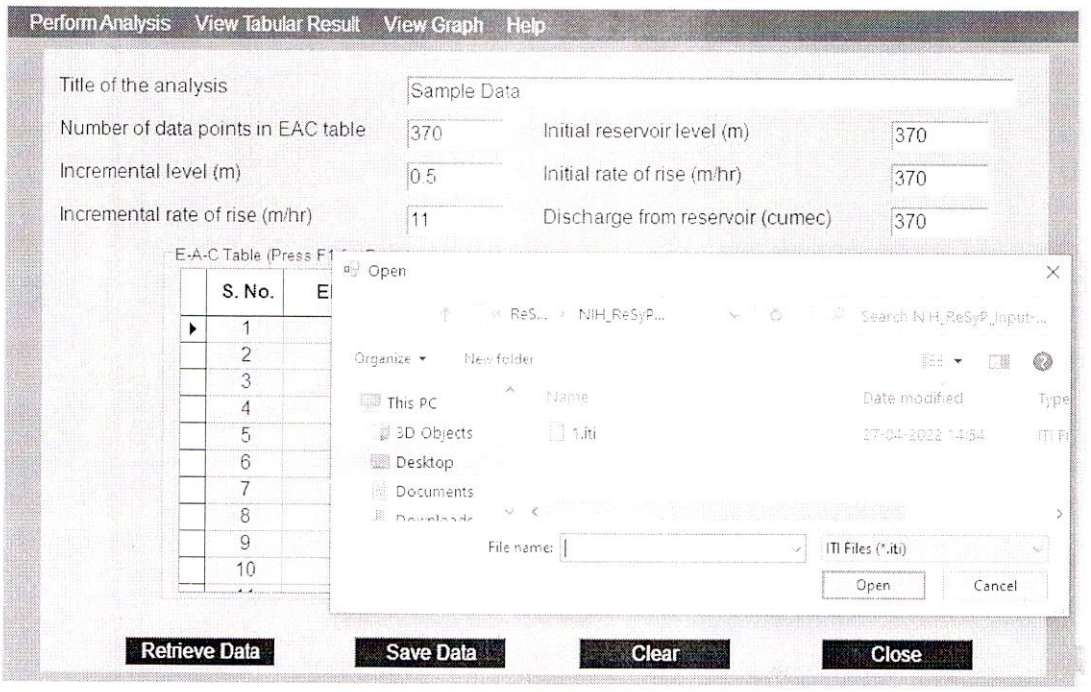
a) Go to the ***Inflow Estimation*** module and select the ***Table for Different Rate of Rise*** sub-module.



b) The data form will be displayed for entry of general details and tabular data.



c) Either retrieve an already existing data file by clicking on the ***Retrieve Data*** button or generate a new file by clearing the default data (by clicking on the ***Clear*** button) in the opening data form and fill all the data cells.

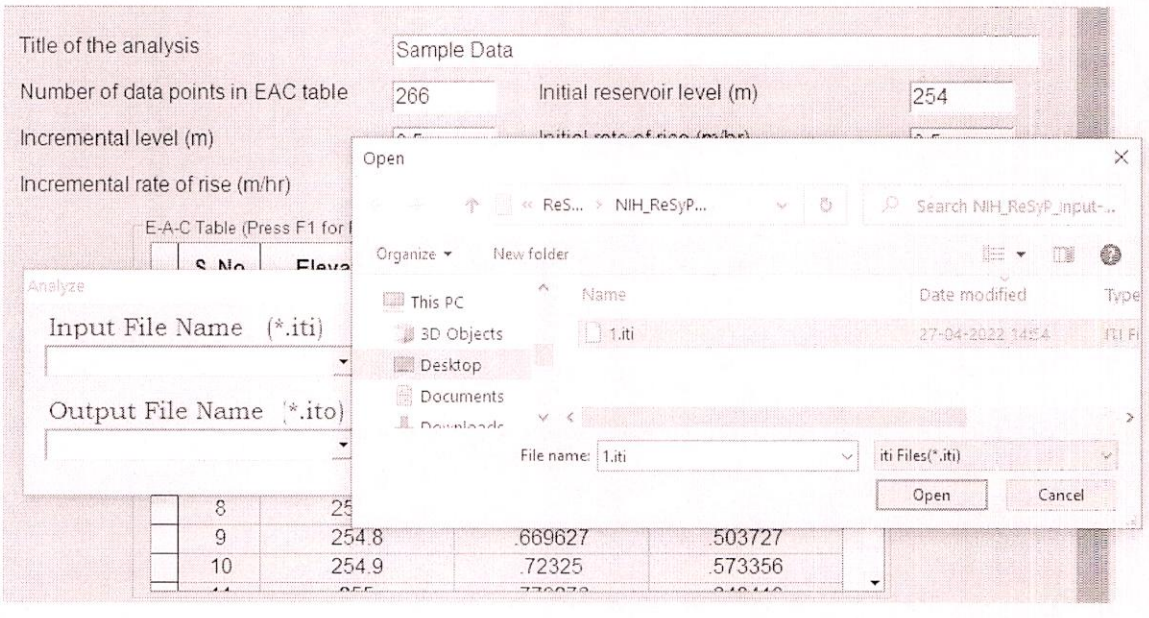


d) After entry of all data cells in the general data section, a blank **E-A-C Table** appears in the lower part of the form for input of elevation, area, and storage capacity values. Fill all the values in the table **in specified units**.

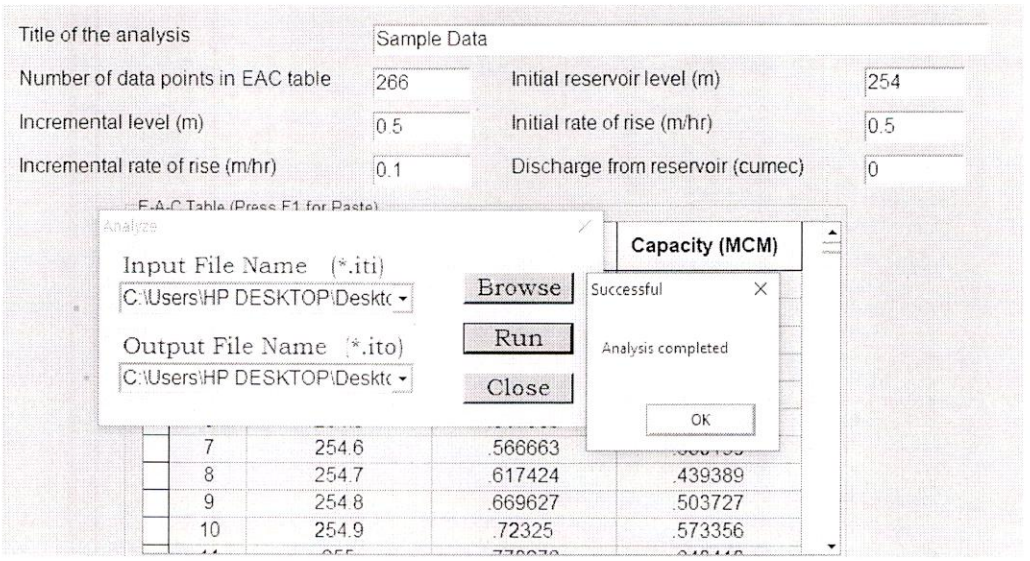
e) In the tabular data, it is also possible to ***Copy-Paste*** the data of all columns from MS-Excel. In that case, copy the data of all columns together from MS-Excel and bring the cursor to the first row in the table and press F1 (function key). Data will get pasted in all columns in the table. Check that data are present in all cells of the table.

f) After entry of all data cells in the form, click on the ***Save Data*** button. A separate window for saving the data file will appear. First select the desired directory and then specify the desired filename for the data file. The file will be saved as ***.iti*** file. There is no need to specify the extension in the filename. It will be automatically attached with the filename.

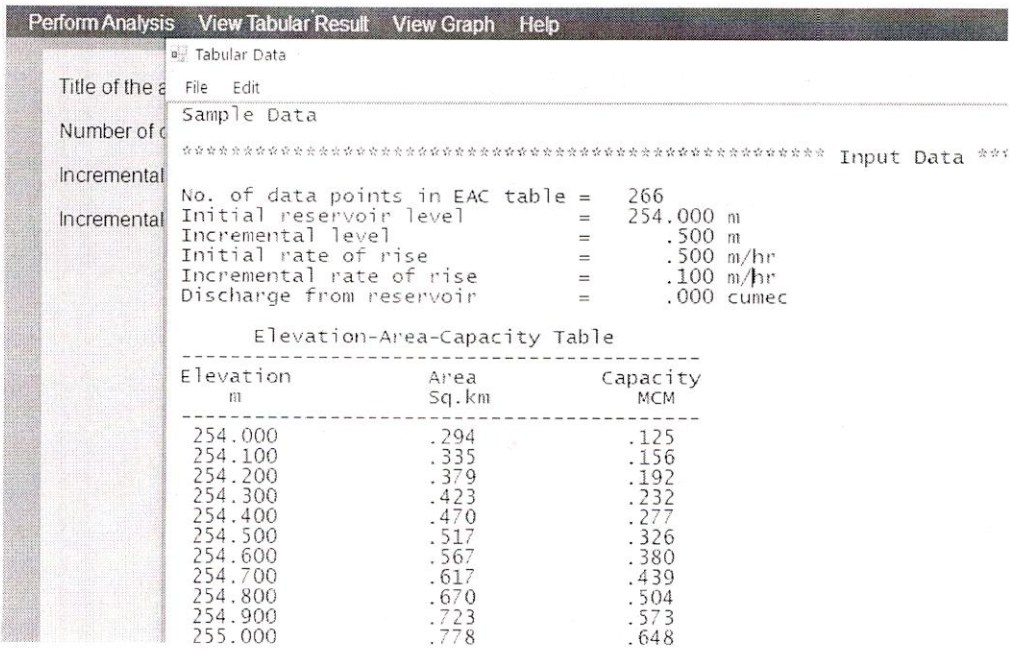
g) Click on the ***Perform Analysis*** button which will open-up a form for the specification of input and output files before the execution of the related program. First click on the ***Input File Name*** cell and then click on the ***Browse*** button. This will open a window for selecting the input file. Go to the desired directory and select the requisite data file. Click on the ***Open*** button to select the file. The file along with the path will appear in the ***Input File Name*** cell. Next, click on the ***Output File Name*** cell and repeat above steps. The filename along with the path will appear in the ***Output File Name*** cell.



h) <u>After specifying the input and output filenames along with their location, the ***Run*** button gets **activated**</u>. Click on the ***Run*** button to execute the related program with the specified input and output filenames. The program runs (in a window which closes automatically after the program execution is complete).



i) Click on the ***View Tabular Results*** button. To view data/results in tabular form, click on the ***Tabular*** button which will invoke the ***Notepad***. Click on the ***File*** and then ***Open*** and a window for file selection will appear. Go to the desired directory and select the requisite Input/Output filenames to see Input/Output files. It needs to be mentioned here that in this window, only files with extension ***.iti*** or ***.ito*** will be displayed. Select the desired filename and click on the ***Open*** button. The file will be displayed in the **Notepad**.



j) It is possible to prepare the graphs in MS-Excel only with specific requirements. For this purpose, ready-made graphs have been prepared in MS-Excel which can be modified. Open the graphical file (*.itg) in MS-Excel as ***"Delimited"*** file with ***"Space"*** delimiters and with column data format as ***"General"***. The file will open in a separate MS-Excel sheet. Select and copy the whole worksheet and paste it in ***"Input"*** worksheet of ***"Infl-RoR_Graph.xlsx"*** file of MS-Excel which is already

built in. The graphs can be copied and pasted anywhere in a document. The graph for the sample analysis is shown in Figure.

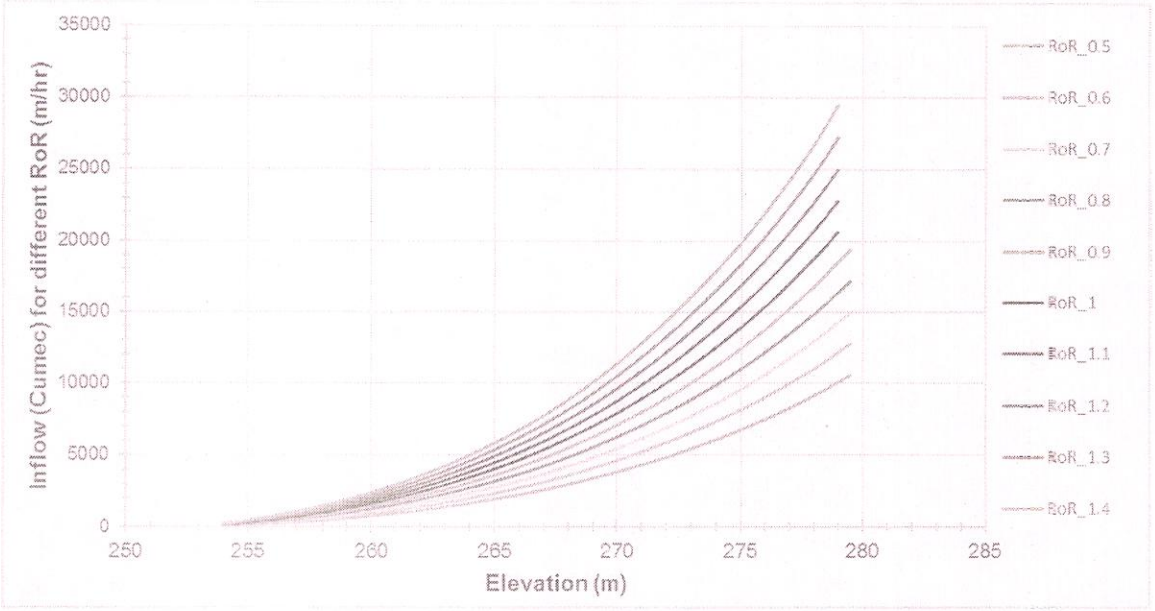


Figure: Computed inflow at different reservoir levels for various RoR

k) Close the ***Table for Different Rate of Rise*** sub-module by clicking on the ***Close*** button.

3.2 Inflow Estimation Using Reservoir Working Table

In general, net inflow to a reservoir from the upstream catchment is estimated from the outflows and losses from the reservoir, rainfall occurrence over the water spread area and the changes in reservoir storage. In such cases, reservoir storage is estimated using the reservoir level data and elevation-storage capacity curve for the reservoir. Generally, the inflows to a reservoir site should be positive or at the minimum zero. However, sometimes these computations lead to negative inflow estimations which may be because of any or more of the following reasons:

a) A small error (of the order of mm) in the measurement or recording of reservoir level data can result in huge variation in the reservoir volume estimation. Further, strong winds over reservoir surface can also cause errors in correct measurement of reservoir level at dam site.

b) Error in reservoir capacity at particular elevations due to non-availability of latest EAC curves after accounting for sedimentation.

c) Since inflows are computed from the observations of various variables, such as storage capacities at beginning and end of a time step, releases for various purposes, various losses/ gains (evaporation, seepage, and rainfall over reservoir water spread), spill from reservoir etc., an error in any of these observations or

their entry can result in negative inflows.

Here, it needs to be mentioned that from the available data/record, it is generally not possible to ascertain the exact cause of negative inflow computation. Further, negative inflows are conceptually not possible and they need to be corrected/adjusted before using the inflow series for reservoir related analysis.

3.2.1. Methodology to deal with negative Inflows

In different methodologies to deal with negative inflows, the reservoir mass balance is conserved in a water year in all the cases. Further, if the negative inflows in a hydrological year exceed the positive values, then all the inflow values in the hydrological year are taken as zero. The methodologies differ in the adjustment of negative inflows either in the values that are most adjacent to the location of occurrence of negative inflow or within the whole water year. Further, negative inflow can be revised to zero or as a long-term average. Based on these options, the following methodologies have been adopted for the adjustment of negative inflows:

Method – I: Negative inflow modified as '0' and adjustment in whole year depending on magnitude

In this method, the negative inflow occurring at a time step is modified as zero and the sum of negative values in a water year (June – May as per Indian conditions) is adjusted in the positive values in the water year in proportion to their magnitude. Thus, water balance is conserved in a hydrological year.

Method – II: Negative inflow modified as '0' and adjustment in adjacent values in accordance with their magnitude

In this method, the negative inflow occurring at a time step is modified as zero and the negative value at a time step is adjusted in the most adjacent positive values in proportion to their magnitude. However, the adjustment is made only in the adjacent values of the same hydrological year.

Method – III: Negative inflow modified as minimum of (long-term average at that time step and average of the adjacent positive values) and adjustment in whole year in proportion of positive values

In this method, the negative inflow occurring at a time step is not modified as zero but taken as the minimum of the long-term average value at that time step and the average of the positive adjacent (forward and backward) values. The sum of the negative value and the positive value considered at the time step is adjusted in the positive values of that hydrological year in the proportion of their magnitude. Thus, water balance is conserved in the hydrological year.

Three time steps are possible for this analysis: Daily, 10-daily, and monthly and any time step can be considered for any selected method.

3.2.2. Assumptions

Some of the assumptions while specifying the data are as follows:

a) Starting value of working table time series correspond to the beginning of a water year.

b) Metric system of units has been adopted and the desirable units of data sequence are specified in the column header.

c) The working table needs to be specified for complete water years. Otherwise, the program aborts and prompts for entry of working table at daily/10-daily/monthly time step for complete water years.

3.2.3. Data Checks

Some of the checks performed by the module include:

a) Elevation-Area-Capacity (EAC) table of reservoir is checked. If the area (or capacity) at any reservoir level decreases with rising elevation, the program aborts and flags the line number in the EAC table for correction.

b) The capacity at each level of EAC table above the lowest level is checked by using the prismoidal formula. If the difference in the computed and specified capacity is greater than 10%, a message is flagged at the screen and in the result file after the presentation of Elevation-Area-Capacity Table in the Input Data section. The program does not abort in this case.

3.2.4. Input Data Description

The file extensions for input file, output file, and graphical files are ***.ili, .ilo,*** and ***.ilg*** respectively. Various items that are input to the program are described below:

Title of the problem

Specify the title of the data file containing general details of the analysis for remembrance at a later date (not more than 100 characters).

Name of reservoir

Specify the name of the reservoir for which analysis is being carried out (not more than 50 characters).

Number of data points in EACS table

Specify the number of elevations for which corresponding water spread area, storage capacity, and the seepage loss rate are given in the EACS table. Based on the entered value, the form for entry of EACS table will generate the specified number of empty cell rows for input of elevation (m), area (sq. km), capacity (MCM), and seepage rate (mm/time step) values at different water surface elevations.

Number of reservoir level data

This refers to the number of data sets of the reservoir data in terms of reservoir level, release for different purposes, spill from reservoir, evaporation loss, seepage loss, and rainfall occurrence over the reservoir water spread at specified time step (daily/10-daily/monthly). Working table is to be specified for complete water years.

Time step size (1-D/2-TD/3-M)

Three time steps are possible: daily, 10-daily, and monthly. Choose the option based on the availability of reservoir data.

Option for Negative flow correction (0-3)

Choose the method for the adjustment of the negative flows. Four possibilities are there: a) No negative flow correction (denoted by "0"), b) Negative flow modified as '0' and adjustment in whole year depending on magnitude (denoted by "1"), c) Negative flow modified as '0' and adjustment in adjacent values in accordance with their magnitude (denoted by "2"), and d) Negative flow modified as minimum of (long-term average at that time step and average of the adjacent positive values) and adjustment in whole year in proportion of positive values (denoted by "3").

Option for Inflow Estimation Location (1/2)

It is important to specify the location where the inflows are to be corrected. The location can be at the u/s of the reservoir (beginning of reservoir where the river enters the reservoir specified with Option - 1) or at the dam site (specified with Option - 2). If the inflow from the reservoir catchment is to be computed at the u/s of the reservoir, then the evaporation depth, seepage loss, and the rainfall over the water spread area are considered. However, if the inflow at the dam site is to be computed, then the seepage loss and rainfall over the water spread area are considered to be part of the reservoir inflow.

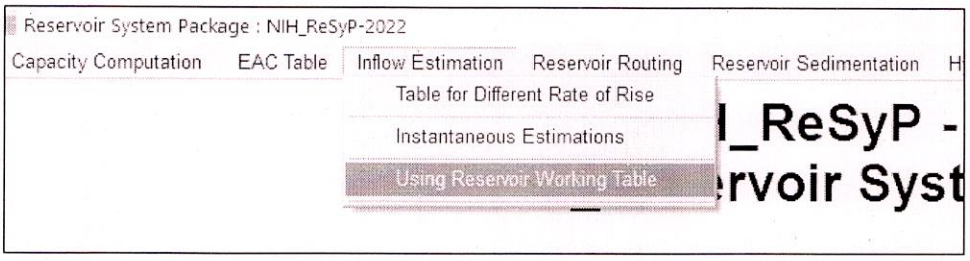
E-A-C-S table

Clicking on the ***EACS Table*** button opens a table for entry of elevation, area, capacity, and seepage rate from the reservoir. The number of cells depend on the data specified in the cell corresponding to number of data points in EACS table.

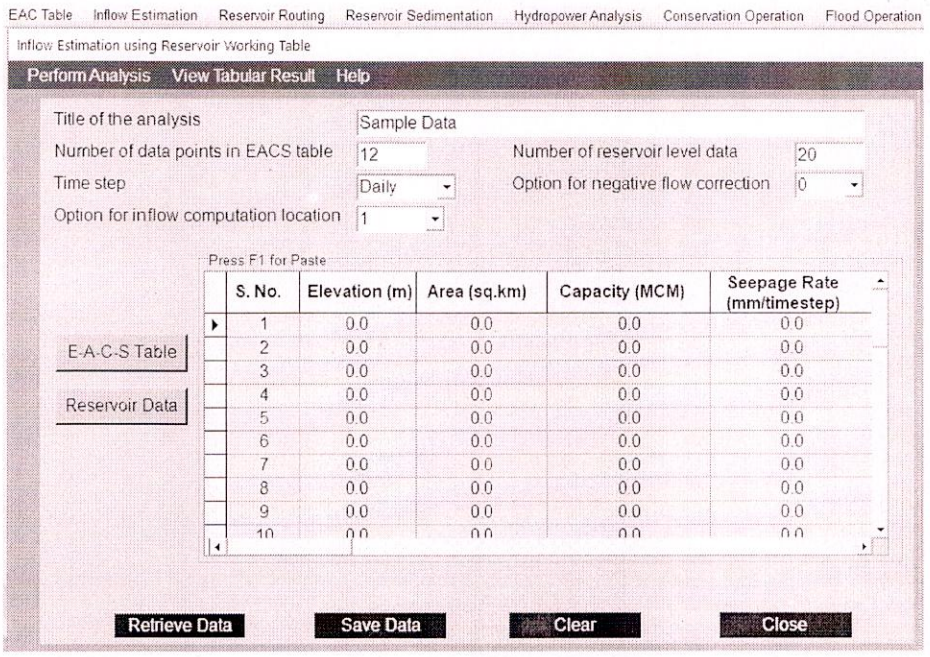
3.2.5. Steps of Analysis

Following are the steps for using the inflow estimation module:

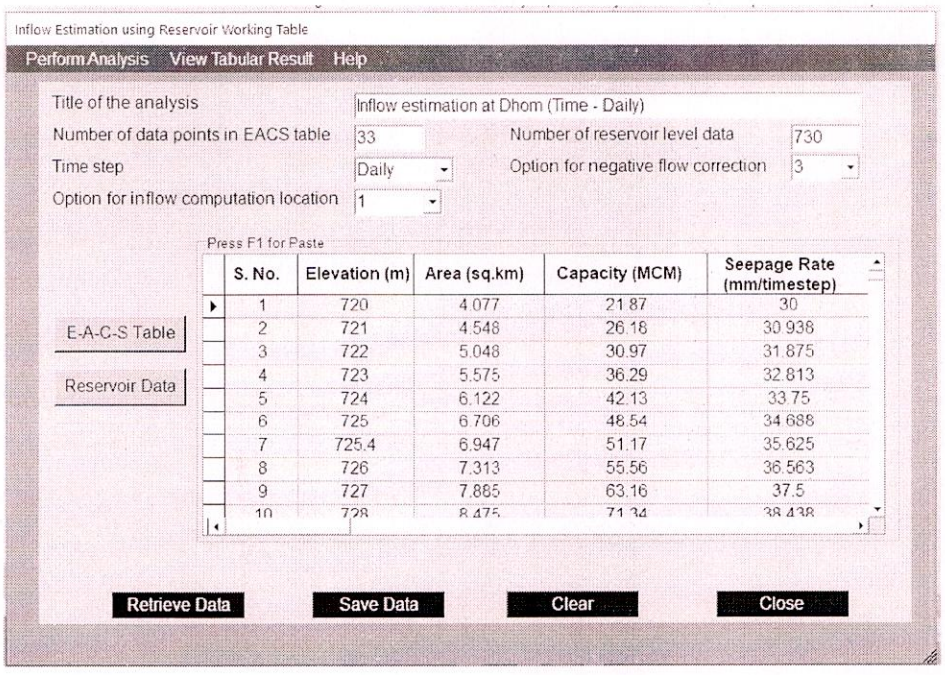
a) Go to the ***Inflow Estimation*** module and select the ***Reservoir Working Table*** sub-module.



The data form will be displayed for entry of general details and tabular data.



b) Either retrieve an already existing data file by clicking on the ***Retrieve Data*** button or generate a new file by clearing the default data (by clicking on the ***Clear*** button) in the opening data form and fill all the data cells.



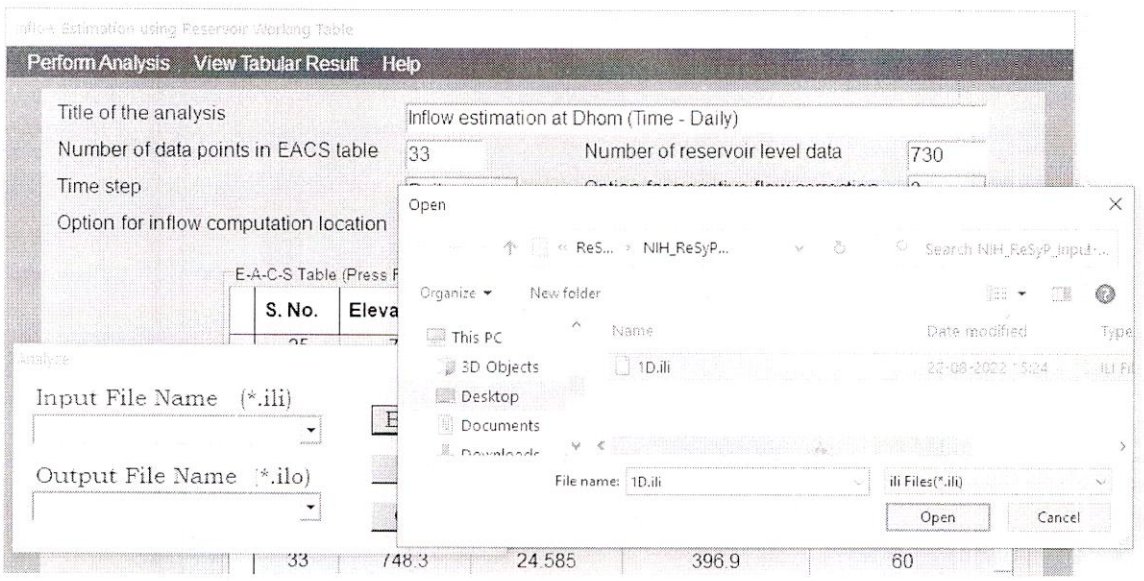
c) After entry of all data cells in the general data section, a blank **E-A-C-S Table** form appears in the lower part of the form for input of elevation, area, storage capacity, and seepage loss rate values. Fill all the values in the table **in specified units**.

d) Next, click on the ***Reservoir data*** button. Fill all working table values in specified columns in the table **in specified units**. It is to mention that days start from the water year with value 1 (say on June 1) and they go up to 365 at the end of water year (or 366 in case of leap year) (say, on May 31 next year). This helps the program to identify the water year and adjust the negative computations within the water year.

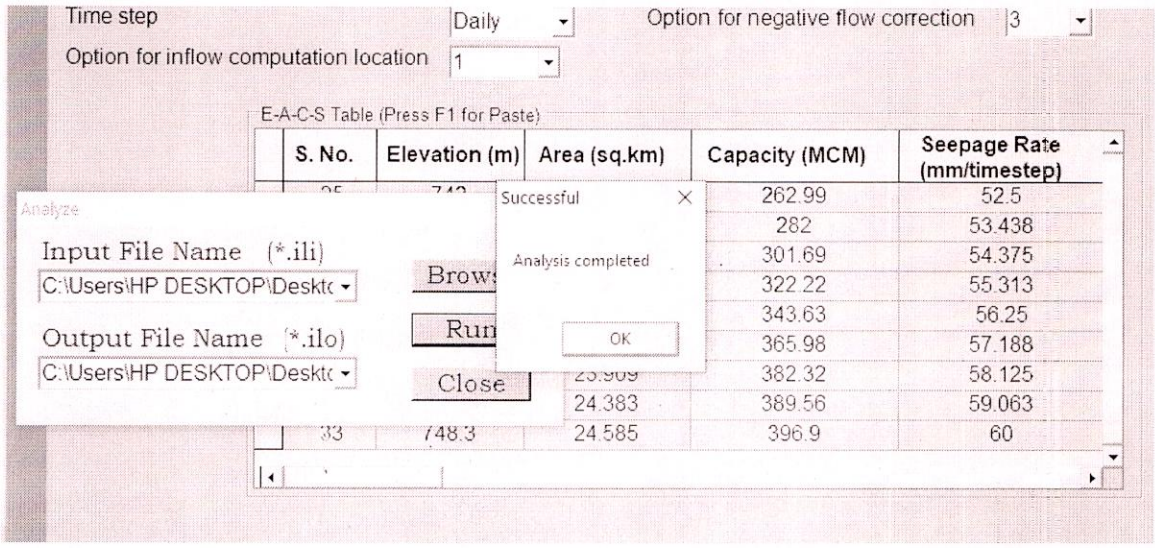
In the tabular data, it is also possible to ***Copy-Paste*** the data of all columns from MS-Excel. In that case, copy the data of all columns together from MS-Excel and bring the cursor to the first row in the table and press F1 (function key). Data will get pasted in all columns in the table. Check that data are present in all cells of the table **in specified units**.

e) After entry of all data cells in the form, click on the ***Save Data*** button. A separate window for saving the data file will appear. First select the desired directory and then specify the desired filename for the data file. The file will be saved as ***.ili*** file. There is no need to specify the extension in the filename. It will be automatically attached with the filename.

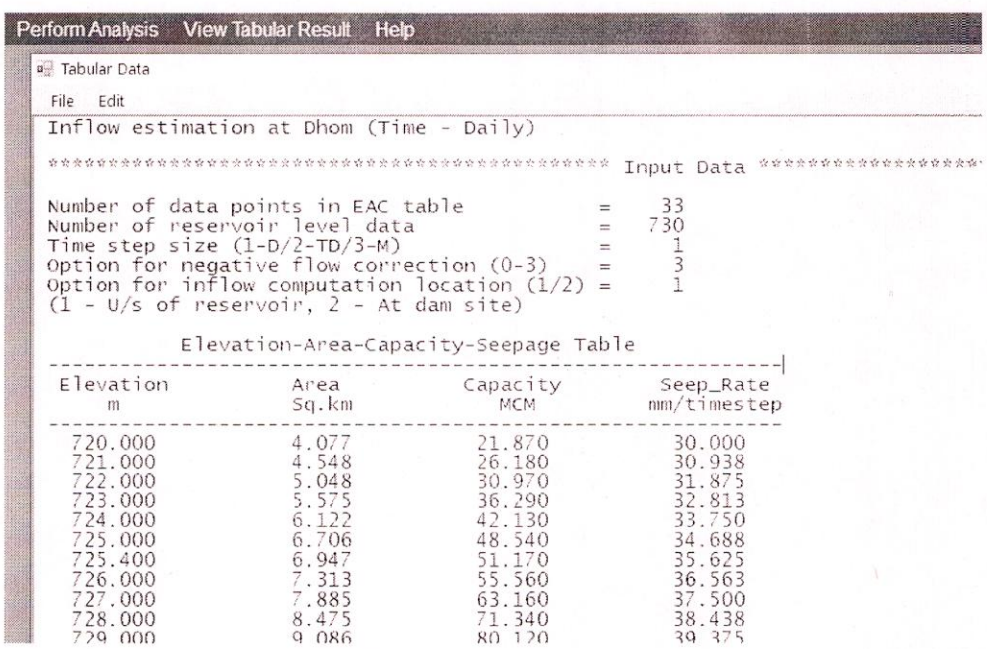
f) Click on the ***Perform Analysis*** button which will open-up a form for the specification of input and output files before the execution of the related program. First click on the ***Input File Name*** cell and then click on the ***Browse*** button. This will open a window for selecting the input file. Go to the desired directory and select the requisite data file. Click on the ***Open*** button to select the file. The file along with the path will appear in the ***Input File Name*** cell. Next, click on the ***Output File Name*** cell and repeat above steps. The filename along with the path will appear in the ***Output File Name*** cell.



g) After specifying the input and output filenames along with their location, the ***Run*** button gets **activated**. Click on the ***Run*** button to execute the related program with the specified input and output filenames. The program runs (in a window which closes automatically after the program execution is complete).



h) Click on the ***View Tabular Results*** button. To view data/results in tabular form, click on the ***Tabular*** button which will invoke the ***Notepad***. Click on the ***File*** and then ***Open*** and a window for file selection will appear. Go to the desired directory and select the requisite Input/Output filenames to see Input/Output files. It needs to be mentioned here that in this window, only files with extension ***.ili*** or ***.ilo*** will be displayed. Select the desired filename and click on the ***Open*** button. The file will be displayed in the **Notepad**.



i) To view the results in graphical form, click on the ***View Graphs*** button. A window

with following graphical option will invoke:

- Computed inflow and Adjusted inflow.

Select the option and then click on the ***View*** button. The corresponding graph will be displayed which can be copy-pasted in a document.

j) It is also possible to prepare the graphs in MS-Excel only with specific requirements. For this purpose, ready-made graphs have been prepared in MS-Excel which can be modified. Open the graphical file (*.ilg) in MS-Excel as ***"Delimited"*** file with ***"Space"*** delimiters and with column data format as ***"General"***. The file will open in a separate MS-Excel sheet. Select and copy the whole worksheet and paste it in ***"Input"*** worksheet of ***"Infl-Rlvl_Graph.xlsx"*** file of MS-Excel which is already built in. The graphs can be copied and pasted anywhere in a document. The graph for the sample analysis at monthly time step is shown in the Figure.

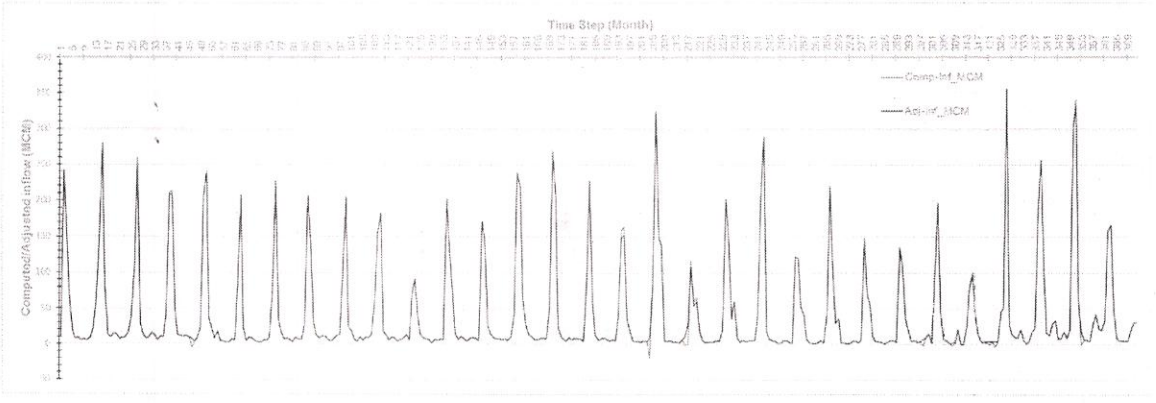


Figure: Computed/adjusted inflow at dam site as plotted in MS-Excel

k) Close the ***Reservoir Working Table*** sub-module by clicking on the ***Close*** button.