NIH_ReSyP – A Reservoir Systems Package Developed at NIH

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Salient Features of NIH_ReSyP

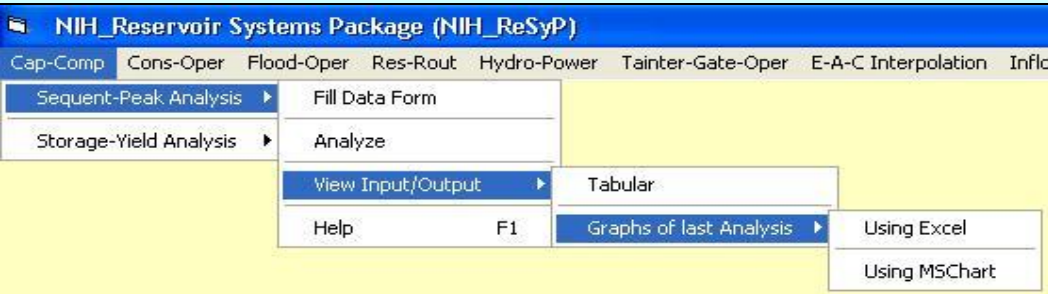
- A number of programs developed for reservoir analysis problems merged to make ReSyP.
- Core in Fortran; forms and chores in Visual BASIC.
- Runs under Windows environment.
- Does not need any specific software or hardware.
- Provides a user-friendly environment.
- Results are presented in tabular and graphical form.
- Online Help is available.
- Results including graphs generated can be used in other applications by cut-copy-paste.
- Data can be prepared in MS-Excel and pasted in input forms or vice-versa.

Opening Banner of *NIH_ReSyP*

Analysis Options Available in NIH_ReSyP

- Reservoir capacity estimation using sequent-peak method
- Storage-Yield-Reliability analysis
- Hydropower analysis
- Operation analysis of a Multi-purpose Multi-reservoir system for conservation purposes
- Operation analysis of a Multi-purpose Multi-reservoir system for flood control
- Reservoir sedimentation analysis
- Probable inflow estimation
- Reservoir routing
- Estimation of trial Rule Curves for a reservoir
- Interpolation of elevation-area-capacity (EAC) table
- Reservoir inflow estimation using rate of rise method

Analysis Ladder for a Module of *NIH_ReSyP*



NATIONAL INSTITUTE OF HYDROLOGY

राष्ट्रीय जल विज्ञान संस्थान

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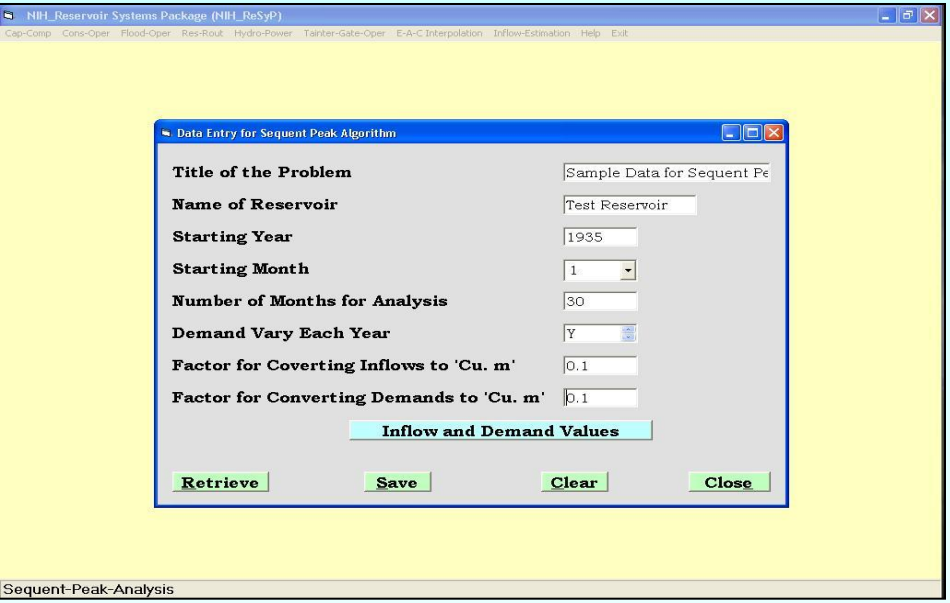
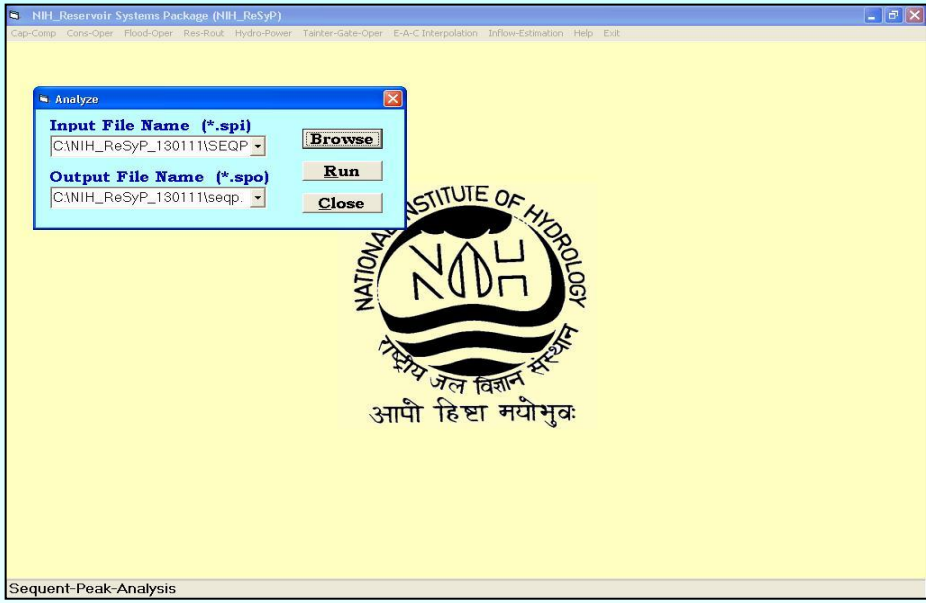
Sequent-Peak-Analysis

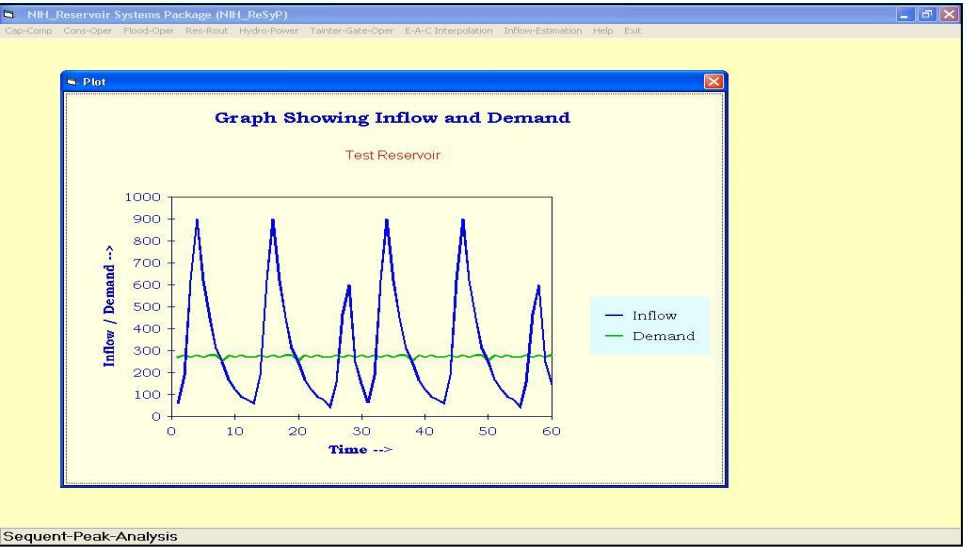
Sample Input-Output of NIH_ReSyP



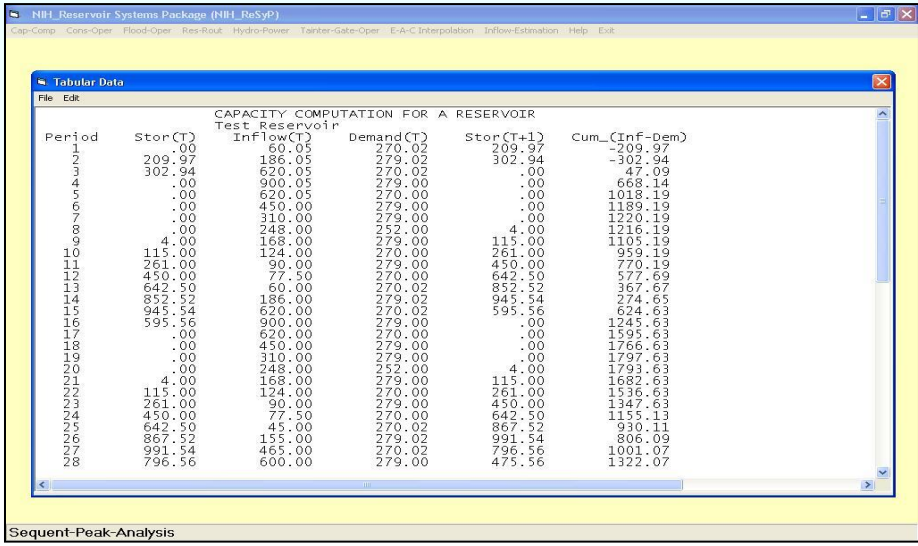
Sample Data Input Form



Sample Analysis Window



Sample Graphical Output



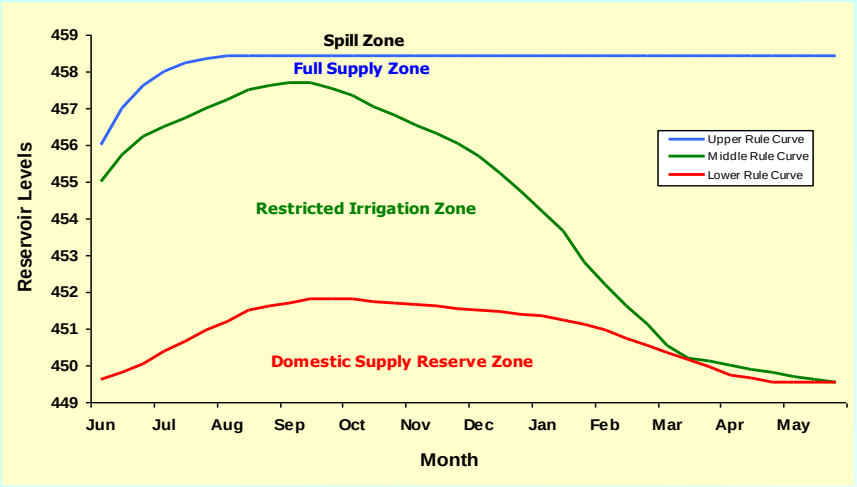
Period	Stor(T)	Inflow(T)	Demand(T)	Stor(T+1)	Cum_(Inf-Dem)
1	.00	60.05	270.02	209.97	-209.97
2	209.97	186.05	279.02	302.94	-302.94
3	302.94	620.05	270.02	.00	47.09
4	.00	900.05	279.00	.00	668.14
5	.00	620.05	270.00	.00	1018.19
6	.00	450.00	279.00	.00	1189.19
7	.00	310.00	279.00	.00	1220.19
8	.00	248.00	252.00	4.00	1216.19
9	4.00	168.00	279.00	115.00	1105.19
10	115.00	124.00	270.00	261.00	959.19
11	261.00	90.00	279.00	450.00	770.19
12	450.00	77.50	270.00	642.50	577.69
13	642.50	60.00	270.02	852.52	367.67
14	852.52	186.00	279.02	945.54	274.65
15	945.54	620.00	270.02	595.56	624.63
16	595.56	900.00	279.00	.00	1245.63
17	.00	620.00	270.00	.00	1595.63
18	.00	450.00	279.00	.00	1766.63
19	.00	310.00	279.00	.00	1797.63
20	.00	248.00	252.00	4.00	1793.63
21	4.00	168.00	279.00	115.00	1682.63
22	115.00	124.00	270.00	261.00	1536.63
23	261.00	90.00	279.00	450.00	1347.63
24	450.00	77.50	270.00	642.50	1155.13
25	642.50	45.00	270.02	867.52	930.11
26	867.52	155.00	279.02	991.54	806.09
27	991.54	465.00	270.02	796.56	1001.07
28	796.56	600.00	279.00	475.56	1322.07

Sample Tabular Output

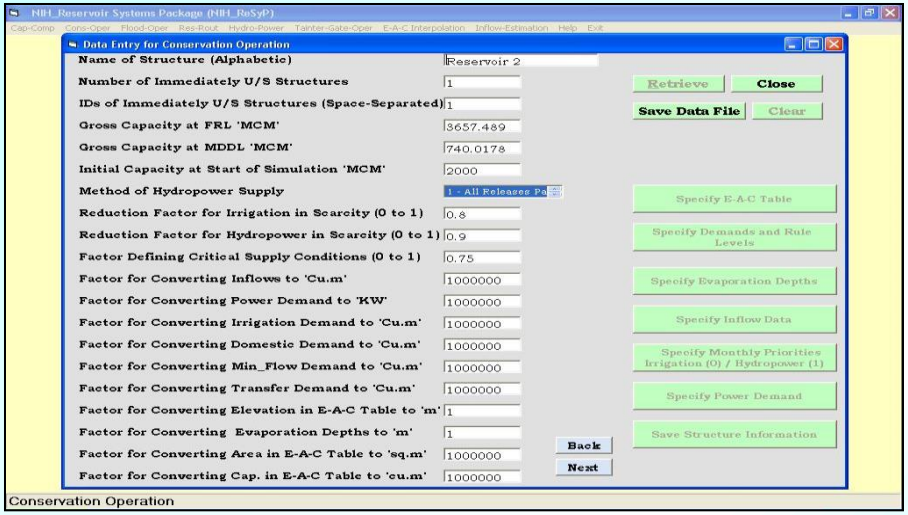
Conservation Operation of a Multi-reservoir System

- **Operates a multi-reservoir system for D&I demands, irrigation, hydropower, and minimum flow requirements.**
- **Any configuration of storage & diversion structures can be simulated.**
- **Ten-daily or Monthly time steps can be used.**
- **Interbasin water transfer can be simulated.**
- **Rule-curves based operation is followed. ReSyP helps fine-tune operation policy of a reservoir system.**
- **Reliabilities/ resilience/ vulnerability of structures are computed.**
- **User-controlled detailed working table is generated for all dams/ diversions.**

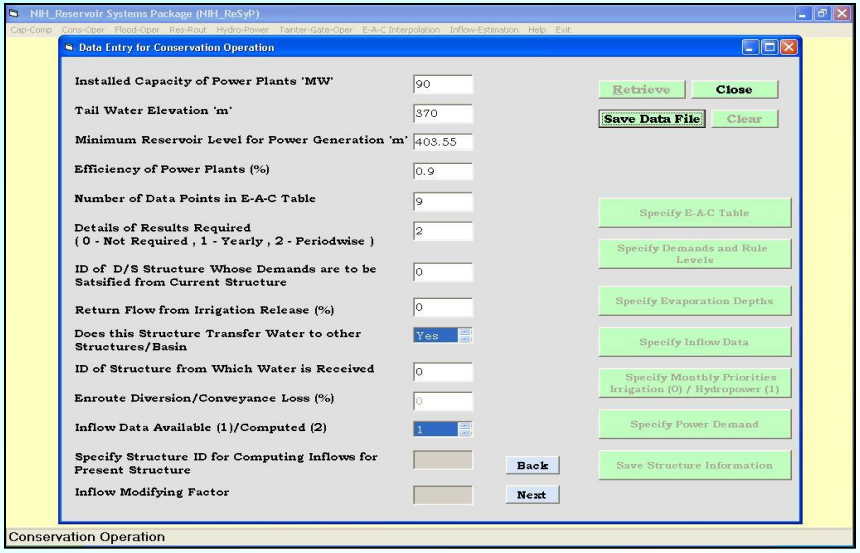
Conservation Operation of a Multi-reservoir System



Rule-curve based operation



Input Data Form



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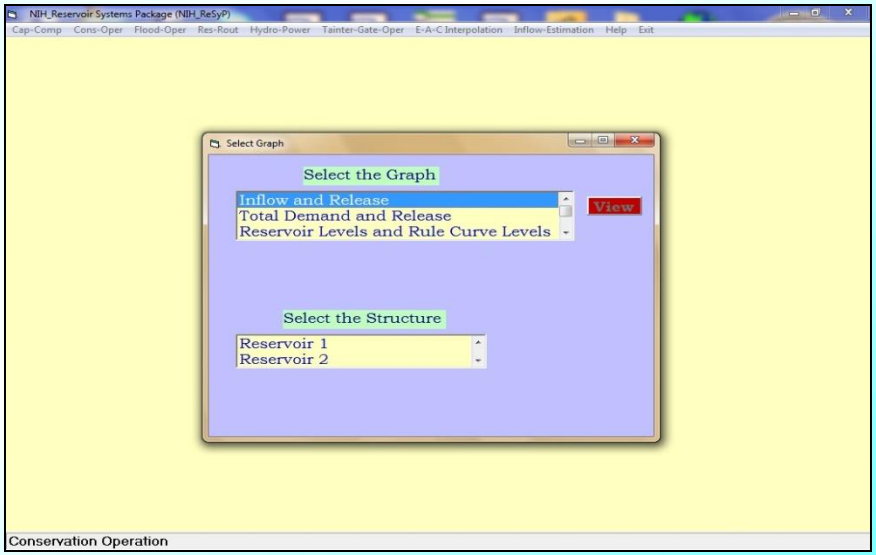


Option for Graphical Output

Conservation Operation of a Multi-reservoir System – Reservoir Working Tables

Working Table for Location No. 1 -Rajghat Dam
At this node, WS + Min_flow only pass thru plant
Monthly priorities (0 means Irrigation has higher priority)

0	0	0	0	0	0	0	0	0	0	0	0

A link diverts water from this node
Water supply demands at this node (m m3)

14.53	15.23	2.77	.92	1.16	11.53	27.22	17.07	10.15	2.31	11.07	11.07

Link demands at this node (m m3)

10.0	10.5	1.9	.6	.8	8.0	18.8	11.8	7.0	1.6	7.7	7.7

Irrigation demand 1 at this node (m m3)

18.11	18.98	3.45	1.15	1.44	14.37	33.92	21.27	12.65	2.87	13.80	13.80

Irrigation demand 2 at this node (m m3)

4.08	4.28	.78	.26	.32	3.24	7.65	4.80	2.85	.65	3.11	3.11

Minimum quantity to be released from this node (m m3)

11.00	11.00	11.00	11.00	11.00	11.00	.00	.00	.00	11.00	11.00	11.00

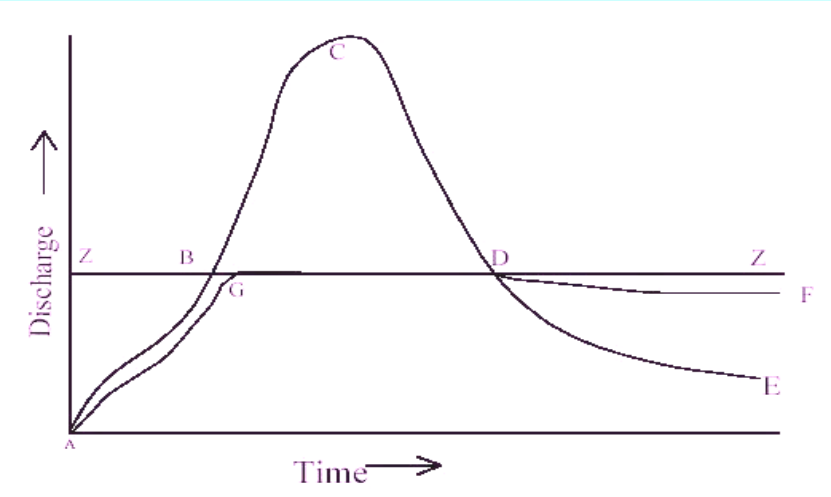
YYYY-Mn-D	Ini_Sto m m3	Loc_Flo m m3	Evapr m m3	Tir_Dem m m3	Pw_Dem m m3	Tds_Dem m m3	Ir_Rel m m3	Ws_Rel m m3	Tot_Rel m m3	Pw_Gen MKwh	PW-Rel m m3	Lin_Dv m m3	Spill m3	End_Lev m	Mdl_Rul m	Upr_Rul m	
1981-06-0	350.0	36.3	20.0	17.6	.0	35.7	.0	11.5	22.5C	.2	22.5	.0L	0.	358.50	364.00	371.00	H
1981-07-0	343.8	302.5	10.8	41.6	.0	58.3	.0	27.2	27.2C	.3	27.2	18.8	0.	361.15	364.00	371.00	A
1981-08-0	589.5	1482.8	15.1	26.1	.0	36.5	21.3	17.1	79.7	1.3	53.6	11.8	0.	369.83	364.00	371.00	I
1981-09-0	1965.7	190.0	23.9	15.5	.0	21.7	12.6	10.1	47.4	1.1	31.9	7.0	0.	370.38	364.00	371.00	I
1981-10-0	2077.4	48.9	20.0	3.5	.0	15.9	2.9	2.3	21.8	.7	18.2	1.6	0.	370.41	364.00	371.00	I
1981-11-0	2083.0	28.9	14.6	16.9	.0	34.7	13.8	11.1	62.7	1.6	45.8	7.7	0.	370.14	364.00	371.00	A
1981-12-0	2026.9	14.0	13.3	16.9	.0	34.7	13.8	11.1	62.7	1.6	45.8	7.7	0.	369.79	364.00	371.00	A
1982-01-0	1957.3	35.7	14.4	22.2	.0	42.1	18.1	14.5	78.8	1.9	56.6	10.0	0.	369.45	364.00	371.00	A
1982-02-0	1889.7	49.6	18.0	23.3	.0	43.6	19.0	15.2	82.1	1.9	58.8	10.5	0.	369.15	364.00	371.00	H
1982-03-0	1828.7	14.3	34.3	4.2	.0	16.9	3.5	2.8	23.9	.6	19.7	1.9	0.	368.92	364.00	371.00	H
1982-04-0	1782.9	1.2	57.5	1.4	.0	13.0	1.1	.9	15.3	.4	13.9	.6	0.	368.56	364.00	371.00	H
1982-05-0	1710.8	5.8	77.0	1.8	.0	13.5	1.4	1.2	16.4	.4	14.6	.8	0.	368.11	364.00	371.00	H
1982		2210.	319.	190.9	0.	367.	131.8	125.	540.	12.	409.	78.	0.				

- **Systems studied**: Sabarmati, Machhu, Bargi, Vellar, Peninsular Part of River Interlinking Scheme, Ken-Betwa Interlinking project, ...
- **Publications:** Jain, S.K., Goel, M.K. and Agarwal, P.K. (1998). "Reservoir operation studies for Sabarmati system, India", J of Water Res Plan and Manag, ASCE, 124(1), 31-38.
- Jain, S.K., Reddy, NSRK, and Chaube, U.C. (2005). "Analysis of a Large Inter-basin Water Transfer System in India." Hydrological Sciences J, IAHS, 50(1), 125-137.
- Jain, S. K., and Bhunya, P. K. (2008). "Reliability, resilience, and vulnerability of a multipurpose storage reservoir." Hydrological Sciences J, IAHS, 53(2), 434-447.
- Jain, S.K. (2010). Investigating the behavior of statistical indices for performance assessment of a reservoir. Journal of Hydrology, 391, 90-96.

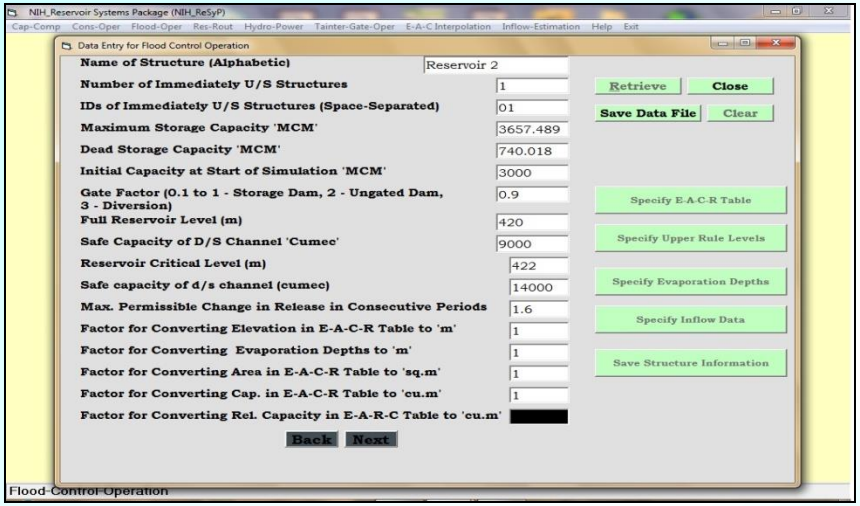
Flood Operation of a Multi-reservoir System

- For operation analysis of a multi-reservoir system for flood control.
- Any configuration of storage & diversion structures can be simulated.
- Time steps – Multi-hours.
- For each structure, inflow hydrograph + flow from intermediate catchment is needed.
- Each reservoir is operated so that incoming flood is passed safely with least d/s flooding while ensuring safety of dam.
- Several methods are available for channel routing.
- User-controlled detailed working table is generated for all dams/ diversions.

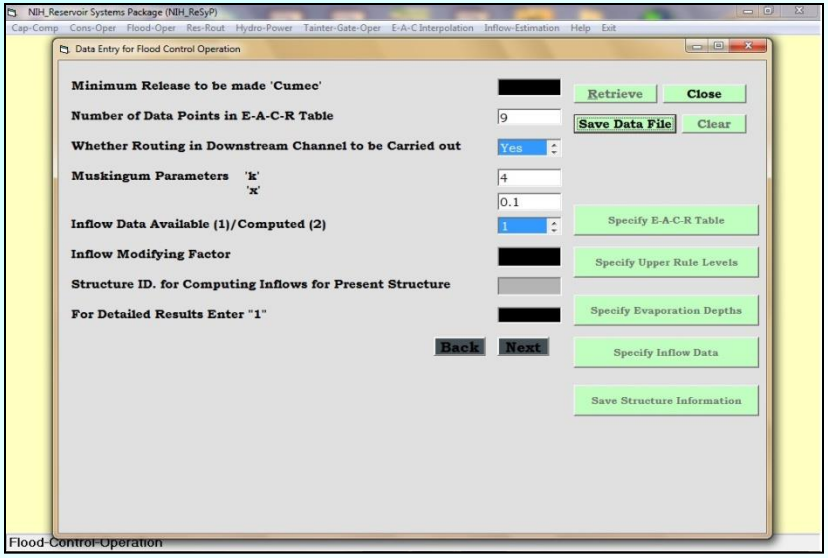
Flood Operation of a Multi-reservoir System



Flood control operation



Input Data Form



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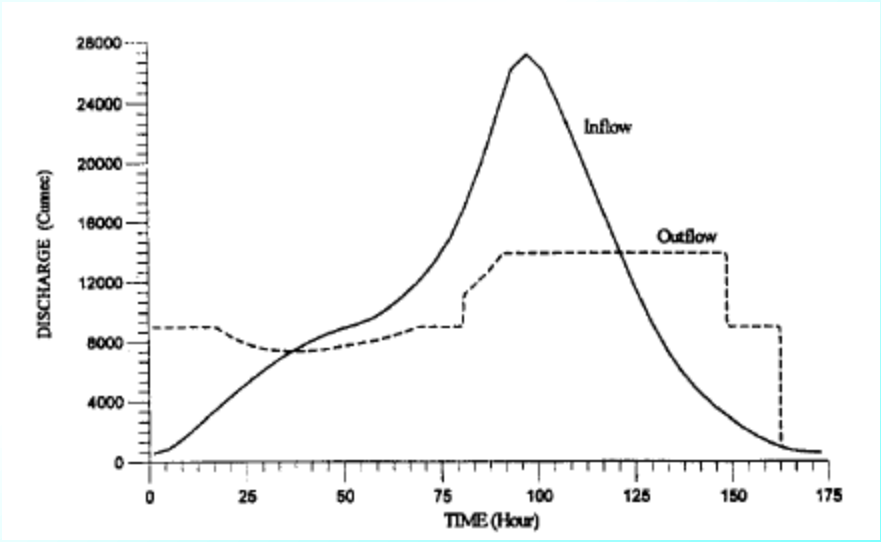
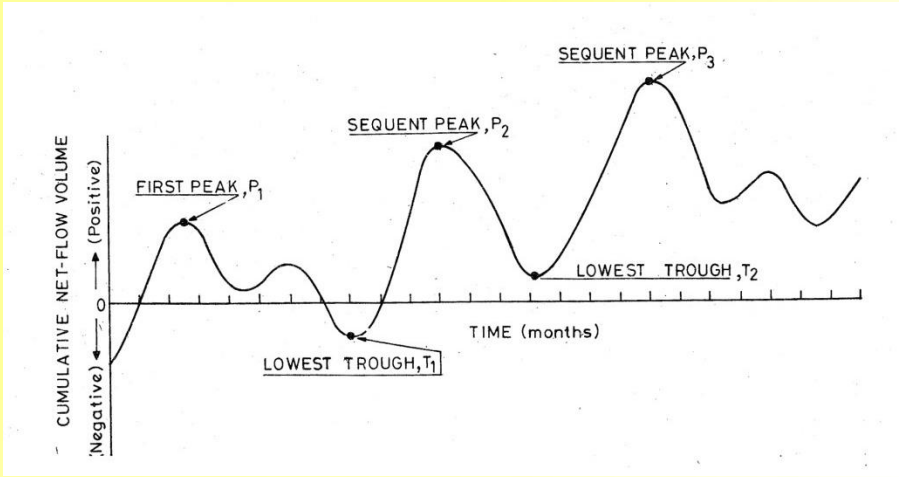
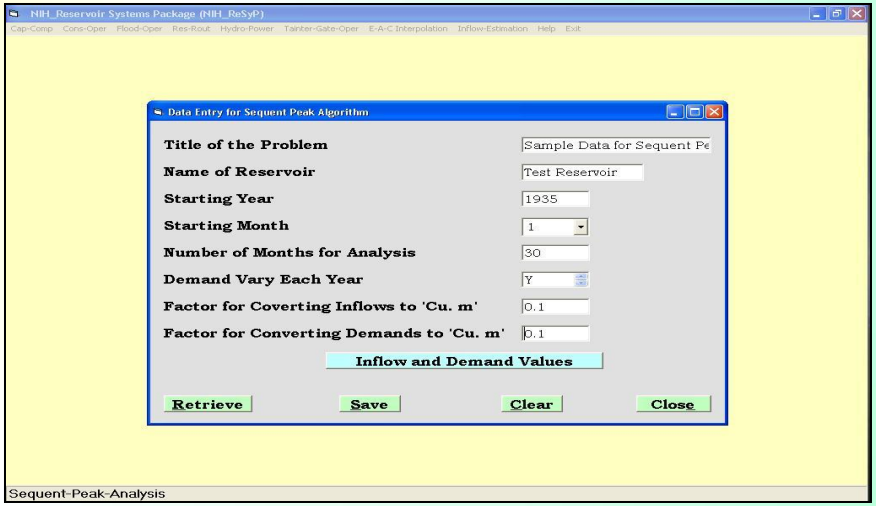


Graphical Output

Capacity Computation Using Sequent Peak Method



Sequent Peak Algorithm



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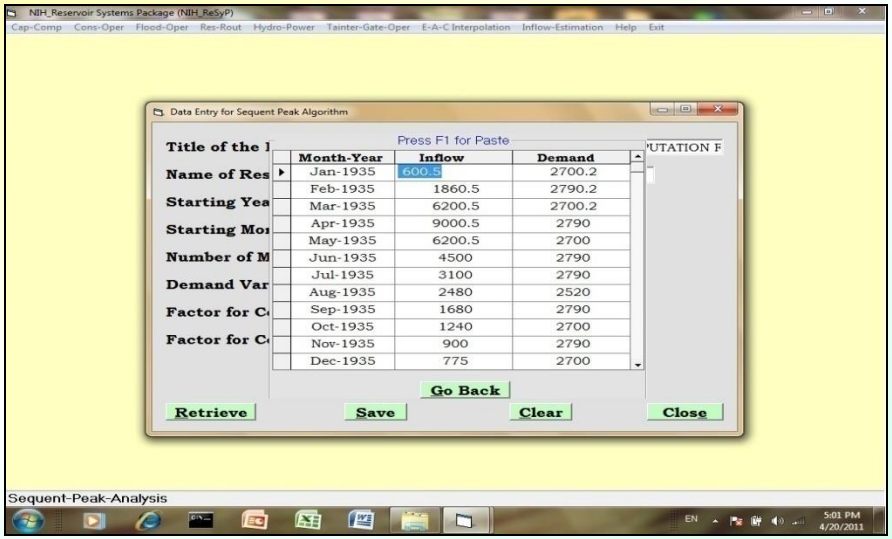
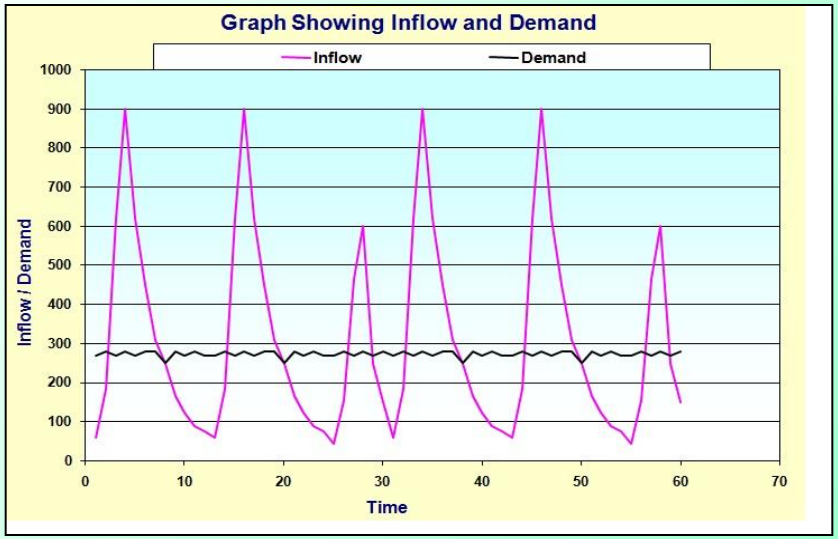


Data Form for Tabular Data



Graphical Output

Hydropower Analysis

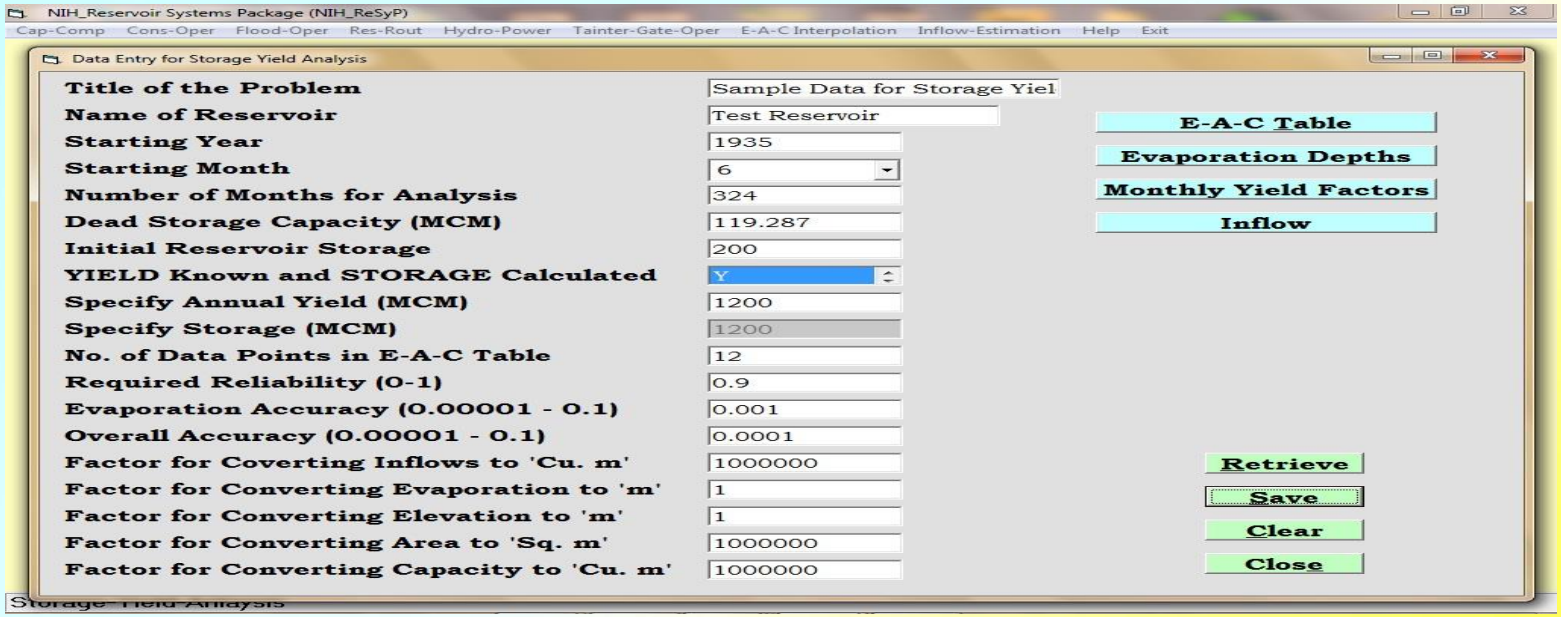
Firm Power Determination

- Maximum possible firm power depends upon the site conditions, hydrology of the area, type of load, and features of power plant.
- An optimization algorithm is used to determine firm power from a reservoir.
- SLOP is used for simulation of reservoir operation. Computations are repeated till convergence is attained.

Hydropower Simulation

- Knowing the given power demand, the reservoir simulation is carried out to find out power generation and reliabilities.

Storage-Yield-Reliability Analysis



Opening data form for storage-yield analysis module

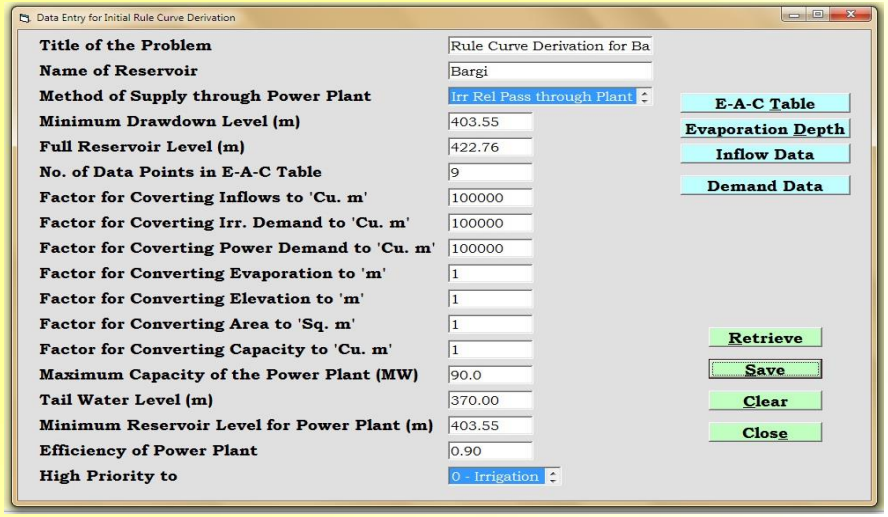
Sample Output file Generated

Reservoir Storage Required = 2812.22 M Cum, Number of Failures = 125
Reliability Achieved = .61

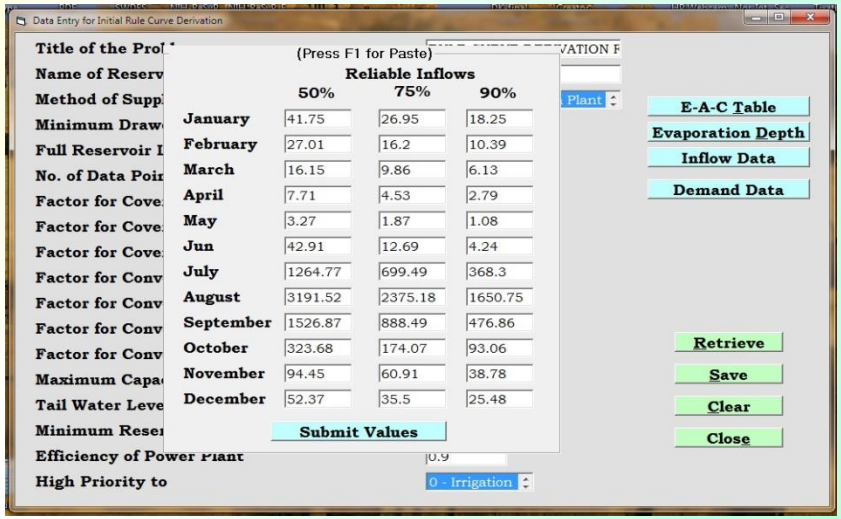
Reservoir Monthly Working Table

Month	Ini_Sto	Inflow	Demand	Release	Evap	End_Sto
1	200.00	13.540	108.000	88.150	6.103	119.29*
2	119.29	333.790	72.000	72.000	6.118	374.96
3	374.96	172.370	72.000	72.000	8.982	466.35
4	466.35	263.220	68.400	68.400	12.079	649.09
5	649.09	45.290	111.600	111.600	13.510	569.27
6	569.27	12.310	109.680	109.680	12.285	459.61
7	459.61	14.300	109.680	109.680	10.504	353.73
8	353.73	.470	109.680	109.680	7.912	236.61
9	236.61	.890	109.680	109.680	5.679	122.14
10	122.14	.860	109.680	.000	4.131	118.87*
11	118.87	.500	109.680	.000	5.125	114.24*
12	114.24	.270	109.680	.000	6.239	108.27*
13	108.27	.460	108.000	.000	4.202	104.53*
14	104.53	229.220	72.000	72.000	4.769	256.98
15	256.98	630.410	72.000	72.000	11.207	804.19

Derivation of Trial Rule Curves



Input Data Form



Data Form for Reliable flows

Sample Output file Generated

```
  RULE CURVE DERIVATION FOR A RESERVOIR
Upper Rule Curve Levels (Jan...Dec)
416.59   413.70   411.26   408.55   406.02   422.76   422.76
422.76   422.76   422.76   420.97   419.17

Irrigation Rule Curve Levels (Jan...Dec)
416.59   413.70   411.26   408.55   406.02   415.81   418.13
420.44   422.76   422.76   420.97   419.17

Hydropower Rule Curve Levels (Jan...Dec)
413.66   412.57   411.26   408.55   406.02   403.55   407.93
412.31   416.69   418.50   416.54   415.22

Domestic Supply Rule Curve Levels (Jan...Dec)
403.76   403.79   403.82   403.78   403.68   403.55   403.58
403.61   403.64   403.67   403.70   403.73
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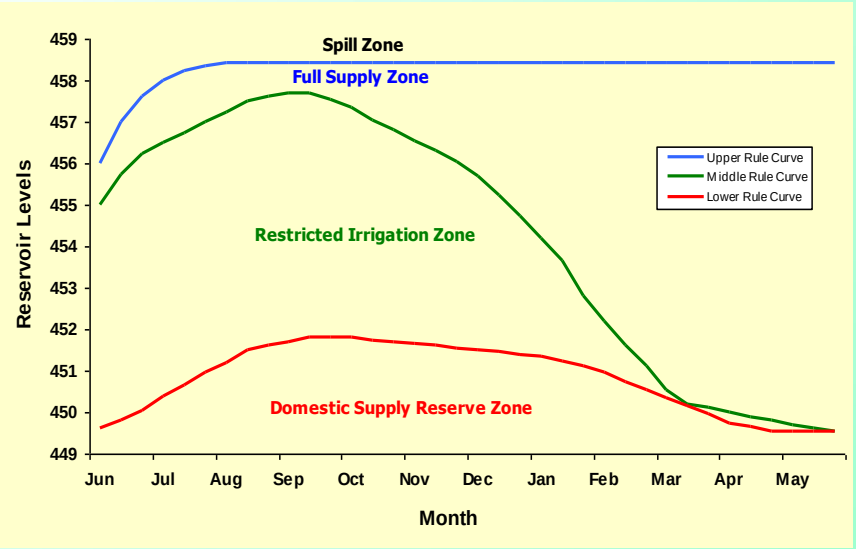
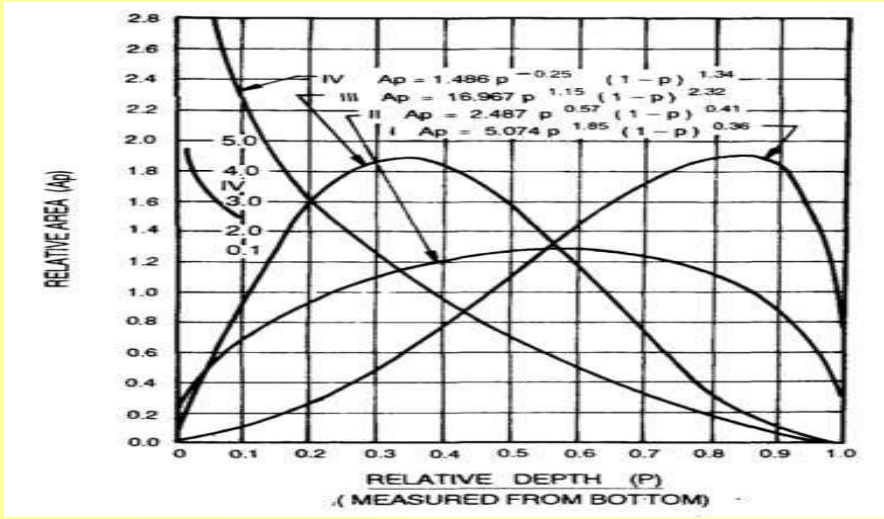
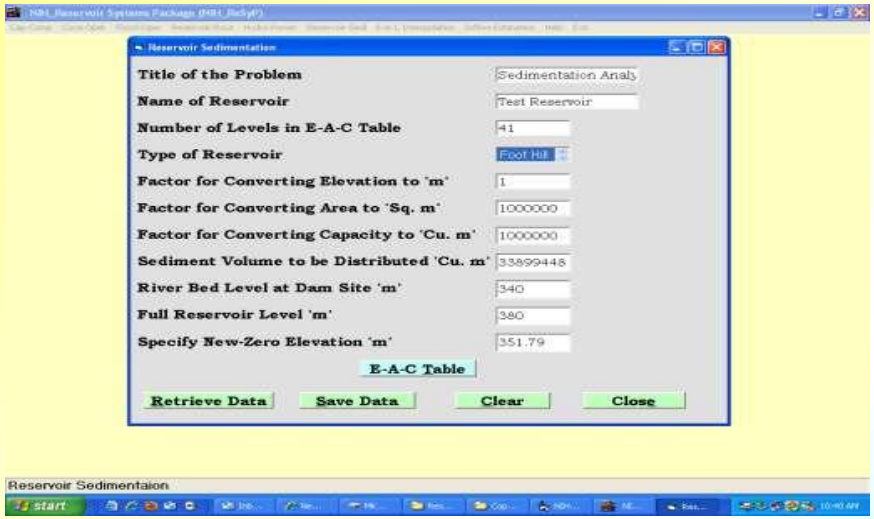


Graphical Output

Reservoir Sedimentation Analysis



Empirical Area Reduction Method

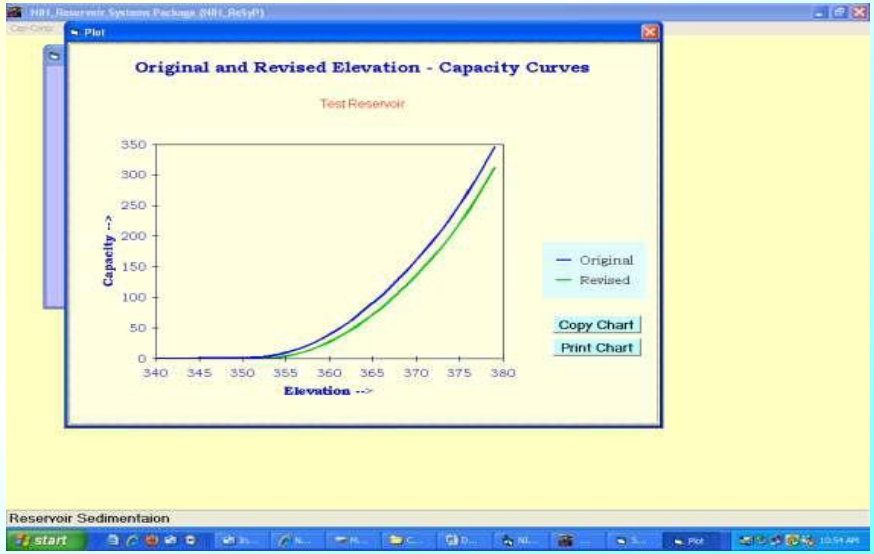


Input Data Form

New Zero Elevation - 351.790

Elev	Ori Ar	Ori Cap	Rel Dep	A_p	Sed Ar	Tot SCap	Rev Ar	Rev Cap
340.00	.004	.000	.000	.0000	.004	.000	.000	.000
341.00	.007	.005	.025	.3006	.007	.005	.000	.000
342.00	.012	.015	.050	.4415	.012	.015	.000	.000
343.00	.018	.030	.075	.5503	.018	.030	.000	.000
344.00	.027	.052	.100	.6411	.027	.052	.000	.000
345.00	.080	.103	.125	.7197	.080	.103	.000	.000
346.00	.044	.164	.150	.7891	.044	.164	.000	.000
347.00	.055	.214	.175	.8510	.055	.214	.000	.000
348.00	.076	.279	.200	.9068	.076	.279	.000	.000
349.00	.203	.413	.225	.9573	.203	.413	.000	.000
350.00	.470	.741	.250	1.0029	.470	.741	.000	.000
351.00	.748	1.344	.275	1.0443	.748	1.344	.000	.000
351.79	1.094	2.102	.295	1.0742	1.094	2.102	.000	.000
352.00	1.186	2.303	.300	1.0817	1.102	2.332	.084	.000
353.00	1.930	3.846	.325	1.1155	1.136	3.451	.794	.395
354.00	2.876	6.233	.350	1.1457	1.167	4.602	1.709	1.631
355.00	3.900	9.608	.375	1.1727	1.194	5.783	2.706	3.825
356.00	4.456	13.783	.400	1.1964	1.219	6.989	3.237	6.794
357.00	5.447	18.726	.425	1.2171	1.240	8.218	4.207	10.508
358.00	6.302	24.596	.450	1.2347	1.257	9.467	5.045	15.129
359.00	7.420	31.449	.475	1.2493	1.272	10.732	6.148	20.717
360.00	8.264	39.287	.500	1.2609	1.284	12.010	6.980	27.277
361.00	9.111	47.971	.525	1.2694	1.293	13.299	7.818	34.672
362.00	9.877	57.463	.550	1.2750	1.298	14.594	8.579	42.869
363.00	10.600	67.699	.575	1.2774	1.301	15.894	9.299	51.805
364.00	11.415	78.704	.600	1.2766	1.300	17.195	10.115	61.509
365.00	12.036	90.428	.625	1.2726	1.296	18.493	10.740	71.935
366.00	12.974	102.930	.650	1.2650	1.288	19.785	11.686	83.145
367.00	13.994	116.411	.675	1.2539	1.277	21.068	12.717	95.343
368.00	14.693	130.753	.700	1.2388	1.262	22.337	13.431	108.416
369.00	15.334	145.766	.725	1.2195	1.242	23.589	14.092	122.177
370.00	15.879	161.371	.750	1.1957	1.218	24.819	14.661	136.552
371.00	16.419	177.520	.775	1.1667	1.188	26.022	15.231	151.498
372.00	17.094	194.275	.800	1.1320	1.153	27.192	15.941	167.083
373.00	18.211	211.924	.825	1.0907	1.111	28.324	17.100	183.600
374.00	19.463	230.758	.850	1.0415	1.061	29.410	18.402	201.348
375.00	21.187	251.077	.875	.9825	1.001	30.440	20.186	220.637
376.00	22.413	272.874	.900	.9112	.928	31.404	21.485	241.470
377.00	23.493	295.825	.925	.8225	.838	32.287	22.655	263.538
378.00	24.721	319.929	.950	.7072	.720	33.065	24.001	286.864
379.00	25.899	345.237	.975	.5402	.550	33.698	25.349	311.539
380.00	27.237	371.802	1.000	.0000	.000	33.882	27.237	337.920

Tabular Output



Graphical Output

SUMMARY

- We present a package for various analyses pertaining to a (system of) reservoirs.
- A Windows based GUI and input menu screens have been developed for easier use.
- Tabular & graphical options with inter-portability of data from MS-Excel.
- Software can be used to develop conservation and flood control policy for a system of reservoirs. It can also consider inter-basin water transfer.
- Software is continuously up-dated with regular annual trainings and is nominally priced.
- Looking for feedbacks to improve.

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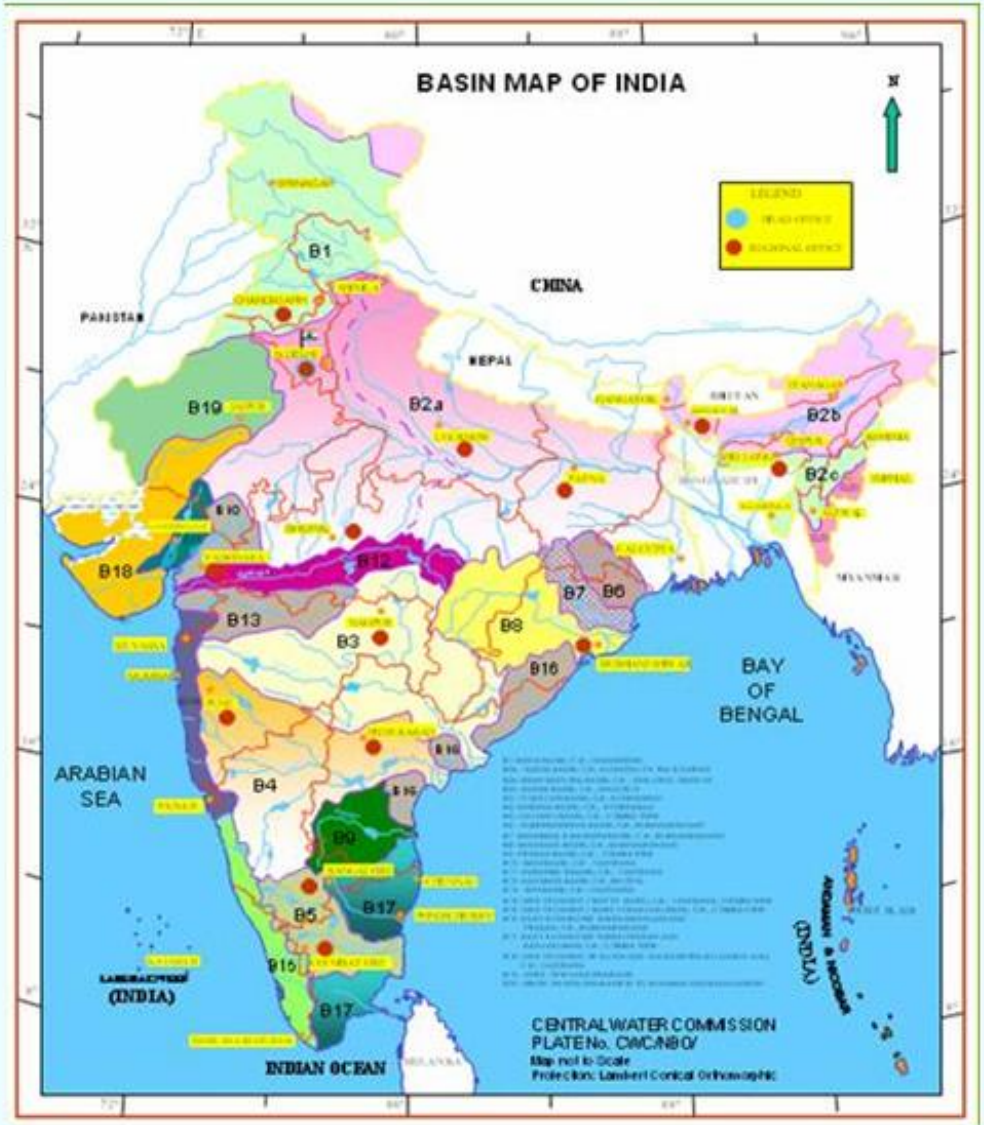

Print

Note: For international / state boundaries and coastline, authoritative Survey of India maps may be referred to