Chapter – 7
Reservoir

7.1   General

The Parbati-Kalisindh-Chambal link project envisages construction of three reservoirs namely Patanpur on river Parbati, Mohanpura on river Newaj and Kundaliya on river Kalisindh.

7.2 Fixation of storage and reservoir levels

The balance water in these rivers is mostly available in monsoon months. Therefore, the storage reservoirs at Patanpur on river Parbati, Mohanpura on river Newaj and Kundaliya on river Kalisindh have been proposed to store the water during monsoon months to cater the requirement during lean season.

The reservoir simulation studies have been carried out for estimating the capacity of the reservoirs, storages required and canal capacities for different reaches. The simulation studies have been carried out considering the simultaneous operation of three reservoirs namely Patanpur, Mohanpura and Kundaliya and also the terminal reservoir i.e. Rana Pratap Sagar or Gandhi Sagar. The studies have been done in series starting from downstream most reservoir in order to see the capacity of terminal reservoirs to accommodate the bulk transfer of water in monsoon months. In the simulation studies the inflow values at each dam site has been worked out on the basis of the discharge data observed at G&D site on the stream and catchment area of the river upto dam site.

The gross storage capacities of Patanpur, Mohanpura and Kundaliya reservoirs are given in Table –7.1.

Table – 7.1
Details of gross storage capacities (Mm^3)

Name of dams	Alternative-(a) (Patanpur to RPS)	Alternative-(b)-I (Patanpur to G.S.) (lift from Kundaliya)	Alternative-(b)-II (Patanpur to G.S) (lift after river Ahu)
Patanpur dam	156	156	156
Mohanpura dam	140	140	140
Kundaliya dam	1234	1085	1234

7.3   Dead storage level

The sedimentation studies of each reservoir have been carried out for fixing the dead storage capacity. The gross storage capacity of Patanpur reservoir at FRL 419 m is 156 Mm³. The sediment load at Patanpur for 50 years & 100 years has been worked out as 45.8 Mm³ and 91.6 Mm³ respectively considering the silt observation data observed at Agra-Bombay road crossing silt observatory site maintained by Central Water Commission and the area intercepted by the projects on the upstream of proposed Patanpur dam. On the basis of sedimentation study, the dead storage (new zero elevation) level for 50 years & 100 years of sedimentation are worked out as 407.0 m & 412.0 m respectively. In the study, the dead storage level for Patanpur

is kept as 407 m in view to fulfill the entire enroute demands for fifty years. By keeping dead storage of Patanpur dam as 407 m, there will not be any encroachment of sediment in the live storage upto 50 years. However, the silting of the live storage will start after 50 years. Due to silting of live storage after 50 years, the availability of water to meet out the enroute irrigation requirement between Patanpur to Mohanpura will gradually be decreased. However, the accumulation of silt even after fifty years would not affect the diversion of water proposed from Patanpur onwards during monsoon period.

The available gross storage capacity of Mohanpura reservoir at FRL 400 m is only 140 Mm³. The sediment load for 50 years and 100 years are calculated as 52.50 Mm³ & 105 Mm³ respectively considering the rate of siltation as 357.18 cum/sqkm/year based on Irrigation Commission Report 1972. The dead storage level of Mohanpura reservoir has been kept 390.00 m considering 50 years of sedimentation due to limitation of reservoir capacity and most of water is proposed to be transferred in monsoon period which will not affect the water transfer even after 50 years. Thus, the live storage capacity at Mohanpura is adopted as 87.50 Mm³ and the remaining capacity of 52.50 Mm³ is kept as dead storage. Most of water is proposed to be transferred during the monsoon period when the reservoir would be full and required quantum of water can be drawn from the Patanpur & Mohanpura reservoirs to divert the water into the link canal. The bed level of the canal offtaking from the Patanpur reservoir is proposed to be kept 1 m below the new zero elevation computed for the 50 year sedimentation study in view to extract the complete live storage of the water during lean season. To meet out the enroute demand in the month of March to May, the F.S.D. of canal has been computed less than 1 m. Accordingly, the bed level and the offtaking level is kept at 406 m and 411 m respectively.

Similarly the bed level of canal offtaking from Mohanpura reservoir has also been kept 3 m below the MDDL which is sufficient to fulfill the enroute demand during lean season requiring F.S.D. of canal about 1m. The bed level and the off taking level is kept at 387 m and 392 m respectively.

The sedimentation study for Kundaliya dam has been carried out for 100 years. On the basis of the sedimentation study, the silt load at Kundaliya dam site has been worked out as 126.4 Mm³ considering the siltation rate as adopted in the case of Mohanpura dam. Therefore, the provision of 130 Mm³ dead storage capacity has been kept and corresponding dead storage level is fixed as 358.5 m. The live storage capacity at Kundaliya dam works out to be 959 Mm³. Details of dead & live storage for three reservoirs are given in Table – 7.2.

7.4   Maximum water level

Flood routing studies has been carried out for Patanpur, Mohanpura and Kundaliya dams using modified pulse method. The maximum water level has been fixed on the basis of this flood routing study. The various levels of the three reservoirs are given below in Table - 7.2.

Table - 7.2
Levels of the reservoirs

Unit : m

Name of the reservoir	MDDL	FRL	MWL
Patanpur	407	419	419.62
Mohanpura	390	400	401.50
Kundaliya	369.2	378	379.50

7.5   Free board requirement

In order to avoid the possibility of water spilling over the dam top due to wave action, the free board has been provided. The following factors have been considered while computing the free board requirement:

(a) Wave characteristics, particularly the wave height and wave length.
(b) Upstream slope of the dam and roughness of the pitching.
(c) Height of wind set up above the still water level.

The free board has been provided as 3/2 hw, where hw is the wave height and given by the equation

$$hw = 0.032 \; \sqrt{VF} + 0.763 - 0.271 \, (F)^{1/4}$$

for   F< 32 km

Where,   V is wind velocity in km/hr

F is the straight length of water expanse in km

Based on these computations, the free board provided is given in Table-7.3.

Table - 7.3
Free board of the reservoirs

Name of reservoir	Height of wave (m)	Free board requirement (m)	Free board provided (m)
Patanpur	0.78	1.18	2.0
Mohanpura	0.82	1.22	1.5
Kundaliya	0.87	1.30	2.5

7.6   The elevation - area capacity curves

The area-capacity curves of the reservoirs have been prepared with the help of the reservoir area map prepared by the National Water Development Agency with contours at 1 m interval plotted on a scale 1 cm=50 m for proposed reservoirs at Patanpur, Mohanpura and Kundaliya. Various capacities of the reservoirs have been worked out on the basis of the elevation - area capacity data and the rate of sedimentation of Parbati, Newaj and Kalisindh rivers. Various capacities of reservoirs worked out for all the three alternatives and the 3 options are given in Table-7.4. However, the reservoir capacities mentioned for the alternatives beyond Kundaliya reservoir for option-I & II are based on preliminary study and are tentative. Detailed study, if felt necessary, for these two options will be carried out at the time of preparation of DPR. In the present study, the simulation study has been carried out for firming up the capacities for all the three alternatives considering option-III.

Table – 7.4
Various capacities of the reservoirs (in Mm^3)

Particulars	Alternative-(a) (Patanpur to RPS)			Alternative-(b)-I			Alternative-(b)-II		
	Opt.I	Opt.II	Opt.III	Opt.I	Opt.II	Opt.III	Opt.I	Opt.II	Opt.III
Gross storage capacity									
Patanpur dam	156	156	156	156	156	156	156	156	156
Mohanpura dam	140	140	140	140	140	140	140	140	140
Kundaliya dam	867	687	1234	718	538	1085	867	687	1234
Live storage capacity									
Patanpur dam	110	110	110	110	110	110	110	110	110
Mohanpura dam	87.5	87.5	87.5	87.5	87.5	87.5	87.5	87.5	87.5
Kundaliya dam	592	412	959	443	263	810	592	412	959
Dead storage capacity									
Patanpur dam	46	46	46	46	46	46	46	46	46
Mohanpura dam	52.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5	52.5
Kundaliya dam	275	275	275	275	275	275	275	275	275

7.7   Water tightness of the reservoirs

On the basis of the geological mapping carried out by geologists of GSI, the bed rocks exposed in the river channel has revealed presence of sound and fresh rock mass suitable for masonry/concrete structures. The basalt is hard, compact, massive and sparsely prophynitic. There are steep to vertical joints apart from close-spaced columnar joints rendering the rock mass blocky. Joints are mostly open and their planes are straight to curved and sometimes circular. Their spacing dip and persistence vary greatly and they are oriented both askew and across to the dam axis. Seepage through such weak planes is to be ruled out by in depth studies through sub- surface exploration and corrective measures such as grouting, if required.

7.8   Evaporation losses

The monthly evaporation losses for Patanpur, Mohanpura and Kundaliya reservoirs have been computed by multiplying monthly PAN Evaporation values of Guna IMD Station with the average submergence area available at the beginning and end of the month. The values of monthly evaporation losses are furnished in Table-7.5.

Table - 7.5
Monthly evaporation losses

Month	Evaporation losses (mm)
January	66.6
February	86.8
March	136.3
April	174.0
May	228.0
June	210.8
July	131.3
August	111.4
September	118.5

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October	114.3
November	74.0
December	59.4

The average annual evaporation loss from reservoirs obtained from the simulation studies carried out considering 16 years data from 1977 –78 to 1992-93, are furnished in Table-7.6.

Table - 7.6
Average annual evaporation losses from the reservoir

Reservoir	Average annual evaporation losses (Mm³)
Patanpur	27.82
Mohanpura	26.06
Kundaliya	102.17

7.9   Utilisation from reservoir

The proposed dams at Patanpur, Mohanpura and Kundaliya will be utilised to store the available water for the requirement of P-K-C link project and onward transfer to river Chambal. The water will be utilised for enroute requirement from Patanpur to Mohanpura, Mohanpura to Kundaliya and Kundaliya to Gandhi Sagar or Rana Pratap Sagar as the case may be. The requirement of water of 663 Mm^3 at Gandhi Sagar reservoir or Rana Pratap Sagar reservoir across Chambal River will be met with the water transferred through P-K-C link project. The water of Chambal thus saved in the upper reaches will be utilised through seven irrigation projects proposed in the upper Chambal basin.

The total quantity of 1325 Mm^3, 1368 Mm^3 and 1360 Mm^3 of water in each alternative viz. Alt.(a), Alt.(b)-I & Alt.(b)-II respectively considering option-III is proposed to be diverted through the link project. The option-I and option-II described in Chapter-5 'Hydrology' under various alternatives have not been studied in detail in the present study. However, the details for enroute irrigation, their water use, transmission losses along the link canal and provision for drinking water supply under all the three alternatives considering option-III are furnished below:

i) Linking to Rana Pratap Sagar Alt.(a)
   a) The enroute irrigation to 1,08,739 ha requiring 538 Mm^3 of water.
   b) Transmission losses along the link canal 97 Mm^3.
   c) Provision for drinking water supply to enroute areas is kept as 13.80 Mm^3.

ii) Linking to Gandhi Sagar Alt.(b)-I
   a) The enroute irrigation to 1,18,860 ha requiring 589 Mm^3 of water.
   b) Transmission losses along the link canal 90 Mm^3.
   c) Provision for drinking water supply to enroute areas is kept as 13.20 Mm^3.

iii) Linking to Gandhi Sagar Alt.(b)-II
   a)The enroute irrigation to 1,17,253 ha requiring 581 Mm^3 of water.
   b) Transmission losses along the link canal 90 Mm^3.
   c) Provision for drinking water supply to enroute areas is kept as 13.20 Mm^3.

In addition to above, the water required by substitution for seven projects in upper Chambal sub-basin viz Ramwasa, Sewarkheri, Chitabad, Padunia, Sonchiri, Bachora and Sekri Sultanpura would be amounting to 663 Mm^3 for irrigating an area 1,09,400 ha.

13 Mm^3 will be utilised for augmenting flows at Kota barrage resulting additional irrigation of 2150 ha through existing system at Kota barrage in the state of Madhya Pradesh.

The average month wise utilisation from Patanpur, Mohanpura and Kundaliya reservoirs for all the three alternatives considering option-III are given in Table-7.7.

Table - 7.7
Month wise water releases from reservoirs

Unit : Mm^3

Months	Reservoirs		Kundaliya		
	Patanpur	Mohanpura	Alt.(a)	Alt.(b)-I	Alt.(b)-II
June	17.33	12.21	81.12	83.44	82.88
July	89.49	193.73	108.03	114.34	113.06
August	147.29	254.33	93.08	97.17	96.29
September	35.33	160.21	81.12	83.44	82.88
October	65.85	9.65	75.14	76.57	76.17
November	15.33	12.21	81.12	83.44	82.88
December	20.29	17.33	93.08	97.17	96.29
January	25.25	22.45	105.04	110.91	109.71
February	22.81	19.67	99.90	107.47	106.35
March	9.17	5.59	67.01	69.70	69.46
April	7.93	4.31	64.02	66.27	66.11
May	7.93	4.31	64.02	66.27	66.11
Total	464.00	716.00	1012.68	1056.19	1048.20

7.10 Submergence

The number of villages affected alongwith their population as per 1991 census coming under submergence of Patanpur, Mohanpura and Kundaliya reservoirs have been estimated. In addition to this, a small population of some peripheral villages will also be affected as land of the people belonging to these villages is coming in the submergence area. Besides, some important species of trees like Teak, Salai, Babul, Amla, Tendu, Sheesam, Neem, Mahua, Palas, Kari etc in the forest may come under submergence.

The area under submergence at FRL 419.0 m of Patanpur reservoir is 2998 ha. The details of area coming under submergence like irrigated, unirrigated and culturable waste land have been worked out. No railway line, major bridges, telephone lines and main power lines are coming under submergence.

The area under submergence at FRL 400.0 m of Mohanpura reservoir is 2510 ha. The details of submergence area like irrigated, unirrigated and culturable waste land

are worked out. No forest area is coming under submergence; therefore, there will be no impact on flora and fauna in the region. Out of total submerged area 52.19% is the culturable area, 32.98% culturable waste while 14.83% area is not available for cultivation. About 3.5 km length of railway line of the western railway in Ruthiyai - Maksi branch between stations Karanwas and Biaora is to be realigned at higher elevation. About 2.65 km of a major road i.e. National Highway No. 3 from Agra to Bombay is to be realigned. One major road bridge and one major railway bridge will be affected. Cart track of approximate 10.0 km length will be affected.

The area under submergence at FRL 378.0 m of Kundaliya reservoir is 11800 ha. The details of area coming under submergence like irrigated, unirrigated, culturable waste land and forest land are worked out. 1.49% of submerged area is forest, however no endangered species of the plants and animals are likely to be affected. Remaining submerged area comprises of 14.14% of the culturable wastes, 60.56% of culturable area and 23.81% area not available for cultivation. No major road and railway track will come under submergence. The cart track of approximate 15 km length will be affected.

No historical monument and valuable mineral deposits are likely to come under submergence of these reservoirs. Also no important mineral excavation activity is presently in operation in the submergence area.

7.11   Submergence ratio

The submergence area of Patanpur reservoir is 2998.00 ha. The command area of the reservoir is 25077 ha. It gives the submergence ratio 0.12: 1. The submergence area of Mohanpura reservoir is 2510.00 ha. The command area of the reservoir is 25785 ha. It gives the submergence ratio 0.10: 1. The submergence area of Kundaliya reservoir is 11800 ha. The command area of the reservoir is 177941 ha (66391+109400+2150). It gives the submergence ratio 0.07: 1.

7.12   Soil conservation measures

The sedimentation studies of the reservoirs have been carried out with the siltation rate worked on the basis of silt observation taken on G&D sites on the respective river. Due to ever increasing accelerated soil erosion because of man made activities in the catchment area, the siltation rate may increase thereby decreasing the life of the reservoirs. To reduce the siltation rates of these reservoirs different soil conservation measures are to be adopted in the catchment area. These measures should be initiated at the time of starting of construction of the project so that the soil conservation measures become operational in the initial years of the reservoir filling. The soil conservation measures should be adopted keeping in view the cost factor and CWC's guidelines for this purpose.

The topography of the catchment contributing to these reservoirs is not very steep, therefore, higher siltation rates are not anticipated. The steeply sloped areas of the catchment are to be identified and Forestation/plantation of these areas may be undertaken to check the soil erosion. The areas of the catchment having rocks, pebbles etc are not likely to contribute towards the siltation of the reservoir. In

addition to plantation, other measures may also be adopted considering its necessity based on assessment of the area.

7.13   Rehabilitation and resettlement of affected population

The rehabilitation and resettlement policy will aim at providing fair and equitable treatment of persons displaced from their homes and profession by the construction of project. The problems related to resettlement and rehabilitation (R & R) are quite complex and the solution requires muti pronged approach such as attractive R & R package, efficient institutional   arrangements for implementing the entire programme of R & R and a humane approach during implementation of the project. Among other factors, enlisting the cooperation of affected persons has become an important aspect of project implementation. It has been observed that many   affected persons are unwilling to handover the physical possession of the land acquired for the projects. It may lead to delay in many projects incurring cost over runs. Recently Department of   Land Resources (Bhumi Sansadhan Vibhag), Ministry of Rural Development (Gramin Vikas Mantralaya), Govt. of India, has formulated a National Policy on Resettlement and Rehabilitation for Project Affected Families-2003 vide their F.No.-Acq.13011/4/2003-LRD   dated 17/2/2004. Hence it is proposed that resettlement   and rehabilitation of the affected population will be done as per the said policy