

Executive Summary

1.0 National Perspective Plan for Water Resources Development

The erstwhile Union Ministry of Irrigation and Central Water Commission (CWC) formulated, in the year 1980, a National Perspective Plan (NPP) for water resources development through inter basin transfer of water which comprises of two components: Himalayan Rivers Development Component, and Peninsular Rivers Development Component. The distinctive feature of the NPP is that the transfer of water from surplus basin to deficit basin would essentially be by gravity and only in small reaches it would be by lifts not exceeding 120 metres. These two components are briefly outlined in the following paragraphs.

Himalayan Rivers Development

Himalayan Rivers Development envisages construction of storage reservoirs on the principal tributaries of the Ganga and the Brahmaputra in India, Nepal and Bhutan, along with inter-linking canal systems to transfer surplus flows of the eastern tributaries of the Ganga to the west, apart from linking of the main Brahmaputra and its tributaries with the Ganga and Ganga with Mahanadi and augmentation of flow at Farakka.

Peninsular Rivers Development

This component is divided into four major Parts:

- i. Interlinking of Mahanadi–Godavari-Krishna-Pennar-Cauvery rivers and building storages at potential sites in these basins
- ii. Interlinking of west flowing rivers, north of Mumbai and south of Tapi
- iii. Interlinking of Ken-Chambal Rivers
- iv. Diversion of other west flowing rivers

The National Water Development Agency (NWDA) after carrying out the detailed technical studies identified 30 link proposals for preparation of Feasibility Reports/ Detailed Project Reports; 14 links under Himalayan Rivers Development Component and 16 links under Peninsular Rivers Development Component. Par – Tapi – Narmada link project is one of the 16 link proposals under Peninsular Rivers Development Component.

2.0 Memorandum of Understanding amongst Centre and Concerned States and Inter-State Aspects

The Feasibility Report of Par–Tapi–Narmada link project was prepared by NWDA during October, 2005 and circulated to all concerned State Governments and members of Technical Advisory Committee (TAC) of NWDA. Since then continuous efforts were made by NWDA, CWC and Ministry of Water Resources to arrive at the consensus between two beneficiary States of Gujarat and Maharashtra. As a result of these efforts, consensus was arrived amongst the Central Government and concerned States of Gujarat and Maharashtra for preparation of Detailed Project Report (DPR) of Par–Tapi–Narmada link project.

The Water Resources Department, Government of Maharashtra and Narmada Water Resources, Water Supply and Kalpasar Department, Government of Gujarat conveyed their concurrence to Union Ministry of Water Resources during May, 2008 for preparation of Detailed Project Report (DPR) of the project. Subsequently, the work for preparation of DPR was entrusted to NWDA.

A tripartite Memorandum of Understanding (MoU) was signed by the States of Gujarat and Maharashtra and the Union Government on 3rd May, 2010 at New Delhi for preparation of Detailed Project Report of Par–Tapi–Narmada link project. The tripartite Memorandum of Understanding indicates that: the Gujarat State will get the benefits of Par–Tapi–Narmada link project through en-route irrigation from the link canal and also in the drought prone Saurashtra and Kutch region by way of substitution. The sharing of Hydro Power produced in the Power House located in this link project will also be studied during the preparation of DPR; The feasibility of utilization of water by Maharashtra State in their territory by lifting water

over the western divide will also be examined during preparation of DPR; The issue of compensating the quantity of water contributed from Maharashtra catchments will be decided by States mutually after preparation of DPR when diversion quantity through this link is firmed up; at DPR stage, the size of canal from Ukai Dam to Narmada Canal will be decided based on simulation studies, keeping in view the request of Government of Gujarat about retaining the size of canal as designed in Feasibility Report of Par-Tapi-Narmada link considering the diversion of water from Tapi Basin.

Accordingly, NWDA has prepared the DPR of Par – Tapi – Narmada link project with active support and co-operation of CWC and other domain expert organizations like Central Soil and Materials Research Station (CSMRS), Geological Survey of India (GSI), Central Water and Power Research Station (CWPRS), Tehri Hydro Development Corporation India Ltd (THDCIL), India Meteorological Department (IMD), National Remote Sensing Center (NRSC), Water and Power Consultancy Services (WAPCOS), Regional Remote Sensing Centre (RRSC), Jodhpur, Bhaskaracharya Institute for Space Applications and Geo-informatics (BISAG), Gandhinagar etc.

It is indicated in the tripartite Memorandum of Understanding that the issue of sharing of Hydro Power produced in the Power Houses proposed in this link project and the feasibility of utilization of water by Maharashtra State in their territory by lifting water over the western divide will be examined during preparation of DPR. Accordingly, the issue of water and power sharing was taken-up for discussion with both Maharashtra and Gujarat States at the level of Chief Engineers. The water availability study of Par–Tapi–Narmada link project has been carried out by CWC for NWDA in consultation of State Governments of Gujarat and Maharashtra. This study was sent to both the States. Three meetings have been held with the Water Resources Departments of Maharashtra and Gujarat Governments at the level of Chief Engineers (CEs) and the water availability study report has been finalized. It has also been agreed by both the States that the sharing of water shall be based on the catchment area of the respective States duly accounting for the variation in catchment rainfall.

The DPR of Par-Tapi-Narmada Link Project was completed by NWDA in August, 2015 and sent to Water Resources Departments of Governments of Gujarat and Maharashtra vide Director General, NWDA, New Delhi D.O. Letter No. NWDA/Tech-I/200/44-I/Vol.V/12269 Dated 25.08.2015 for their views.

The issue of water sharing and power sharing between the States of Gujarat and Maharashtra has been discussed at the level of Chief Engineers of the States of Gujarat and Maharashtra and NWDA. Further matter in this regard is taken up at the Senior Officers level of the two States and MoWR, RDandGR, Government of India. Hon'ble Union Minister for WR, RDandGR held meeting with the Hon'ble Chief Minister, Government of Maharashtra at Mumbai on 3rd May, 2016 where in Damanganga-Pinjal and Par-Tapi-Narmada Link Projects were discussed among other issues.

2.1 Proposed Modifications in DPR of Par-Tapi-Narmada Link Project

2.2 Need for Modification

The DPR of the Par-Tapi-Narmada Link Project was completed by NWDA in August, 2015 and sent to the Governments of Gujarat and Maharashtra vide Director General, NWDA, New Delhi D.O Letter No.NWDA/Tech-I/200/44-I/Vol.V/12269 dated 25.08.2015 for their views.

In response, Government of Gujarat have conveyed their observations on DPR of Par-Tapi-Narmada Link Project vide letter No.Gen/2010/GoI-3/Part-I/MI Cell dated 21.05.2016 and letter No. S/2015/NWDA/2540/J dated 29.07.2016. Government of Gujarat suggested (i) to explore possibilities for providing maximum irrigation facilities to tribal areas on right side of the canal by lift (ii) to include the command area of five projects proposed by the Government of Gujarat on left side of the canal in addition to enroute command and target command in Saurashtra etc. to the extent possible.

In this context, Chief Engineers level meeting was held between NWDA and NWRWS and Kalpasar Department, Government of Gujarat at Gandhinagar on 11th November, 2016 for firming up of modifications in

DPR of Par-Tapi-Narmada Link Project. Also, discussions were held between the then OSD now the Secretary, MoWR, RD&GR, Government of India and the Chief Secretary, Government of Gujarat on 16th November, 2016 regarding Par-Tapi-Narmada Link Project. In continuation, Secretary, MoWR, RD&GR vide D.O Letter No. 2/7/2007-BM(pt) dated 25.11.2016 requested to convey the consent of Government of Gujarat for new irrigation Planning of Par-Tapi-Narmada Link Project so as to revise the DPR and facilitate early implementation of the project. As a result, to finalise the issues on modifications of DPR, Secretary, MoWR, RD&GR along with the officers of NWDA and NWRWS and Kalpasar Department, Government of Gujarat held a meeting with the Hon'ble Chief Minister of Gujarat on 31.12.2016. Chief Engineers level Meeting was held at Gandhinagar on 9th February, 2017 for firming up of modifications and to revise the DPR of Par-Tapi-Narmada Link Project.

During discussions in the above meetings following modifications in DPR of Par-Tapi-Narmada Link Project are firming up

(i) Inclusion of command areas of the Projects proposed by the Government of Gujarat on left side of the canal in South Gujarat.

It was decided to include the command area of five projects proposed by the Government of Gujarat namely i) Ugta ii) Sidhumber iii) Khata Amba iv) Zankhari and v) Khuntali.

(ii) Providing irrigation to the Tribal areas enroute right side of Link Canal by lift.

Providing water for irrigation by lift for possible maximum Tribal areas on right side of the Par-Tapi-Narmada Link Canal.

(iii) Irrigation in Tribal areas in the vicinity of reservoirs.

Providing irrigation in tribal areas of Dang and Valsad districts of Gujarat directly from the reservoirs under Par-Tapi-Narmada link by lift.

(iv) Irrigation in Tribal areas right side of the Narmada Main Canal by lift in Chhota Udepur and Panchmahal Districts.

It was further suggested to explore the possibilities of providing irrigation in the tribal areas of Chhota Udepur and Panchmahal districts of the Gujarat State from Narmada Main Canal on substitution basis.

(v) Provision for drinking water

Provision for drinking water for all villages of Dang and Navsari districts and villages of Kaprada and Dharampur taluks of Valsad district is to be made from this project.

(vi) Filling of Panchayat and village tanks in the periphery of Reservoirs.

Provision for filling all possible tanks in benefitted areas to be made.

Also, during the meeting with the Hon'ble Chief Minister, Gujarat State on 31.12.2016, it was decided to explore techno-economic feasibility for providing pipe line system instead of open canal for main canal of the link to avoid/minimize the land acquisition in tribal areas as well as to reduce evaporation/seepage losses under Par-Tapi-Narmada Link Project. Secretary, Government of Gujarat vide letter No. Gen/2010/GoI-3/(3)/Part/MI Cell(K-1) dated 18.01.2017 has conveyed NWDA to explore the above possibility, while revising the DPR.

NWDA examined the feasibility of pipe line system instead of open canal for Par-Tapi-Narmada Link Canal. As per the study, it reveals that the gradient vis-à-vis ideal velocity of flows in pipe lines have become the constraints in laying the pipe line system due to prevailing large difference of head between the canal off-take point and out-fall point at Ukai reservoir. As the link canal runs mostly in deep cutting, laying a number of gravity pipe lines with very flatter gradients and lesser velocities for diversion of large discharges lead to heavy excavation which escalates the project cost leading to no significant reduction in land acquisition for the Par-Tapi-Narmada link canal. The note on techno-economic feasibility of providing

pipe line in lieu of main canal has been sent to the NWRS and Kalpsar Department, Government of Gujarat vide Letter No. NWDA/IC/V/T-143/504-10 dated 14.03.2017. However, NWDA suggested gravity pipe line can be adopted in place of feeder canals as discharges are small and lies in hilly terrain. Copy of the minutes of the Chief Engineers level meeting dated 09.02.2017 is enclosed at **Annexure – 1.18 of Annexures Volume**.

Based on the decision taken by the Government of Gujarat from time to time during the above meetings, NWDA modified the DPR of the Par-Tapi-Narmada Link Project.

3.0 Aim and Objective of the Project and Description of Works

The main objective of the Par-Tapi-Narmada Link project is to provide maximum irrigation facilities to Tribal areas enroute the link canal lying on Right side including drought prone Saurashtra region of Gujarat. The link project will also cater the command areas of five projects namely Khuntali, Ugta, Sidhumber, Khata Amba, Zankhari, proposed by Government of Gujarat. Command in tribal areas of Chhota Udepur and Panchmahal districts from Narmada Main canal on substitution basis, tribal dominant districts of Dang and Valsad of Gujarat State and Nasik district of Maharashtra State along with Drinking water of most of the villages in the vicinity and filling of most of Panchayat tanks/Check dams will be served under Par-Tapi-Narmada link canal.

There is a wide variation in distribution of water resources in different regions of Gujarat State due to variation in rainfall. The rainfall in Saurashtra and Kutch regions of Gujarat is very scanty and the area is frequently affected by droughts. The annual normal rainfall (1951-2000) in Saurashtra and Kutch region is 507 mm and where as the average annual rainfall in Par, Auranga, Ambica and Purna river basins of South Gujarat region is assessed to be 2180, 2055, 1830 and 1472 mm respectively. Par, Auranga, Ambica, Purna and Mindhola are the important west flowing rivers in the western ghat region, North of Mumbai and South of Tapi in Southern Gujarat. All these rivers originate in the State of Maharashtra and after flowing through the States of Maharashtra and Gujarat outfall into

Arabian sea. Only about 14% of the catchment area of the above rivers lies in Maharashtra State and the remaining 86% lies in the State of Gujarat.

Par, Auranga, Ambica, Purna and Mindhola river basins have the same hydro-meteorological characteristics. About 95% to 97% of annual rainfall confines to monsoon only from June to September. The rainfall pattern of the river basins is given in Table-1.

Table-1

Rainfall pattern of the river basins

Sl. No.	Name of the Basin	Catchment Area (sq.km)	Avg. Annual Rain-fall (mm)
1	Par	1648	2217
2	Auranga	748	2063
3	Ambica	2685	1833
4	Purna	2193	1472
5	Mindhola	1056	780

From the above Table, it is seen that the rainfall is decreasing from South to North direction.

Surface Water Availability:

Out of total 38100 MCM of estimated utilizable surface water resources in Gujarat State, the utilizable surface water resources in South and Central Gujarat region is 31750 MCM (83%). Whereas, it is 2100 MCM (6%) in North Gujarat, 3600 MCM (9%) in Saurashtra and 650 MCM (2%) in Kutch region. Consequently, there is large variation in per capita water availability in different regions of the State. The per capita water availability in South and Central Gujarat region is about 1100 m³ (2011 census) and it is about 600 m³ in Saurashtra and Kutch region. With the anticipated growth of population in the State by 2050, the per capita availability of water would further reduce. The rivers in Saurashtra and Kutch region are mostly dry through the year, where as sizeable quantum of flows of Par, Auranga, Ambica and Purna rivers situated in South Gujarat are going to Sea unutilized every year. The water availability studies of these basins carried out by CWC indicates availability of sizable surplus

water after meeting in basin requirements. The water availability study of the following river basins indicates availability of sizeable surplus water after meeting the in-basin requirements, as given in Table-2.

Table-2
Surplus water available for Diversion

Unit: MCM

Sl. No.	Name of the Basin	Effective drainage area (sq.km)	Gross annual yield at 75% dep.	Planned Basin Utilisations projected by States	Surplus yield at 75% dep.
1	Par	1648	1725.9	647.44	1078.46
2	Auranga	748	857.7	507.39	350.31
3	Ambica	2685	1914.1	1493.66	420.44
4	Purna	2193	1101.1	958.95	142.15
	Total	7274	5598.8	3607.44	1991.36

In light of the above scenario, the Par-Tapi-Narmada Link Project in the western part of India is envisaged to transfer the surplus flows from west-flowing Par, Auranga, Ambica and Purna rivers between Par and Tapi to water deficit drought-prone regions lying on both sides of the link canal, towards North including tribal areas and upto drought-prone Saurashtra and Kutch regions. Index plan of the link project is at Plate-I.

The Par-Tapi-Narmada link projects contemplated at Feasibility Report stage by NWDA envisage construction of 7 dams: viz i) Jheri, ii) Mohankavchali, iii) Paikhed, iv) Chasmandva, v) Chikkar, vi) Dabdar and vii) Kelwan. However, due to public resistance no field topographical surveys and geotechnical investigations could be conducted at the Mohankavchali dam site (proposed downstream of Jheri dam site) either at Feasibility Report stage or DPR stage by NWDA. Therefore, while preparing the DPR of the link project the Mohankavchali dam has not been considered and the water planning has been revised to ensure that the overall objective of the Par-Tapi-Narmada link project is achieved. It is planned now to divert the surplus waters of Par river tapped at Jheri reservoir to Paikhed reservoir through a 12.70 km long tunnel. The feeder canal and the Chikkar weir from which the feeder canal is proposed for

diversion of surplus waters of Ambica River at Feasibility Report stage is also dropped now to avoid passing of the canal through the Vansda national park.

The Par-Tapi-Narmada Link Project comprises construction of six dams: namely i) Jheri dam across river Par in Peint taluka of Nasik district in Maharashtra; ii) Paikhed dam across river Nar – a tributary of river Par, iii) Chasmandva dam across river Tan–tributary of river Auranga–all in Dharampur taluka of Valsad district in Gujarat; iv) Chikkar dam across river Ambica, v) Dabdar dam across river Khapri – a tributary of river Ambica and vi) Kelwan dam across river Purna – all in Ahwa taluka of Dang district in Gujarat. Also, construction of 2 diversion barrages—one each in the downstream of Paikhed and Chasmandva dams; 6 power houses; and construction of about 406.118 km long link canal (including feeder pipe line and tunnels along the link canal) passing through Dharampur taluka of Valsad district, Ahwa taluka of Dang district, Vansda taluka of Navsari district, Vyara and Songadh talukas of Tapi district, Mandvi and Mangrol talukas of Surat district, Valia, Jhagadia and Nandod talukas of Bharuch district, Tilakwada and Sankheda talukas of Vadodara district of Gujarat connecting all 6 dams with existing Miyagam Branch Canal of Narmada Canal System of Sardar Sarovar Project are envisaged.

The surplus water proposed for diversion through Par-Tapi-Narmada link project will provide irrigation to a total area of 232175 ha, of which 61190 ha lies enroute the link canal i.e., 10100 ha is en-route command in the reach between Par and Tapi; 49820 ha en-route command in the reach between Tapi and Narmada; 630 ha en-route command under Dabdar feeder pipelines; 640 ha en-route command under Kelwan feeder pipelines. The command area of five projects proposed by Government of Gujarat on the left side of canal is about 45561 ha to be irrigated by gravity through link canal. Tribal area on right side of canal is 36200 ha will be irrigated by lift. About 12514 ha tribal area will also be irrigated directly by lift from proposed six reservoirs. The link project will take over the area of 76710 ha under the command of existing Miyagam branch canal of Narmada canal system. Narmada Water so saved will be utilized to provide irrigation facilities in tribal area on right side of Narmada Main canal to the extent of 23750 ha in Chhota Udepur district and 10592 ha in Panchmahal district through lift

directly from Narmada Main canal on substitution basis and 42368 ha area in Saurashtra region of Gujarat State. A provision of about 76 MCM of water is allocated to meet drinking water supply to 27.60 lakh population in the above areas. Also, a provision of 50 MCM is made for filling of 2226 panchayat and village tanks/check dams in the benefitted areas. The project will also generate about 102 MU of hydropower from the power houses proposed at various dams and canal fall, besides providing drinking water to the villages in the region.

NWDA and CWC jointly carried out hydrological studies of Par-Tapi-Narmada Link Project during March, 2012 to assess the water balance position at the ultimate stage of development (by the year 2050 AD) in Par, Auranga, Ambica, Purna river basins and at the proposed dam sites. As per these studies the net annual yields at Jheri, Paikhed, Chasmandva, Chikkar, Dabdar and Kelwan dam sites are assessed to be 371 MCM, 250 MCM, 64 MCM, 170 MCM, 262 MCM and 308 MCM respectively keeping a provision for upstream utilizations planned by the States for irrigation, domestic requirement, industrial requirement, regeneration from domestic and industrial uses and the environmental and ecological needs in the downstream. Thus about 1425 MCM of surplus water at 75% dependability is available at the 6 reservoirs proposed in Par, Auranga, Ambica and Purna river basins.

The total utilisation through Par-Tapi-Narmada link from 6 dams will be 1330 MCM. However, at later stage when the public hindrance is resolved and the required field survey and investigations are carried out the proposed Mohankavchali dam will also be dovetailed with Par-Tapi-Narmada link project.

4.0 Interlinking of the Proposed Project with Other Existing and Future Projects

It is planned to drop the Par-Tapi-Narmada link canal in to the existing Ukai reservoir on the river Tapi and to take it off from the right bank. However, neither the storage of Ukai reservoir nor the waters of Tapi river would be used under the Par-Tapi- Narmada link canal project. But the

Ukai reservoir will be used just as a 'Level Crossing' for diversion of water through the link canal.

The link canal crosses Narmada river downstream of Sardar Sarovar Project (SSP) and out-falls in to the existing Miyagam branch canal of Narmada Main Canal at RD 16.70 km and takes over part of its command area. Thus saved water under Narmada Main Canal by substitution with the diverted water through the link canal, will be utilized in Saurashtra and Kutch region by further extending the Narmada canal system. So, the Par-Tapi-Narmada link canal is integrated with SSP for delivery of surplus waters of Par, Auranga, Ambica and Purna Rivers to drought prone Saurashtra and Kutch region.

And also, the Government of Gujarat had proposed a barrage across river Narmada (as part of Kalpasar project) at Bhadbhut and it was desired by Government of Gujarat that instead of terminating the Par-Tapi-Narmada link canal at existing Miyagam Branch Canal of Narmada Main Canal, the NWDA should plan to release water diverted through Par-Tapi-Narmada link into Narmada river at suitable location upstream of proposed Bhadbhut barrage. Accordingly, NWDA has studied an alternative proposal to terminate the Par-Tapi-Narmada link canal at Amravati river (a stream joining the Narmada river downstream of Sardar Sarovar Project) and release the water intended for substitution in the Command Area of Miyagam Branch Canal of Narmada Main Canal into Amravati river for tapping the same at proposed Bhadbhut barrage as planned by Government of Gujarat. However, the Water Resources Department, Government of Gujarat, Gandhinagar, later requested NWDA to carry out Survey and Investigations as envisaged in original proposal. Accordingly, the Survey and Investigations were carried out while preparing the DPR.

5.0 Methodology Adopted

The Feasibility Report of Par-Tapi-Narmada link project prepared by NWDA formed the basis for proceeding further for preparation of Detailed Project Report and make suitable changes based on detailed surveys and investigations and up-dated hydrological and other studies. During preparation of DPR detailed surveys and investigations such as

topographical surveys, geological and geotechnical investigations including drilling bore holes on dam axes for obtaining rock cores, construction material investigations including borrow area surveys, socio-economic, ecological and environmental impact assessment studies, seismo-tectonic studies etc. have been undertaken departmentally through various specialized organizations in order to examine the feasibility of the scheme. Detailed geological and geo-technical investigations etc were carried out through GSI and CSMRS; hydrological studies were carried out through CWC. To complete the work in a time bound manner private agencies were hired where Government agencies were not available for the works like topographical surveys, drilling and submergence area survey. Based on these investigations and studies the layout and designs of various components of the project have been finalized. However, while carrying out the topographical surveys and geotechnical investigations at the proposed dam sites and along the canal alignment, resentment against the project by local people has been encountered forcing NWDA's field engineers to abandon all field surveys and investigations. The subsequent efforts made by NWDA to convince the local people with the help of public representatives and State Government agencies could not yield the desired results. Thus, the detailed surveys and investigations planned at various locations of the link project could not be completed fully. Therefore, in respect of the components for which the detailed surveys and investigations could not be taken up /completed at DPR stage, the information based on the surveys and investigations carried out at Feasibility Report (FR) stage of the link project have been compiled and supplemented for preparation of DPR, as found necessary.

The DPR has been prepared with active support and co-operation of CWC and other domain expert organizations like, GSI, CWPRS, CSMRS, THDCIL, IMD, NRSC, WAPCOS, RRSC, BISAG etc.

The Union Ministry of Water Resources has constituted a Committee under the Chairman, CWC to monitor and supervise the work of preparation of DPR; and also a Steering Committee under Secretary (WR). These 2 Committees monitored the progress of work and guided NWDA in preparation of DPR.

The DPR of the project is in 11 Volumes. The main report of the DPR is contained in Volume – I. The data and detailed reports of various expert agencies associated with work are contained in Volume - II to V as Annexure / Appendices. The cost estimate of the project is in Volume-VI. The relevant drawings are furnished in Volume -VII and VIII.

5.1 Data Collection

The preparation of DPR of Par-Tapi-Narmada link project requires various data / information. The rainfall and meteorological data were collected from IMD, Pune; hydrological data collected from CWC and State Water Resources Departments; Remote sensing data (LISS- IV) from NRSC, Hyderabad; topo-sheets from Survey of India. The data / information required by various Designs Directorates of CWC were collected during the field surveys.

Laboratory testing of rock core samples and various construction material samples were carried out by CSMRS; geological mapping and investigations were carried out by GSI, Jaipur. These data formed the inputs for design of various components of the project. Simulation analysis was carried out for optimizing the storage capacities and heights of Jheri, Paikhed, Chasmandva, Chikkar, Dabdar and Kelwan dams. The simulation analysis formed in-puts for the power potential studies carried out by THDCIL and the out-put given by THDCIL in the form of power potential studies formed in-put for civil designs of hydel structures. Thus, there were many activities apart from the normal data collection and these activities were successfully managed by NWDA officers and various data required by the consultants were supplied to them for carrying out various consultancy works for preparation of DPR of Par-Tapi-Narmada link assigned to them.

5.2 Planning and Lay-out

The Par-Tapi-Narmada Link Project has been planned to transfer the surplus waters of West flowing Par, Auranga, Ambica and Purna river basins of South Gujarat and neighbouring Maharashtra to provide irrigation facilities to tribal area in the right side of the Par-Tapi-Narmada link canal, tribal dominant districts of Dang and Valsad of Gujarat and Nasik district of

Maharashtra. The link project will also take-over the part command area of existing Miyagam Branch Canal of Narmada Canal System. The Narmada waters so saved in Sardar Sarovar Project would be utilized in Tribal areas of Naswadi, Kavant, Sankheda, Jetpur Pavi, Chhota Udepur talukas of Chhota Udepur district and Halol, Ghogamba and Kalol talukas of Panchmahal district through lift directly from Narmada Main Canal on substitution basis and drought affected Saurashtra area of Gujarat through Narmada Canal System to meet irrigation, domestic and other requirements.

For storage and diversion of surplus waters of Par, Auranga, Ambica and Purna Rivers under the link project six dams viz i) Jheri across Par river, ii) Paikhed across river Nar (a tributary of river Par), iii) Chasmandva across river Tan (a tributary of river Auranga), iv) Chikkar across river Ambica, v) Dabdar across river Khapri (a tributary of river Ambica) and vi) Kelwan across river Purna are to be constructed. Also, 2 diversion barrages – one each in the downstream of Paikhed and Chasmandva dams; a tunnel 12.70 km inter connecting Jheri and Paikhed reservoirs and about 406.118 km long link canal (including 4 feeder pipe lines of 37.075 km and 5 tunnels of 1.15 km along the link canal) are required for effecting the proposed utilisation of 1330 MCM under the link project. 6 Power Houses, one each at the toe of the dams except Jheri dam and at the drop of Kelwan feeder pipe line are also planned to generate hydro-power by utilizing water proposed to be released to meet the link canal and downstream requirements and spills from the respective dams. Various components of the project are described below:

5.2.1 Jheri Dam

Jheri dam is proposed across river Par near village Jheri in Peint taluka of Nasik district of Maharashtra. The total length of Jheri dam is 808.32 m of which 663.32 m is concrete face rock fill dam (CFRD) and the length of concrete non-overflow section and spillway is 145.00 m.

The surplus waters available at Jheri reservoir will be transferred to Paikhed reservoir through a tunnel of 12.70 km length.

5.2.2 Paikhed Dam

Paikhed dam is proposed across Nar River a tributary of Par River near village Paikhed in Dharampur taluka of Valsad district of Gujarat. The total length of Paikhed dam is 1431.85 m of which 1310.85 m is concrete face rock fill dam (CFRD) and the length of concrete non-overflow section and spillway is 121.00 m. The spillway has been proposed in the right flank. A penstock is proposed in extreme left of the concrete portion of the dam for taking water to the power house located at the toe of the dam.

The surplus water available at Paikhed reservoir is to be released into the river through powerhouse and will be picked-up at Paikhed barrage from where the Par–Tapi–Narmada link canal will off take and carry the surplus waters of Jheri and Paikhed reservoirs.

5.2.3 Chasmandva Dam

Chasmandva dam is proposed across river Tan, a tributary of Auranga River near village Chasmandva in Dharampur taluka of Valsad district of Gujarat. The total length of Chasmandva dam is 2781.00 m of which 2703.00 m is concrete face rock fill dam (CFRD) and the length of concrete non-overflow section and spillway is 78.00 m. The chute spillway has been proposed in the right flank. A penstock is proposed in extreme left of the concrete portion of the dam for taking water to the power house located at the toe of the dam.

The surplus water available at Chasmandva reservoir is to be released into the river through powerhouse and will be picked-up at Chasmandva barrage, from where a feeder pipe line will carry the surplus water of Chasmandva reservoir up to main Par-Tapi–Narmada link canal.

5.2.4 Chikkar Dam

Chikkar dam is proposed across river Ambica near village Chikkar in Ahwa taluka of Dang district of Gujarat. The total length of Chikkar dam is 1887.00 m of which 1736.00 m is concrete face rock fill dam (CFRD) and the length of concrete non-overflow section and spillway is 151.00 m. The chute spillway has been proposed in the right flank. A penstock is proposed

in extreme left of the concrete portion of the dam for taking water to the power house located at the toe of the dam.

The Chikkar and Dabdar reservoirs will be inter-connected through pipe line. The surplus water available at Chikkar reservoir will be released into inter-connecting pipe line through the powerhouse and will be taken to Dabdar reservoir.

5.2.5 Dabdar Dam

Dabdar dam is proposed across river Khapri a tributary of Ambica river near village Dabdar in Ahwa taluka of Dang district of Gujarat. The total length of Dabdar dam is 1170.00 m of which 1035.00 m is concrete face rock fill dam (CFRD) and the length of concrete non-overflow section and spillway is 135.00 m. The spillway has been proposed in the right flank. A penstock is proposed in extreme left of the concrete portion of the dam for taking water to the power house located at the toe of the dam.

A feeder pipe line will carry the combined surplus waters of Chikkar and Dabdar reservoirs up to main Par–Tapi–Narmada link canal after power generation at its head.

5.2.6 Kelwan Dam

Kelwan dam is proposed across river Purna near village Kelwan in Ahwa taluka of Dang district of Gujarat. The total length of Kelwan dam is 1330.00 m of which 1141.00 m and the length of concrete non-overflow section and spillway is 189.00 m. The spillway has been proposed in the left flank. A penstock is proposed in extreme right of the concrete portion of the dam for taking water to the power house located at the toe of the dam.

After the power generation in dam toe power house, a feeder pipe line will carry the surplus water available at proposed Kelwan reservoir up to main Par–Tapi–Narmada link canal. Hydro-power will also be generated at the canal fall of feeder pipe line.

5.2.7 Paikhed Barrage

Paikhed barrage is proposed across river Nar about 4.60 km downstream of proposed Paikhed dam to facilitate the release of combined surplus waters of Jheri and Paikhed reservoirs into the link canal. The length of Paikhed barrage is 147.50 m.

5.2.8 Chasmandva Barrage

Chasmandva barrage is proposed across river Tan about 8.50 km downstream of proposed Chasmandva dam to facilitate the off take of the feeder pipe line to release the surplus water of Chasmandva reservoir into the link canal. The length of Chasmandva barrage is 128.00 m.

5.2.9 Link Canal and Feeder pipe lines

The Par–Tapi–Narmada link canal will off take from proposed Paikhed barrage with Full Supply Level (FSL) of 142.800 m. The canal will out fall in to existing Ukai reservoir at RD 177.736 km with FSL of 105.275 m. The Par–Tapi–Narmada link canal will further off-takes from saddle of Ukai dam in the right flank with FSL 81.790 m. The link canal will cross Kim, Amravati, Karjan, Narmada, Orsang and Hiren rivers, besides other small streams, before joining existing Miyagam Branch Canal at RD 191.307 km with FSL of 53.573 m and will take over its part command area.

A 2.859 km long feeder pipe line from Chasmandva weir transfer surplus waters of Chasmandva reservoir in to the link canal at RD 62.072 km. A 14.342 km long inter-connecting pipe line from Chikkar reservoir to transfer surplus waters available at Chikkar dam to Dabdar reservoir. A 12.258 km long feeder pipe line from Dabdar reservoir transfer the combined waters of Chikkar and Dabdar reservoirs in to the link canal at RD 108.250 km. A 7.616 km long feeder pipe line from Kelwan reservoir transfer surplus water of Purna River available at Kelwan dam to the link canal at RD 129.600 km.

5.2.10 Power House

A power house is proposed at the toe of Paikhed dam to generate the hydro power from the combined surplus waters of Jheri and Paikhed reservoirs. For generation of hydro power from the surplus Chasmandva waters, a power house has been proposed at the toe of proposed Chasmandva dam. A power house is proposed at the toe of proposed Chikkar dam. After hydro power generation the Chikkar water will be transferred to proposed Dabdar reservoir through inter-connecting canal. The power house proposed at the toe of Dabdar dam will generate the hydro power by utilizing combined waters of proposed Chikkar and Dabdar reservoirs. At Kelwan dam a power house is proposed at the dam toe. A power house is proposed at the available drop of Kelwan feeder pipe line. Thus total 6 power houses are proposed.

5.3 Surveys and Investigations

On receipt of concurrence from Government of Maharashtra and Gujarat, the work for preparation of DPR of Par-Tapi-Narmada Link Project was taken-up by NWDA during January, 2009. The work for preparation of DPR of the Project was taken-up by NWDA utilizing one Circle Office located at Valsad. Based on the location of the various components of the project and accessibility, the Investigation Division of NWDA located at Valsad was entrusted with the survey and investigation works of Jheri, Mohankavchali, Paikhed and Chasmandva reservoirs, Paikhed and Chasmandva barrages and Par to Ambica reach of the Link canal / Feeder pipe lines and consultancy works assigned to expert agencies. The Investigation Division of NWDA located at Vadodara was entrusted with the survey and investigation works of Chikkar, Dabdar and Kelwan reservoirs, Chikkar weir and Ambica to Out-fall of link canal in to Miyagam branch canal / Feeder pipe lines for preparation of DPR of Par-Tapi-Narmada link project.

The permission for carrying out the survey and investigations work in the forest area was obtained from Principal Chief Conservator of Forest, Government of Gujarat, Gandhinagar vide their letter No. Land/29/B/3034-36/08-09 dated 12th Dec, 2008. Similar permission for Maharashtra area has been obtained from Deputy Conservator of Forest (West), Government of Maharashtra, Nasik vide their letter No. B/Land/CF/4294 dated 25th Nov,

2008 for Surgana and Peint talukas of Nasik district. The NWDA has adopted two pronged strategy for carrying out the survey and investigation works for preparation of DPR of Par-Tapi-Narmada link project. The major parts of the detailed survey and investigation works of the project for which in-house capability was available has been carried out by NWDA itself, whereas other specialized survey and investigation works and other technical studies were out sourced to the institutions of eminence in respective fields, mostly the government agencies.

Certain survey and investigations, which could not be completed due to resistance from local peoples in the project area, are proposed to be carried out at pre-construction stage.

6.0 Climate

The climate of the Par-Tapi-Narmada link project area is moderate except during the months of April and May. Summer is hot and winter is generally cold. The year may be divided into four seasons, the cold season from December to February followed by the hot season from March to May and the south-west monsoon season from June to Sept followed by the post-monsoon season from October to November.

Par–Tapi–Narmada link involves Par, Auranga, Ambica and Purna river basins of South Gujarat and neighboring Maharashtra. All these 4 river basins have the same hydro meteorological characteristics. Most of the rainfall is received during the South-West monsoon period, i.e. from June to Sept. The average annual rainfall in the Par, Auranga, Ambica and Purna river basins is 2180 mm, 2055 mm, 1830 mm and 1472 mm respectively.

Two meteorological observatories i.e. Surat and Vadodara maintained by IMD located adjacent to the project area have been used to characterize the climatic conditions of the project area. The average maximum and minimum temperatures recorded are 39.9 °C and 13.2 °C respectively. The monthly mean relative humidity data of the project area indicates the maximum and minimum values of humidity as 94% (Aug) and 44% (Apr) during monsoon and summer seasons respectively. The maximum and minimum wind velocities observed are 13.3 km/hr and 1.7 km/hr

respectively. The maximum cloud cover is observed during the months of July and August whereas the minimum cloud cover is observed during months of Jan and Feb. There is no pan-evapometer installed in the project area. The mean monthly average evapotranspiration computed for Surat IMD observatory varies from 99.2 (Dec) to 202.0 mm (May), whereas the same at Vadodara IMD observatory varies from 92.9 mm (Dec) to 246.4 mm (May).

7.0 Topography and Physiography

Jheri and Paikhed Reservoirs: The Jheri reservoir is proposed across Par river and Paikhed reservoir is proposed across Nar river, a tributary of Par. The Par river originates from the Sahyadri hill ranges near village Gogul of Surgana taluka in Nasik district of Maharashtra. The Par basin can be divided into two prominent physiographic zones. The eastern part comes under rugged mountain chains of the Sahyadri hills and undulating slope on the western side to the edge of the uplands of Valsad district. This region is placed at a steep slope of elevation 1050 m to 100 m. The Western part, barring the coastal plains, is essentially in the sub-Sahyadrian zone of hills and valley generally lies at an elevation below 100 m. Deccan traps with dykes of quarternary and tertiary ages occupy most of the area of the basin. The middle ranges have developed on the Deccan traps and the intermediate amphitheatres have developed out of the alluvial debris washed from the hills. The lower reaches of the basin upto the coastal margins are mainly alluvial plains.

Chasmandva Reservoir: The Chasmandva reservoir is proposed across Tan river, a tributary of Auranga river. The river is known as Auranga after the confluence of its two tributaries the Man and the Tan. Both tributaries originate in the Sahyadri hill ranges in the Nasik district of Maharashtra. The area is hilly and covered with forest in the upstream reaches, while the area down-wards from about 30 km upstream of confluence of the Tan and the Man rivers can be described as plain with cultivated lands. Physiographically, the basin can be divided into five groups namely i) hill tops and hill slopes, ii) hill terraces and uplands, iii) upper and lower foot slopes (medium land) iv) valley plains and local depressions (low lands) and v) river and stream beds. The geological formations in the region belong to

the Precambrian, Mesozoic, Tertiary and Quaternary ages. Deccan traps occupy major portion of the upper reaches.

Chikkar and Dabdar Reservoirs: The Chikkar reservoir is proposed across Ambica river and Dabdar reservoir is proposed across Khapri river, a tributary of Ambica river. The Ambica river originates in the Sahyadri hill ranges near village Kotambi of Surgana taluka in Nasik district of Maharashtra. Ambica basin is bounded by Western Ghats separating Ambica and Tapi rivers in east, the ridge separating Auranga and Ambica rivers in south, Arabian Sea in west and the ridge separating Ambica and Purna rivers on north. The basin can be divided into two prominent physiographic zones. The eastern part comes under rugged mountain chains of the Sahyadri hills and undulating slope on the western side up to the edge of the uplands of Surat district. This region is placed at a general elevation of 1050 m to 100 m. The western part, barring the coastal plains, is essentially in the sub-Sahyadrian zone of hills and valleys generally below 100 m elevation. Deccan traps with dykes of Quaternary and Tertiary ages occupy most of the area of the basin.

Kelwan Reservoir: The Kelwan reservoir is proposed on Purna river. The river rises in the Sahyadri hill ranges of the Western Ghats at an elevation of about 1300 m in the Ahwa taluka of Dang district in Gujarat and after traversing a distance of 180 km, it outfalls into the Arabian sea. The level of the river bed drops steeply from 1300 m at source to about 115 m at the dam site as the river in this reach passes through hilly area covered with dense forest and patches of cultivated land. Physiographically, the basin can be divided into three zones namely, i) eastern zone, ii) middle zone and iii) coastal zone. The eastern zone of the basin cover a chain of rugged mountain ranges of the Western Ghats running to elevations of over 1300 m and descending to an elevation of about 100 m at the edge of the uplands of the Surat district. The middle zone of the basin is marked by high relief zone with ridges and valleys. The hilly region then merges into the plain through an undulating piedmont coastal zone running parallel to the sea.

Link Canal and Feeder pipe lines: The Par-Tapi-Narmada link canal is aligned through Valsad, Navsari, Tapi, Surat, Bharuch, Narmada, and Chhota Udepur districts of South Gujarat. The terrain through which the

link canal is aligned is undulating. Three Feeder pipe lines are proposed, one each from Chasmandva barrage; Dabdar and Kelwan dams respectively for diversion of water in to the link canal. The canals are aligned skirting the hill slopes and the terrain is undulating.

The Command Area of the link canal lies in Navsari, Tapi, Surat and Bharuch districts. The Command Areas of Dabdar and Kelwan Feeder pipe lines lie in Ahwa taluka of Dang district and Vyara Taluka of Tapi district. Topography of the command area is undulating and of moderate slope. Basaltic out crops are seen in Vansda taluka of Navsari district in which the Command area lies. The Command Area in Tapi district comprises of Deccan trap Basalt of Cretaceous-Eocene age, which is overlain by quaternary alluvium. Limestone and clay formation of Eocene ages and quaternary alluvium formation are seen in the Command Area lying in Surat district. In the eastern side of Bharuch district, where the Command Area lies, Basaltic rocks are seen.

8.0 Population

The population in the Valsad, Dang, Navsari, Tapi, Surat, Bharuch, Narmada, and Chhota Udepur and Panchmahal districts of South Gujarat and Saurashtra and Kutch region will get irrigation and drinking water supply benefits from the link project.

9.0 Geology, Geophysical, Geo-technical and Seismic Study

i) Local Geology

The Par-Tapi-Narmada link project area is occupied by Deccan Lava flows intruded by dolerite dykes and sill. Very commonly due to differentiation the middle portion of a flow exhibits a dolerite texture. They are of Cretaceous-Eocene age.

ii) Sub-surface Geology and Foundation Investigations

The geological investigations were carried out for Jheri, Chasmandva, Chikkar, Dabdar and Kelwan dam sites during the preparation of Feasibility Report (FR) of Par-Tapi-Narmada link project by Engineering Geology Division, GSI, Western Region, Jaipur. The DPR stage geological

investigation work of Par–Tapi–Narmada link project was assigned to GSI, Jaipur and the geological and geo-technical investigations at Paikhed and Chasmandva dam sites were carried out by them. But, due to opposition from local peoples in carrying out the field survey and investigation work the geological investigations could not be taken-up by GSI at other dam sites. As such, the data of geological investigation carried out at FR stage have been used for designing the various components of Par–Tapi–Narmada link project at DPR stage.

Jheri Dam: Jheri dam site has been explored by four numbers bore holes, in order to evaluate the sub-surface rock / over burden conditions. The bore hole cores have been logged by GSI, Jaipur and their data was analyzed to find out foundation grade levels and water tightness of bed rock as well as to ascertain the soil structure and its permeability characteristics.

Paikhed Dam: In order to evaluate the sub-surface rock / over burden conditions the Paikhed dam site has been explored by 12 numbers of NX size bore holes. The bore hole cores have been logged and their data was analyzed to find out foundation grade levels and water tightness of bed rock as well as to ascertain the soil structure and its permeability characteristics.

Chasmandva Dam: The Chasmandva dam site has been explored by 19 numbers of NX size bore holes. The bore hole cores have been logged and their data was analyzed to find out foundation grade levels and water tightness of bed rock as well as to ascertain the soil structure and its permeability characteristics.

Chikkar Dam: Chikkar dam site has been explored by four numbers of NX size bore holes and eight numbers of trail pits, in order to evaluate the sub-surface rock / over burden conditions. The bore hole cores and trail pits have been logged and their data was analyzed to find out foundation grade levels and water tightness of bed rock as well as to ascertain the soil structure and its permeability characteristics.

Dabdar Dam: Dabdar dam site has been explored by four numbers of NX size bore holes and seven numbers of trail pits, in order to evaluate the sub-surface rock / over burden conditions. The bore hole cores and trail pits

have been logged by GSI, Jaipur and their data was analyzed to find out foundation grade levels and water tightness of bed rock as well as to ascertain the soil structure and its permeability characteristics.

Kelwan Dam: To evaluate the details sub-surface conditions at Kelwan dam site four numbers of bore holes were recommended by GSI; two in the river section and one each on the either bank. Due to public hindrance in the project area no bore hole could be drilled. However, the Kelwan dam site could be explored by 8 trial pits / trenches.

Tunnels: Due to public hindrance no subsurface explorations could be carried out.

iii) Seismicity

Par- Tapi- Narmada project area lies in the Seismic zone –III as per the seismic zone map of India. The studies for site specific design ground motion parameters for the various components of Par-Tapi-Narmada link project has been carried out by CWPRS, Pune during the year, 2011. As per these studies the deterministic estimate is found to be governed by a maximum credible earthquake magnitude of 6.3 at a closest distance of 20.1 km to the fault rupture plane. The area of 7 dams and three barrage sites proposed in Par–Tapi–Narmada link project has been divided into three clusters. Both deterministic and probabilistic approaches have been applied to arrive at the Maximum Credible Earthquake (MCE) and the Design Basis Earthquake (DBE) levels of ground motion. For both the MCE and DBE levels of design ground motion, it is found that the deterministic target spectra are higher than the probabilistic spectra for all the three clusters. To be on the conservative side, the same has been recommended as a basis for the design ground motion. The values of the peak ground acceleration for horizontal and vertical components are found to be 0.172 g and 0.145 g for MCE condition, and 0.089 g and 0.076 g for DBE condition, respectively for Cluster-1. For Cluster-2 and Cluster-3, the corresponding values are found to be 0.171 g and 0.139 g for MCE condition, and 0.079 g and 0.067 g for DBE condition respectively. This report has been approved by the National Committee on Seismic Design Parameters in its 23rd meeting held on 20th Nov, 2012.

10.0 Hydrology and Water Assessment

The water availability studies at Jheri, Paikhed, Chasmandva, Chikkar, Dabdar and Kelwan dam sites have been carried out by the Hydrological Studies Organization, CWC, New Delhi as a part of “Hydrological Studies of Par-Tapi-Narmada link project” in consultation with NWDA and Water Resources Departments of Gujarat and Maharashtra to assess the water balance position at the ultimate stage of development (by the year 2050 AD). As per the study the 75% dependable gross annual yields at Jheri, Paikhed, Chasmandva, Chikkar, Dabdar and Kelwan dam sites are 391 MCM, 264 MCM, 70 MCM, 220 MCM, 323 MCM and 362 MCM respectively.

After considering the upstream utilizations planned by the States for irrigation through existing, ongoing and proposed projects, hydropower projects, reservoir evaporation losses, domestic and industrial requirements about 371 MCM, 250 MCM, 64 MCM, 170 MCM, 262 MCM and 308 MCM of surplus waters at 75% dependability are available at proposed Jheri, Paikhed, Chasmandva, Chikkar, Dabdar and Kelwan dam sites respectively for diversion through Par-Tapi-Narmada link canal.

11.0 Flood Control and Drainage

No flood storage is earmarked in any of the reservoirs proposed under Par-Tapi-Narmada link project. However, due to storage in the reservoirs and release into the link canal / feeder pipe lines for irrigation domestic and industrial water supply, there will be incidental flood moderation in the areas down-stream of Jheri, Paikhed, Chasmandva, Chikkar, Dabdar and Kelwan dam sites.

12.0 Reservoir and Power

Six reservoirs viz., Jheri, Paikhed, Chasmandva, Chikkar, Dabdar and Kelwan are planned to be utilized for diversion of surplus waters of Par, Auranga, Ambica and Purna Rivers into the Par-Tapi-Narmada link canal. The Jheri reservoir will have gross storage capacity of 206.03 MCM at FRL 246.00 m and dead storage of 9.23 MCM at MDDL of 204.00 m. The

Paikhed reservoir will have gross storage capacity of 229.53 MCM at FRL 248.00 m and dead storage of 0.92 MCM at MDDL of 190.00 m. The Chasmandva reservoir will have gross storage capacity of 83.63 MCM at FRL 214.00 m and dead storage of 0.36 MCM at MDDL of 190.00 m. The Chikkar reservoir will have gross storage capacity of 141.99 MCM at FRL 210.00 m and dead storage of 3.69 MCM at MDDL of 179.00 m. The Dabdar reservoir will have gross storage capacity of 222.38 MCM at FRL 169.00 m and dead storage of 4.32 MCM at MDDL of 139.00 m. The Kelwan reservoir will have gross storage capacity of 282.17 MCM at FRL 164.00 m and dead storage of 6.51 MCM at MDDL of 136.00 m.

Hydropower of the order of 21 MW and annual energy of 102 million units will be generated through the 6 power houses installed at 5 dam sites viz. Paikhed, Chasmandva, Chikkar, Dabdar and Kelwan and one at Canal fall of Kelwan Feeder Pipe line. The power house (of 9 MW) at Paikhed dam will be with 3 units each of 3.0 MW installed capacity. The annual energy generation in the 90% dependable year will be 45.53 Million Units (MU). Power house (of 2 MW) at Chasmandva dam will be with 2 units each of 1.0 MW installed capacity. The annual energy generation in the 90% dependable year will be 5.67 MU. Power house (of 2 MW) at Chikkar dam will be with 2 units each of 1.0 MW installed capacity. The annual energy generation in the 90% dependable year will be 8.35 MU. Power house (of 3.2 MW) at Dabdar dam will be with 2 units each of 1.6 MW installed capacity. The annual energy generation in the 90% dependable year will be 16.60 MU. Power house (of 2.5 MW) at Kelwan dam will be with 2 units each of 1.25 MW installed capacity. The annual energy generation in the 90% dependable year will be 13.07 MU. Power house at canal fall of Kelwan feeder will be with 2 units each of 1.0 MW installed capacity. The annual energy generation in the 90% dependable year will be 12.48 MU.

13.0 Irrigation and Command Area Development

As per water planning, the total Culturable Command Area (CCA) of about 232175 ha has been identified under the link canal. The enroute Culturable Command Area (CCA) of 61190 ha with Annual Water Utilization of 382 MCM is proposed, out of which the CCA identified in Par-Tapi reach is 10100 ha with Annual Water Utilization of 63 MCM; in Tapi-Narmada

reach is 49820 ha with Annual Water Utilization of 311 MCM; and 1270 ha identified under Dabdar and Kelwan Feeder pipe lines with Annual Water Utilization of 8 MCM are firming up of en-route command area of the link canal. The command area of five projects proposed by Government of Gujarat on the left side of canal is about 45561 ha with Annual Water Utilization of 285 MCM to be irrigated by gravity through link canal. Tribal area right side of canal is 36200 ha with Annual Water Utilization of 138 MCM will be irrigated by lift. About 12514 ha with Annual Water Utilization of 48 MCM tribal area will also be irrigated directly by lift from proposed six reservoirs of this project. The Link Project will take over an area of 76710 ha CCA with annual irrigation of 76710 ha with Annual Water Utilization of 291 MCM under the command area of existing Miyagam branch canal of Narmada canal system. Narmada Water so saved will be utilized to provide irrigation facilities in Tribal area on right side of Narmada main canal 23750 ha with Annual Water Utilization of 90 MCM of Chhota Udepur district and 10592 ha with Annual Water Utilization of 40 MCM of Panchmahal district by lift directly from Narmada main canal on substitution basis and in Saurashtra and Kutch region of Gujarat.

14.0 Navigation and Tourism

Navigation is not proposed under this project. Regarding tourism development, the tourist / picnic spots are proposed to be developed on the periphery of Jheri, Paikhed, Chasmandva, Chikkar, Dabdar and Kelwan reservoirs and near Paikhed and Chasmandva barrages.

15.0 Design Features

Jheri Dam: The height of the Jheri dam has been designed as 73.00 m with top width as 10.00 m. The FRL of the Jheri dam has been kept as 246.0 m. The concrete portion of the dam will be 145.00 m long whereas concrete faced rock fill portion will be 663.32 m. The spillway will have 5 nos. of gates of size 15 X12 m.

Paikhed Dam: The height of the Paikhed dam has been designed as 93.0 m with top width as 10.0 m. The FRL of the Paikhed dam has been kept as 248.0 m. The concrete portion of the dam will be 121.0 m long whereas concrete faced rock fill portion will be 1310.85 m. The spillway will have 4 nos. of gates of size 15 X 12 m. The power house at dam toe is proposed with 3 units of 3 MW each.

Chasmandva Dam: The height of the Chasmandva dam has been designed as 52.0 m with top width as 10.0 m. The FRL of the Chasmandva dam has been kept as 214.0 m. The concrete portion of the dam will be 78 m long whereas concrete faced rock fill portion will be 2703 m. The spillway will have 3 nos. of gates of size 12 X 12 m. The power house at dam toe is proposed with 2 units of 1 MW each.

Chikkar Dam: The height of the Chikkar dam has been designed as 63.0m with top width as 10.0 m. The FRL of the Chikkar dam has been kept as 210.0 m. The concrete portion of the dam will be 151.0 m long whereas concrete faced rock fill portion will be 1736.0 m. The spillway will have 4 nos. of gates of size 15 X 12 m. The power house at dam toe is proposed with 2 units of 1 MW each.

Dabdar Dam: The height of the Dabdar dam has been designed as 65.0 m with top width as 10.0 m. The FRL of the Dabdar dam has been kept as 169 m. The concrete portion of the dam will be 135.0 m long whereas concrete faced rock fill portion will be 1035 m. The spillway will have 5 nos. of gates of size 15 X 12 m. The power house at dam toe is proposed with 2 units of 1.6 MW each.

Kelwan Dam: The height of the Kelwan dam has been designed as 58.0m with top width as 10.0 m. The FRL of the Kelwan dam has been kept as 164 m. The concrete portion of the dam will be 189.0 m long whereas concrete faced rock fill portion will be 1141.0 m. The spillway will have 5 nos. of gates of size 15 X 12 m. The power house at dam toe is proposed with 2 units of 1.25 MW each. The power house proposed at canal fall of the feeder pipe line connecting Kelwan dam with link canal will have 2 units of 1MW each

Tunnel Connecting Jheri and Paikhed Reservoirs: The total length of tunnel from Jheri and Paikhed reservoirs will be about 12.70 km with diameter as 3.00 m and bed slope 1:875. The tunnel will be of D shape.

Paikhed Barrage: This barrage will be 147.50 m long with spillway of 138.50 m (7 bays of 15 m width with 5 nos. of piers of 4.5 m thick and 1 no. of double pier of 11 m thick). A head regulator is provided at the upstream right side of the barrage. Par-Tapi-Narmada link canal will offtake from this head regulator at crest level of 136.0 m.

Chasmandva Barrage: This barrage will be 128 m long with spillway of 122 m (8 bays of 12 m width with 6 nos. of piers of 3.0 m thick and 1 no. of double pier of 8 m thick). A head regulator is provided at the upstream right side of the barrage. Chasmandva feeder pipe line will offtake from this head regulator at crest level of 123.0 m.

Link Canal: Total length of Par-Tapi-Narmada link canal is 406.118 Km including feeder pipe lines and tunnels along the link canal. The length of Par-Tapi reach link canal is 177.736 km offtaking from the Paikhed barrage. The head reach of canal has been designed for a capacity of 38.17 cumecs. The canal will have 8.50 m bed width and 2.8 m full supply depth at its head and 16.50 m bed width and 2.80 m full supply depth at its tail end. The length of Tapi-Narmada reach of link canal is 191.307 km offtaking from the Ukai reservoir. The head reach of canal has been designed for a capacity of 46.64 cumecs. The canal will have 8.80 m bed width and 3.22 m full supply depth at its head and 5.0 m bed width and 2.650 m full supply depth at its tail end.

16.0 Construction Material

Coarse as well as fine sand including gravel are available in required quantities in the river bed, both upstream and downstream within leads of 1 to 9 km in respect of Jheri, Chasmandva, Chikkar, Dabdar and Kelwan dam sites. However, in case of Paikhed dam site, the lead varies from 2 to 35 km. Good rubble stone suitable for construction work is available from

quarries, in the vicinity of each dam site within economical leads of 1 to 4 km.

The nearest cement factory for the dam sites is Narmada Cement Factory, Magdalla in Surat district. The cement manufactured from this factory can be transported to Vyara and Valsad through rail head. Friends Ispat plant is located at Ahmadabad. The steel required for project construction can be procured from this plant and transported to Valsad, Billimora, and Vyara rail heads by rail and further up to project sites by road.

17.0 Accessibility and Infrastructure

The Par-Tapi-Narmada link project is located in Gujarat except Jheri dam which falls in Maharashtra while remaining dams viz. Paikhed, Chasmandva, Chikkar, Dabdar and Kelwan dams are located in Valsad and Dang districts of Gujarat. Par-Tapi reach of link canal passes through Valsad, Navsari, Dang, Tapi and Surat districts whereas Tapi-Narmada reach of link canal passes through Surat, Bharuch, Narmada and Vadodara / Chhota Udepur districts of Gujarat.

The Jheri dam across Par River is located near village Jheri in Peint taluka of Nasik district of Maharashtra. The Jheri dam site is approachable from Peint as well as from Dharampur, taluka head quarters in Nasik and Valsad districts respectively via Valsad - Nasik National Highway. The nearest railway station is Nasik on Central Railway and nearest town is Peint. The distance of Jheri dam site from Nasik via Peint is about 75 km.

The Paikhed dam across Nar River, a tributary of river Par is located near village Paikhed in Dharampur taluka of Valsad district. The nearest town is Dharampur and the nearest railway station is Valsad on Western Railway. The Paikhed dam site is approachable from Dharampur on Valsad – Nasik National Highway. The distance of Paikhed dam site from Dharampur is about 38 km.

The Chasmandva dam across Tan River, a tributary of river Auranga is located near Chasmandva village in Dharampur taluka of Valsad district. The nearest town is Dharampur and the nearest railway station is Valsad.

The dam site is approachable from Dharampur on Dharampur – Vansda road and the distance of Chasmandva dam site from Dharampur is about 25 km.

The Chikkar dam across Ambica River is located near village Chikkar in Ahwa taluka of Dang district in Gujarat. The Chikkar dam site is approachable from Waghai / Vansda on Gandevi – Saputara National Highway No - 360. The nearest town and railway station is Waghai on narrow gauge (Bilimora – Waghai section) and Bilimora on Broad gauge of Western Railway. The dam site is approachable from Dharampur. The distance of Chikkar dam site from Waghai is about 12 km.

The Dabdar dam across Khapri River, a tributary of river Ambica near village Dabdar in Ahwa taluka of Dang district in Gujarat. The Dabdar dam site is approachable from Waghai on Gandevi – Saputara National Highway No - 360. The nearest town is Waghai and the nearest railway station is Waghai on narrow gauge (Bilimora – Waghai section) and Bilimora on Broad gauge of Western Railway. The distance of Dabdar dam site from Waghai is about 8 km.

The Kelwan dam across Purna river is located near village Kelwan and Kakarda in Ahwa taluka of Dang district in Gujarat. The Kelwan dam site is approachable from Waghai on Gandevi – Saputara National Highway No - 360. The nearest town is Waghai and the nearest railway station is Unai on narrow gauge (Bilimora – Waghai section) and Vyara on Broad gauge (Surat – Bhusaval section). The distance of Kelwan dam site from Vyara and Waghai is about 30 km.

The nearest airports in the vicinity of the link project are at Mumbai, Nasik and Surat.

18.0 Construction and Equipment Planning

The Construction Planning, Equipment Planning and Man-power Planning has been carried out by Construction Machineries Consultancy (CMC) Directorate of Central Mechanical Organization, CWC, New Delhi.

19.0 Environmental and Ecological Aspects of the Project

The water resources projects when built increase the water availability leading to various developmental activities and prosperity in the area, but some adverse impacts on the environment are also seen. As such it is necessary to identify the adverse impacts of the project and suggest the measures to mitigate or ameliorate the anticipated adverse impacts on the environment. To identify the possible environmental impacts, both positive and adverse due to the proposed Par-Tapi-Narmada link project and to suggest measures to mitigate or ameliorate the anticipated adverse impacts on the environment, the Environmental Impact Assessment Study of Par-Tapi-Narmada link project has been carried out through WAPCOS Ltd.

i) Base Line Study and EIA Study

The baseline levels of environmental parameters which could be significantly affected by the implementation of the project are essential to be ascertained before implementation of the project. The baseline status shall involve both field work and review of data collected from secondary sources. The baseline survey planning commenced with the short listing of impacts and identification of parameters for which the data needs to be collected. Baseline status has been ascertained for air environment, water environment, land environment, public health and biological (terrestrial and aquatic) environment. The likely impacts due to the project during construction and operation phases have been studied on the aspects like land, water and air environments, aquatic and terrestrial ecology, socio-economic, impact on public health, risk on failure of dam structures etc.

ii) Flora and Fauna

The impacts on forest cover; rare, endangered and threatened species and impacts on wildlife such as impact due to habitat change having effect like corridor loss and loss of migratory path for wildlife including birds, impact on breeding grounds of species, impacts on access of animals to food and shelter have been studied. The study indicates that rare, endangered and threatened species are not reported in the study area.

The impacts due to acquisition of forest land shall be mitigated through compensatory afforestation measures and implementation of bio-diversity conservation measures suggested in the EMP. The area to be brought under irrigation within the command area is devoid of forests. The project area is interspersed with settlements and agricultural land. In such settings large scale faunal population is not observed. Thus, no significant impact on wild life is anticipated due to the project. Purna and Vansda Wild life Sanctuaries are falling within the study area. The project shall not acquire any land from these sanctuaries. However, adverse impacts on account of increased human interferences may take place during project construction phase. A detailed anti-poaching plan including surveillance measures outlined in the Environmental Management Plan.

The impact on aquatic ecology due to increase in the turbidity levels; spawning areas of fishes; damming of rivers and impacts on migratory fish species etc. have also been studied.

iii) Land Use Pattern

Majority of the environmental impacts during construction phase are temporary in nature, lasting mainly during the construction phase and for small duration beyond the construction period. The major impacts anticipated on land environment during construction phase are: environmental degradation due to immigration of labour population; operation of construction equipment; soil erosion; and solid waste management. Remedial measures have been suggested to mitigate/ameliorate these impacts. During operation phase the impact is mainly due to submergence of land by the Jheri, Paikhed, Chasmandva, Chikkar, Dabdar and Kelwan reservoirs. These 6 reservoirs will submerge about 6065 ha land (Jheri 836 ha, Paikhed 994 ha, Chasmandva 615 ha, Chikkar 742 ha, Dabdar 1249 ha and Kelwan 1629 ha) of which 2829 ha forest land, 2364 ha culturable and other and river portion land 872 ha.

(iv) Environmental Management Plan (EMP)

The various environmental aspects such as pollution control at construction sites; water quality management; land management plan, biodiversity conservation and management plan; green belt development plan; environmental management in labour camps; public health management; catchment area treatment (CAT) plan, dam break analysis and disaster management programme (DMP), environmental monitoring programme etc have been considered and suitable provisions have been kept in the estimate.

The total water demand of Par-Tapi-Narmada link project is about 1330 MCM (PTN link canal requirement: 1210 MCM; Environmental releases d/s of proposed dam sites: 20 MCM; Local domestic and industrial requirement in the vicinity of proposed reservoirs: 60 MCM; and evaporation losses proposed in the reservoir: 40 MCM). The reservoirs are devoid of any minerals of economic importance and no monuments or any remains of archaeological importance were noticed in the project area of the Link. Ensured release of minimum quantity of water required to maintain the river ecology down-stream of dams during lean season will increase the river ecology. Due to creation of Jheri, Paikhed, Chasmandva, Chikkar, Dabdar and Kelwan reservoirs the ground water level in the down-stream areas will rise. The water samples tests indicate that organic and heavy metal components in the water are within permissible limits. The rocks in the reservoirs area are hard, massive and devoid of any major fault or shear zones while the joints are mostly tight and as such there will be no problem of reservoir leakage. The total estimated cost for implementation of Environmental Management Plan (EMP) is Rs 445 crore (excluding the cost of R and R Plan).

20.0 Socio-Economic Aspects and Resettlement and Rehabilitation

About 6065 ha land area will come under submergence of proposed reservoirs. Total number of affected families would be 2509 of which 98 families would be affected due to creation of Jheri reservoir spread over 6 villages, 331 families would be affected due to Paikhed reservoir spread over 11 villages, 379 families would be affected due to creation of

Chasmandva reservoir spread over 7 villages, 345 families would be affected due to creation of Chikkar reservoir spread over 9 villages, 563 families would be affected due to creation of Dabdar reservoir spread over 11 villages and 793 families would be affected due to Kelwan reservoir spread over 17 villages. The affected villages are located in Surgana and Peint talukas of Nasik district in Maharashtra and Dharampur taluka of Valsad, Vansda taluka of Navsari and Ahwa taluka of Dang districts in Gujarat. The affected families may lose their lands or houses or both in the submergence when the reservoirs are created. All the affected families would be compensated for the loss of their lands and houses. The families whose houses are coming under submergence would be resettled in the new habitations and would be assisted to take up some alternative occupation in the new surroundings.

(i) Resettlement and Rehabilitation Plan

The Department of Land Resources (DLR), Ministry of Rural Development, Government of India formulated a policy entitled, “National Rehabilitation and Resettlement Policy-2007”. Similarly, the State Governments of Madhya Pradesh, Gujarat and Maharashtra also developed the R and R Policies for Project Affected Peoples (PAPs) of Sardar Sarovar Project. The provisions of Land Acquisition, Rehabilitation and Resettlement Bill - 2013 have also been considered. The provisions in all these documents have been compared. Keeping in view these policies a R and R package has been developed to compensate the project affected families enabling them to gain at least their levels of living standards. All major sons in a joint family are to be treated as separate families and would be entitled for all R and R benefits.

Creation of 6 reservoirs viz. Jheri, Paikhed, Chasmandva, Chikkar, Dabdar and Kelwan would submerge one villages fully and 60 villages partly. The affected villages are located in Dang and Valsad districts of Gujarat and Nasik district of Maharashtra. All the Project Affected Families will be provided Rehabilitation and Resettlement assistance. The rehabilitation assistance would include sanction of productive asset grant to each head of project affected households and also to each of the major son of such households, besides provision of subsistence allowance, annuity,

mandatory employment for one member from each family or compensation, RandR relief aid, vocational training grant, etc. The costs for resettlement of displaced persons includes free residential plot, house building assistance, grant for construction of cattle shed, and civic amenities like domestic water, electricity, school, playground and children park, health centre, resettlement centre, place of worship, community hall, sanitation, drainage, approach roads, public transport, place of funeral etc. The total cost of Resettlement and Rehabilitation of the project affected families including cost of Local Area Development Plan and monitoring and evaluation aspects works out to be Rs.1126 crore.

Socio-economic condition of the people living in command area as well as in near vicinity of the project will improve in general. No major adverse impacts are anticipated due to the link project on the socio-economic front.

21.0 Cost estimate

The cost estimate for Par-Tapi-Narmada link project has been prepared based on the quantities of various material and works involved in the various components worked out based on the engineering drawings. To work out the rates of various items the rate analysis has been carried out using the rates of various material, man power etc. from schedule of rates for South Gujarat region of Water Resources Department, Government of Gujarat for the year 2012-13 and enhanced to 2014-15 price level by considering 5% escalation per annum to arrive the cost of the project components.

The total cost of Par-Tapi-Narmada link project has been estimated to be Rs. 989325 lakh. The details are in the following table:

Sl. No	Item	Estimated cost Rs in lakh
1.	Unit-I Head works	474773
2.	Unit-II Canals and Conveyance system	455710
3.	Unit-III Power installations	18091
4.	Unit-IV Navigation	-
5.	Unit-V Water Supply	-

6.	Unit-VI Command Area Development	72547
	Total cost of the project	1021121

22.0 Economic and Financial Evaluation

Sl. No	Description	Rs in lakh
1.	Net return from agricultural produce	
(i)	Pre-project	165068.25
(ii)	Post-project	53891.55
(iii)	Total net return from agricultural produce	111176.70
2.	Revenue from sale of power @ Rs. 6.00/kwh for 102 MU	6120.00
3.	Revenue from Water supply @ Rs. 118.25 lakh per MCM for 76 MCM	8987.00
4.	Revenue from Fisheries	303.00
	Total Revenue	126586.70
5.	Annual cost like interest, depreciation, charges of operation and maintenance (OandM) for command area and head works, power plants, etc.	122364.64
6.	Benefit-Cost (BC) Ratio	1.035
7.	Internal Rate of Return (IRR)	10.172%

23.0 Clearances Required

The Par-Tapi-Narmada link project will require the following clearances:

Sl. no.	Clearance	Agency
(i)	Techno-economic	Central Water Commission, TAC of MoWR, RD and GR
(ii)	Forest Clearance	Ministry of Environment, Forest and Climate Change
(iii)	Environmental clearance	Ministry of Environment, Forest and Climate Change

(iv)	R and R Plan of Tribal Population	Ministry of Tribal Affairs
------	--------------------------------------	----------------------------

24.0 Data Base

During preparation of DPR the data required for various studies / design of various components were collected from field while carrying out field investigations and also from various Government agencies and data base has been prepared in the field office.