

Chapter – 4

Surveys and Investigations

The surveys and investigations for the Par-Tapi-Narmada Link Project have been carried out in order to study the technical feasibility of the scheme.

4.1 Topographical surveys

Topographical surveys of the link consist of following items of works.

4.1.1 River surveys

(a) River Par

The river survey has been carried out along the river Par on which two dams, namely, Jheri and Mohankavchali are proposed. The L-Section along the river has been taken for 5 km u/s and 10.5 km d/s of the Jheri dam site upto RLs of 200.735 m and 140.655 m respectively. Altogether, 10 nos. of cross-sections have been taken for grid survey in the vicinity of Jheri dam site at 60 m interval. The river survey in the vicinity of Mohankavchali dam site could not be carried out due to local hindrance. As such, the details of the area have been taken from Survey of India toposheet (scale 1:50,000).

(b) River Nar

The river survey has been carried out along the river Nar (a tributary of river Par) on which Paikhed dam is proposed. The L-Section along the river has been taken for 5 km u/s and 5.5 km d/s of the Paikhed dam site upto RL of 193.21 m and 141.945 m respectively. However, cross-section could not be taken due to local hindrance.

River survey along river Nar has also been carried out for a length of 8.42 km in the vicinity of Paikhed Weir. The L-Section has been taken for 1.6 km u/s and 6.82 km d/s of Paikhed weir site upto RL 143.715 m and 112.095 m respectively.

(c) River Tan

The river survey along river Tan (a tributary of river Auranga) has been carried out in the vicinity of Chasmandva dam site. The L-Section has been taken upto 15.80 km d/s of Chasmandva dam site covering from RL 167.0 m to 91.015 m. Altogether 8 nos. of cross-sections have been taken at an interval of 100 m.

The L-Section in upstream has not been taken as the reservoir survey in the u/s has been carried out by Survey of India. The L-Section taken upto 15.80 km d/s covers the area of Chasmandva weir site and aqueduct of main canal.

(d) River Ambica

The river survey has been carried out along the river Ambica on which Chikkar dam is proposed. The L-Section has been taken for 6.87 km u/s and 14.412 km d/s of the Chikkar dam site upto RL 181.507 m and 98.605 m respectively. Altogether 9 nos. of cross-sections have been taken at 100 m interval.

The L-Section taken upto 14.412 km d/s covers the Chikkar weir site including a reach of 5.7 km d/s of weir site.

(e) River Kapri

The river survey has been carried out along the river Kapri (a tributary of river Ambica) on which Dabdar dam is proposed. The L-Section along the river has been taken for 4.23 km u/s and 10.53 km d/s of the Dabdar dam site upto RL of 139.780 m and 89.97 m respectively. Altogether 8 nos. of cross-sections have been taken at 100 m interval.

(f) River Purna

The river survey has been carried out along the river Purna on which Kelwan dam is proposed. The L-Section along the river has been taken for 14.31 km u/s and 5.04 km d/s of the Kelwan dam site upto RL of 143.625 m and 96.115 m respectively.

4.1.2 Reservoir surveys

Based on the toposheet studies, the location of various dam sites were selected for detailed surveys. Out of seven reservoirs proposed in the Par-Tapi-Narmada link, reservoir surveys of three sites, namely Chikkar, Dabdar and Kelwan were earlier got done by Govt. of Gujarat through Survey of India. The reservoir surveys of Mohankavchali and Chasmandva reservoirs were entrusted by NWDA to Survey of India. Reservoir surveys of remaining two reservoirs namely Jheri and Paikhed reservoirs were carried out departmentally by NWDA. While the survey of Chasmandva reservoir could be completed by Survey of India, the survey of Mohankavchali reservoir was abandoned due to resistance from local people. So, the reservoir map for this site has been prepared by NWDA on the basis of topo sheets (1:50,000 scale) having a contour interval of 20 m. The details for the seven reservoirs are given in Table - 4.1.

Table - 4.1
Survey details of all reservoirs

S. No.	Reservoir	FRL proposed by NWDA (m)	RL upto which survey has been conducted (m)	Scale	Contour interval (m)	Remarks
1.	Jheri	246.00	270	1:10,000	5	For Mohan -kavchali reservoir, maps are prepared on topo-sheet of 1:50,000 scale
2.	Mohankavchali	158.00	--	1:10,000	5	
3.	Paikhed	248.00	280	1:10,000	5	
4.	Chasmandva	214.00	220	1:10,000	5	
5.	Chikkar	210.00	212.5	1:15,000	2.5	
6.	Dabdar	169.00	190	1:15,000	5	
7.	Kelwan	164.00	180	1:25,000	5	

4.1.3 Head works

It was proposed to take altogether 56 river cross sections (8 cross-sections against each of the dam site) near vicinity of the seven dam sites at an interval of 100 m c/c in a block of 1000 m x 700 m, on an average. However, out of 56 cross-sections proposed, only 43 cross sections could be taken at 5 dam sites i.e. Jheri, Chasmandva, Chikkar, Dabdar & Kelwan. The same survey could not be carried out for Paikhed and Mohankavchali dam site due to local hindrances. In addition, 5 cross sections were also taken for saddle dam portion at Kelwan site. Spot levels were taken along the cross sections at an interval of 20 m to 30 m. With the help of these river cross-sections, the contour plan with contour interval of 2 m to 5 m covering the dam sites was plotted and dam axis for each site was marked.

Similar work in respect of all the three proposed weirs was also completed by taking 5 cross sections at each weir site. The surveys done for head works cover the areas required for power house, switch yard and tail race at the respective sites.

4.1.4 Plant and colony layout

Detailed survey for plant and colony layout has not been carried out. This will be required to be carried out at the stage of Pre-construction survey. However there are suitable locations available for installation of various plants near each dam site. An organizational set up for the Par-Tapi-Narmada Link

Project without considering Ukai water has been proposed as per which there will be five Chief Engineers headed by one General Manager. For each Chief Engineer, a number of Circles, Divisions and Sub-divisions have been proposed. These show that residential and non-residential accommodation will be required to be constructed at following places:

- | | | |
|----------------|---------------|-------------------|
| 1. Gandhinagar | 9. Vyara | 17. Coswadi |
| 2. Vadodara | 10. Bheskatri | 18. Dhamni |
| 3. Bharuch | 11. Waghai | 19. Mohankavchali |
| 4. Ankleshwar | 12. Vansda | 20. Valsad |
| 5. Rajpipla | 13. Bopi | 21. Sawarna |
| 6. Mandavi | 14. Dharampur | 22. Peint |
| 7. Surat | 15. Pindwal | 23. Nasik |
| 8. Ukai | 16. Tutarkhed | |

4.1.5 Canal and canal structures

The detailed surveys in respect of Par-Tapi portion of Par-Tapi-Narmada Link have been carried out for a length of 196 km out of 210 km (including feeders and tunnels). The survey work for remaining 14 km length spread over three small reaches (first reach near Sidhumber project, second near Chasmandva feeder and third near left bank of Ukai reservoir) could not be carried out done due to local hindrances. However, alignment in these small patches was finalised on the basis of toposheets and other available drawings. The detailed surveys in respect of Tapi-Narmada portion without considering Tapi water have been carried out for its entire reach of 190.14 km. Tracing and chaining for cross-sections are done at 50 m to 200 m interval extending to 150 m on either side of the alignment. Further, double levelling along the canal alignment for levels and single levelling for cross-sections were also done. Double leveling for connecting the alignment with GTS bench mark was done for a length of 103.2 km. Since the main canal is a contour canal it crosses a number of valleys and in order to facilitate crossing of these valleys, different types of cross-drainage works like aqueducts and tunnels are proposed depending upon the site condition. Single lane bridges and double lane bridges are proposed across the canal for all roads and important cart track crossings. Block levelling for C.D. and C.M. works were carried out for a total area of 10.64 Sq. km.

4.1.6 Power houses, switch yard etc.

The topographic survey of the dam site have been utilised for locating the power house and switch yard etc. Out of six power houses, four power houses are proposed to be located at the toe of the Jheri, Paikhed,

Chasmandva and Chikkar dams. The remaining two power houses will be located at the falls of the feeder canals connecting Dabdar and Kelwan reservoirs to the main canal of Par-Tapi reach. More details regarding power houses have been given in Chapter-9 "Power". The switch yards may be conveniently located near the proposed power houses except in Jheri where suitable location will have to be surveyed.

4.1.7 Tunnel surveys

The Par-Tapi-Narmada link involves a tunnel of 5 km length connecting Mohankavchali reservoir with Nar river upstream of Paikhed weir and 0.50 km tunnel from RD 21.60 km to RD 22.10 km. The survey for the tunnels could not be conducted due to local hindrances. Information regarding tunnel was therefore, taken from the toposheet of scale 1:50,000 for drawing purpose. Detailed survey and investigation of the tunnel alignment will have to be conducted at DPR stage.

4.1.8 Command area survey

In Par-Tapi portion, gross command area (GCA) of 24,873 hectare has been identified for enroute irrigation with the culturable command area (CCA) of 17,411 ha. Since the survey of entire command was time consuming, only 4,500 ha (GCA) was surveyed so that the cost per hectare of command area development could be worked out. The detailed analysis of command area development, carried out for command of 760 ha of Purna basin near Amania village gave the cost of development as Rs.65,023 per hectare which includes the cost of land acquisition.

The major portion of the command of the Par-Tapi-Narmada Link falls in Tapi-Narmada portion. However the command area survey for the enroute command in Tapi-Narmada portion as well as in Narmada Command was not done as the same was already got done by Government of Gujarat through Survey of India in connection with Narmada Project. Composite maps to the scale of 1:15,000 with contour intervals of 0.5 m, 1 m, and 2.5 m respectively are available for Tapi-Narmada portion. The block wise rate analysis for Narmada Command has already been carried out by the project authorities of the Narmada Project. These rates have been brought to uniform price level of 2004-05 and the average cost of command area development for Narmada Command, which constitutes the major part of command area of the proposed link works out to be Rs.35,600 per hectare. As the rate of Rs.65,023/- per ha as worked out above for Par – Tapi portion seems to be on higher side and unrealistic, the rate of Rs.35,600/- per ha has been adopted for working out the cost of command area development of the entire Par – Tapi – Narmada link project.

4.2 Geological and foundation investigation

There are a number of important structures, such as dams, weirs, aqueducts etc. in the proposed Par-Tapi-Narmada Link project. In order to know the characteristics of the foundation strata of these important structures, it is essential to carry out geological and foundation investigations. Accordingly, the geophysical and geotechnical investigations of all the seven dam sites and geotechnical investigation of interlinking tunnel were entrusted to the Geological Survey of India, Jaipur. However, geophysical and geotechnical investigations of only five sites namely Jheri, Chasmandva, Chikkar, Dabdar and Kelwan could only be completed. The investigation in respect of Mohankavchali and Paikhed dams including tunnel could not be completed due to resistance from local public.

In addition to above, the drilling of four boreholes, two in river bed and one each on either bank of river was also entrusted to Engineering Geology Division, Government of Gujarat, Vadodara in respect of four dams, namely Jheri, Chasmandva, Chikkar and Dabdar. However, the drilling work could only be completed in respect of Jheri, Dabdar and Chikkar. The aim of this drilling was to confirm the bed rock profile based on geophysical investigation and ascertain the sub-surface geology of the dam axis and the energy dissipation line. The State Government of Gujarat has carried out drilling works along five boreholes at their proposed dam site at Kelwan dam which almost coincided with the alignment of NWDA's proposed site. As such it was decided to utilize the existing borehole data of Kelwan dam site for establishing sub-surface geology of that site. More drilling works along dam axis and geological investigation, along the periphery of the reservoirs will be required to be done at a later stage. Various steps followed by GSI for geological investigation are described below :

4.2.1 Photogeological interpretation

First of all, the photogeology unit of GSI, Jaipur studied the aerial photographs, available on the scale of 1:25,000/1:30,000 of the area, adjoining dam axis with the help of mirror stereoscope and tried to know general idea of major structural features of rocks, such as delineation of major lineaments, fault, dykes, shear zone, major joints, fractures etc in the vicinity of dam axis. This photogeological interpretation was followed with ground truth verification.

4.2.2 Geotechnical investigation

Since idea developed regarding structural features of rock from photogeological interpretation had its limitations, geotechnical and geophysical investigations were carried out. The basic purpose of geotechnical investigation was to find out type of rock in the area, major joints, shear zone, faults, fracture zone and also to know some of the properties of rock through laboratory testing. This investigation consisted of mainly four parts.

(a) To study surface geology

To study surface geology, visual inspection of the surface area 500 m on either side of dam axis was carried out by the geologists and shots were taken at all those points which were having some important geological feature. The purpose of taking shots was to find the exact location and level of the points having important features so that these can be correlated while preparing geotechnical maps.

(b) To study subsurface geology

All the dams proposed in the Par-Tapi-Narmada link project are having composite sections, part of dam is concrete whereas the remaining part is earthen. For the earthen portion of the dam, trial pits of varying depth were excavated to determine depth of clay. Soil samples taken from these trial pits were also got tested at Gujarat Engineering Research Institute (GERI) laboratory at Surat to know the properties of the soil. However, these trial pits were not sufficient to know subsurface geology in respect of concrete portion of dam. As such, drilling of minimum four boreholes was carried out in respect of dams of the proposed link project.

(c) Petrographic Studies

Under this study, the rock samples collected from the site were examined through microscope at GSI laboratory, Jaipur, in order to identify the type of rock and mineral in the area.

(d) Laboratory Tests

Following laboratory tests were also carried out on the rock samples collected from various dam sites :

- (i) Compressive strength (confined and unconfined) test to know bearing capacity of rock.
- (ii) Slake durability test to know water absorption percentage in rock.

(iii) Water percolation test for establishing clay.

4.2.3 Geophysical investigation

This investigation was carried out by a geophysical party headed by a senior geophysicist. The team consisted of about 10 persons. The basic purpose of this investigation was to find out depth of rock and major features like fault, shear zone and fracture at different depths and widths.

This survey was carried out along two lines, i.e. along dam axis and energy dissipation line. Electrical resistivity, refraction seismic and magnetic (Vertical field) methods were employed for the purpose. The velocities of waves/shocks generated through the hammer in various strata were utilised for determining depth of rock. However, where depth of rock was more, electrical resistivity test was carried out. In this manner, the approximate profile of hard rock was determined. Further to confirm their results, seismic survey was carried out at suitable intervals. In seismic survey, use of explosives was made and velocities of the shocks generated through various stratas were noted to establish depth of rock.

Two investigation reports viz. 'Interim Report on Geophysical Surveys' and 'Report on Preliminary Geotechnical Investigations' for Par-Tapi-Narmada link project of National Water Development Agency in the Dang and Valsad districts, Gujarat and Nasik district, Maharashtra were received from Geological Survey of India, Jaipur. As per these reports, the foundation rocks of the 5 dam sites viz. Dabdar, Chikkar, Kelwan, Chasmandva and Jheri for which investigations were carried out are mainly vesicular and amygdular basalts, which contain amygdules of zeolites calcite and green-earth and occasional presence of redbole beds. The foundation rocks have a unconfined compressive strength (UCS) ranging between 807.46 M. Pa to 207.32 M.Pa porosity 3.83% to 0.55% and specific gravity 3.0 to 2.36.

At the Dabdar site, photogeological studies have indicated presence of tight joints. It, however, could not indicate presence of a burried channel on the right bank as established by geophysical traverses and confirmed buy exploratory bore hole DBR-2. Tentative foundation grade has been suggested between 7.62 m (R.L.105.735 m) and 24.7 m (R.L.98.67 m) in hard massive basalt.

At the Chikkar dam site, dolerite dykes parallel to dam axis have been picked up on air-photo and also in the large scale geological mapping. A dyke which is about 200 mm downstream of proposed axis is anticipated to arrest retrogression. In the riverbed, piezometric conditions are observed in BH-1. Photogeological studies suggest that this probably is due to a lineament

extending about 3 km upstream. The depth to bed rock varies from 7.0 m to 8.0 m. Tentative foundation grade has been suggested at 10.66 m (R.L. 143.947 m) in fresh, hard compact, basalt. The proposal to locate spillway in saddle has been advised to assess for engineering feasibility.

At Kelwan dam site, the photogeological studies have picked up a 3 m wide shear zone affecting the left abutment besides NEW – SSW trending faults. Geophysical traverses have shown that the depth to bed rock varies between 2.5 m to 10.0 m. Although 5 exploratory bore holes have been drilled about 14 years back. The cores are not available for logging. These bore holes have indicated a tentative foundation grade between 2.5 m and 8.5 m depth. Geological mapping has established presence of major shear zone in the left abutment and on the downstream, where a water fall exists. A possibility of retrogression along these shear zone/lineament exists.

At Chasmandva dam site, photogeological studies have suggested that the water-fall on the downstream is along a master joint extendign along the left bank at dam axis. Geophysical traverses have shown that bed rock is at 3.0 m – 18.5 m depth along dam axis and 2.5 m – 18.5 m at the stilling basin site. No exploratory drilling could be carried out at Chasmandva dam site due to resistance from local people.

At Jheri dam site, photogeological studies have indicated a very low frequency of joints which are tight. Geophysical traverses indicate that the depth to bed-rock varies from 2.9 m -2.0 m along dam axis and 3.0 m – 21.5 m at the stilling basin site. Large scale mapping have brought out that the foundation rocks are traversed by a number of minor shear zone. Tentative foundation grade has been suggested between 2 m and 7 m.

The paikhed and Mohankavchali dam sites could not be geophysically and engineering geologically examined due to resistance from local people.

4.3 Hydrological and meteorological investigation

There are number of gauge and discharge sites, maintained by CWC and Govt. of Gujarat within the basins of west flowing rivers. Similarly, there are also a number of raingauge stations in and around these basins. These raingauge stations are maintained by either IMD or the State Government. So, G&D and rainfall data of selected sites were collected for a number of years and use of these data was made. However G&D data of following four sites were used for developing unit hydrographs for the sites and estimation of design flood at various dam sites on proportionate catchment area basis :

1. Kalibel G&D site on Purna river for Kelwan dam site.
2. Unai G&D site on Kapri river for Dabdar and Chikkar dam sites.
3. Amba G&D site on Tan river for Chasmandva dam site.
4. Nanivahial G&D site on Par river for Jheri, Mohankavchali and Paikhed dam sites.

Most of the G&D sites, as indicated above are located very much in the downstream of the dam sites. It was therefore, felt necessary to make hydrological observations on some of the rivers near dam sites. Accordingly, following three new G&D sites were established in the year 1992.

1. Veribhavada site on Par river (in the d/s of Mohankavchali dam site).
 2. Paikhed site on Nar river (in the d/s Paikhed dam site).
 3. Kilad site on Ambica river (in the d/s of Chikkar dam site).
- Hourly gauge readings during monsoon season of the year 1992 and 1993 were observed at these three sites. In addition to this, discharge observations were carried out at these sites based on area-velocity method.

4.4 Construction material investigation

For construction of concrete dams and weirs, cement, sand, gravel rubble, steel etc. will be required whereas for construction of earthen dam suitable soils for hearting and casing zones and other materials such as sand and gravel for filter and rubble for upstream pitching and downstream toe will be required. Similarly these materials will also be required for construction of canals of 400.00 km length and construction of cross drainage structures along link canal. Keeping these facts in view necessary surveys have been conducted by NWDA for construction materials in case of Jheri dam site. For remaining dam sites information furnished in State Government's publication (districtwise) viz. 'Use of local materials for construction' and information collected from Gujarat Engineering Research Institute (GERI) have been utilised. Details regarding different construction materials are furnished in the following paragraphs.

4.4.1 Soils

For earthen dam portion, hearting and casing materials are required. In general it was observed during investigation that impervious soil required for hearting material is available in ample quantities near almost all dam sites. However, there is a problem for casing materials. Total 42 nos. of soil samples were collected from borrow pits of Kelwan, Chikkar, Chasmandva and Paikhed reservoir sites and tested by Gujarat Engineering Research Institute.

4.4.2 Sand and gravel

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 Mohankavchali and Paikhed dam sites, the lead varies from 2 to 35 km. These materials are suitable for filter materials and for concrete constructions in the spill way and dam portion. The percentage passing on 4.75 mm size sieve and 0.06 mm size sieve are 81.75 and 73.4 respectively.

4.4.3 Rock and aggregates

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, except for Mohankavchali site where the lead may extend upto 9 km. Crushers can be installed near the dam sites to make coarse aggregates. In addition to the stones available from quarries, advantage could be taken of the stones and boulders blasted from the banks and foundation of the dam sites. The type of stone available in the area of Par-Tapi-Narmada link is mainly basalt.

In addition to above, a number of crushers are located along the link canal. The required quantities of coarse aggregate can be supplied through these crushers. On enquiry, it has been found that Sardar Sarovar Project Authorities are using small size gravel (20 mm) instead of coarse aggregate in Narmada Canal System. So, the same material can be used in Tapi-narmada portion of Par-Tapi-Narmada Link as it will involve only sieving instead of crushing. The remaining requirement can be fulfilled from the nearby quarries.

4.4.4 Bricks

Soils of suitable quality for manufacture of bricks is available at many places near the link alignment. So, availability of bricks in the districts of Valsad, Surat, Bharuch and Vadodara for construction of residential and office accommodation will not be a problem. Samples of bricks from different kilns in Bharuch, Surat and Valsad districts were collected and tested in GERI laboratory at Vadodara for developing suitable specifications for bricks in this region. The bricks in general are well shaped reddish brown colour and give clear ringing sound. They do not break when released from a height of 1.5 m on the ground. The mean values of compressive strength, flexural strength and percentage water absorption in respect of bricks of Valsad, Surat and Bharuch districts, are given in GERI's publication "Use of local materials for construction, Series of District Reports No. 8" .

4.4.5 Puzzolona

Though the use of Puzzolonic materials has not been considered, if necessary, the same can be obtained from Bharuch and Surat districts. A good quantity of shale, a puzzolonic material is available in the vicinity of Narmada dam site i.e. at places Baharphalia, Limdi, Navgam and Bhadarva. Similarly, the soil available on the left bank in the downstream of Ukai dam in Surat district can be burnt for making burnt clay puzzolona. This puzzolona has been used in cement mortar for the construction of Ukai dam across river Tapi.

4.4.6 Cement

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. Later the cement bags collected at Vyara can be transported to Chikkar, Dabdar and Kelwan sites by road, whereas cement bags collected at Valsad can be transported to remaining other sites. Since requirement of cement for all the seven dam sites and other structures will be considerably high, the cement can also be procured from other factories located at Ahmedabad and Mumbai etc.

4.4.7 Steel

Steel procured from outside can be collected at Valsad, Bilimora and Vyara Railway Stations for further transshipment by road to the construction site. For Tapi-Narmada portion, Cement and Steel can be collected at Bharuch Railway Station, because the main consumption of these items in this portion will be in the construction of aqueduct across river Narmada.

4.4.8 Other materials

Apart from above, there will be many other items such as Asbestos sheet, CGI sheet, Coal tar, wood, Paint etc. which will be required for construction of temporary sheds, approach road etc. All such items are available at different places along the link canal.

4.5 Archaeological surveys

The area likely to be submerged under this link project is not having any historical monuments or structures of archaeological importance as per the report received from the Superintending Archaeologist, Archaeological Survey of India, Vadodara. However, necessary provision for a museum has been

made in the estimate so that if any important item is found during construction, the same can be kept in it.

4.6 Communication surveys

All the dam sites of this link are approachable through pucca/kachcha roads. Similarly, the command area and link canals are also approachable through various state highways and village roads.

4.7 Submergence under reservoirs

Due to the construction of 7 reservoir, a total no. of 75 villages will be affected out of which 24 will be submerged fully and the rest will get partly affected. The total population that would require to be resettled is about 14832. The total submergence area under all reservoirs will be 7559 ha, out of which 3572 ha is under forests, while 2850 ha is culturable area and 1137 ha is under river portion.