Chapter – 6
Design Aspects

6.0 General

The Ponnaiyar (Nedungal) – Palar intra-state link canal envisages diversion of 86 Mm^3 of flood water of existing Krishnagiri Dam located across Ponnaiyar river. The diversion of water is proposed during monsoon months (October to December) during floods to stabilise the tank irrigation and recharging the ground water along en-route and in Palar river course. The total quantum of water diversion proposed is 86 Mm^3 with peak discharge of 68 cumec. The main components of the link project are:

1. Existing Nedungal anicut on Ponnaiyar river 16 km D/S of existing Krishnagiri dam
2. Proposed head regulator on left flank of Nedungal anicut
3. New unlined canal of 54.15 km length.
4. En-route structures along the link canal

6.1 Details of Existing Nedungal Anicut on River Ponnaiyar

The existing Nedungal anicut consists of body wall without shutters over crest. The anicut was constructed during 1887-88. The catchment area of Ponnaiyar river at Nedungal Anicut is 5694 sq.km. The total length and the crest level of anicut is 278.0 m and 434.71 m respectively. The new scouring sluices were constructed during 1938 at about 27.0 m from the extreme edge on left flank. 2 low level vents of 1.83 m x 2.13 m and another 2 vents of 1.83 m x 1.98 m are provided. The crest level of low level vents is 432.58 m and that of high level vent is 432.73 m. The scouring sluices are provided with screw gearing shutters. The historic flood is recorded on 11-11-1903 with observed level of 438.26 m and corresponding discharge of 3041 cumec.

At the extreme end on left flank, a head sluice to supply water to Barur tank is provided. The head sluice consists of 4 vents of 1.83 m x 1.52 m. The sill level of Barur head sluice is 433.16 m. Another canal namely Agaram canal off takes from the right flank of anicut. It consists of 2 vents of 1.53 m x 0.62 m in size with sill level of 432.70 m.

Layout Plans of Krishnagiri Reservoir Project and Nedungal Anicut are shown in **Plates-6.1 and 6.3** respectively. The Plan showing the masonry dam of Krishnagiri Reservoir Project is placed at **Plate-6.2.**

6.2 Head Regulator

The head regulator is proposed to be constructed about 60 m upstream of Nedungal anicut on left flank. The location is so chosen not to affect the drawal of water to Barur canal. The head regulator will be 21.5 m long with 5 vents. The vent sizes will be 3.3 m wide and 2.0 m height with piers thickness of 1.25 m. The regulator sill level and pond level are considered as 433.00 m and 434.68 m respectively. The link canal is proposed to be operated during surplus spills from Krishnagiri dam. To economise the cost of offtake structure it is considered 0.3 m as normal flood level over crest available for diversion during spill. Thus the sill level of head regulator and pond level in front of head regulator is considered as 433.0 m and 435.01 m respectively. The regulator is designed for 68 cumec discharge.

The under sluices of anicut and Barur canal off take regulator are located 60 m D/S of proposed regulator. River deep channel is located abutting to left bank. The river scouring sluices are also to be operated to release the D/S requirement in tandem. Hence it is assumed that almost silt free water is available for canal and accordingly silt ejector/excluders are not considered in the main canal.

Fixed Wheel Type Vertical Lift service gates are proposed for head regulator. The size of service gates shall be 3300 mm X 2000 mm. The service gates shall be provided with downstream skin plate and downstream sealing's. The gates shall be operated by screw type hoist consisting of supporting structure, platform, ladder etc. One stop log gate having 2 sets of elements shall be provided to carry out the maintenance of service gates. The stop log shall be provided with downstream skin plate and downstream sealing's.

The detailed design of head regulator and its service gates are shown at **Annexure: 6.1 to 6.1.5** and relevant drawings are shown at **Plate 6.4 and Plate 6.4.1.**

6.3 Link Canal

The Ponnaiyar (Nedungal) - Palar intrastate link canal is proposed to off take from the existing Nedungal anicut located at 16 km D/S of Krishnagiri dam on Ponnaiyar. The total length of link canal is 54.15 km. The canal is proposed to divert 86 Mm^3 flood water of Krishnagiri dam to recharge ground water en-route and at the tail end in Palar basin for stabilization of tank irrigation. Hence the canal is proposed to be unlined to facilitate ground water recharge. The canal section is 25 m wide and 2.45 m full supply depth and trapezoidal in section. The bed slope of the canal will be 1: 4500 and side slope

will be 1 Vertical to 1.5 Horizontal. The canal is uniform in section throughout its length in order to transfer more water to Palar river. The design of canal section is furnished at **Annexure: 6.2**. A Number of cross drainage structures and various road bridges are proposed en-route the canal which are described in the following Paras.

6.3.1 Canal Alignment

The alignment of the proposed Ponnaiyar (Nedungal) - Palar intrastate link canal is firmed up on the basis of actual field surveys. The alignment consists of straight lines and circular curves as per clause of IS Code 5968: "Guidelines for planning and lay out of canal system". Keeping in view these guidelines, 300 m radius of curve have been proposed for canal alignment.

The canal is proposed as gravity canal throughout its length. The proposed canal alignment passes through full cutting, partial cutting, partial embankment and in full filling sections. The canal crosses a number of rivers, existing feeder canals of system tanks, roads, railway line etc., therefore, provisions of cross drainage/ masonry structures have been made at each crossing. One cross regulator coupled with canal escape is also proposed for safety of canal. An outfall regulator at tail end is also provided.

The head losses of all major CD/CM structures have been computed for firming up the link alignment. The list of CD structures showing location, type of CD works, FSL at various points, head losses due to various CD structures etc., are furnished in **Annexure 6.3.**

The Ponnaiyar (Nedungal) - Palar intrastate link canal will finally outfall into Godd Ar (Kal Ar, a tributary of Palar) near village Makhanpur of district Vellore at RD 54.15 km. Alignment of the link canal is shown in **Plates 6.5.1 to 6.5.3.**

6.3.2 Design Discharge of Canal at Off take Point

The design discharge of link canal is so firmed so as to pass maximum discharge throughout its length. Though 10 Nos. of outlets are proposed along the canal to stabilize the tank irrigation en-route, the uniform section of canal is considered to divert maximum quantum of water to Palar when all the tanks remain full. The discharge through each outlet along the canal at different RDs is given in **Table 6.1.**

Table 6.1

Firming up of Discharges

Sl. No.	RD in km	Outlet No.	Command area of tanks to be stabilized (ha)	Utilisation @ delta 0.911 m (Mm^3)	No of days considered for diversion	Discharge (cumec)
1	14.00	1	260	2.37	5	5.49
2	26.90	2	39	0.36	2	2.08
3	27.50	3	14	0.13	2	0.75
4	29.58	4	943	5.59	10	6.47
5	36.40	5	120	1.09	4	3.15
6	40.60	6	112	1.02	4	2.95
7	42.40	7	30	0.27	2	1.56
8	43.75	8	198	1.80	4	5.21
9	45.49	9	133	1.21	4	3.50
10	51.25	10	51	0.46	2	2.66

6.4 Designs

6.4.1 Head Works

The existing Nedungal anicut is proposed to be used without any remodeling. The link canal will off-take from the left flank of existing Nedungal Anicut. The proposed Head Regulator at Nedungal Anicut is 21.5 m long with 5 nos. of gates of size 3.3 m width and 2.0 m height. The design discharge of regulator is 68 cumec. The offtake FSL of canal will be 434.45 m.

6.4.2 Design Aspects of Link Canal

6.4.2.1 Cross Section of Canal

The design of canal cross sections have been done as per provisions laid down in the manual on Irrigation and Power Channels (March 1984) published by CWC and BIS: 7112/2002. The required canal section for passing peak discharge of 68 cumec is found to be 25.0 m bed width and 2.45 m full supply depth. The assumptions and relevant literature considered for design are given below.

6.4.2.2 Manning's Co-efficient (n)

The excavated canal is assumed to be formed with gravel, uniform section and free from weed growth. The corresponding normal value of rugosity co-efficient for the above formation in BIS: 7112/2002 is shown as 0.025. The same value is proposed to be adopted for design of canal.

6.4.2.3 Shape

The shape of the canal has been selected as trapezoidal section of uniform size throughout the reach.

6.4.2.4 Side Slope

The material for construction of canal available en-route is red soil/murum in embankment and soil to disintegrated rock and hard rock in cutting. The minimum slope to be adopted for unlined canal for various type of materials are given in **Table 6.2.**

Table: 6.2

Recommended Side Slopes for the Unlined Canals

Sl. No.	Type of soil	Side slope (Horizontal: Vertical)	
		In cutting	In filling
1	Very light loose sand to average sandy soil	1.5 : 1 to 2:1	2:1 to 3:1
2	Sandy loam, loamy soil and similar soil	1:1 to 2 :1	1:1 to 2 :1
3	Sandy gravel / murum	1:1	1.5:1 to 2:1
4	Murum, hard soil	0.75:1, to 1.5 :1	2:1 to 3.5:1
5	Rock	0.25:1 to 0.5:1	0.25:1 to 0.5:1

The side slope of canal is adopted depending upon the physical properties of material viz., angle of repose, etc. It is proposed to adopt the side slopes of 1.5:1 to 0.5:1 for canal in cutting depending upon the nature of material available during excavation like soil, disintegrated rock and hard rock. The berm of 2.0 m width is also provided on each side wherever the change of values of side slope occurs or depth of cutting exceeds about 6.0 m. In embankment section, a uniform side slope of 1.5:1 for inner side and 2:1 for outer slope is considered. The berm width of 2.0 m on outer slope is also considered at every 6.0 m height of embankment. The sections of canal in filling at RD 24306 m, in deep cutting at RD 28700 m and in partial cutting and partial filling at RD 11400 m are given in **Plate: 6.6.**

6.4.2.5 Free Board

As per Clause 4.3 of BIS: 7112 -2002: "Criteria for design of unlined canals in alluvial Soil" the value of free board is considered as 0.75 m as the discharge of canal is more than 10 cumec.

6.4.2.6 Bed Slope

Bed slope of the link canal has been considered as 1 in 4,500 throughout the canal length based on economic consideration and level at outfall at Kal Ar, a tributary of Palar River.

6.4.2.7 Top width of Bank

As per BIS: 7112-2002, the general recommendations of top width of the bank are as given in **Table 6.3.**

Table 6.3

Top Width of Bank of Canal

Discharge (cumec)	Minimum top width of bank (m)	
	For inspection road	For non-inspection bank
0.15 to 7.5	5.0	1.5
7.5 to 10.0	5.0	2.5
10.0 to 15.0	6.0	2.5
15.0 to 30.0	7.0	3.5

The canal discharge is more than 30 cumec. As such the minimum bank width specified (8.0 m for inspection bank and 5.0 m non inspection bank) in the manual of Irrigation and Power Channel (March 1984) of CWC publication is provided. The inspection road is provided on right bank as the outlets are proposed in the right bank of the link canal.

The size of dowel is considered as 0.5 m top width and 0.5 m height with side slope of 1.5:1.

6.4.3 Description of Soil Profile along the Canal Alignment based on Geo-physical Investigation

The geo-physical investigation was carried out by the National Geophysical Research Institute (NGRI) Hyderabad. The Electrical Resistivity Tomography (ERT) was carried out at a spacing of 0.5 km along the entire length of canal. Eight major CD/CM structures were also covered at different RD locations separately. It is seen that in general the top soils are red sandy soil to red sandy clayey soil of about 1.0 m depth for entire length. Below top soil, a highly weathered, semi-weathered/ fractured formation was encountered with hard rock as basement. The weathered/ fractured formation is seen to a maximum depth upto 17.0 m and hard rock to a maximum depth upto 10.5 m along the canal alignment. In addition, disturbed and undisturbed soil samples were collected along the link alignment. The undisturbed samples (100 mm dia) in core cutters and disturbed samples in gunny bags were collected from different pits for determination of their Index and engineering characteristics at laboratory. These pits were excavated to various depths along the canal at suitable locations as suggested by the CSMRS field parties.

6.4.4 Evaluation of the Design Parameters based on the Samples Collected along the Canal Alignment, Borrow Area and Suggested Treatment for Problematic Reaches

The link canal has been designed in such a way that it carries the required discharge with safety, economy and efficiency. For this purpose the following design-criteria based on the relevant provisions of IS codes, and established design practices is adopted.

1. Non-silting non scouring velocities should be generated for efficient sediment transport.
2. The system should be flexible to cater to any combination of requirement of irrigation of en-route command and water transfer.
3. The transmission losses should be minimum.
4. The canal should not overtop in any reach and hydraulic gradient line should be well below 0.3 m from the exposed section.
5. Designed discharge should be available at all the outlets at designed water level.
6. Deep cutting or high embankments are to be avoided and cutting and filling should be balanced as far as possible.
7. Head loss due to various structure and section resistance should be minimum and compatible with design etc.,

6.4.5 Backwater Effect

The link canal is proposed to be operated in monsoon months during flood from Krishnagiri dam and also when Palar and its tributaries are not in spate. An outfall structure is proposed at tail end of the canal. FSL of canal at tail end is well above the firm bank level of Kal Ar as such the back water effect due to Kal Ar flood is not anticipated.

6.4.6 Transmission Losses

The link canal is proposed to be unlined and planned to divert flood water through the link canal. The geophysical investigation carried out along the link canal indicates the top soil is covered by red earth for a depth of 1.0 m followed by disintegrated rock/murum and hard rock. Considering an average transmission losses at the rate of 2.50 cumec per million sq.m of wetted area of canal as specified in the Manual on Irrigation and Power Channel (March, 1984) of Central Water Commission, the total transmission loss for entire length of canal works out to 6.977 Mm^3.

6.4.7 Canal Structures across Link Canal

A number of structures are proposed in link canal from its off take point to its outfall. Brief descriptions of these structures are furnished in following paras.

6.4.7.1 Cross Regulators / Canal Regulators

The Ponnaiyar (Nedungal) - Palar link canal will finally outfall into Godd Ar of Kal Ar, a tributary of Palar near Makhanpur village of Vellore district. The FSL of canal at outfall point is well above the firm bank level of Kal Ar as such no back water effect due to Kal Ar flood is anticipated. Moreover, the Godd Ar river can accommodate the required canal discharge at outfall. However, a minor modifications have to be done in certain reaches of Godd Ar river to pass the discharge smoothly in to Palar river.

Two cross regulators will be provided on the link canal, one at RD 29.55 km and another at 53.584 km at outfall point. The cross regulator at RD 29.55 km is coupled with canal escape where as the outfall regulator is coupled with single lane bridge.

The cross regulators are provided for the following functions:

1. To ensure pond level in front of head regulator so that the desired quantity of water may be diverted to the requisite purpose.
2. To enable maintenance of a particular stretch of the canal.
3. To facilitate operation of canal escapes.

4. Efforts shall be made to combine bridges with the canal cross-regulators to effect economy.

Following design criteria has been adopted for design of canal cross regulators:

1. Cross regulator should cause minimum head loss for water flow through the canal. To fulfill this criteria sufficient waterway of the cross regulator shall be provided.
2. The cross regulator should be able to dissipate energy satisfactorily in the partial flow. To fulfill these criteria, stilling basin shall be provided.
3. The cross regulator should be able to withstand the uplift pressure. To fulfill these criteria, thickness of floor as well as pressure release valves shall be provided.
4. The cross regulator should be able to prevent piping. To fulfill this criteria sufficient length of floor is provided and cutoff wall is provided.
5. Upstream and Downstream protection. The cross regulator should be strong enough to with stand the various hydraulic forces due to water flowing over and below it. The canal section is lined on the upstream and downstream for a distance of 50 m.

5 vents of 4 m width and pier thickness of 1.25 m are considered for the design of cross regulator. The bed level of the canal is lowered by 20 cm in the D/S of cross regulator. Fixed Wheel Type Vertical Lift service gate is proposed to be provided in each cross regulator. Size of service gates shall be 4000 mm X 2450 mm. The service gates shall be provided with downstream skin plate and downstream sealing's. Wedge type seal shall be provided for bottom sealing and music note solid bulb seals shall be provided for side sealing's. The gate structure shall consist of skin plate stiffened by vertical stiffeners and horizontal girders. The gates shall be operated by screw type hoist consisting of supporting structure, platform, ladder etc. No stop logs gates are provided. In addition an operating platform of 2.0 m width is also provided for inspection of regulators.

The outlets are proposed to release water to the streams which cater the system of tanks en-route. The operation of outlets depends on the quantum of water to be released. The locations of outlets and the capacity of outlet structures proposed to be provided are shown at **Table-6.1**. It is proposed to provide RCC pipes/boxes for outlets depending upon the discharge with suitable operating mechanism. The requirement of water to be released at RD 29.55 km (outlet structure) will be served by the canal escape as such no additional structure is needed.

The design of cross regulator and its service gates at RD 29.550 km and outfall regulator cum road at RD 53.584 km and design of outlet proposed at RD 43.750 km are given in **Annexure-6.4 to Annexure-6.6** respectively**.** The plan and sectional elevation of the cross regulator cum canal escape at RD 29.550 km are given at **Plates-6.7.1** and **6.7.2.** General installation of Cross regulator Service gate is given as **Plate – 6.7.3.** The plan and section of proposed Outfall regulator cum SLRB at RD 53.584 km and Canal outlet at RD 43.750 km are given at **Plates-6.8 and 6.9** respectively.

6.5 Cross Drainage Works

The link canal is predominantly contour canal. It crosses several streams, existing feeder canals for system tanks and several roads. The type of cross drainage works depends upon the catchment area of the streams and its bed level with reference to the bed level of the canal it crosses.

A minor bridge shall be combined with every Aqueduct and Cross Regulator to ensure at least one passing over. Besides, other independent bridges are proposed across the length of the link canal. The brief description of the structures provided in the link canal is as given below:

6.5.1 Aqueducts

Aqueduct has been provided if the HFL of the drain is lower than the canal bed. The canal discharge remains same and the design of canal trough size for all aqueducts is also kept same. The canal bed width is flumed from 25.0 m to 15.7 m for economical consideration. 3 Nos. of troughs having 5.0 m clear width and 3.3 m height are considered. The troughs are supported by piers. The length of the aqueduct is kept to a maximum of (i) width of river bank to bank and (ii) Lacey's water way. Road with carriage way of 4.5 m width is proposed on the right side of trough. The intermittent walls will be 0.35 m thick whereas end walls are considered 0.5 m thick. Suitable contraction and expansion transitions are also provided. 6 Nos. of aqueducts are proposed along the canal. The design of aqueducts at RDs 18.205 km, 29.581 km and 45.490 km are shown at **Annexure-6.7.1, 6.7.2 and 6.7.3** and plans and sectional elevations are depicted at **Plate-6.10.1, 6.10.2 and 6.10.3** respectively.

6.5.2 Canal Syphon

Canal syphon has been provided if the FSL of the canal is sufficiently above the bed level of the drainage trough, so that any one of the flows shall be put

under syphon action. However while deciding the canal syphon, other factors like topography of the terrain, regime of the stream, dewatering requirements, ratio of design flood of drainage to canal discharge, head losses and sediment load in drainage etc have also been considered. Normally canal siphons have been provided in place of syphon aqueduct as the canal waters are mostly free from floating debris and silt free which will not clog the barrel. The canal discharge remains same and the size of syphon barrel for all canal syphons is kept same. The canal is flumed from 25.0 m bed width to 15.7 m for economical consideration. 3 Nos. of barrel having 5.0 m clear width and 2.75 m height are considered. The length of the canal syphon is kept to maximum of (i) width of river bank to bank and (ii) Lacey's water way. The barrels will be box type and thickness of member will be 0.35 m. Suitable contraction and expansion transitions are also provided. The transition barrel length is considered the maximum length derived for (i) horizontal transition and (ii) vertical transition. 6 Nos. of canal syphons are proposed along the canal. The design of canal syphons at RDs 36.207 km, 39.060 km and 42.890 km shown at **Annexure-6.8.1, 6.8.2 and 6.8.3** and plans and sectional elevations are depicted at **Plate-6.11.1, 6.11.2 and 6.11.3**.

6.5.3 Super Passages

Super passages are provided if the canal FSL is well below the river bed at canal crossing. The canal discharge remains same and the design of barrel sizes for all super passages is kept same. The canal bed width is flumed from 25.0 m to 14.2 m for economical consideration. 3 Nos. of barrel having 4.5 m clear width is considered. The height of barrel depends on the canal bed level minus 0.6 m thick earth cushion over barrel roof. The width of the super passage is kept to maximum of (i) width of river bank to bank and (ii) Lacey's water way. The thickness of barrel will be 0.35 m. Suitable contraction and expansion transitions are also provided. 2 Nos**.** of Super passages are proposed along the canal. The design of super passage at RDs 38.005 km and 41.343 km are shown at **Annexure-6.9.1 and 6.9.2** and plans and sectional elevations are depicted at **Plate-6.12.1 and 6.12.2.**

6.5.4 Under Tunnels/ Elevated Trough

The under tunnels / elevated troughs will be provided where the link canal crosses the small streams having less discharge. The link canal crosses nos. of minor feeder canals connecting system tanks which have very less discharge. It is proposed to provide under tunnel for feeder canals where the link canal bed is considerably above FSL/Bed of

feeder canal. The elevated trough is provided where the feeder canal is sufficiently above FSL of the link canal. The Nos. and size of pipes/ boxes in RCC below canal or trough above canal depends on discharge of canal. The design of under tunnels at RDs 24.306 km, 36.108 km and 51.358 km are shown at **Annexure-6.10.1, 6.10.2 and 6.10.3** and plans and sectional elevations are depicted as **Plate-6.13.1, 6.13.2 and 6.13.3**

6.5.5 Bridges

Total 34 road bridges are proposed along the length of the canal. Loss of head of 0.01 m is considered at each bridge. The double lane bridge is designed for the carriage way of 7.5 m width and IRC Class A loading. The single lane bridge is designed for the carriage way width of 4.5 m with lesser class of loading. Typical design of road bridge at RD 52.434 km for double lane is shown in **Annexure-6.11** and drawing is given in **Plate-6.14**.

A railway line also crosses the link at RD 51.530 km where a canal syphon is provided against bridge in view of FSL of link canal and track level remains same. Plan and sectional elevation of canal syphon at railway crossing are depicted as **Plate-6.15.**

6.5.6 Canal Escape

One canal escape is proposed at RD 29.550 km. The canal escape is coupled with cross regulator. The escape is provided to take care of the vulnerable embankment reaches by diverting the canal flows into the nearby stream in case of any danger of breach in embankment. The capacity of escape is designed for half of the designed discharge i.e., 34 cumec. The canal escape will also serve as one of the outlet to release water through river course to benefit the system tanks lying downstream of canal crossing. The design of escape is similar to head regulator. The design details are shown at **Annexure 6.12** and its plan and sectional elevation are depicted as **Plates- 6.7.1 and 6.7.2.**

6.6 Infrastructure Studies

Almost entire area of the project is well connected with road network and railways net work. No constraints on transportation of heavy equipment upto project site are envisaged as the area is well connected by NH-45 which can bear class-A loading.

6.7 Navigation and Tourism Development

There is no provision for development of navigation aspect in the project, since the diversion of water through the link canal is proposed during the duration of flood only i.e. for 18 days in a year.

6.8 Operation and Maintenance

The proposed organizational set up at the construction stage can be used for operation and maintenance of the project. The entire operation and maintenance will be looked after by one Executive Engineer along with sufficient support staff. A suitable operation and maintenance programme has to be developed for fulfilling the various objectives of the project.