Chapter 4
Surveys and Investigations

4.1 Topographical Surveys

4.1.1 Canal and Canal Structures

The centre line of the link canal marked on 1:50000 scale toposheets of Survey of India, is transferred to the ground by measuring the bearings of the alignment on the toposheets and then setting them on ground with the help of compass/ theodolite. The topographical surveys by conventional methods for a length of about 221 km of the main canal i.e. from Warangal – Mulug road to its out fall point, (Nagarjunasagar reservoir), out of the total length about 299.256 km and for the lead canal of length about 21.85 km were taken up and have been completed by NWDA. The initial reach of about 78.35 km i.e. from its off-take point in the foreshore of Inchampalli reservoir to Warangal - Mulug road crossing was not approachable since the alignment of the canal in this reach is passing through dense and protected forests and highly infested by extremist activists. Hence, it was decided that the topographical surveys and contour mapping of the entire canal and the intermediate reservoirs proposed along the alignment should be carried out by aerial photogrammetric techniques as a pilot project and the work has been awarded to NRSA.

Along the centre line of the link canal so transferred to the ground, levels are taken at 200 m interval from RD 78.35 km to the tail end by double levelling. The double levelling carried out was checked for its accuracy by connecting to the GTS benchmarks available along the alignment.

Cross sections are taken at 400 m interval along the alignment with levels at 100 m interval extending upto 200 m on either side of the alignment. Wherever appreciable change in topography is noticed levels are taken at closer intervals.

Block levelling has been carried out at places where cross drainage works are proposed by forming 50 m or less interval grid lines to cover an area upto 300 m on either side of the centre line of the link canal along the stream and laterally upto the firm bank plus 100 m on either bank of the stream. Similarly, block levelling by forming 50 m interval grids was done at road/railway crossings along the alignment, covering an area

upto 300 m on either side of the centre line of the link canal and 100 m either side from the centre line of the road/railway line.

Similar topographical surveys have been carried out for the lead canal which is proposed to transfer water from Inchampalli – Nagarjunasagar Link Canal to Kakatiya Canal Stage – II.

4.1.2 Pump House, Switch-yards etc.

Block levelling by conventional method has not been carried out by NWDA near the off-take point of the link canal pump house sites and intermediate reservoirs due to non approachability. However, the topographical surveys were entrusted to NRSA for the mapping of the area of the head works, area of the link canal and lead canal by aerial photogrammetry. NRSA has conducted grid survey of dam site (50 m grid basis) covering the upstream upto 250 m and downstream upto 500 m from the dam axis. (contour interval – 0.5 m for plain areas and 2 to 5 m for hilly areas). Grid survey for intermediate reservoirs namely Peddavagu, Lower Tummalagutta and Upper Tummalagutta have also been taken up by NRSA.

4.1.3 Tunnel

A tunnel of length 9.150 km has been proposed between RD 86.35 and 95.50 km where the link canal passes through the ridge between Godavari and Krishna basins. Block levelling has been carried out by forming 50 m grid lines extending upto 250 m on upstream and 250 m on downstream of in-let and exit of tunnel, extending upto 500 m on either side of the centre line of the tunnel. Levels at 200 m interval were taken for the complete length along the centre line of tunnel.

4.1.4 Command Area

No new command area is proposed under this link canal, and as such command area surveys were not carried out by NWDA. It caters only to the ongoing command areas proposed by Govt. of Andhra Pradesh under the Kakatiya Canal Stage – II of the SRSP Stage-II and Srisailam Left Bank Canal. Necessary command area surveys have been carried out by the designated state Govt. agencies. The details are discussed in Chapter on “Water and Irrigation Planning”.

4.2 Soil Conservation, Archaeological and Mineral Surveys

It is envisaged to construct two intermediate reservoirs at RD 13.5 km (Peddavagu), RD 26.5 km Thummalagutta (Lower and Upper). Archaeological and mineral surveys and surveys for soil conservation as required in case of these reservoirs were not undertaken as these reservoirs are very small in area and were proposed as balancing reservoirs to take advantage of the topography along the canal and also as the alignment is not passing through the mineral and archaeological areas.

4.3 Geology and Geo-technical Features

The Geological Survey of India (GSI) was entrusted with the work of preparation of preliminary geological report of the link canal to derive the general geology of the link. The report has been finalised by the GSI after extensive field investigations by their Geologists, of the areas along the alignment of link canal and the lead canal. Geological mapping of the proposed tunnel alignment and link alignment were carried out during the investigations.

The geological inferences of the above investigations, as enunciated by the GSI in their report are enumerated in the following paras.

a) Link Alignment

Broadly, the Inchampalli – Nagarjunasagar Link Canal passes through three major geological domains, viz.

i) Gondwana Supergroup of rocks comprising pebbly / feldspathic Stand Stones, Ferruginous Sandstones, Siltstones, Shales and Dolomitic Limestones; and Sandstones belonging to Penganga group of rocks, collectively occupy the initial reach from chainage 0 to 55 km.

ii) Grey to dark grey coarse to very coarse-grained Granodiorite of Peninsular Gneissic Complex, between Chainage 55 and 102 km.

iii) Generally leucocratic, fine to medium grained Granite gneisses and Magmatities which contain xenoloths of older metamorphics, from chainage 102 km to the end point of the canal i.e. 299.256 km. Dolerite, Pegmatite and Quartz intrusive bodies were observed

only at a few places, mostly in this granitic suite of Peninsular Gneissic complex.

(b) Tunnel

A 16 m dia and 9.150 km long free flow tunnel with its invert levels at + 191.904 (inlet) and 190.074 m (outlet), is proposed between R.D. 86.350 and 95.500 km, in view of the deep excavations likely to be involved which are of the order of 50 to 60m. The tunnel alignment, in general, is covered with soil and scree material. The excavated dug well sections in the inlet portions, middle reaches and exit portions have exposed 9 to 11 m of weathered to moderately weathered and compact Granodiorite beneath a thin over burden of top soil cover and deeply decomposed kankar dominant soil.

(c) Lead Canal

The alignment of lead canal connecting the link to the Kakatiya canal is also located in a Granodiorite terrain. The sub-surface scenario is more or less the same i.e. weathered rock extending down to 11 to 13 m depth in general below 1 to 2 m thick overburden. Formation of embankment by filling in a major portion of the canal alignment is required.

(d) Conclusions of GSI Investigations

The preliminary evaluation of the data indicates that the sub-stratum is weathered down to depths ranging between 10 and 15m, below the ground level in general, irrespective of the two major rock types viz, Granodiorite and Granites and its variants, of the Peninsular Genissic Complex that would form the canal medium. Fresh rock is interpreted to be available below 10 to 15 and 17 m depth, in different stretches.

Two to three sets of moderately close to widely spaced vertical to sub-vertical joints and sub-horizontal sheet joints dissect the rock mass.

Barring the top 1 to 2 m of overburden and deeply disintegrated rock which is almost transformed into soil, the underlying weathered to highly weathered horizon with high incidence of kankar that extends down to 4 to 5 m depth, and the weathered to moderately weathered granite rock zone that was observed to a depth of 10 to 15 m, in almost all the dug

well sections, althrough the canal alignment, were observed to stand with near vertical to vertical stable slopes.

Fresh Granodiorite will be the tunnelling media at the proposed 16 m dia and 9.150km long free flow tunnel with its level of 191.904 m at the inlet and 190.074 m at the outlet in between R.D. 86.350 and 95.500 km. The sub-surface along the tunnel alignment will be in a weathered to moderately weathered rock, down to 11 to 15 m depth, followed by fairly fresh to fresh and hard Granodiorite.

The stream / river courses are covered with transported sandy overburden. The weathered bedrock is likely to be available below 5 to 6 m depth, in general, along the minor stream courses while, it is likely to be available at a depth of 10 to 12 m along the major river courses.

On the basis of the preliminary Geotechnical evaluation, it is considered that no sub-surface explorations are necessary along the major part of the I-N Link Canal alignment excepting to explore the proposed tunnel reach and aqueduct sites along the water courses crossing the canal alignment.

4.4 Geophysical Investigations along the Canal Alignment

To derive the sub-surface profile of the formations along the link alignment beyond RD 78.35 km, Geophysical investigations of the link canal have been assigned to National Geophysical Research Institute, Hyderabad. The objective of NGRI is to carry out geophysical investigations along the Godavari (Inchampalli) – Krishna (Nagarjunasagar) link canal alignment by conducting Vertical Electrical Soundings (VES) at 1.00 km interval to a depth extending to a little beyond the bed level of the canal, to determine the sub-surface lithology and to estimate the depth of bed rock. The investigations will cover a length of about 222 km along the main canal starting from RD 78.35 to 299.256 km where it outfalls into Nagarjunasagar reservoir and around 21 km along the lead canal i.e. canal interconnecting the link and Kakatiya canal of Sri Ram Sagar Project. These investigations will help in ascertaining the estimated quantities of earthwork accurately.

4.5 Construction Materials Investigation

Necessary borrow / quarry area surveys have been carried out for construction materials such as soils for embankments, fine aggregate and coarse aggregate etc. after identifying the locations of quarries and borrow areas in the vicinity.

4.5.1 Soils

Borrow Area Survey along the link canal alignment form part of the studies required for the feasibility report. The work of carrying out the Borrow Area Surveys along the proposed link alignment was entrusted to Andhra University, Visakhapatnam, Andhra Pradesh.

The objective of this survey is to carryout the Borrow Area Survey along the link canal alignment at selected locations identified as potential Borrow Areas in the vicinities of embankment reaches between R.D 78.350 and 299.256 km of the link canal. Representative bulk soil samples from the trial pits excavated have been collected in the potential Borrow Areas and laboratory tests have been conducted in order to ascertain their suitability for the construction of canal embankment.

Soil samples have been collected from trial pits excavated in the potential Borrow Areas at 500 m interval in general or change of strata. The number of soil samples to be collected for carrying out laboratory investigations have been decided based on inferences arrived by the visiting field party in consultation with NWDA. The following tests have been conducted in the laboratory for obtaining the required soil parameters.

a) Grain size analysis
b) Atterberg limit
c) Proctor density
d) Specific gravity
e) Direct shear
f) Triaxial shear
g) Chemical analysis

Soil samples have been collected from thirty-five borrow area pits identified along the length of the alignment and got tested in Andhra University, Visakhapatnam. The test results indicate that soils from most

of the identified borrow areas are generally suitable for embankment. It is estimated that about 64.40 Mm^3 of earth is available from these areas. The average lead is about 500 m.

4.5.2 Coarse / Fine Aggregate

Consultancy for the construction materials survey and laboratory testing of coarse and fine aggregate samples for ascertaining their suitability as construction materials for the proposed structures along the canal alignment was awarded to the Department of Civil Engineering, College of Engineering, Osmania University, Hyderabad.

The objective is to carryout the construction materials survey and collection of coarse and fine aggregate samples at the identified prospective quarry sites in the project area and testing the samples in their laboratory at Osmania University, Hyderabad to ascertain their suitability for use as coarse and fine aggregates respectively for the proposed structures along the Godavari (Inchampalli) – Krishna (Nagarjunasagar) link canal project.

The following tests have been carried out for construction materials by Osmania University, Hyderabad.

Coarse Aggregate	Fine aggregate
i) Specific Gravity	i) Specific Gravity
ii) Water Absorption	ii) Grading & Finess modules
iii) Aggregate Crushing value	iii) Silt and Clay content
iv) Aggregate Impact value	iv) Organic impurities
v) Los-Angeles Abrasion value	v) Petrographic analysis
vi) Soundness Loss value (5 cycles)	
vii) Petrographic analysis	

Twelve sites have been identified as potential sand quarries for the entire length of the link canal from Warangal – Mulug road crossing to Nagarjunasagar. These have been identified in the rivers Hallia, Akeru, Vattivagu, Muneru, Palleru, Tettevai vagu and Musi etc. The lead varies from 5 km to a maximum of 50 km. Samples have been collected one each from each site and were tested in the laboratories of Osmania University for their suitability. The total sand available from all the 12 quarries is about 41.24 Mm^3. Reach-wise comparison of quantity of sand

required and that available is worked out. The test results indicate that sand from most of the identified quarry sites are grossly homogenous and can be used for construction from 8 quarries out of 12 numbers so identified.

Fifteen stone quarries have been identified in the vicinity of link canal, which cumulatively yield 76.32 Mm^3 of stone. The samples collected were tested in the laboratories of Osmania University. The average lead from different quarries varies from 5 to 50 km to the respective canal reaches.

4.5.3 Bricks

Soils of suitable quality for manufacture of bricks and tiles for use in building construction are available along the entire length of canal alignment. Warangal, Suryapet and Nalgonda towns are famous for good quality bricks.

4.5.4 Cement and Steel

Cement manufactured by reputed companies located in the vicinity at Warangal, Suryapet and Nalgonda is proposed to be used. Cement and steel can be received at the railway stations located near the canal alignment i.e Warangal, K.Samudram and Nalgonda and transported to the site of construction.

4.6 Soil Surveys - Mapping of Existing Land Use/Land Cover and Irrigability

Govt. of A.P. has got conducted the soil surveys of SRSP command area through NRSA. Hence, NWDA has not taken up the soil surveys for the command area under Inchampalli – Nagarjunasagar link canal. The details of soil and land Irrigability classification of command under SLBC available from Govt. of A.P. are utilised. The details are discussed in Chapter on “Water and Irrigation Planning”. Red earths, red sandy soils and black cotton soils are the predominant soils available in the command.

4.7 Drainage Survey

The proposed enroute command area is well drained by rivers/streams like Maner, Muneru, Akeru, Musi, Palleru, and Hallia and also by a number of major/minor drains. As such, the proposed command area is

not likely to encounter any serious drainage problem. However, certain provisions are made in the estimate for providing drainage facilities in the command, though no detailed surveys were undertaken for the purpose. The available natural drainage system in the command area in the form of rivers, streams, nallas etc. will be utilised. Since the branch canals and major distributaries are planned as ridge canals, no major drainage problem is anticipated in the command area.

4.8 Communication Surveys

All the important structures of the Inchampalli – Nagarjunasagar link canal are approachable by pucca / kachcha roads. The National High way No. 9 and the Hyderbad – Guntur Railway line connecting Vijayawada passes through a part of the proposed command area. All the important villages/towns situated along the canal alignment and in the command area are well connected by telephone lines, power lines and wide network of roads. There can be further improvement in the communication system in the command area in the course of development in future. Inspection roads of major branch canals in the command area would lead to further improvement in the communication systems.

4.9 Hydrological and Meteorological Investigations

The data from hydrological and meteorological stations available in the command area were collected and used for computations and designs of the canal components. The details of these stations are given in the following paragraphs.

4.9.1 Hydrological Data

There are four Gauge and Discharge stations nearer to the link canal in the basins connected with the link canal. The Perur G&D site on Godavari, Somanpalli on Maner, Damarcherla on Musi and Pondugala on Krishna River. In addition to the above, outflows of SRSP and Nagarjunasagar project are also available.

4.9.2 Climate and Rainfall

The general climate in the area is characterized by a hot summer and general dryness except during the Southwest monsoon season. The year may be divided into four seasons. The cold season from December to

February is followed by the summer season from March to May. The period from June to September marks the monsoon season and contributes about 80% of the annual rainfall. October and November contribute the post-monsoon season or retreating monsoon season. On an average, there are about 46 rainy days i.e., days with rainfall of 2.5 mm or more in a year in the area.

4.9.3. Temperature

There is no meteorological observatory in the command area.The account which follows is based on the record of the observatories in the neighbouring areas, where similar Meteorological conditions prevail. From February, both day and night temperatures increase rapidly. May is the hottest month with mean daily maximum temperature at about 40^{o} C and with mean daily minimum temperature at about 20^{o} C. The day temperature may occasionally go to about 45^{o} C during May or in June, prior to the on set of the monsoon. From June the day temperatures drop appreciably. After October both the day and night temperatures decrease rapidly. December is the coldest month, with the mean daily maximum temperature at about 30^{o} C and the mean daily minimum at about 16^{o} C. On some days in the cold season, night temperature may drop down to 10^{o} C.

4.9.4 Relative Humidity

During the Southwest monsoon season, relative humidity is generally high. Humidity decreases from the post monsoon period. The driest part of the year is the summer season when the relative humidity in the afternoon is less than 35%.

4.9.5 Wind Speed

Winds are generally light with some strengthening in force during the later part of summer and early part of the monsoon season. In May and Southwest monsoon season, winds are predominantly westerly or northwesterly and during the period from October to February, winds from easterly direction are common. In the next two months, the morning winds are light and variable in direction and in the afternoons they are generally from the east or southwest.

4.9.6 Cloud Cover

During the Southwest monsoon season, the sky is mostly heavily clouded. The sky is generally clear or lightly clouded in the rest of the year.