

BOMBAY ELECTRIC GRID



REPORT

ON THE

HYDRO ELECTRIC RESOURCES

OF THE

KALINADI BASIN

BOMBAY PRESIDENCY

BY

ASSOCIATED CONSULTING ENGINEERS (INDIA)



DECEMBER, 1948.

BOMBAY & LONDON



NAGJIRI PIPE-LINE & POWER STATION



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KALINADI REPORT.

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No.

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 Plate 2. Supa Dam and Power Station.

APPENDIX I.

RESULTS OF PRELIMINARY BORING PROGRAMME

MAY 1947 TO MAY 1948.

A. Supa Dam Site.

Three core borings were drilled, a total of 156 feet. The borings revealed sound foundation conditions in the bed of the river and on the right bank near a cavernous lenticle of sideritic quartzite.

B. Bomanhalli Weir Sites.

Fiftyeight percussion bores were sunk, a total boring length of 1810 feet. Of these bores fourteen did not reach rockhead either because of the limited depth to which the rigs could bore, or else they landed on a boulder which could not be broken. Of the remaining bores, there are five doubtful cases where it cannot be stated with any certainty that rock was reached and not a boulder.

These borings reveal that particular care will be required in the final selection of the weir site and a considerable depth of overburden must be allowed for in its design.

C. Nagghiri Tunnel Site.

Four percussion bores were sunk along the preliminary tunnel line, a total of 110 feet of boring. Although rock was not reached in one bore at a depth of 40 feet, no undue difficulty is expected on this tunnel line due to lack of sufficient rock cover. The tunnel proper would be approached by open cut at the intake and as far as necessary to provide a satisfactory rock face from which driving operations could be undertaken.

APPENDIX II.

RAINFALL RECORDS USED FOR PREPARATION OF THE
ISOHYETAL MAP - FIGURE No. 3.

A. Department of Agriculture - Poona.

Supa - Monthly Rainfall	1876 - 1946
Haliyal - Monthly Rainfall	1875 - 1946
Karwar - Monthly Rainfall	1875 - 1946

These gauges are in the Kalinadi Basin. There are also long term monthly records from 9 gauges in adjacent catchment areas.

B. Customs.

Castle Rock - Annual Rainfall	1921 - 1946
Daily Rainfall	1940 - 1946

C. Madras and Southern Mahratta Railway.

Castle Rock - Daily Rainfall	1933 - 1946
Monthly Rainfall	1916 - 1920
Londa Monthly Rainfall	1939 - 1941
Daily Rainfall	1942 - 1946

D. Bombay Electric Grid.

Monthly rainfall at 30 gauges in the Kalinadi Basin. These records vary in duration from one to seven years and were taken only during the period from June to November.

E. Forest Department.

Dandeli - Daily Rainfall	1946
--------------------------	------

APPENDIX III.SILT SAMPLES TAKEN AT SUPA AND BOMANHALLI.

SUPA.

Date	Location		Total Depth D Ft.	Dry silt - Grammes per litre	
				at Depth 1'0" below Surface	at Depth 0.6 D Ft.
1.9.47	500 yds. upstream of con- fluence	I	32'	0.180'	0.177
		II	28'	0.190	0.180
		III	40'	0.170	0.183
4.9.47	½ mile upstream of con- fluence	I	25'	0.176	0.190
		II	20'	0.176	0.189
		III	30'	0.181	0.179
6.9.47	At con- fluence of Pandri and Kalinadi Rivers	I	18'	0.176	0.178
		II	20'	0.163	0.168
		III	22'	0.174	0.181
AVERAGE				0.176	0.180

LOCATION of samples.

I ... 15 feet from right bank
 II ... 5 feet from left bank
 III ... 10 feet from left bank

BOMANHALLI.

Date	Location	Dry silt - Grammes per litre at Depth 1'0" below surface.
30.8.47	Near Temporary River Gauge	0.062
31.8.47		0.072
1.9.47		0.072
2.9.47		0.074
3.9.47		0.070
4.9.47		0.072
5.9.47		0.065
6.9.47		0.071
AVERAGE		0.070

APPENDIX IV.

DETAILED STUDY OF ANNUAL COSTS
OF OPERATING THE HYDRO ELECTRIC STATIONS
AND ASSOCIATED LOCAL TRANSMISSION SYSTEM.

1. The annual cost of operating the hydro-electric stations and associated local transmission system may be broadly divided under the following headings :-

- (a) Interest on Capital.
- (b) Sinking Fund.
- (c) Rates and Taxes.
- (d) Operating Costs including Salaries and Wages.
- (e) Maintenance and Repairs.
- (f) Management.
- (g) Wayleaves for Transmission Line Right of Way.

2. An estimate of the operating costs under each of these headings is given below.

(a) Interest

It has been assumed that a loan will be obtained for the project and that interest will be payable thereon at the rate of $3\frac{1}{2}$ per cent. per annum. The total capital cost of the works, including interest during construction and other charges, is estimated at Rs. 39.28 crores for the ultimate development. The annual interest payment on the estimated capital expenditure for ultimate stage of development amount to Rs. 137.41 lakhs.

TABLE 18.

SUMMARY OF INTEREST CHARGES.

S T A T I O N	Lakhs of Rupees	
	CAPITAL COST	ANNUAL INTEREST CHARGES at 3.5%
Supa	932	32.62
Nagjhiri	1536	53.68
Kaneri	795	27.83
Lower Kalinadi	665	23.28
TOTAL	3928	137.41

(b) Sinking Fund

In calculating the annual cost of contribution to sinking fund, the following assumptions have been made, based on the provisions of Section 68 of the 7th Schedule of the Indian Electricity Supply Bill, 1948.

- (i) Loan Charges are based on annual repayment by the fixed annuity method with interest compounded at 3 per cent. per annum.
- (ii) Loans are repaid within the period applicable to the asset concerned, the period dating from the year in which the scheme commences operation.
- (iii) That the loan periods would be as follows :-
 - (a) Hydro-Electric Work.
 - (i) Dams, Tunnels etc. 100 years.
 - (ii) Pipelines, Hydraulic Valves Gates and Control Equipment. 40 years.
 - (iii) Hydro-Electric and Mechanical Plant, including foundations and power station building. 35 years.
 - (b) Electrical Plant and Transmission System.
 - (i) Switchgear. 20 years.
 - (ii) Transformers. 35 years.
 - (iii) Underground Cables. 40 years.
 - (iv) Overhead Lines. 30 years.
- (iv) That loan repayments are made on the total estimated capital cost including interest during construction.
- (v) An allowance of 10 per cent. of the original value has been made for the residual value of the assets at the end of the amortisation period.

The following Table 19 shows that the total annual contribution to sinking fund is estimated at 7.84 Lakhs for the initial development of the Supa Power Station and Rs. 38.94 Lakhs for the ultimate development of the complete scheme.

TABLE 19.

SUMMARY OF SINKING FUND CHARGES.

STATION	CAPITAL COST Lakhs of Rupees.	SINKING FUND CHARGES
		Lakhs of Rupees.
Supa	932	7.84
Nagjhiri	1536	17.36
Kaneri	795	6.79
Lower Kalinadi	665	6.95
TOTAL	3928	38.94

It may be considered desirable during the early stages of development to suspend sinking fund payments until revenue is built up and to make a correspondingly increased contribution over a shorter period later on. The estimates in this Report, however, take no account of such a policy.

(c) Rates and Taxes

It is assumed that being in the nature of a Government Scheme, local rates would not be chargeable on land, buildings, civil engineering works, or plant. It is also assumed that no income tax would be chargeable on the interest earned by investment of sinking fund accumulation.

(d) Salaries and Wages,
Maintenance and Management.(1) Hydro-Electric Stations

Reference to the costs of operating fully attended stations similar to those described in this Report in various parts of the world indicates that the total of the annual costs under the above three headings amounts on an average to 1.25 per cent. of the total capital expenditure. At the Supa

station, however, we consider that it would be wise to assume that the cost of salaries and wages and maintenance may be higher than average in the early stages of development.

With the development of the major station at Nagjhiri the three subsidiary generating stations would be remote controlled and would not therefore be normally attended.

With large stations such as Nagjhiri, the total cost of salaries, wages, maintenance and management usually falls below the average figure of 1.25 per cent. and taking all these factors into account in conjunction with available statistics for actual station operation at similar load factors, the allowances which should be made for items c, d, e and f (salaries and wages, maintenance and management) as percentages of capital expenditure work out approximately as follows :-

SUPA Initial Development (Attended)	1.35%
Unattended Subsidiary Stations	1.10% - 1.15%
NAGJHIRI Development	1.235%

(ii) Local Interconnecting
Transmission System

The total annual expenditure in the United Kingdom for operating the British Electricity Authority transmission system under the foregoing headings is approximately 2.5 per cent. of the total capital cost.

For the conditions in the area it would be appropriate to increase the annual percentage in the case of the system under consideration. Since climatic conditions would have the effect of increasing maintenance costs beyond those experienced in more temperate climates.

We therefore are of the opinion that it would be wise to assume that the cost of repairs and maintenance, management and other expenses on the system under consideration would amount to not more than 3 per cent. per annum on the total capital expenditure involved.

(e) Wayleaves

Since the transmission lines associated with the subsidiary power stations would run through jungle and forest country we have made no allowance for the payment of wayleave rentals. Table 20 which follows, gives annual operating costs of the proposed transmission system on the basis of the above remarks.

The percentages given above have accordingly been used in Table 20 from which it will be seen that the total annual cost of salaries, wages and maintenance of management is estimated at Rs. 50.63 lakhs for the ultimate development of the complete project.

TABLE 20.

SALARIES AND WAGES, MAINTENANCE AND MANAGEMENT,
GENERATING STATIONS AND TRANSMISSION SYSTEM.

<u>STATION</u>	<u>ANNUAL OPERATING CHARGES</u> <u>Lakhs of Rupees</u>
Supa	11.52
Nagjhiri	21.24
Kaneri	9.68
Lower Kalinadi	8.19
TOTAL	50.63

APPENDIX V.

EXPLANATORY MEMORANDUM ON THE COST ESTIMATES

INCLUDED IN TABLES 12, 13 AND 14.

(A) SUMMARY OF WORKS IN EACH SECTION.

1. Roads and Bridges.

Under this section is included the cost of improving and re-surfacing the forest and country roads to make them fit to carry the heavy traffic which will arise during construction. Also included are the new roads and bridges necessary to provide permanent access to the works and the road diversions which will result from the inundation by the reservoirs of existing means of communication.

2. Dams.

This section includes the cost of dams, spillways, flood gates, drawoff valves and culverts, and the necessary protection works associated therewith.

3. Tunnels.

Included under this section are the necessary tunnel intakes and intake shafts together with gates, screens and appurtenant works. Also included are the surge shafts and chambers, tunnel portal works and construction shafts and adits.

4. Pipelines.

This section comprises the portal valves and valve house at the head of the pipeline, the cost of preparing the pipe track and providing a permanent inclined railway alongside the pipes for service and maintenance. It also includes the cost of all pipe foundations and anchorages.

5. Generating Stations.

Included under the heading are the power house buildings, offices, workshops, stores and garages together with any excavation or protection works for the tailrace.

6. Hydro-Electric & Mechanical Plant.

This section includes the main turbines and alternators, auxiliary turbines and alternators, and machine tool equipment but not the generator protection which is included in Section 7.

This section also includes the turbine house cranes, auxiliary cranes, machine tools and plant required for the workshops, station dewatering pumps and pipework, water supply and conditioning plant, generator, transformer and station fire fighting equipment, and the station compressed air services. It also includes oil and water storage tanks, miscellaneous pumping plant and pipework, and laboratory and testing equipment.

7. Electrical Plant.

This section comprises the power station cables for interconnecting the generators with the transmission system, 11 kV. switchgear and the various auxiliary transformers required. It also includes electrical protective equipment for the main and auxiliary generators, the station low voltage auxiliary switchgear with all the necessary remote and local control equipment, as well as the alarm and relay equipment required.

This section also provides for station batteries and charging equipment, all auxiliary cables required in the station as well as lighting, heating, power and air conditioning installations and the telephone and inter-communication system.

8. Local Transmission System.

This section includes the 11/110, 110/220 and 11/220 kV. step-up transformers associated with each power station, the 220 kV. switchgear and transmission lines required for connecting the subsidiary power stations to the 220 kV. busbars at Nagjhiri and also for the switchgear required to connect the 7 machines at Nagjhiri to the same busbars.

(B) SOME FACTORS AFFECTING
THE ESTIMATES OF CAPITAL COSTS.

INTEREST DURING CONSTRUCTION.

1. The estimates given in Tables 12, 13 and 14, Chapter XIII. include interest during construction. The amount has been calculated on the basis that idle money is reinvested at $3\frac{1}{2}$ per cent. per annum. As the amount involved is substantial and in view of the nature of the scheme it is suggested that if possible short term borrowing should be advanced at a low rate of interest during the construction period.

2. Customs Duties.

It is assumed that for a scheme of this nature no Customs Duties would be levied by the Government on plant for the permanent installations or on the contractors plant required during construction. No allowance has accordingly been made for Customs Duties in the estimates.

3. Contingencies and Engineering Charges.

Suitable allowances have been included in the estimates to cover reasonable contingencies and the cost of engineering services during construction.

4. Transport of Plant and Material to Site.

The four stations forming the Kalinadi scheme are close to the road and rail system connected to the Port of Bombay. In view of the distances involved and the loads to be carried, transport, handling and haulage charges constitute an important factor in the total erected cost of the plant required. The estimates in the Report include for

- (a) The cost of sea transport to Bombay.
- (b) The cost of rail and road haulage between Bombay and the power station sites, including the provision of suitable vehicles.
- (c) Suitable sidings with lifting facilities for off loading plant at the rail terminals.

Estimates of transport costs have been based on information available concerning transport conditions and the recommended size of the individual main generator units has been fixed as far as possible to meet the limitations imposed by :-

- (i) Handling and off loading facilities at the Port of Bombay.
- (ii) Weight and dimensional limitations for rail and road transport between Bombay and the sites, assuming that suitable access facilities will become available with the construction of the scheme.

5. Labour During Construction.

In order to restrict the amount of skilled labour required during construction of the Project, it has been assumed that as much of the plant as possible should be prefabricated so as to reduce work on site to a minimum and that the contractors would provide skilled labour and supervision. It has also been assumed that the civil engineering work would be mechanised to the greatest extent practicable.

The stations have been designed so that erection, maintenance and operation of the plant will be as simple as possible and on the assumption that permanent operating staff will ultimately be required only at the major station at Nagjhiri.

6. Current Prices and Delivery.

The estimates of costs and deliveries assumed in this Report are based on prices for electrical and mechanical plant and civil engineering work ruling in mid 1949, but it is not possible to forecast with certainty what may be the future price levels with the present day unsettled industrial and social conditions obtaining throughout the world. We would emphasize that no allowance has been made in our estimates for any increased costs which may take place between now and the time when it is decided to proceed with the construction of the Scheme.

7. Power During Construction.

It is recommended that the power required during the construction period be obtained by provision of independent diesel engine generating plant to be erected on the site of the works. It would no doubt be possible to obtain a supply from the existing system or direct from Jog Falls, which is about 75 miles from the site of the Supa Dam, but we consider the independent diesel plant to be preferable in this instance.

APPENDIX VI.VARIATION OF COST OF ENERGY WITH LOAD
FACTOR.

In the Covering Report we have referred to the variations in the cost of firm energy when the load factor is altered.

The following table shows the relative plant installations and costs for the complete development on which the figures given in the Report are based.

TABLE 21.Variation of Cost of Energy with Load
Factor.

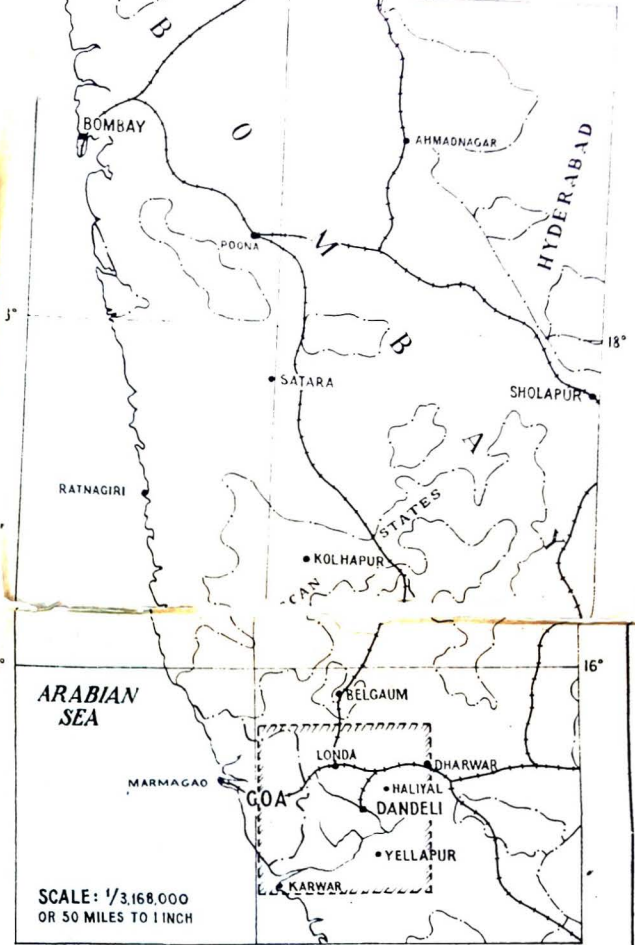
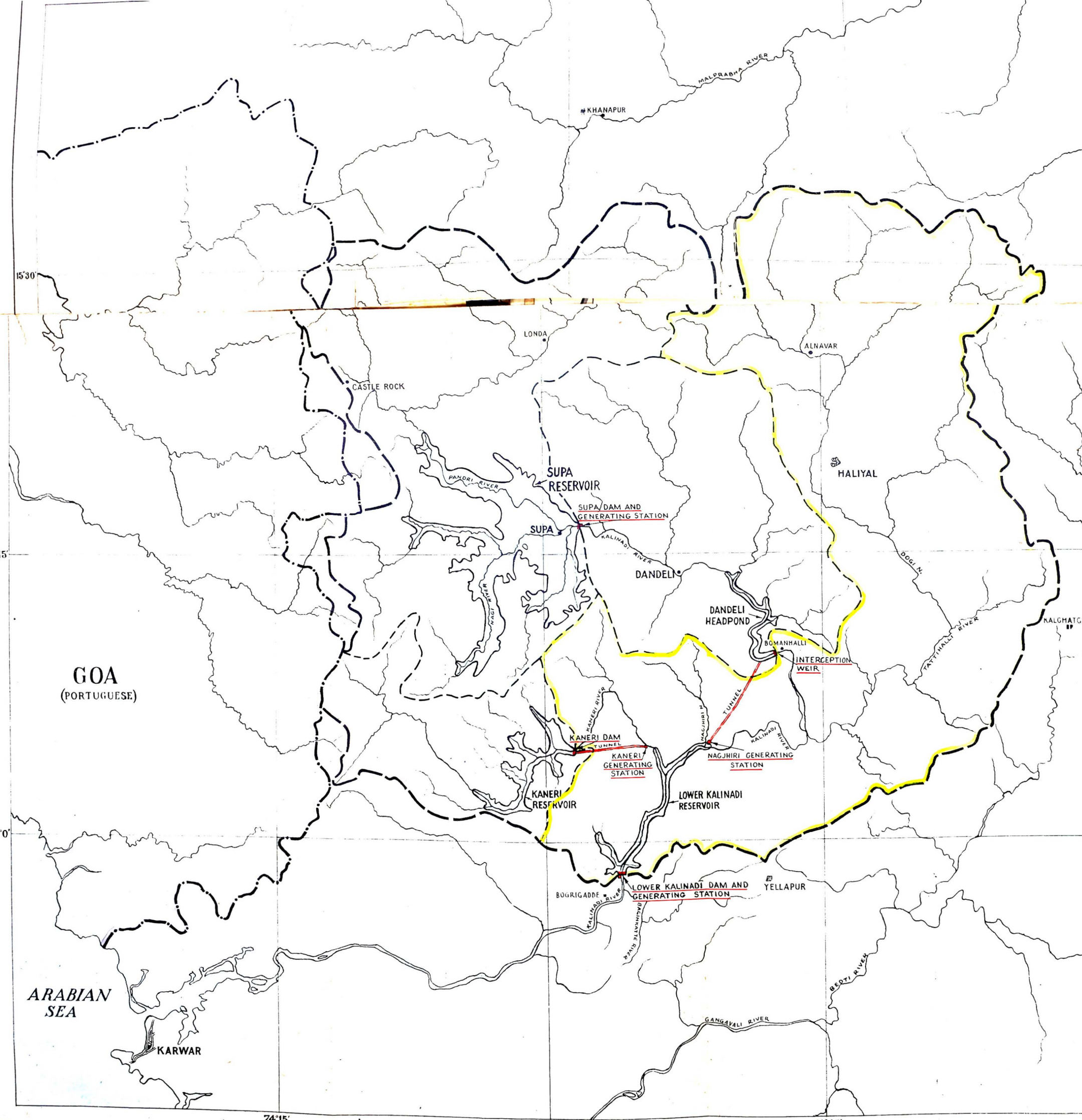
Load Factor	40%	60%	80%
Firm annual output millions of kWh	2,800	2,800	2,800
Firm plant capacity kilowatts	800,000	540,000	400,000
Installed plant capacity kilowatts	890,000	590,000	440,000
Capital Cost of Development Crores of Rupees	49.6	39.28	35.4
Annual Cost of Operation Lakhs of Rupees	285	226.98	205.0
Cost per kWh of firm energy delivered to the 220 kV. busbars.	0.163 annas	0.130 annas	0.117 annas

It should be noted that in the above analysis we have assumed that the firm annual output remains constant. The method of operating the four stations as a co-ordinated Group would depend on the manner in which the total installed plant is distributed among the individual stations. As the load factor decreased and the installed plant capacity increased, there would



be greater opportunity for utilising water which would otherwise be spilt during the monsoon, while the regulation afforded by the Supa reservoir would permit some of the additional energy obtained in this way to be converted into firm output. Conversely an increase of load factor would tend to reduce the firm annual output.

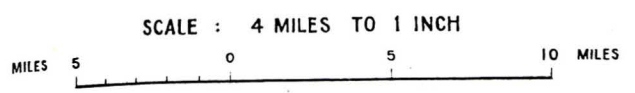
We have discounted the probability of any great benefit accruing to the Kalinadi scheme from interconnection with other sources of supply, but it may be observed here that such interconnection could result in an increase in the firm output. Such an increase would occur, for instance, if it should prove possible to operate the Group in such a way that the average output required during the monsoon months was greater than that given during the dry season, that is to say if the annual load factor was made subject to a favourable seasonal variation.

For the above reasons, the costs given for load factors other than 60% must be regarded as approximate only, but they nevertheless show the general trend in the cost of energy with varying load factor.



KEY MAP
 (AREA COVERED BY GENERAL PLAN SHOWN HATCHED ON KEY MAP)

NOTE.
 SCHEME CATCHMENT AREA BOUNDARY SHOWN THUS 
 PROJECT " " " " " " " " 



KALINADI HYDRO-ELECTRIC SCHEME
GENERAL PLAN SHOWING PROPOSED
NEW WORKS

DECEMBER 1948

FIGURE N^o 1

GOA
(PORTUGUESE)

ARABIAN
SEA

KARWAR

74°15'

74°30'

74°45'

15°0'

15°15'

16°

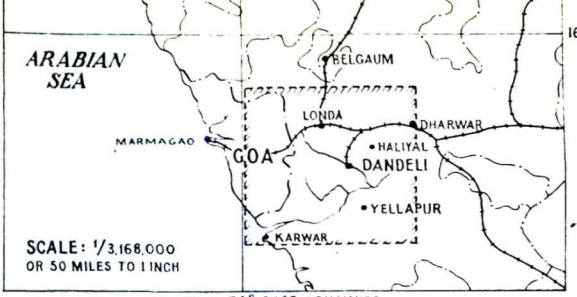
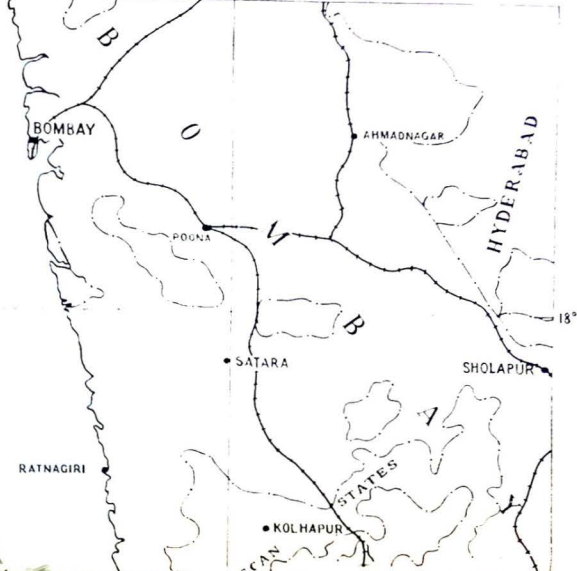
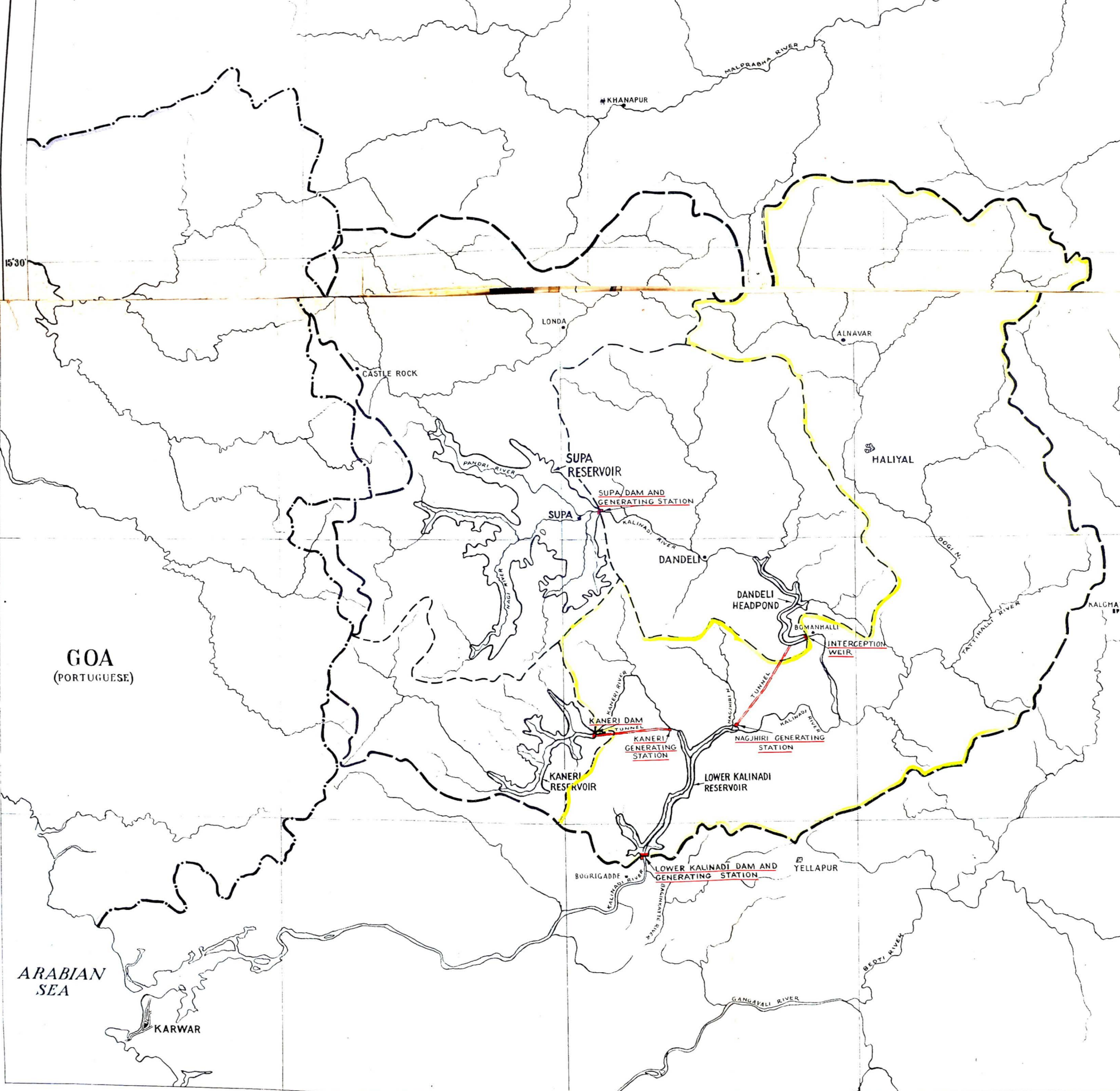
18°

15°30'

APPENDIX VII.

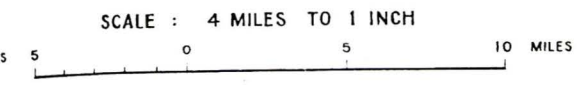
BIBLIOGRAPHY.

1. Hydro-electric Survey of India:
"Triennial Report 1919 to 1921" by J.W. Meares, C.I.E.
2. "A Critical Study of Runoff and Floods of Catchments of the Bombay Presidency with a Short Note on Losses from Lakes by Evaporation" by C.C. Inglis with A.J. de Souza - Government of Bombay, P.W.D. Technical Paper No. 30.
3. "Annual Report (Technical)" - 1941.
Central Board of Irrigation, India.
4. "Annual Reports of Supplies of Water Available for Irrigation" up to 1926 - Government of Bombay P.W.D.
5. Annual Records of Rainfall in Bombay Presidency.
Government of Bombay, Department of Agriculture.
6. Plans and records of investigations by Mr. P.L. Bowers in 1921 - Bombay Electric Grid.
7. "Geological Reconnaissance Report of the Kalinadi Project" by Dr. J.B. Auden - Geological Survey of India.
8. "Inspection Notes on Geological Reconnaissance of Kalinadi Project" by Dr. B.C. Roy - Geological Survey of India.
9. "Evaporation in India calculated from other meteorological factors" - by P.K. Raman and V. Satakopan. Scientific Notes of Government of India Meteorological Department. Volume VI No. 61.
10. "Control of Reservoir Silting" - Miscellaneous Publication No. 521 of the Department of Agriculture, U.S.A.
11. "Statistical Atlas of the Bombay Presidency" by The Director of Agriculture, Government of Bombay.

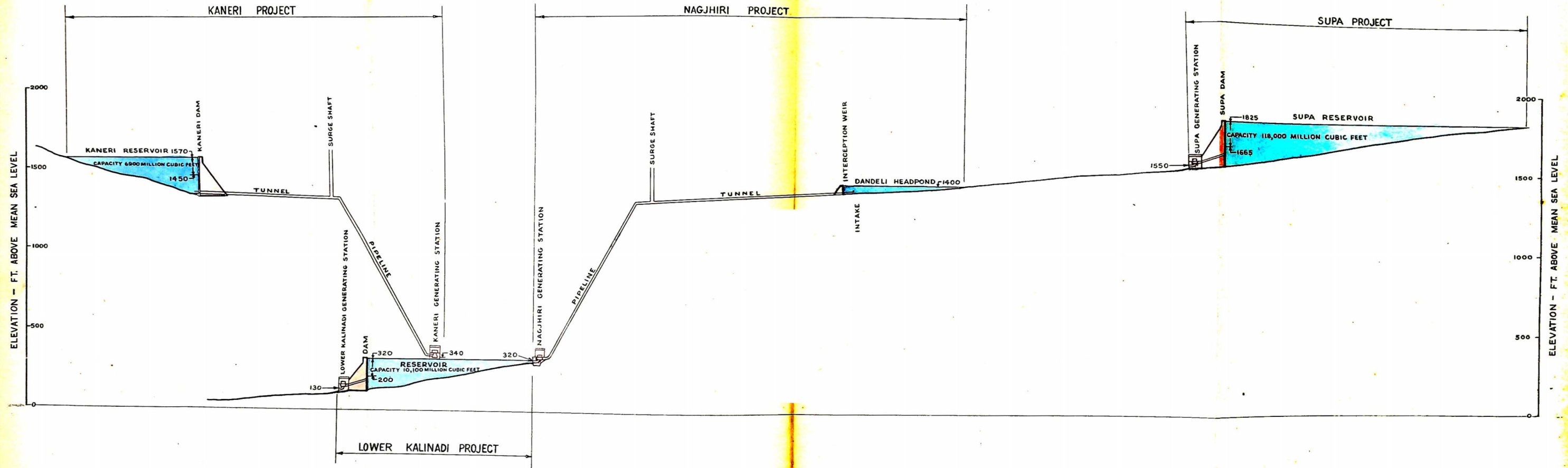


KEY MAP
 (AREA COVERED BY GENERAL PLAN SHOWN HATCHED ON KEY MAP)

NOTE.
 SCHEME CATCHMENT AREA BOUNDARY SHOWN THUS ---
 PROJECT "



**KALINADI HYDRO-ELECTRIC SCHEME
 GENERAL PLAN SHOWING PROPOSED
 NEW WORKS**

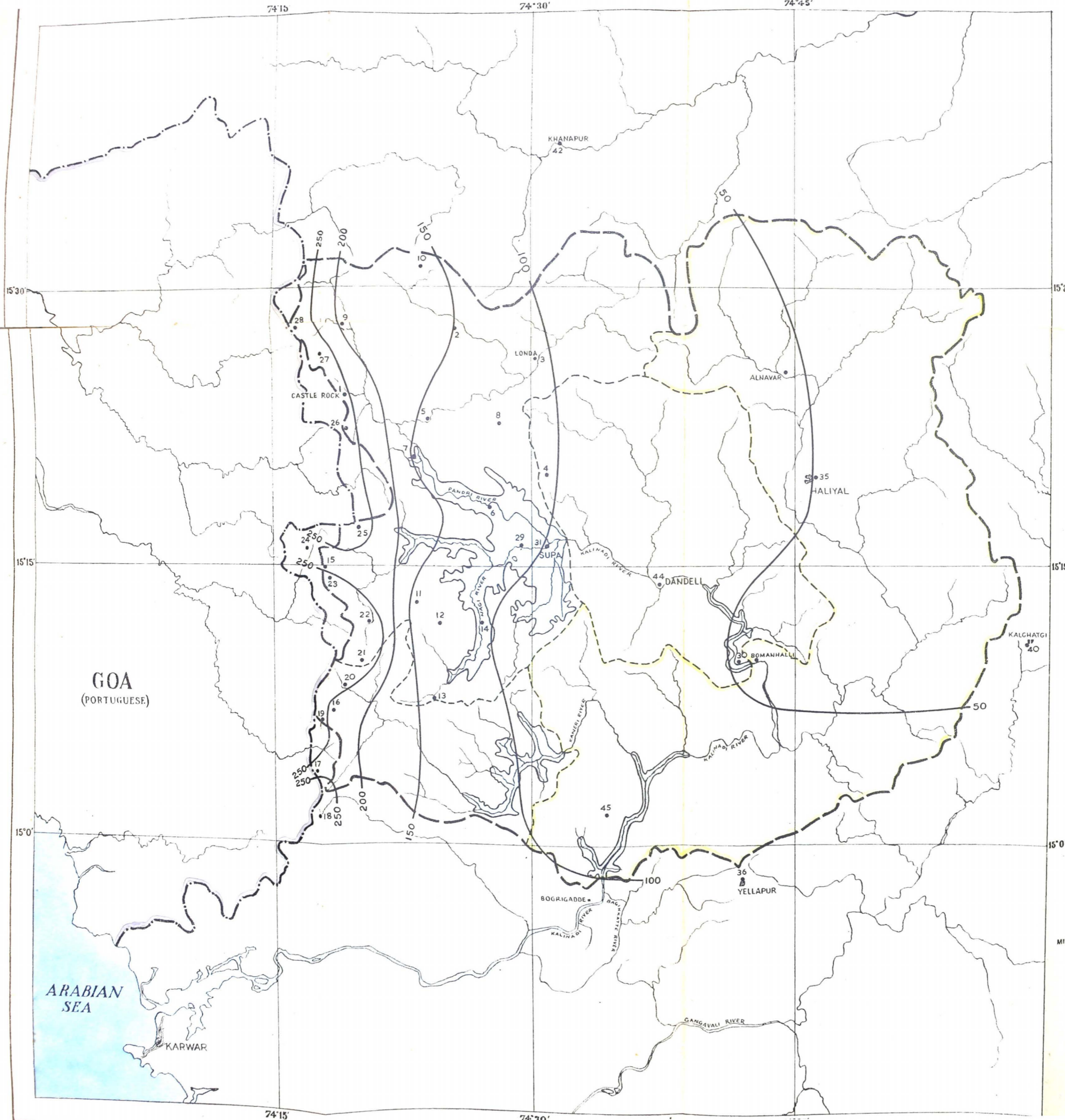


NOTES ON LEVELS INDICATED.
 STORAGE AREAS...PROPOSED TOP WATER LEVEL AND THE LOWEST DRAWDOWN LEVEL
 FOR POWER ARE SHOWN TOGETHER WITH THE STORAGE CAPACITY
 AVAILABLE BETWEEN THESE LEVELS.
 GENERATING STATIONS...THE NORMAL TAIL RACE LEVEL IS SHOWN.

KALINADI HYDRO-ELECTRIC SCHEME
 DIAGRAMMATIC SECTION SHOWING
 PROPOSED METHOD OF DEVELOPMENT

DECEMBER 1948

FIGURE No. 2

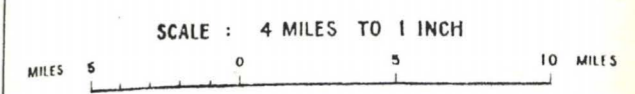


REF. No.	LOCATION	PERIOD OF RECORD	MEAN ANNUAL RAINFALL	REF. GAUGE
A - GAUGES AT PRESENT IN EXISTENCE				
1	CASTLE ROCK	1916-1946	255.9	
31	SUPA	1876-1947	91.52	
35	HALIYAL	1875-1946	48.45	
36	YELLAPUR	1876-1947	98.04	
40	KALGHATGI	1875-1946	35.28	
42	KHANAPUR	1876-1946	66.50	
44	DANDELI	1946-1947	62	S.
45	NANDIGADDA	1946		
B - GAUGES ABANDONED				
2	TINAI GHAT	1921-1927	150	C.R.
3	LONDA	" - "	105	C.R.
4	JAGALBAT	" - "	103	S.
5	CHANDVADI	" - "	134	S.C.R.
6	APELI	" - "	124	S.
7	AVEDA	" - "	140	C.R.
8	ASU	" - "	113	S.C.R.
9	AKETIDUDEGALI	" - "	195	C.R.
10	HEMADGA	" - "	156	S.C.R.
11	KALPA	" - "	130	S.C.R.
12	GURAVADI	" - "	118	S.C.R.
13	KAMBHARWADI	" - "	143	S.C.R.
14	PALLI	" - "	103	S.
15	DIGGI	1920-1921	245	C.R.
16	KUNDAL	" - "	225	C.R.
17	DHOKARPA	" - "	245	C.R.
18	JAMBOADA (LANDHA)	1921 ONLY	300	C.R.
19	POY	" - "	275	C.R.
20	KELOLI	" - "	270	C.R.
21	KUSAVLI	" - "	280	C.R.
22	BUMNIA	" - "	290	C.R.
23	DUDHMALA	" - "	275	C.R.
24	KADNA	" - "	245	C.R.
25	SOLIYA	" - "	285	C.R.
26	DHANGARWADI (ALU)	" - "	265	C.R.
27	ANMOD	" - "	275	C.R.
28	KASKARWADI (KARJAL)	" - "	275	C.R.
29	KHEDA	1921-1927	119	S.
30	BOMANHALLI	" - "	42.5	H.

NOTES.

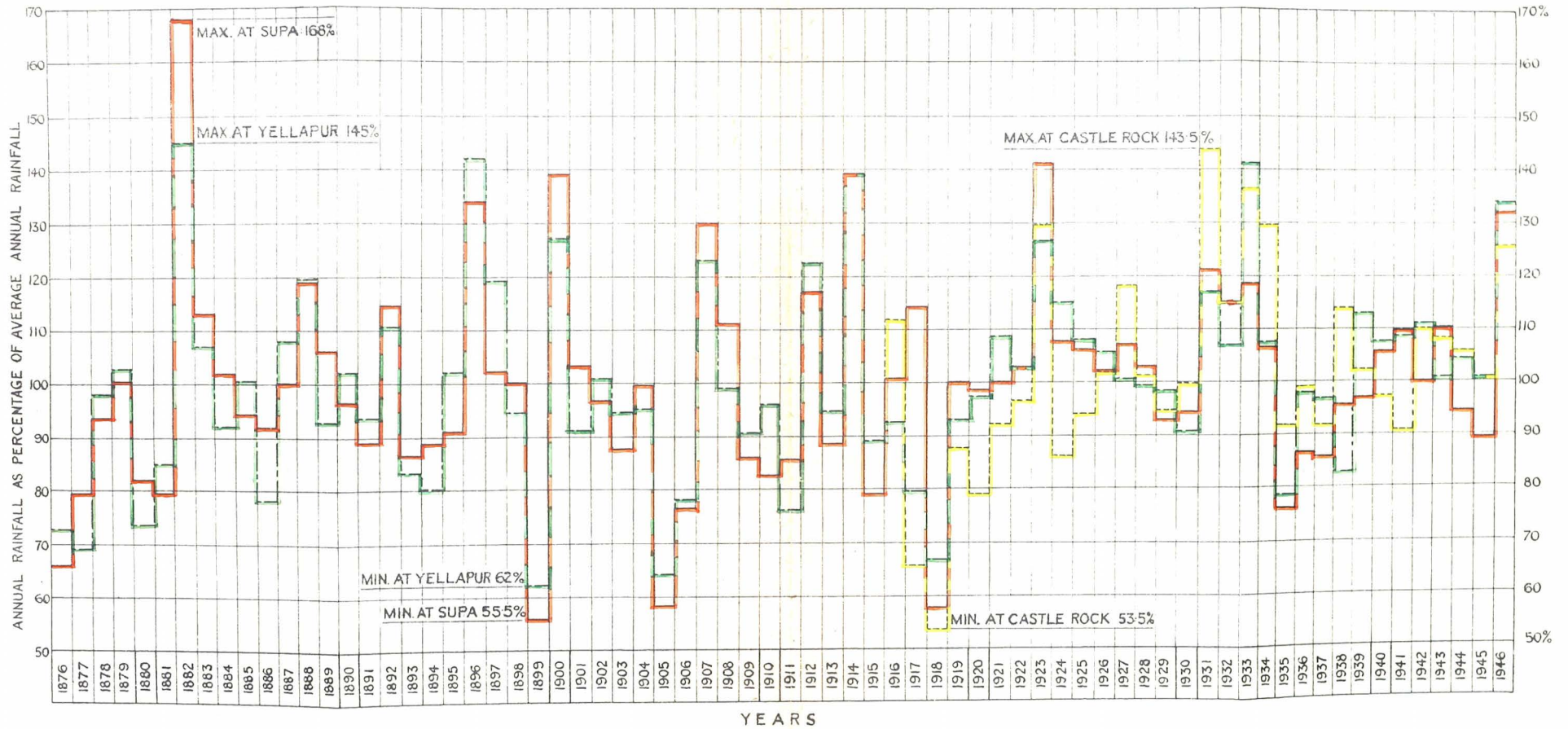
- REFERENCE NUMBERS.
A AND B. REFERENCES GIVEN BY A.C.E(1) TO EXISTING AND ABANDONED GAUGES.
- MEAN ANNUAL RAINFALL.
FOR SHORT TERM RECORDS, THE MEAN ANNUAL RAINFALL HAS BEEN ESTIMATED BY COMPARISON WITH A GAUGE WHICH HAS A LONG RECORD.
- REFERENCE GAUGE.
THE LONG PERIOD GAUGE WHICH HAS BEEN USED FOR ESTIMATION OF THE MEAN ANNUAL RAINFALL IS INDICATED:-
C.R. CASTLE ROCK.
S. SUPA.
H. HALIYAL.
S.C.R. SUPA AND CASTLE ROCK.
- VALUES OF ISOHYETAL LINES GIVEN IN INCHES.

SCHEME CATCHMENT AREA BOUNDARY SHOWN THUS PROJECT



KALINADI HYDRO-ELECTRIC SCHEME
PLAN OF CATCHMENT AREA
SHOWING ISOHYETALS

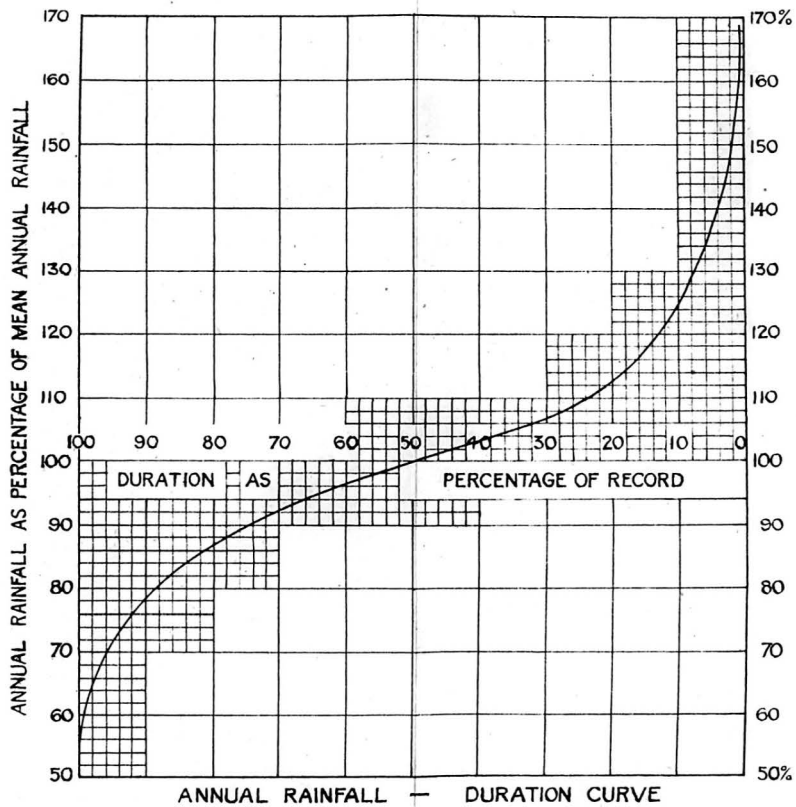
SUPA RAINGAUGE 1876-1946
 YELLAPUR RAINGAUGE . . . 1876-1946
 CASTLE ROCK RAINGAUGE . 1916-1946



VARIATION OF ANNUAL RAINFALL
 SUPA RAINGAUGE, 1876-1946. SHOWN THUS: ————
 YELLAPUR RAINGAUGE, 1876-1946 SHOWN THUS: - - - - -
 CASTLE ROCK RAINGAUGE, 1916-1946 SHOWN THUS: - - - - -

AVERAGE ANNUAL RAINFALL
 SUPA : 91.7 ins.
 YELLAPUR : 98.3 ins.
 CASTLE ROCK : 250.3 ins

KALINADI HYDRO-ELECTRIC SCHEME
 VARIATION OF ANNUAL RAINFALL,
 COMPARISON OF SUPA, YELLAPUR
 AND CASTLE ROCK

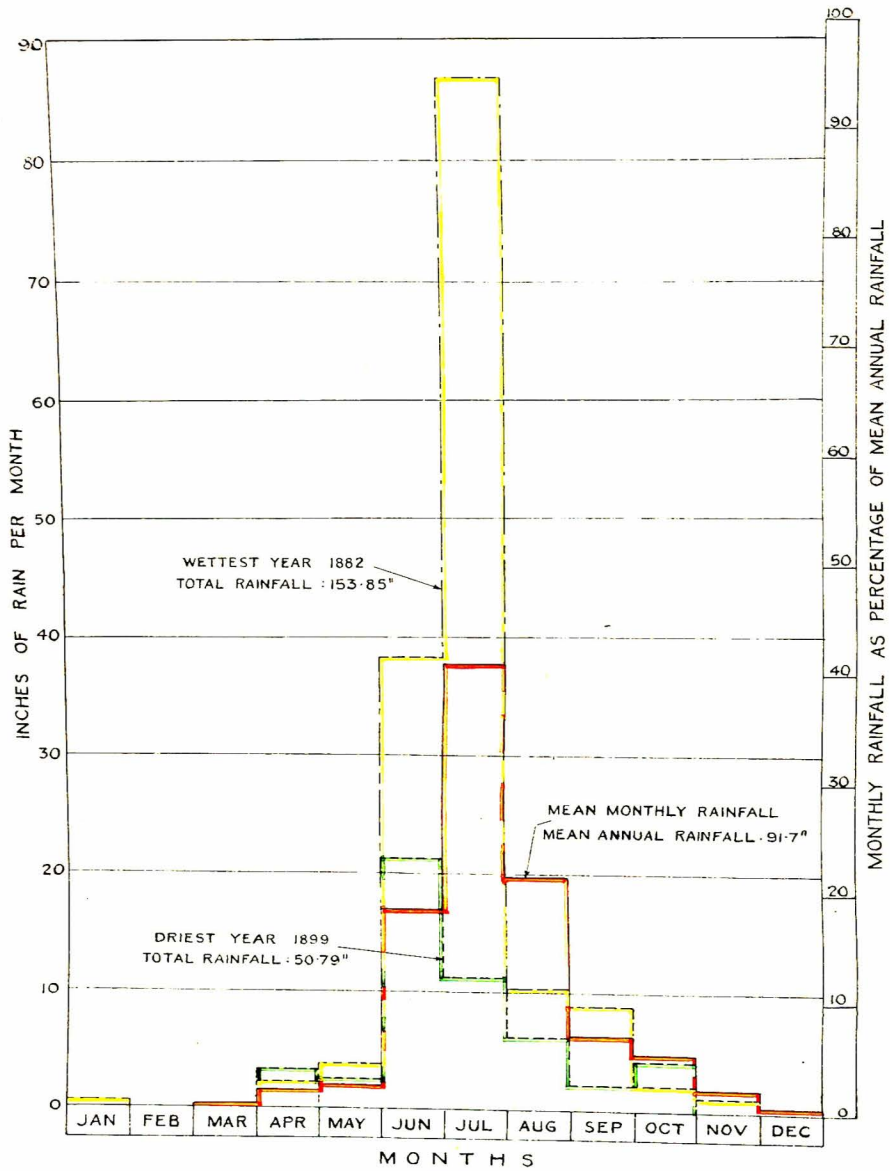


ANNUAL RAINFALL — DURATION CURVE

BASED ON ANNUAL RECORDS FROM SUPÁ AND YELLAPUR 1876-1946.
 THIS CURVE SHOWS THE PERCENTAGE OF TIME (YEARS) IN WHICH
 THE ANNUAL RAINFALL IS GREATER THAN A GIVEN PERCENTAGE OF
 THE MEAN ANNUAL RAINFALL.

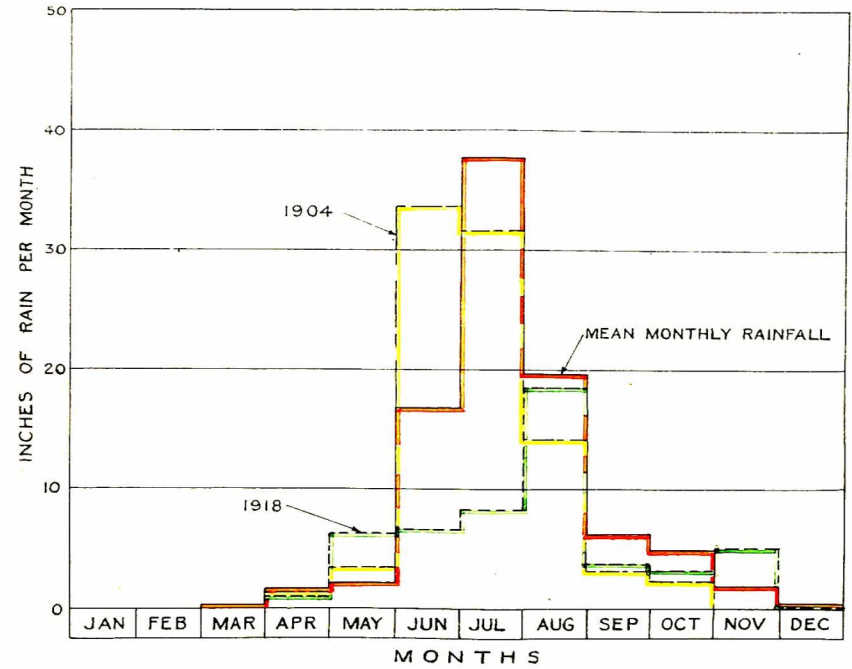
KÁLINADI HYDRO-ELECTRIC SCHEME

ANNUAL RAINFALL DURATION CURVE



MONTHLY DISTRIBUTION OF RAINFALL

MEAN MONTHLY DISTRIBUTION SHOWN THUS:
 MONTHLY DISTRIBUTION IN 1882 (WETTEST RECORDED YEAR) SHOWN THUS:
 MONTHLY DISTRIBUTION IN 1899 (DRIEST RECORDED YEAR) SHOWN THUS:

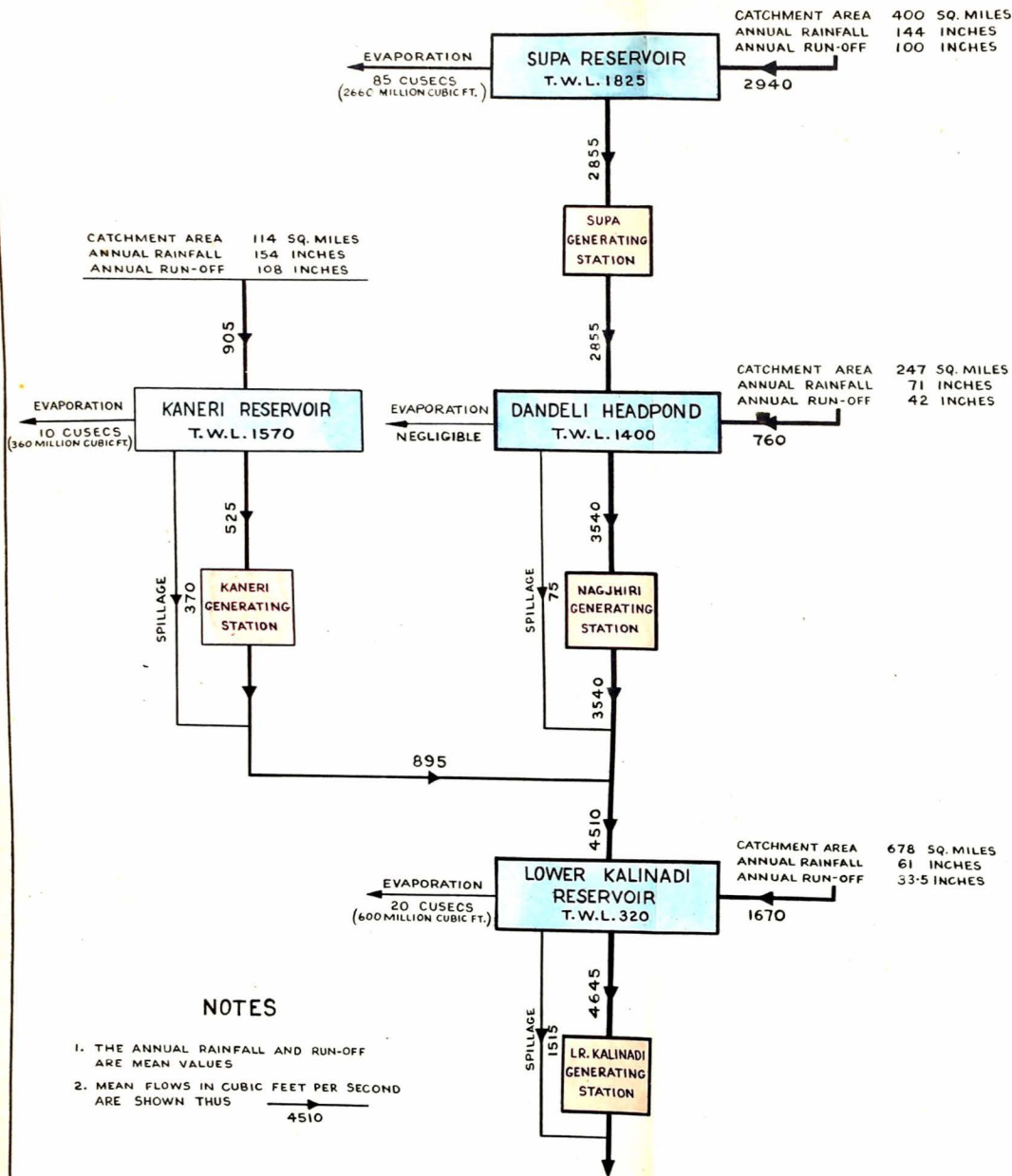


MONTHLY DISTRIBUTION OF RAINFALL

MEAN MONTHLY DISTRIBUTION SHOWN THUS:
 1904 (EARLY MONSOON OF NORMAL INTENSITY) SHOWN THUS:
 1918 (FAILURE OF MONSOON & LONG RAINY PERIOD) SHOWN THUS:

KALINAĐI HYDRO-ELECTRIC SCHEME

MONTHLY RAINFALL DISTRIBUTION AT SUPA

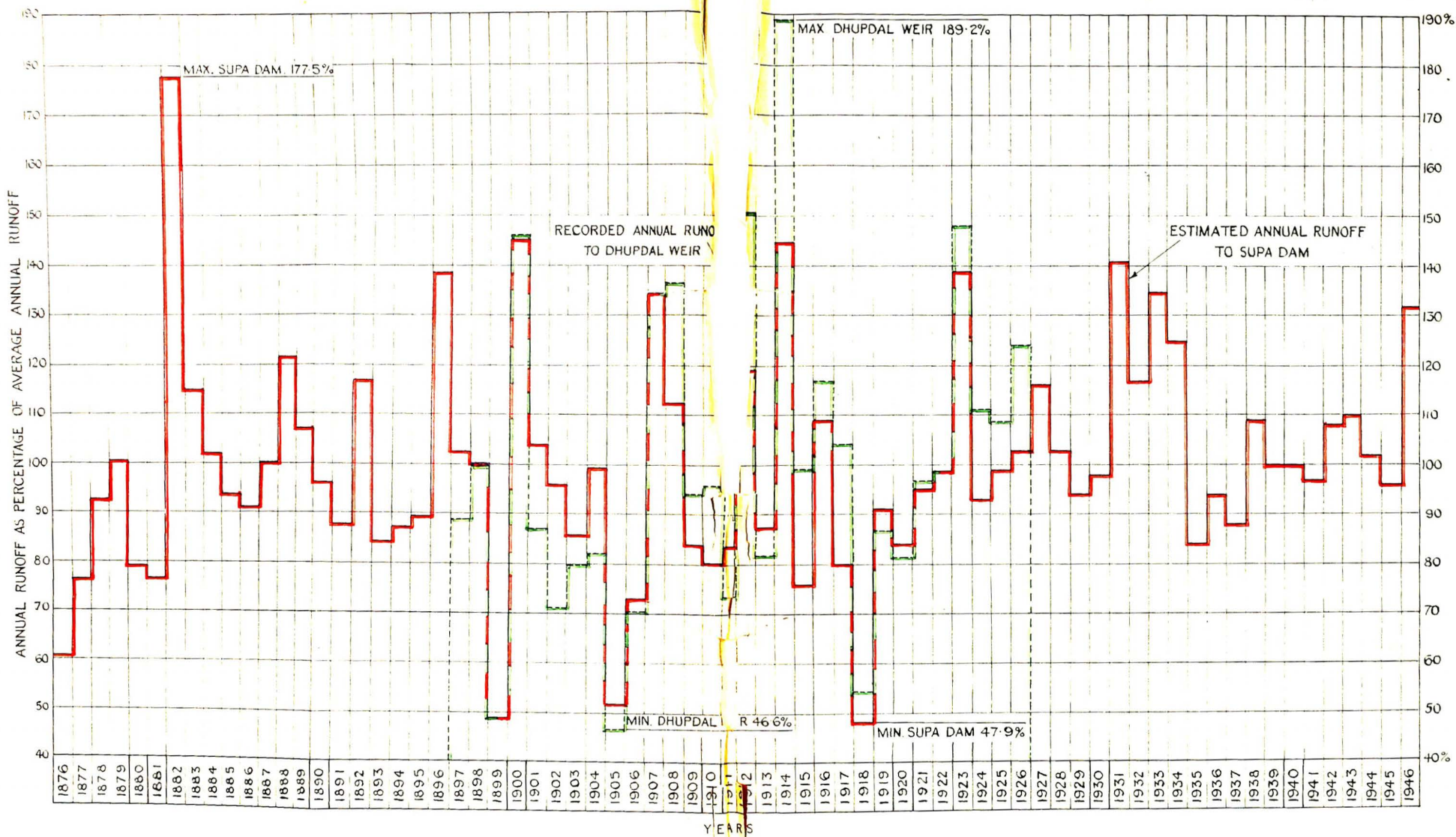


KALINADI HYDRO-ELECTRIC SCHEME

FLOW DIAGRAM
FOR AVERAGE YEAR

DECEMBER 1948

FIGURE No 7



VARIATION OF ANNUAL RUNOFF

ESTIMATED RUNOFF TO SUPA DAM 1876-1946 SHOWN THUS: —

RECORDED RUNOFF TO DHUPDAL WEIR 1897-1926 SHOWN THUS: - - -

(SEE ANNUAL REPORTS OF THE SUPPLIES OF WATER AVAILABLE FOR IRRIGATION WORKS AND THE DISCHARGE FROM CATCHMENT AREAS IN THE BOMBAY PRESIDENCY. GOVT. OF BOMBAY P.W.D.)

AVERAGE ANNUAL RUNOFF

SUPA DAM (ESTIMATED) 93,300 MILLION CU. FT.

DHUPDAL WEIR (MEASURED) 114,000 MILLION CU. FT.

KALINADI HYDRO-ELECTRIC SCHEME

ANNUAL RUNOFF TO SUPA DAM

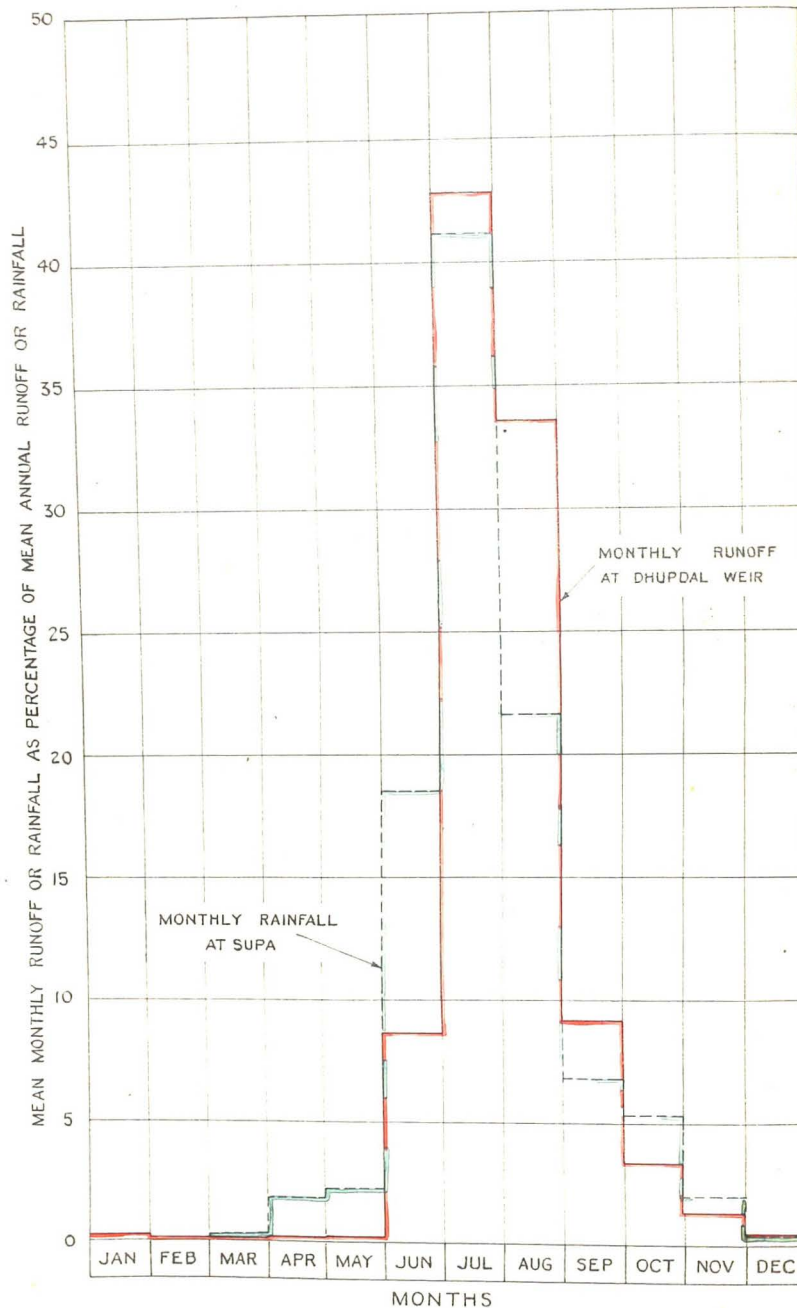
COMPARED WITH

ANNUAL RUNOFF TO DHUPDAL WEIR

MEAN MONTHLY RAINFALL AT SUPA
DEPARTMENT OF AGRICULTURE RECORDS. 1876-1946

MEAN MONTHLY RUNOFF AT DHUPDAL WEIR

DHUPDAL WEIR ON R. GHATPRABHA NEAR GOKAK, BELGAUM DISTRICT.
RECORDS FROM "ANNUAL REPORT OF THE SUPPLIES OF WATER
AVAILABLE FOR IRRIGATION WORKS AND OF THE DISCHARGE FROM
CATCHMENT AREAS IN THE BOMBAY PRESIDENCY" 1896-1927.



MONTHLY VARIATION OF RUNOFF AT DHUPDAL WEIR
COMPARED WITH MONTHLY VARIATION OF RAINFALL AT SUPA

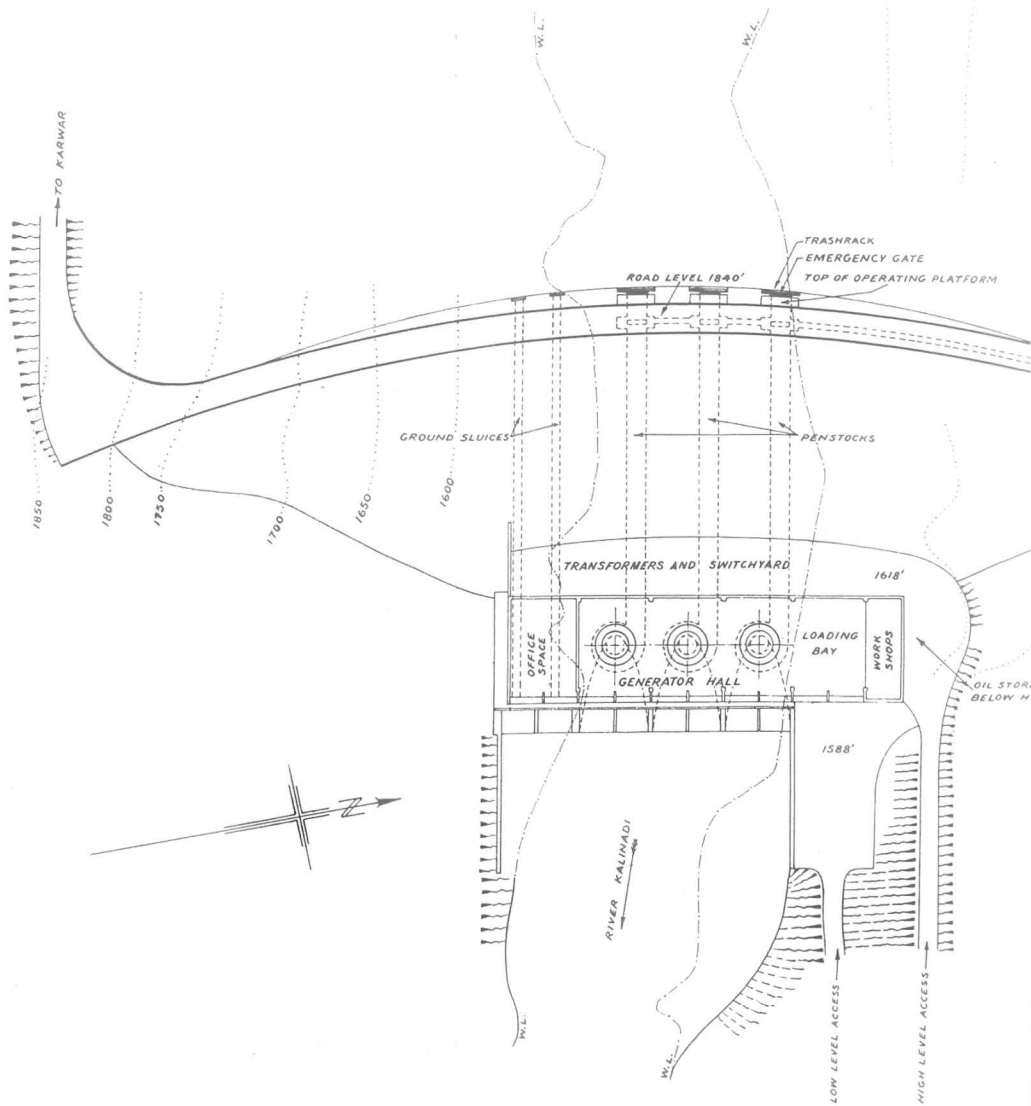
MONTHS	RAINFALL AT SUPA		RUNOFF AT DHUPDAL WEIR	
	MEAN RAINFALL IN INCHES	RAINFALL AS % OF ANNUAL	MEAN RUNOFF IN CUSEC. DAYS	MONTHS RUNOFF AS % OF ANNUAL
JAN	0.04	0.0%	3,295	0.2%
FEB	0.05	0.0%	2,195	0.2%
MAR	0.29	0.3%	1,848	0.1%
APR	1.64	1.8%	2,125	0.2%
MAY	2.04	2.2%	2,815	0.2%
JUN	16.94	18.5%	116,648	8.6%
JUL	37.68	41.1%	576,608	42.7%
AUG	19.74	21.6%	452,327	33.6%
SEP	6.24	6.8%	123,694	9.2%
OCT	4.86	5.3%	44,574	3.3%
NOV	1.82	2.0%	17,651	1.3%
DEC	0.35	0.4%	5,961	0.4%
MEAN ANN. TOTAL	91.69 INS.	100.0%	1,349,696 CUSEC. DAYS	100.0%

KALINADI HYDRO-ELECTRIC SCHEME

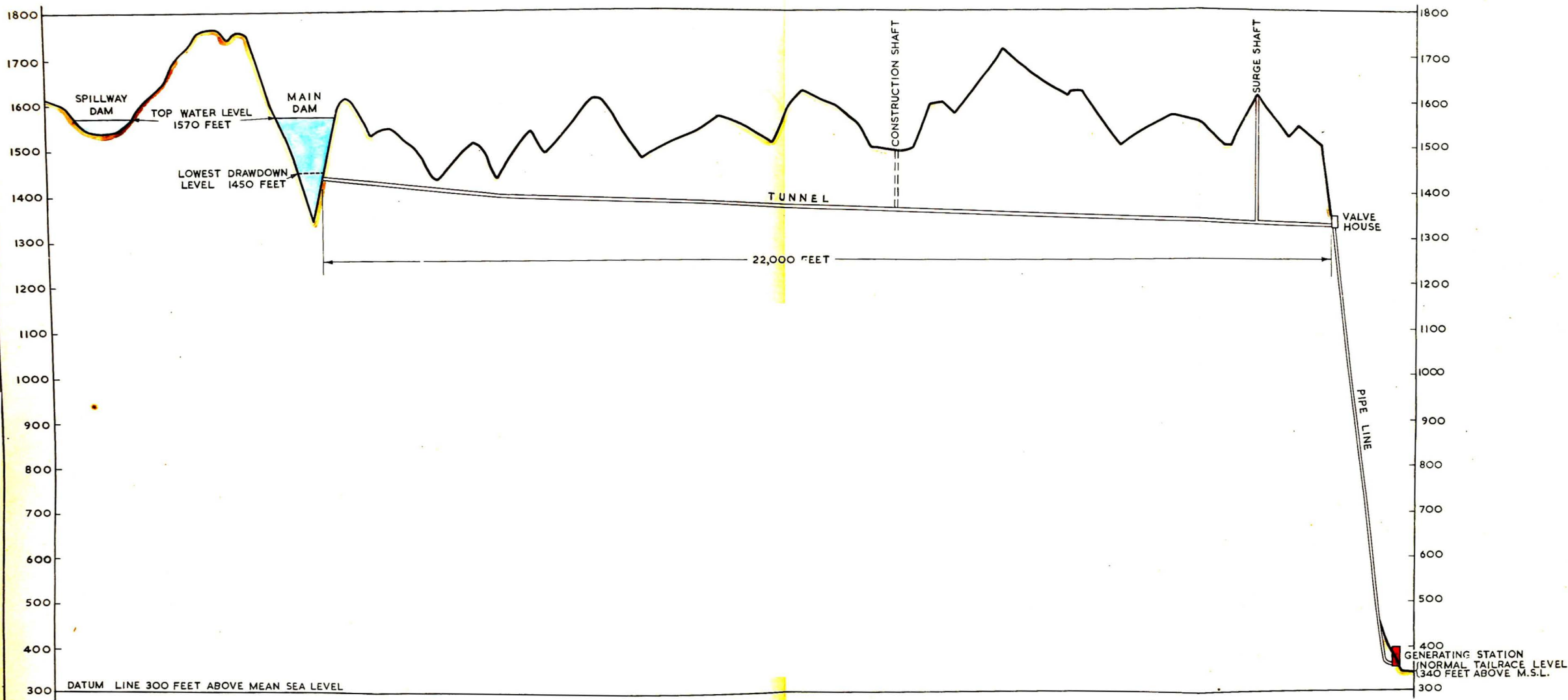
MONTHLY DISTRIBUTION OF RAINFALL AT SUPA
COMPARED WITH MONTHLY RUN-OFF AT DHUPDAL

DECEMBER 1948

FIGURE No 9



PLAN



HORIZONTAL SCALE:- 3 INCHES TO 1 MILE

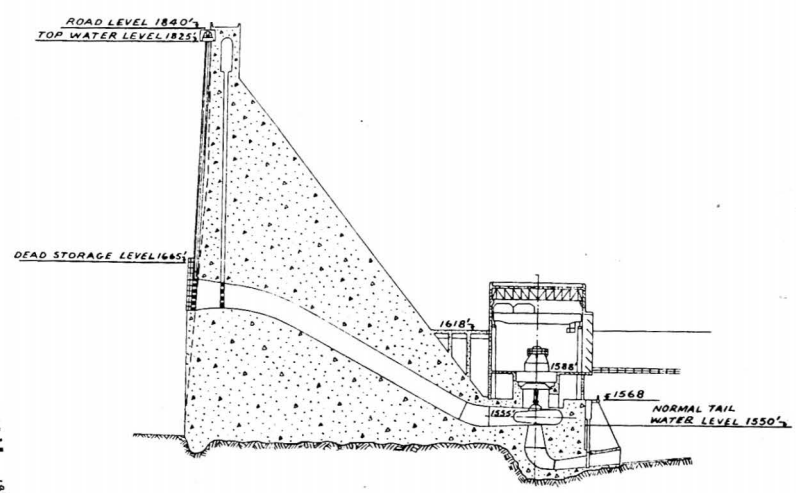
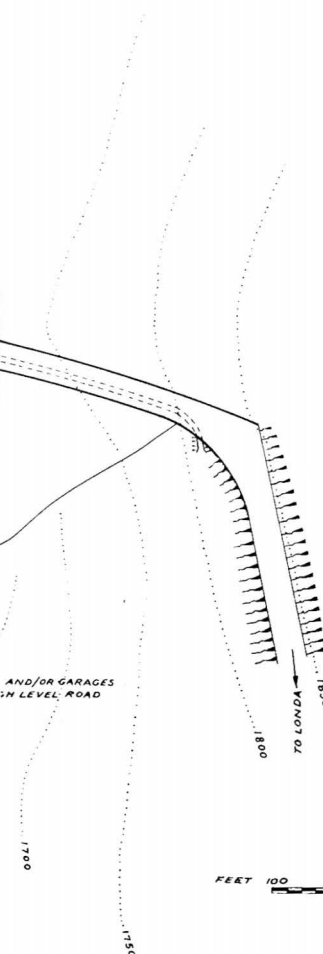


VERTICAL SCALE:- 30 INCHES TO 1 MILE



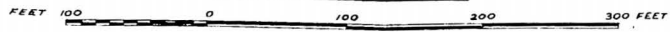
KALINADI HYDRO-ELECTRIC SCHEME

KANERI PROJECT - SECTION THROUGH PROPOSED WORKS



SECTION THROUGH PENSTOCK

SCALE - 88 FEET TO 1 INCH

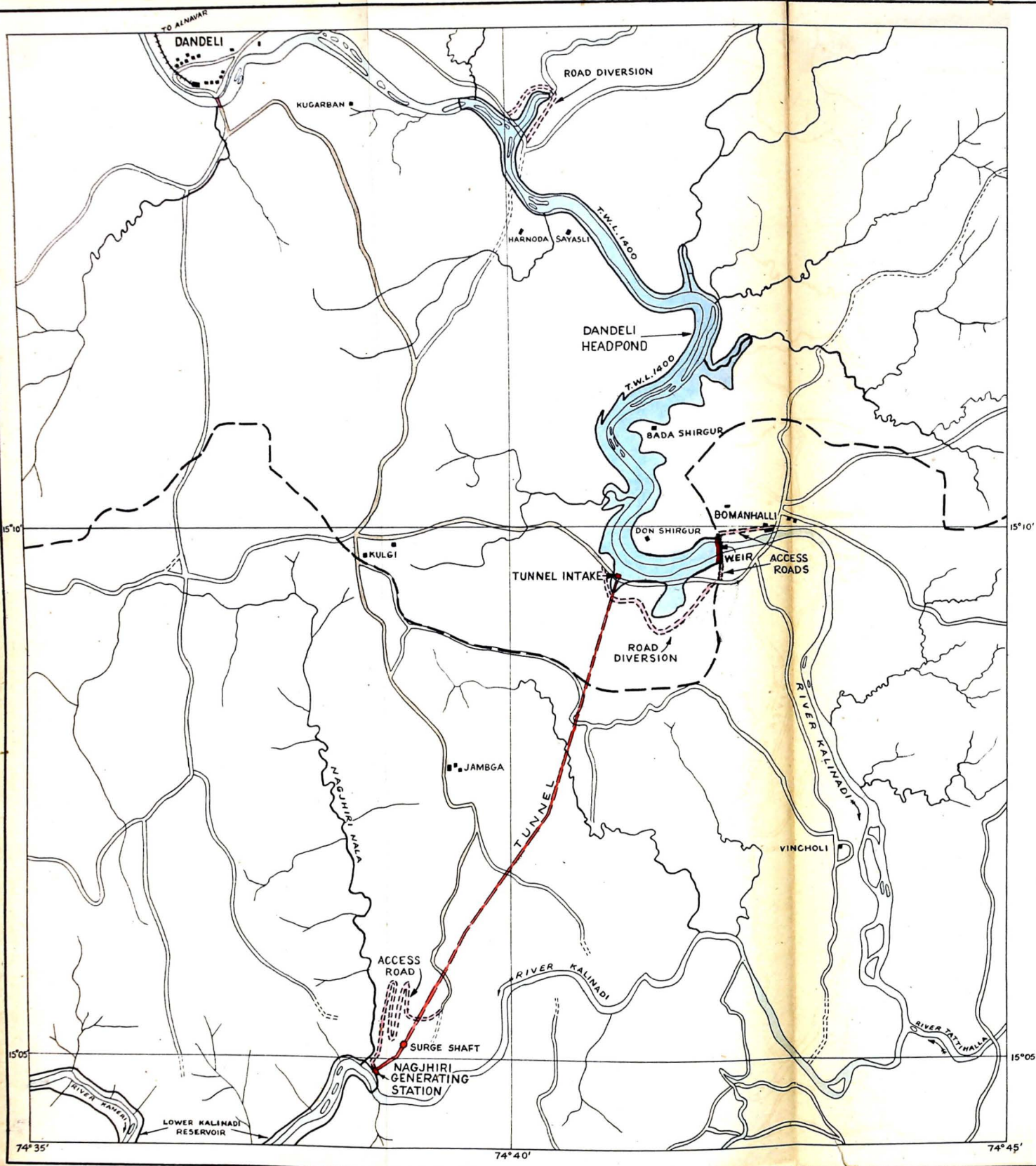


KALINADI HYDRO-ELECTRIC SCHEME

SUPA DAM AND POWER STATION

DECEMBER 1948

FIGURE NO. 11



NOTE.

CATCHMENT AREA BOUNDARY SHOWN THUS. — — —

SCALE:- 1 INCH TO 1 MILE.

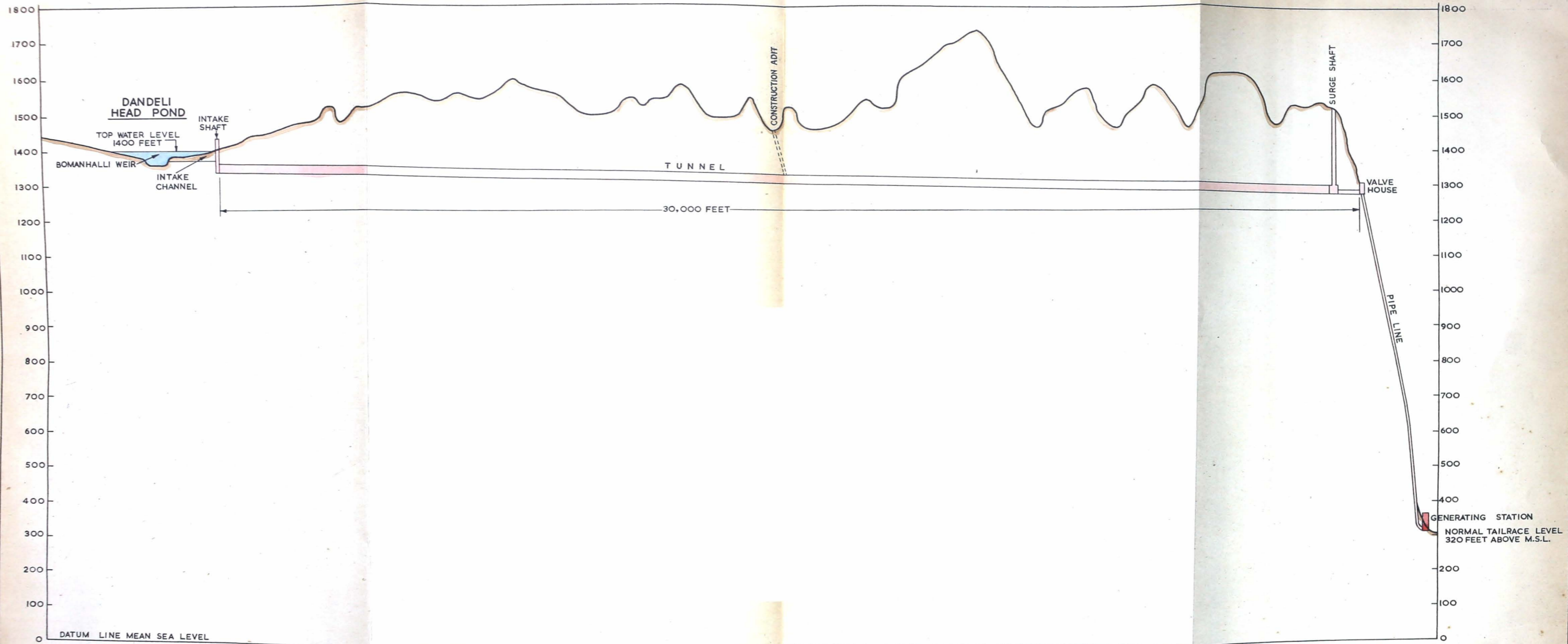


KALINADI HYDRO-ELECTRIC SCHEME

PLAN SHOWING NAGJHIRI PROJECT

DECEMBER 1948

FIGURE N^o 12

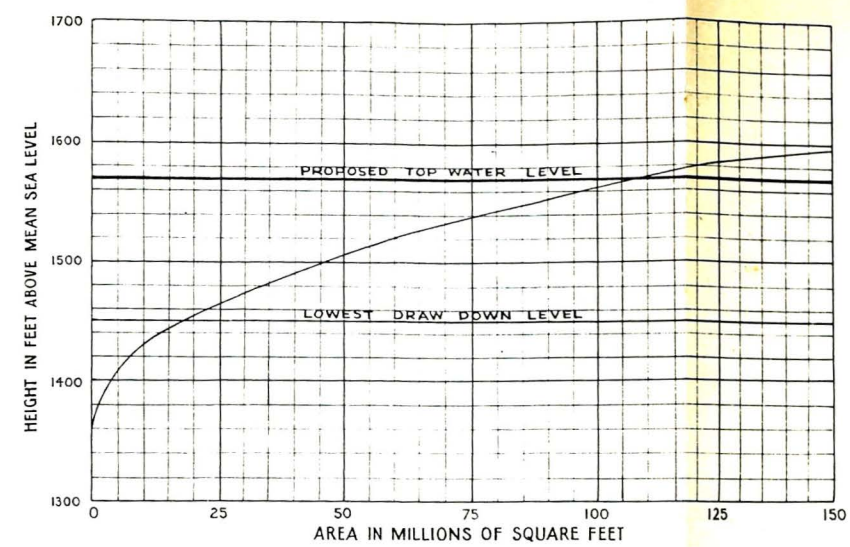
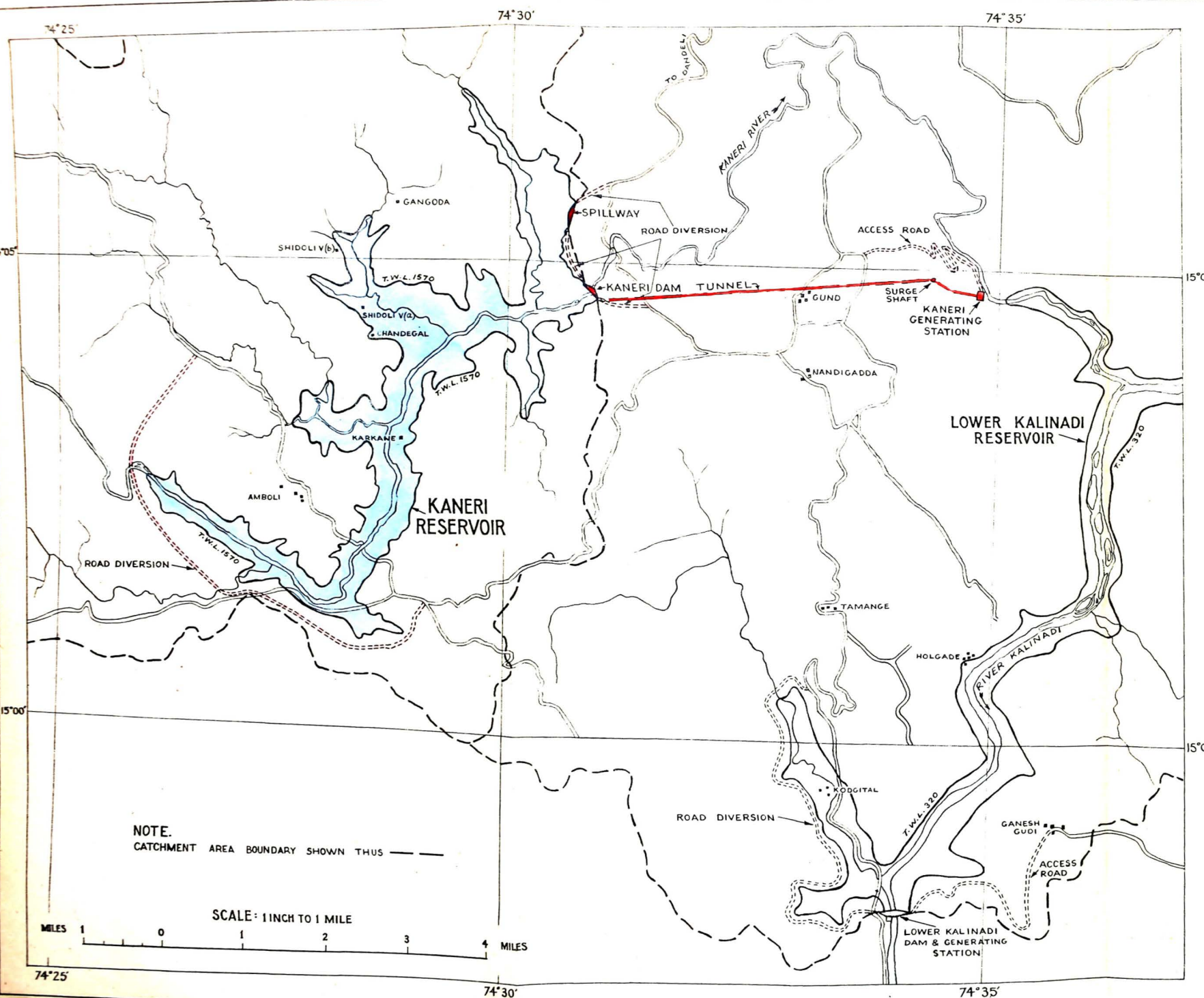


HORIZONTAL SCALE:- 3 INCHES TO 1 MILE
 FEET 1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

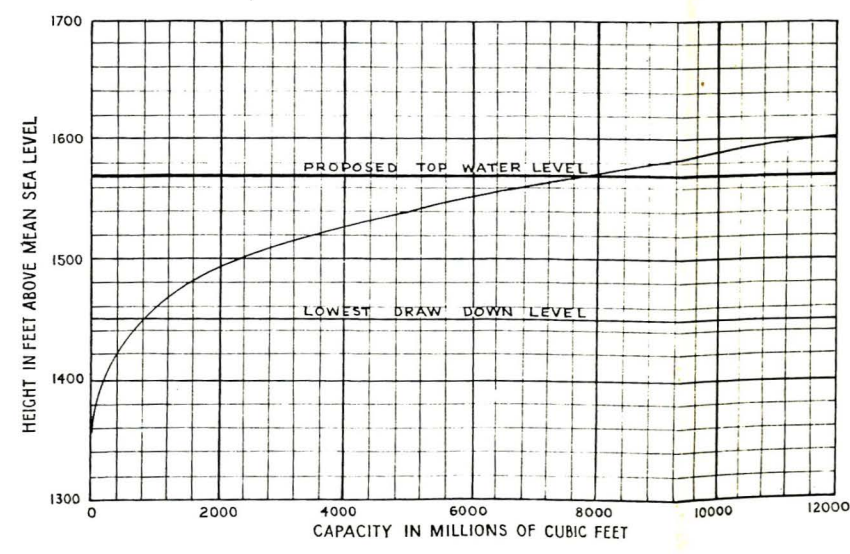
VERTICAL SCALE:- 30 INCHES TO 1 MILE
 FEET 100 0 100 200 300 400 500 600 700 FEET

KALINADI HYDRO-ELECTRIC SCHEME

NAGJHIRI PROJECT - SECTION THROUGH PROPOSED WORKS

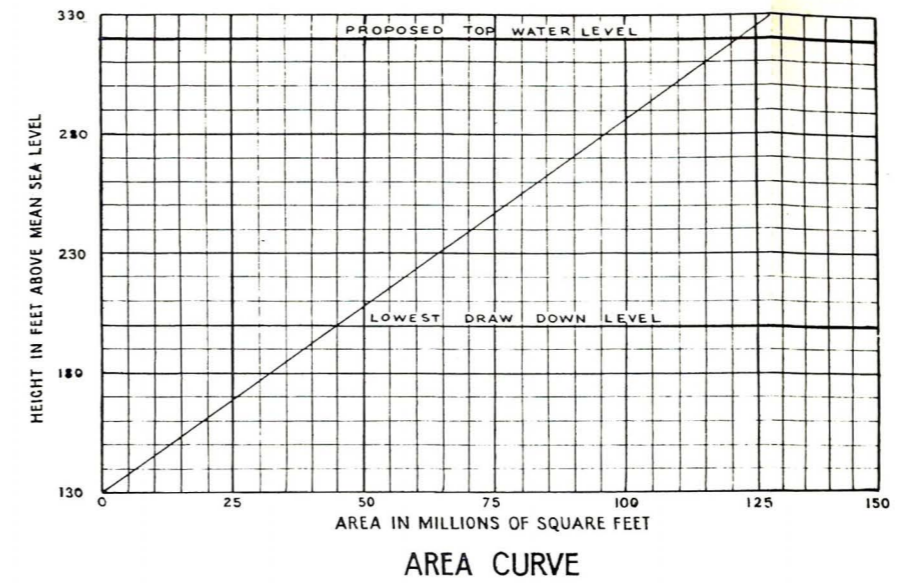
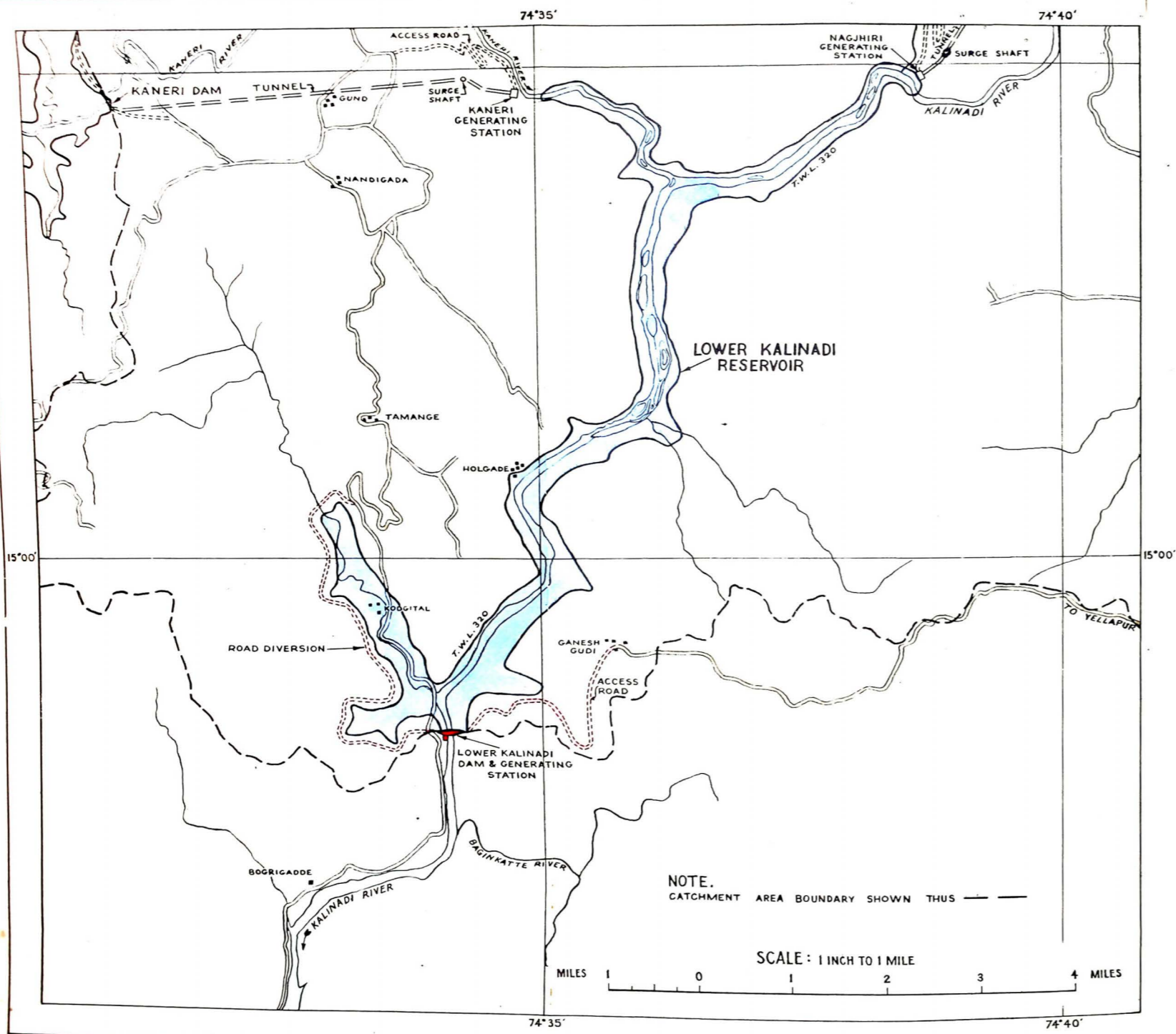


AREA CURVE
KANERI RESERVOIR

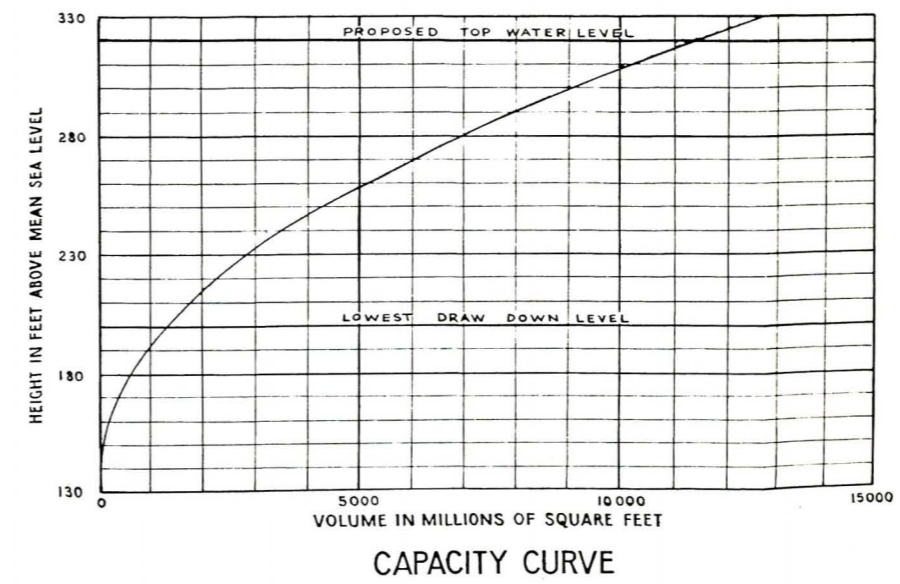


CAPACITY CURVE

KALINADI HYDRO-ELECTRIC SCHEME
PLAN SHOWING KANERI PROJECT

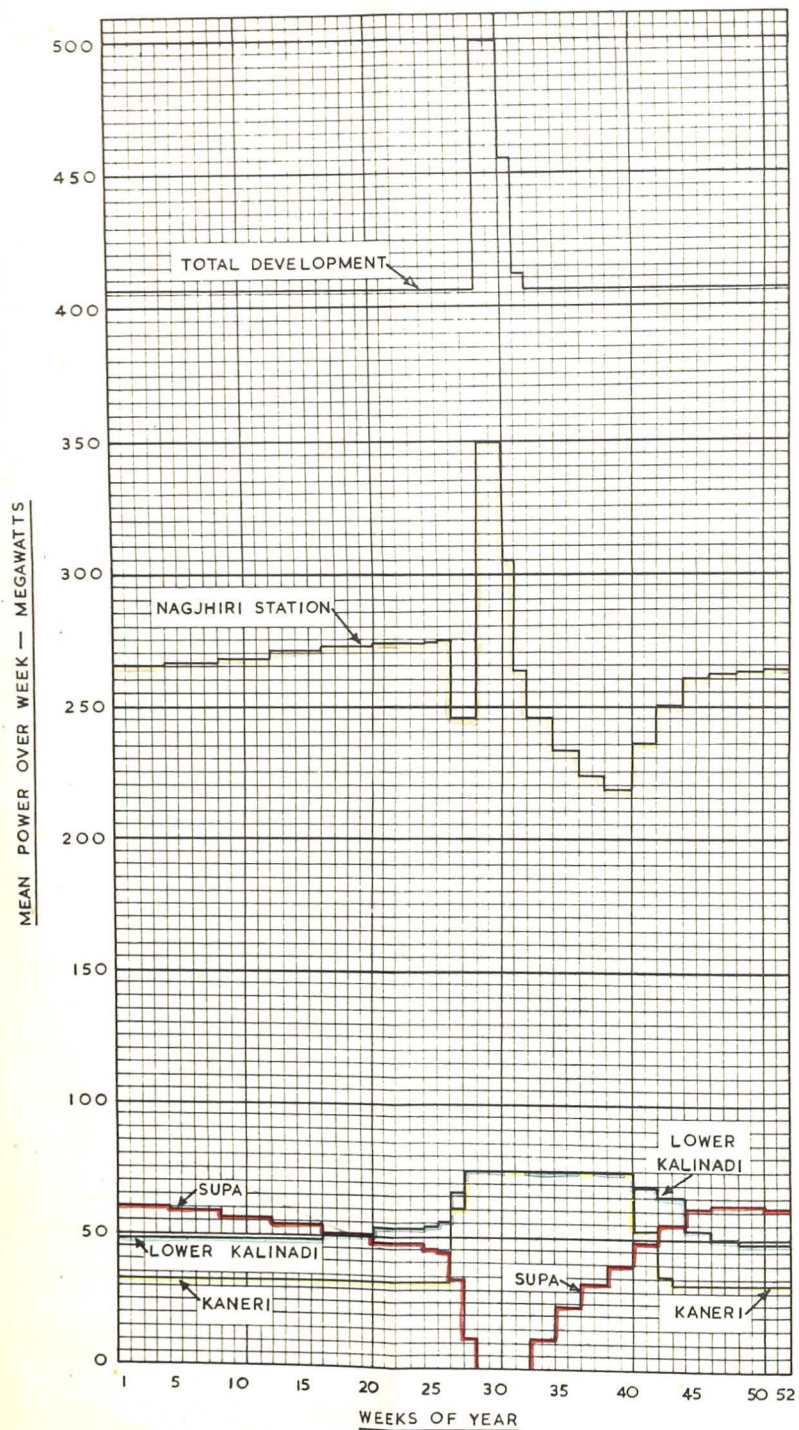


AREA CURVE
LOWER KALINADI RESERVOIR

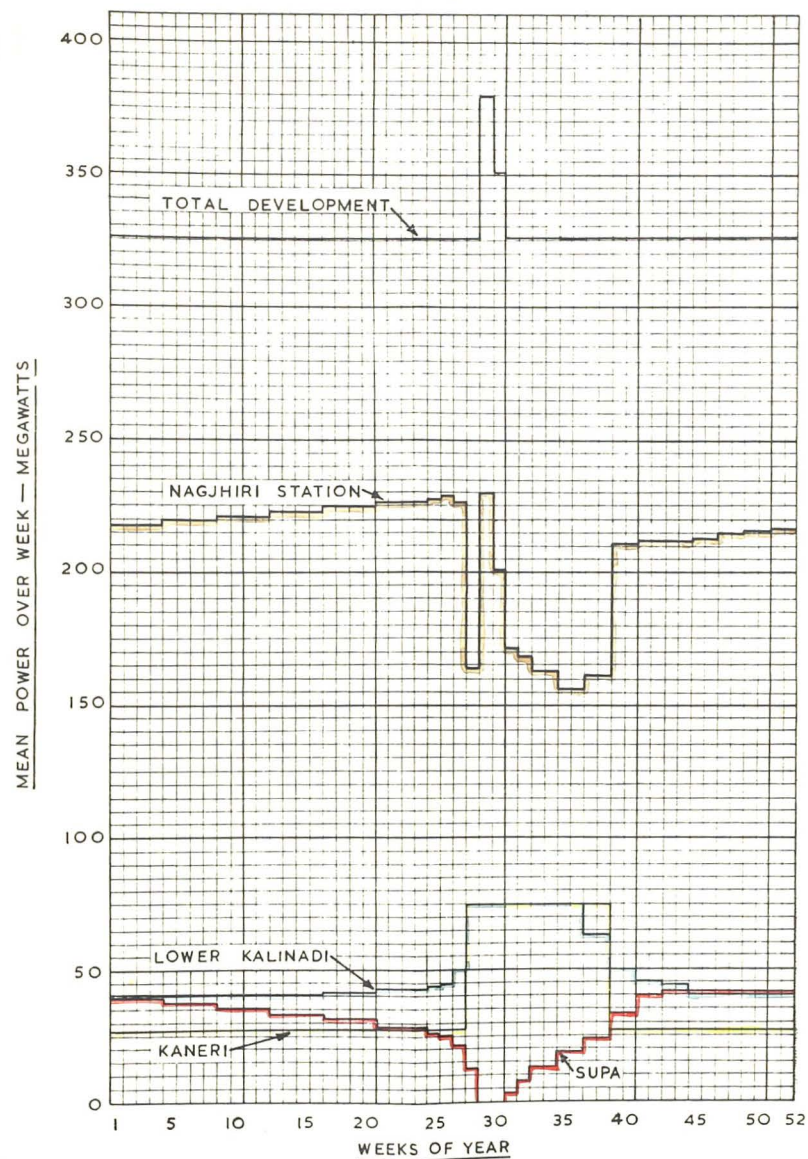


CAPACITY CURVE

KALINADI HYDRO-ELECTRIC SCHEME
PLAN SHOWING
LOWER KALINADI PROJECT



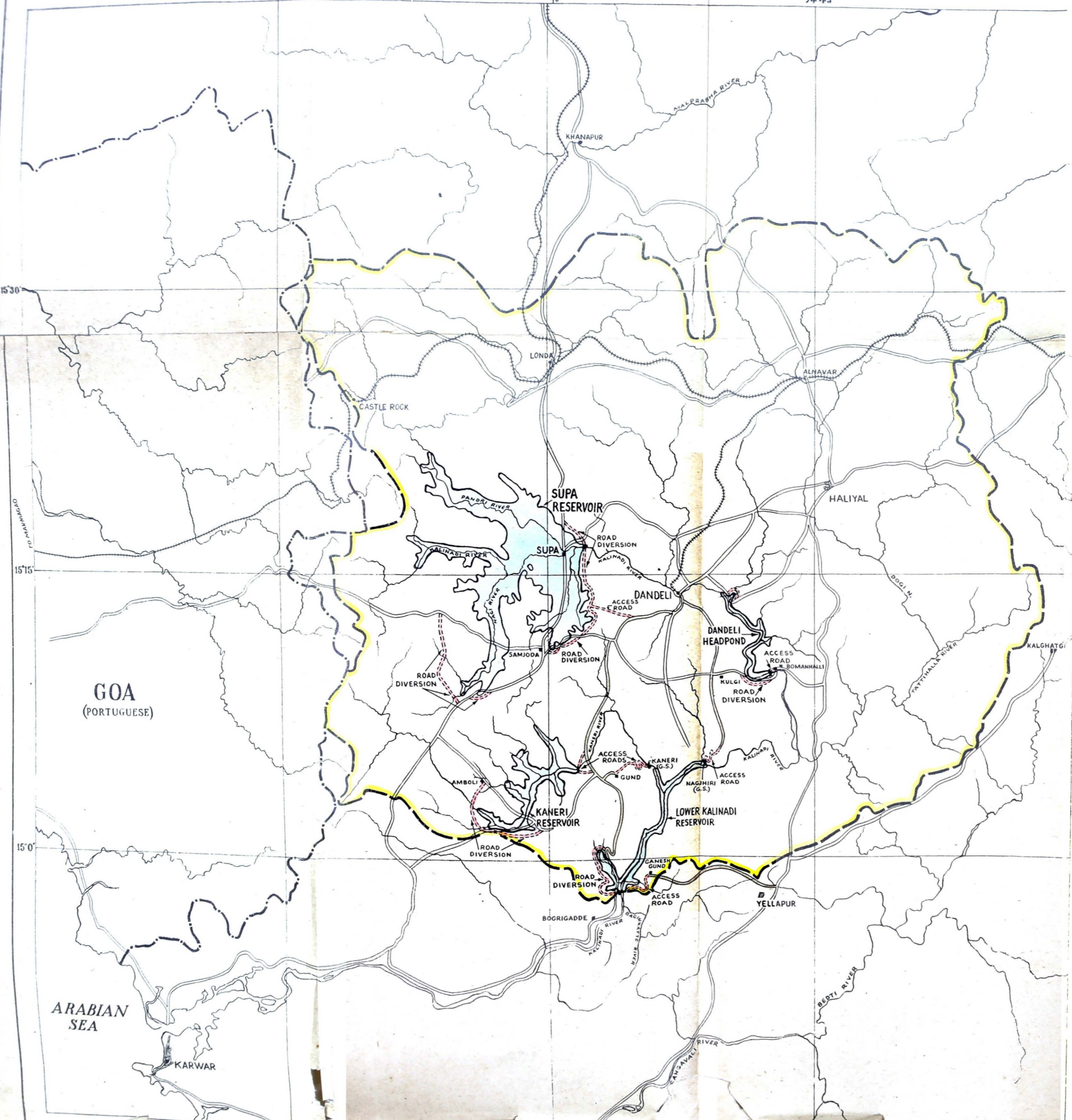
AVERAGE YEAR OPERATION OF KALINADI DEVELOPMENT







DRY YEAR OPERATION OF KALINADI DEVELOPMENT

KALINADI HYDRO-ELECTRIC SCHEME

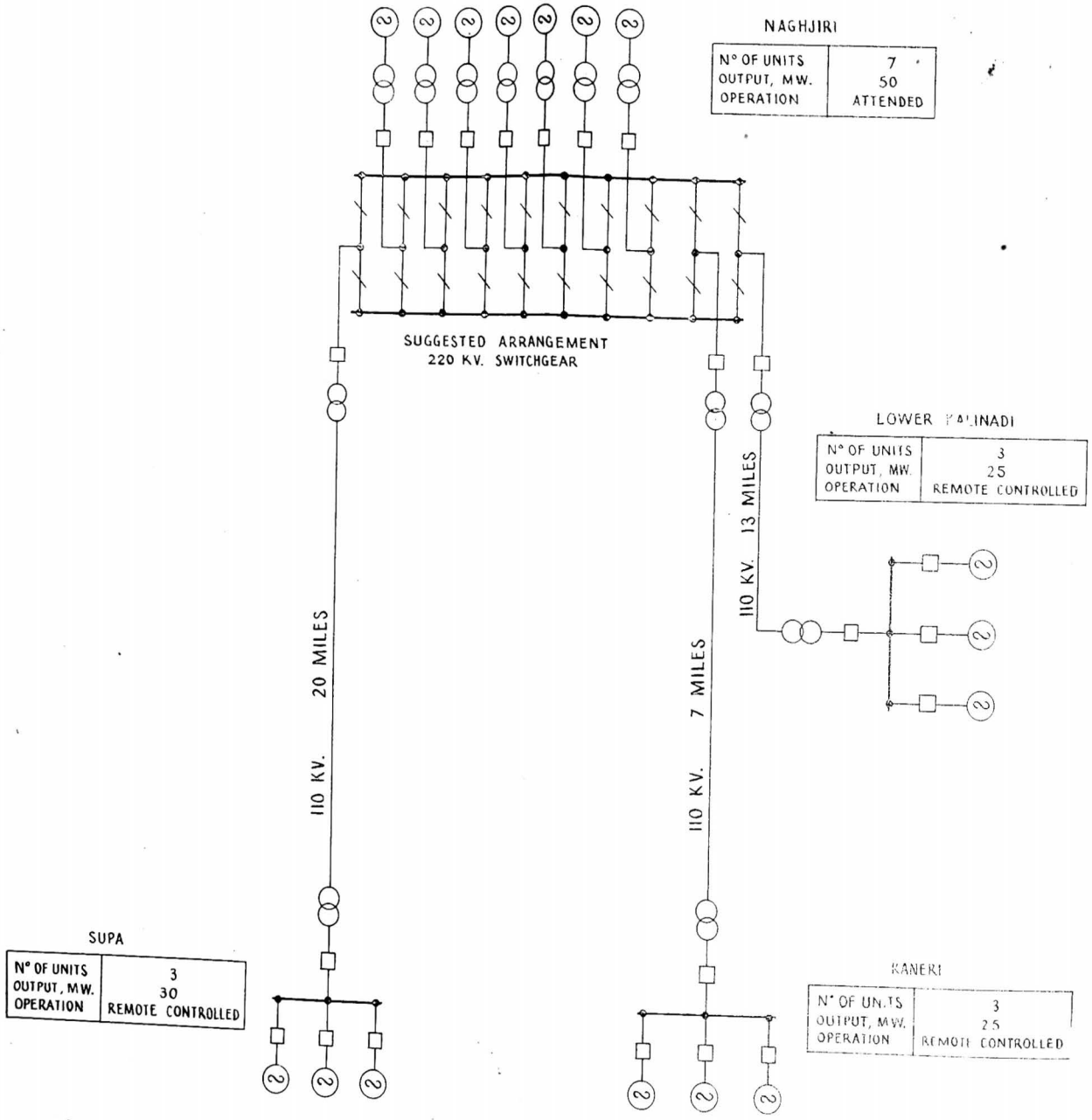
OPERATION DIAGRAM FOR
COMPLETE DEVELOPMENT



NOTES.
 CATCHMENT AREA BOUNDARY SHOWN THUS 
 PROPOSED NEW ROAD WORKS SHOWN THUS 
 EXISTING ROADS SHOWN THUS 
 IMPROVEMENTS TO EXISTING ROADS SHOWN THUS 

SCALE : 4 MILES TO 1 INCH
 MILES 5 0 5 10 MILES

KALINADI HYDRO-ELECTRIC SCHEME
 PLAN OF CATCHMENT AREA
 SHOWING COMMUNICATIONS



NAGHJIRI

N° OF UNITS	7
OUTPUT, MW.	50
OPERATION	ATTENDED

LOWER PALINADI

N° OF UNITS	3
OUTPUT, MW.	25
OPERATION	REMOTE CONTROLLED

KANERI

N° OF UNITS	3
OUTPUT, MW.	25
OPERATION	REMOTE CONTROLLED

SUPA

N° OF UNITS	3
OUTPUT, MW.	30
OPERATION	REMOTE CONTROLLED

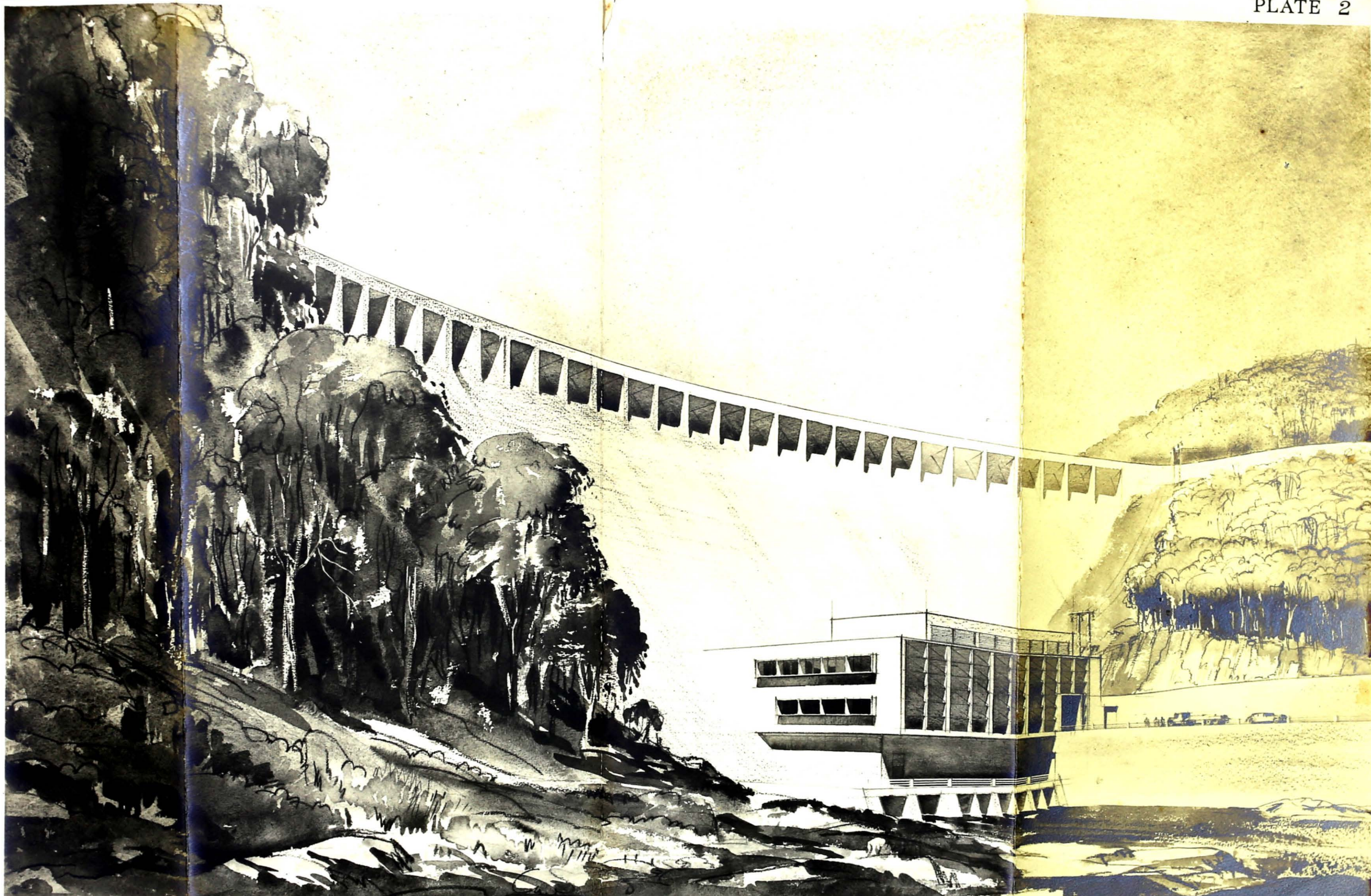
- KEY TO SYMBOLS
- GENERATOR
 - SWITCH
 - TRANSFORMER
 - ISOLATOR

KALINADI HYDRO-ELECTRIC SCHEME

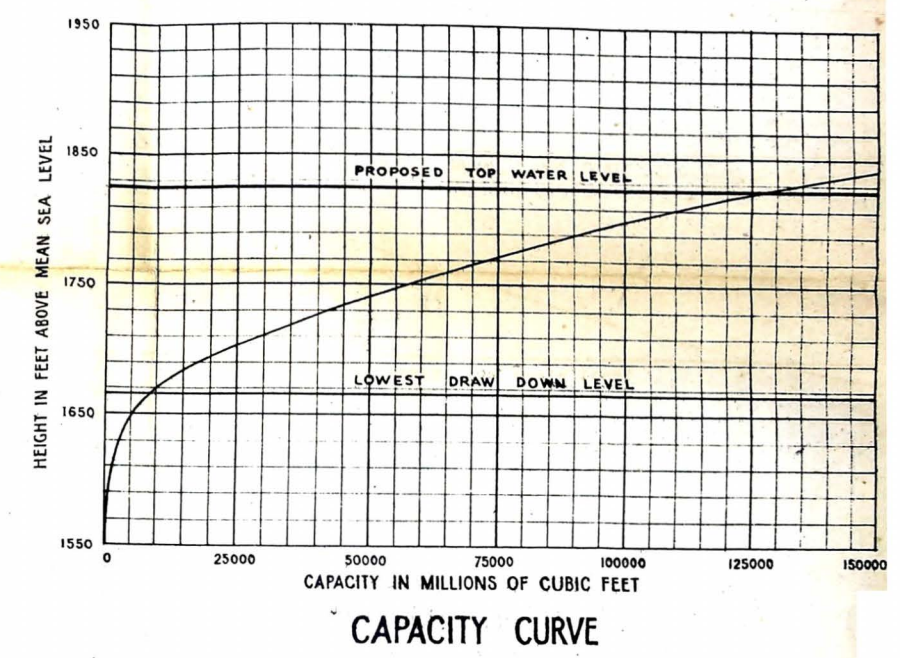
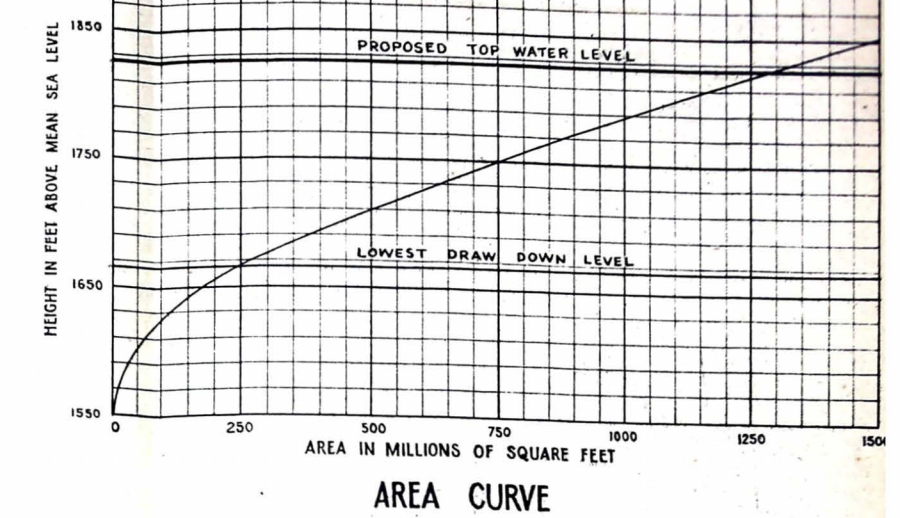
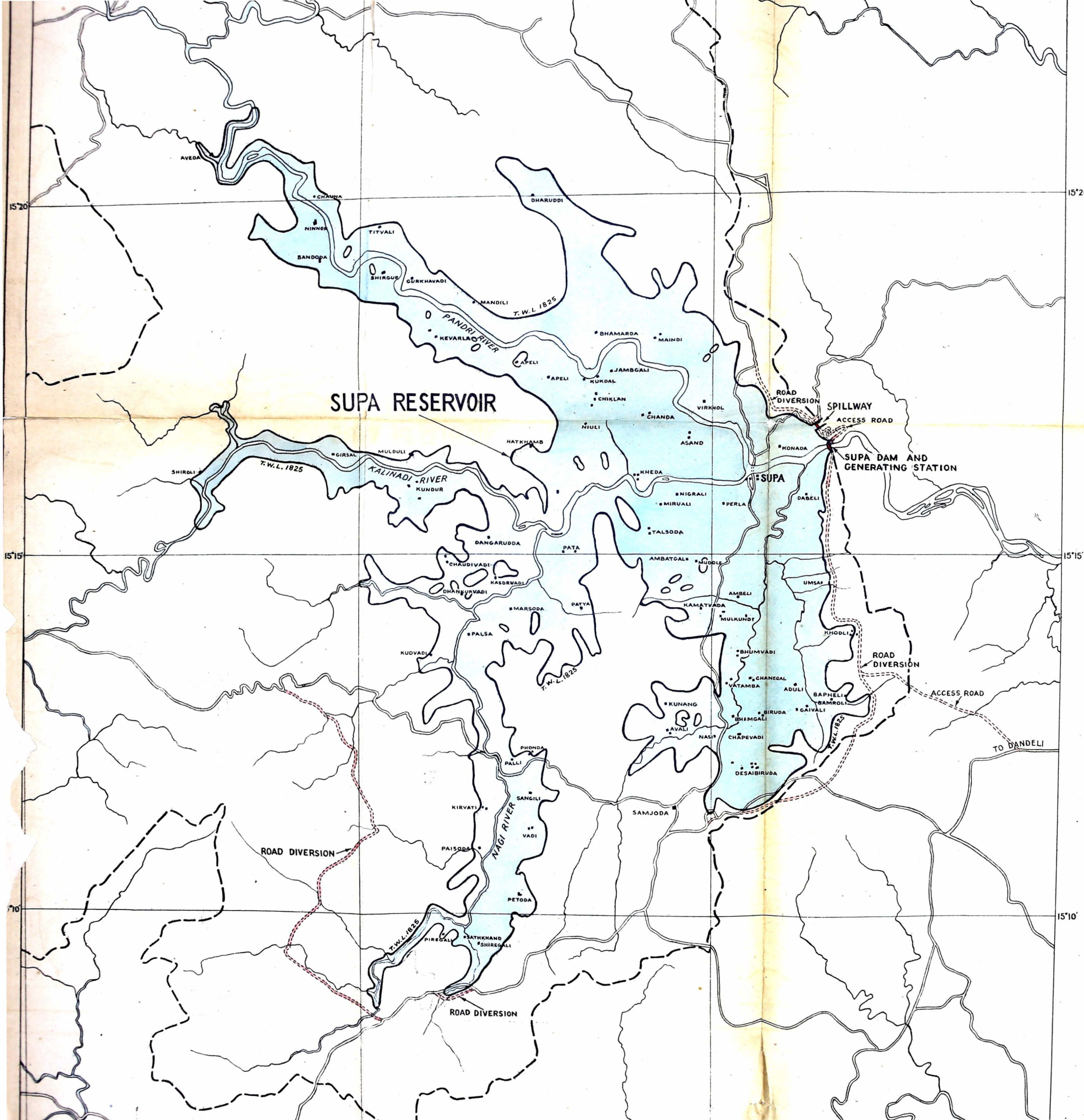
PROPOSED ARRANGEMENTS OF LOCAL INTERCONNECTING TRANSMISSION SYSTEM

DECEMBER 1948

FIGURE N°19



S U P A D A M & P O W E R S T A T I O N



NOTES.
 VILLAGES SHOWN IN STORAGE AREA ARE TAKEN FROM 1" TO 1 MILE SURVEY OF INDIA MAPS AND ARE NOT NECESSARILY IN OCCUPATION AT PRESENT.
 CATCHMENT AREA BOUNDARY SHOWN THUS ———

