CHAPTER - V

TERRAIN RESOURCES - II :
SURFACE WATER
AND
GROUND WATER

CHAPTER - V

TERRAIN RESOURCES:II

SURFACE WATER AND GROUND WATER

INTRODUCTION

Morphology of drainage basin, type of aquifer systems and pattern of rainfall can be considered as the bases to determine surface water as well as ground water potentials for the region. The terrain characters determine the scope and mode of development of the resources. The study area lies at the lower most reaches of the watershed system of Mahi, Dhadhar and Narmada rivers. In view of the large size catchments with favourable rainfall conditions the region has got vast surface water potential. Thick alluvial succession have produced a rich aquifer system. The total available potential is much higher than the optimum requirement in their own drainage basin and surplus could be diverted to the adjoining basins of deficient potential. The spatial and temporal distribution of the surface water and groundwater is such that it is the problem of proper managment rather than availibility. In spite of very high potential several parts in the study area face problem of water supply on account of either quality or quantity or both.

SURFACE WATER POTENTIAL

A river basin has been regarded as a unit of available surface water potential. According to Rao(1979) the total average annual run-off of all the river systems in India is 1,645000 Mm^3, distributed in 14 major, 40 medium and 55 minor river basins (Fig. V.1). The two major basins of Mahi and Narmada and one medium basin of Dhadhar form the water potential for the area. These three basins together drain total 1,36,408 sq.km. of which the study area shares only 4.4 %. Annual average discharge from these basins is of the order of 49,895 Mm3 which shares as much as 3% of total national potential. The study area being located at the lower most reaches of these drainage basins, all the discharge flows through the area. This discharge could therefore be regarded as annual gross potential for the area, In terms of height of water column it works out as much as 10m approximately. Out of which its own share from direct rainfall is only 1 m at annual mean precipitation rate of 1000 mm. The 10m of surface water per year is a tremendous potential. Discharge estimates of these river basins are available in the works of (Rao, 1979; Phadtare,1988). Details of surface water potential for the three river basins are given in Table VI-1.

It is interesting to observe that out of the total 6,000 km^2 of study area 60% is shared by the catchments of Dhadhar, which is medium basin with seasonal flow.

Fig. V.I FLOW DIAGRAM OF MAHI AND NARMADA

(AFTER RAO, 1979)

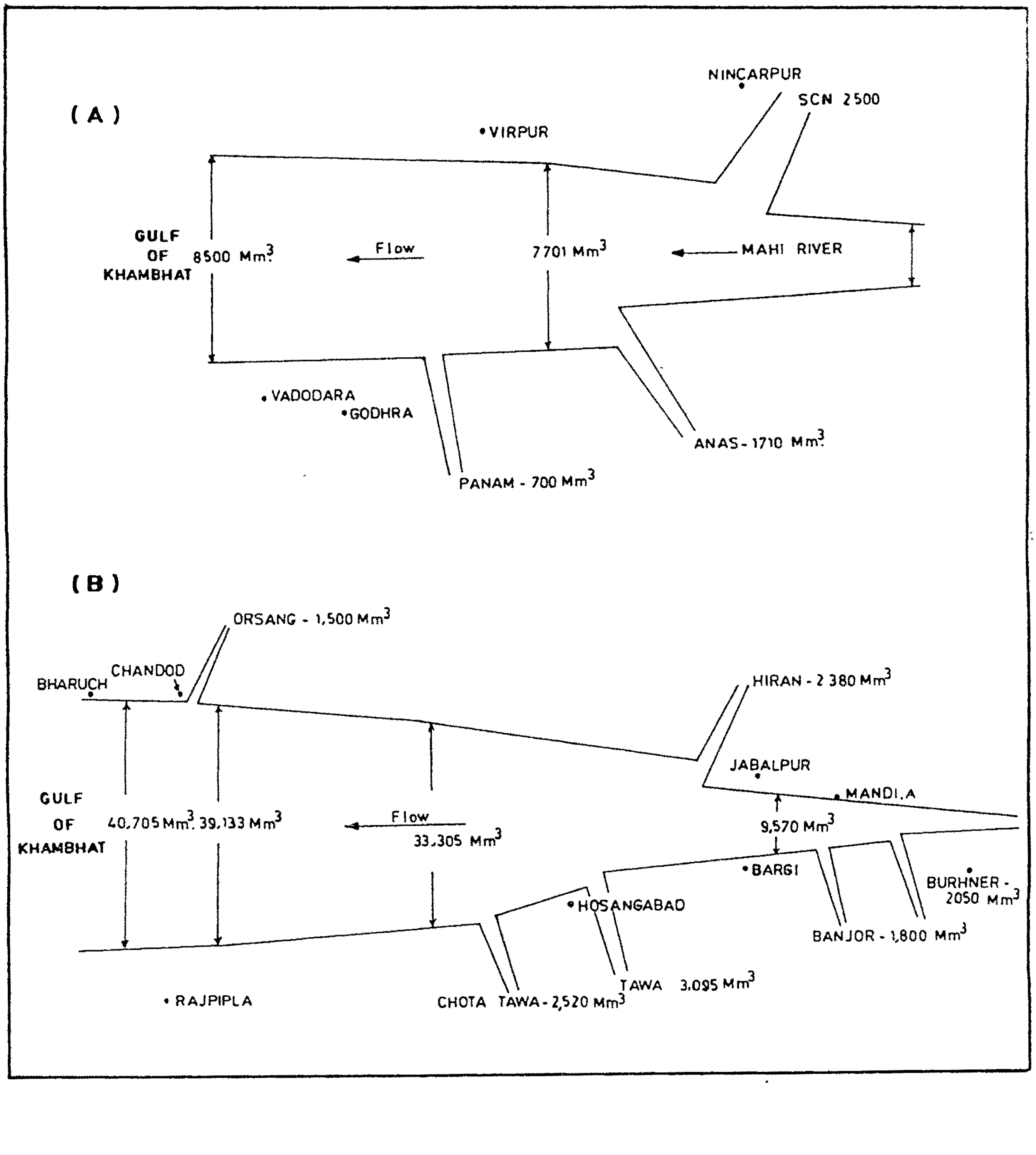


Table V.1 Basin-Wise details of Surface Water Potential

Name of River Basin	Nature of Basin/ River	Length of River Km.	Max. Elevation	Catchment area Km	Av.Am. Rainfall mm	Av.An Discharge Mm
Mahi	Major Parennial	a. 533 b. 110 (20%)	500	a. 34,842 b. 650 (1.8%)	1000	8,500
Dhadhar	Medium Seasonal	a. 160 b. 130 (81%)	300	a. 4,250 b. 3,650 (86%)	1100	690
Narmada	Major Parennial	a. 1322 b. 145 (11.5%)	900	a. 98,796 b. 1,700 (1.7%)	1100	40,705
	Total	---		a. 1,36,400 b. 6,000 (4.4%)	--	49,895

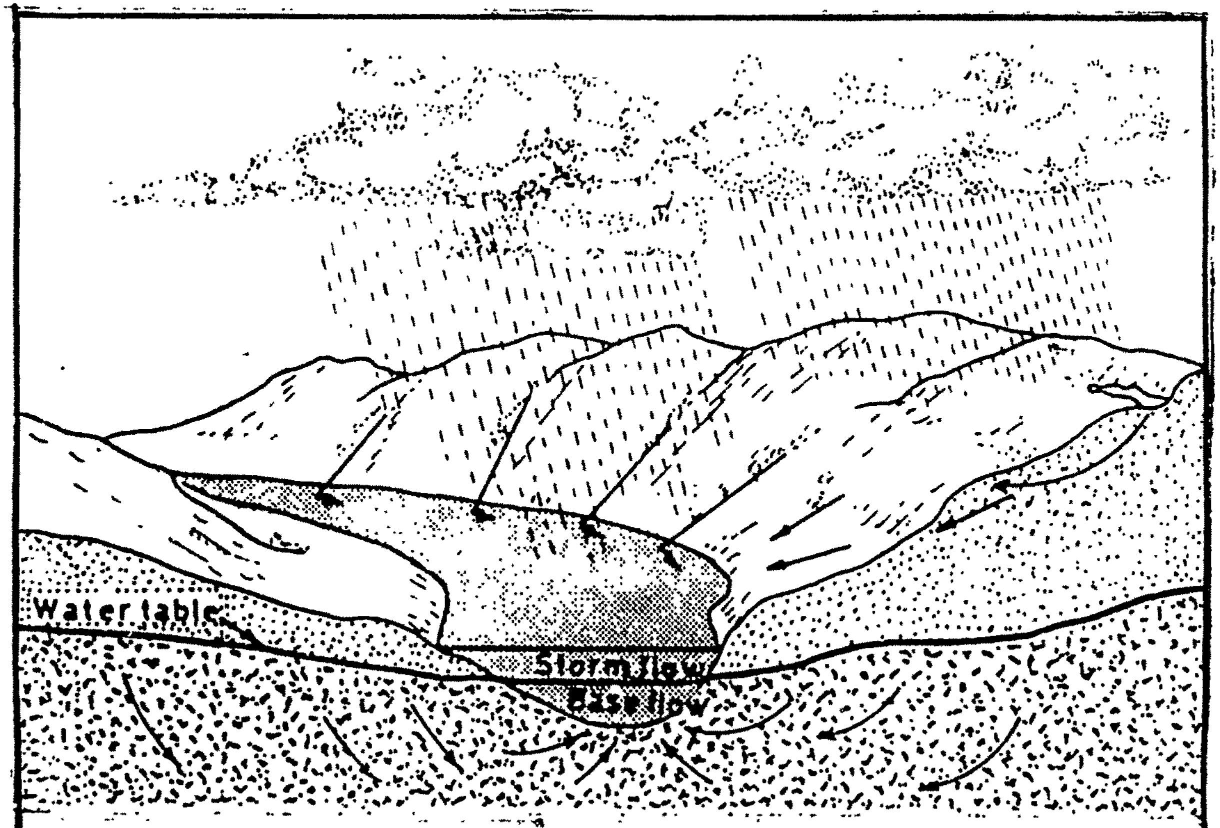
OCCURRENCE AND USE

The distribution pattern of the available gross surface water potential in space and time is really important for planning and its use. Schematic distribution of water resources in space and time as described by Valdiya (1988) is shown in (Fig. V-2). During monsoon a part of the precipitation evaporates into atmosphere; a major portion of it flows on the surface down the slopes to stream channels as surfacial storm runoffs and the balance infiltrates into ground percolating slowly to become groundwater. A part of the groundwater reappears on the surface down the slope after the rainfall to give rise to baseflow that sustains streams during non monsoon period. The surface runoff fills depressions on the ground and the spilling over runs down in irregular sheets, called overland flow, increasing in volume and velocity as, more and more is added.

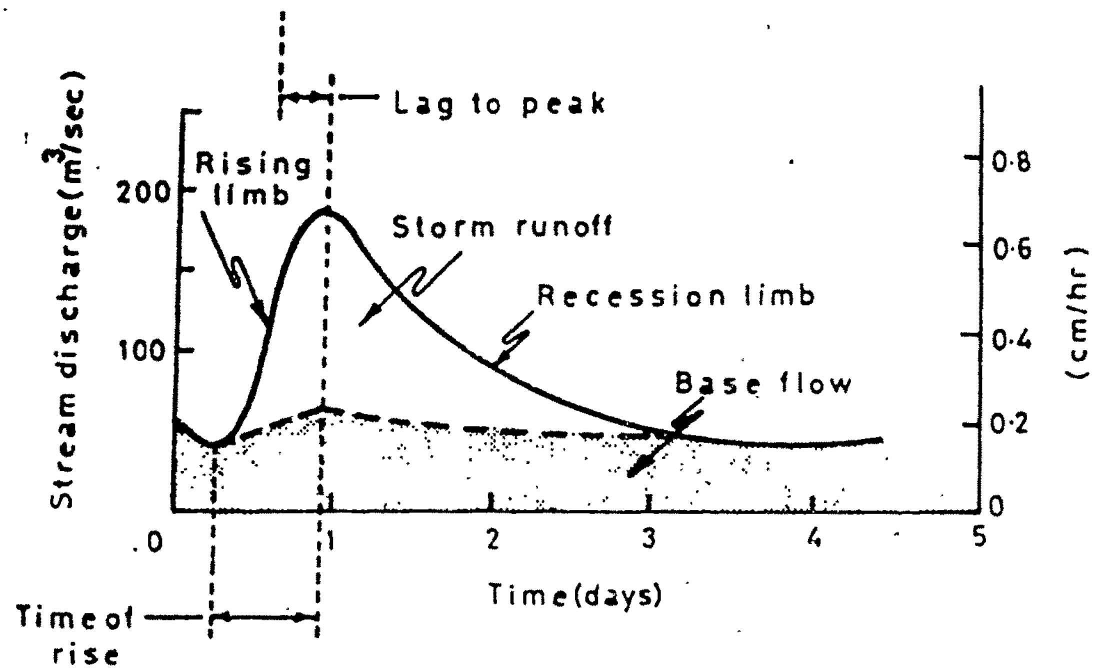
Most of the availabe water is discharged as stormflow during 40 to 50 rainy days during the year. This can hardly be of any use. Of course part of the storm flows are stored in upstream reservoirs and regular release add to the base flows. Table V-2 provide idea about the upstream storages in the three river basins. However, there is sizable baseflow available in the two perennial rivers of Mahi and Narmada. The base flows carry huge quantity and it can be planned for different requirements.

FIG:- V-2

SCHEMATIC DIAGRAM OF SURFACE WATER DISTRIBUTION IN SPACE AND TIME IN A DRAINAGE BASIN



DISTRIBUTION IN SPACE
(after Marsh, W. M. and Dozier, J.; 1981 In Valdiya 1987)



DISTRIBUTION IN TIME
(after Dune, T. and Leopold, L. B.; 1978 . In Valdiya 1987)

Table V-2 Potential v/s Utilisation of the surface water Resources of Mahi, Dhadhar and Narmada.

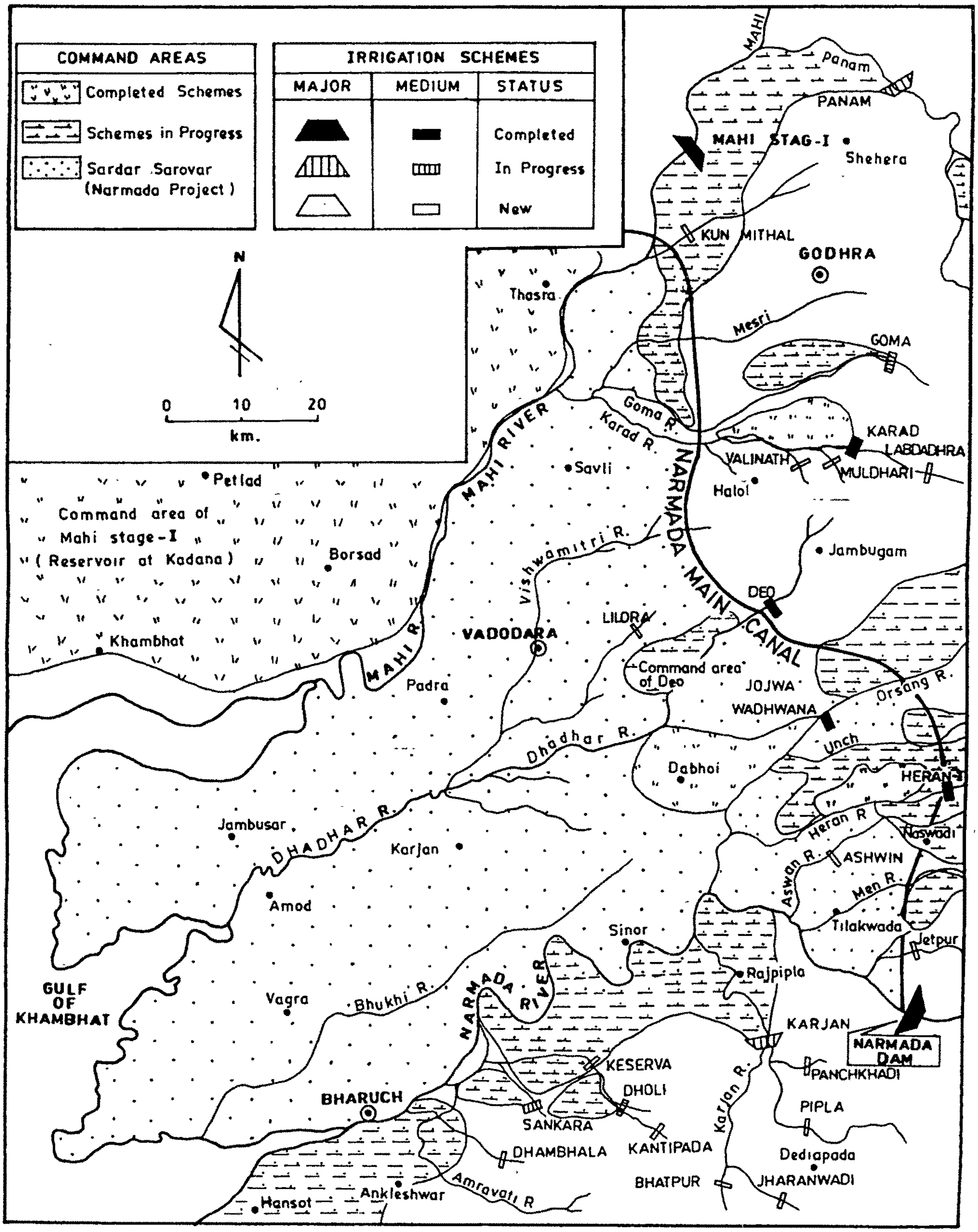
Name of Basin	Gross Potential Mm^3	Utilisation Mm^3	Percentage of total
Mahi	8,500	4,286	56%
Dhadhar	690	84	12%
Narmada	40,705	2,550	6%

Regular release from Kadana and Panam reservoirs on the Mahi maintain the base flow. This flow is used by French Well lifts for industrial and domestic water supplies. At present there are 9 wells in Mahi river bed drawing at a rate of 454 Mld and few more are being planned. Small scale pump lifts for irrigation are also installed on the banks. There are several storages reservoirs in the upstream of Mahi which include Kadana, Banaswada, Panam, Machchanala, Hadaf, Bhadar etc. Water potential of Narmada basin is also planned to harness in several storage reservoirs. The base flow is utilised for lift irrigation and water supply schemes. Dhadhar is seasonal river, and there is a storage dam for irrigation on its major tributory Deo, on the upstream.

Extensive utilisation of the Mahi and Narmada waters had been planned for irrigation, hydropower and supply by constructing storage reservoirs in the upstream. Most of the use is for irrigation purpose (Fig. V.3). The Narmada water are planned to be taken far away from its own basin. The entire

FIG-V-3

SURFACE WATER IRRIGATION MAP OF STUDY AREA



study area is covered under its command. While Mahi waters are utilised on its right bank only i.e.out side the area.

The other mode of surface water occurrence in the area is in the form of tanks and ponds. The boardering area along the east, provides excellent sites for small size storages, tanks. There are several tanks constructed across the tributories of Dhadhar river (Plate V.1). These are utilised for irrigation and water supply (plat V.2). Water potential of all these tanks is approximately estimated and given in the Table VI - 3

Table VI.3 Surface water potential of tanks in the study area.

S.No.	Name of Tank	Max. Depth m	Approx. Area m	Storage x 1000m
1.	Javia Talav	2	312500	312.5
2.	Muval Talav	3	104166	156.249
3.	Karchiya Talav	3	323100	484.65
4.	Lumda Talav	3	250000	375.00
5.	Wadhwana Talav	5	3312500	8281.25
6.	Vadidia Talav	4	1312500	2625.00
7.	Pratappura Talav	5	2500000	6250.00
8.	Kambhonya Talav	4	375000	750.00
9.	Dhavara Talav	4	2000000	4000.00
10.	Sarvan Talav	2	125000	125.00
11.	Sayaji Sarovar Talav	8	17375000	69500.00
12.	Khodiyarpura Talav	2	187500	2625.00
13.	Shipoortimbi Talav	3	1562500	2343.75

PLATE V.1 A view of the wardala irrigation tank in the eastern Peidmont zone, Loc. near Sonalaya

PLATE V.2 A view of the irrigation cannal from wardala tank

PLATE V.3 A view of village pond, Loc. near Jalia village

In the inner and coastal parts of the area there are smaller size water collection ponds (Plate V-3). The storage is utilised for domestic (other than drinking) purposes and cattles etc. The sites of the ponds are generally determined by the microgeomorphic features like local depressions or palaeochannels etc. Many a times local drains are blocked by the habitants to form a pond. Thus, the ponds have mixed characters of natural as well as artificial. Storage distributed all over the area make their optimum utilisation. The pond in the inner part have less density compared to that in the coastal part, but average depth in inner area is about 6m while in the coastal part, it is about 4m. Islam and Tiwari (1988) carried out detailed survey of ponds in the coastal areas around the gulf of Khambhat. Total water potential of the ponds is estimated as 50 Mm^3 as shown in the Table V-4.

Table V-4 Water potential of ponds in the study area

Area	Nos. of Ponds	Average Area m^2	Average depth m	Potential Mm^3
Inner	250	40000	6	30
Coastal	270	50000	4	27
Total	520	45000	5	57

GROUNDWATER RESOURCES

Regional hydrogeological map of Gujarat and adjacent areas is given in (Fig. V.4) showingground water conditions in

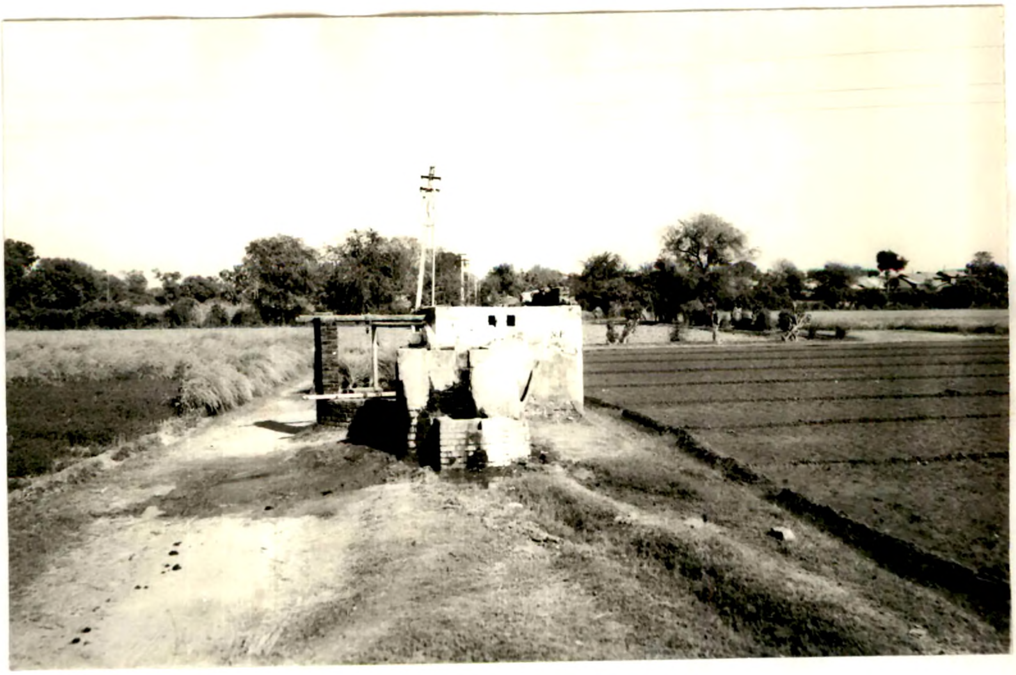


PLATE V.4 Tube well draining high supply from deeper semi-confined aquifers, Loc. near Padra

PLATE V.5 Shallow well of limited sweet water in coastal area, Loc. near Dahej

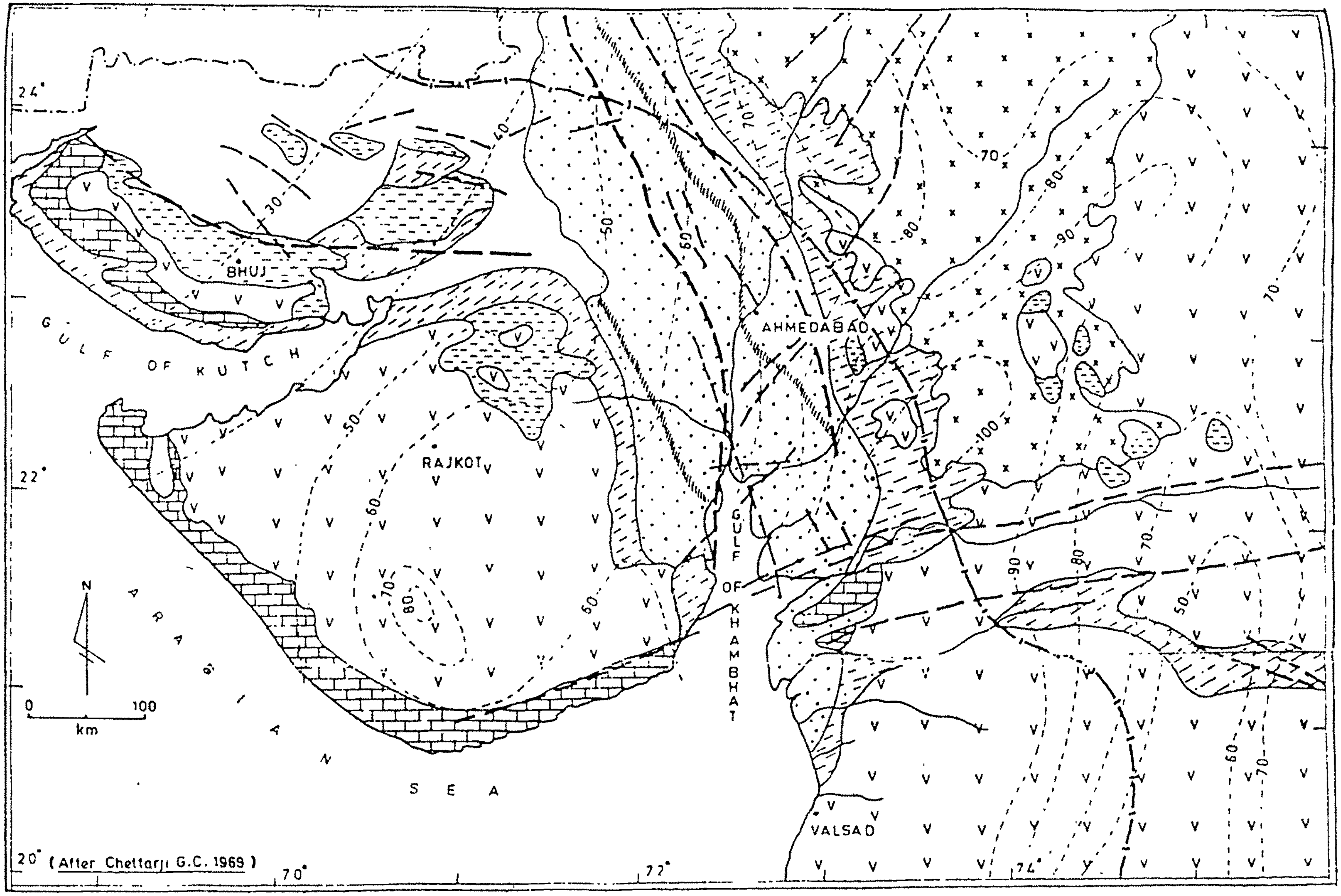


FIG-V-4 HYDROGEOLOGICAL MAP OF THE GUJARAT AND ADJACENT AREAS

SYMBOL	AGE GROUP		LITHOLOGY	TECTONIC FRAMEWORK	GROUNDWATER CONDITIONS
	QUATERNARY UPPER TERTIARY	UNCONSOLIDATED FORMATION	CLAY, SILT, SAND GRAVEL, PEBBLES, BOULDERS, CALCAREOUS CONCRETIONS	GROUNDWATER BASIN OCCURING IN PLATFORM AREA AND FORE-DEEP ZONE.	GROUNDWATER BASIN HAVING EXTENSIVE LATERAL EXTENT AND THICKNESS OF AQUIFERS UNDER CONFINED CONDITIONS BEYOND ,100 m
				PLATFORM MARGINS IN PARTS OF MAINLAND RIVER BASIN, COASTAL PLAINS OF KUTCH	MARGINAL AREAS OF GROUNDWATER BASINS HAVING AQUIFERS WITHIN 100 m WITH LIMITED EXTENSION DUE TO BOUNDRY CONDITIONS
	QUATERNARY AND TERTIARY	SEMI CONSOLIDATED FORMATION	LIMESTONES (Miliolite, Guj Kirthar)	COASTAL AREAS OF SAURASHTRA AND BETWEEN TAPI AND NARMADA MOUTHS	KARSTIC LIMESTONES (MILIOLITE, AND GUJ) IN COASTAL AREA HAVING GROUNWATER IN CAVERNS AND SOLUTION CHANNELS WITHIN 50m.
	TERTIARY AND MESOZOIC		GRITS, SANDSTONS, SILTSTONES, SHALES, CONGLOMERATES, LIMESTONE	PLATFORM AREAS IN KUTCH AND NW SAURASHTRA OUTLIRES AND INLIRES IN E. GUJARAT AND NARMADA VALLEY	TERTIARY AND MESOZOIC SEDIMENTARY ROCKS WITH RESTRICTED CONFINED AQUIFERS IN PLATFORM AREAS
V V	CRETACEOEOCENE	CONSOLIDATED FORMATION	BASALTS (WITH INTERTAPPEAN BEDS)	TERRESTRIAL VOLCANIC EFFUSIONS ON PLATFORMS	GROUND WATER OCCURRENCE RISTRICTED TO WEATHERED ZONE, JOINT PLANES, ZONES OF SHEARING AND FAULTING AND VESICALS PHREATIC UNCONFIND CONDITIONS PREVAIL IN WEATHERED ZONE AND PIESTIC CONDITIONS IN DEEP FRACTURES
x x x	PRECAMBRIAN		SANDSTONES,SHALES SLATES, PHYLLITES, QUATIZITES, DOLOMITES, MARBLES, SCHISTS, GRANITES, BASIC IGNEOUS ROCKS	ANCIENT PLATFORM AREAS OF ARCHAEAN FOLDING	GROUNDWATER OCCURRENCE RESTRICTED TO SOIL & REGOLITHIC COVER AND WEATHERED AND FISSURRED ZONES UNDER PHREATIC UNCONFINED CONDITIONS

WATER QUALITY

- GROUNDWATER SALINITY WITH LITTLE POSSIBILITY OF ENCOUNTERING FRESH WATER AT DEPTH
- GROUNDWATER SALINITY INCREASES WITH DEPTH
- GROUNDWATER FREE FROM SALINITY HAZARDS

SPECIAL HYDROLOGICAL FEATURES

- BOUNDARY AREAS WITH ARTESIAN FLOWING CONDITIONS
- 50 — ISOHYTES ANNUAL AVERAGE RAINFALL IN cm

GEOTECTONIC FEATURES

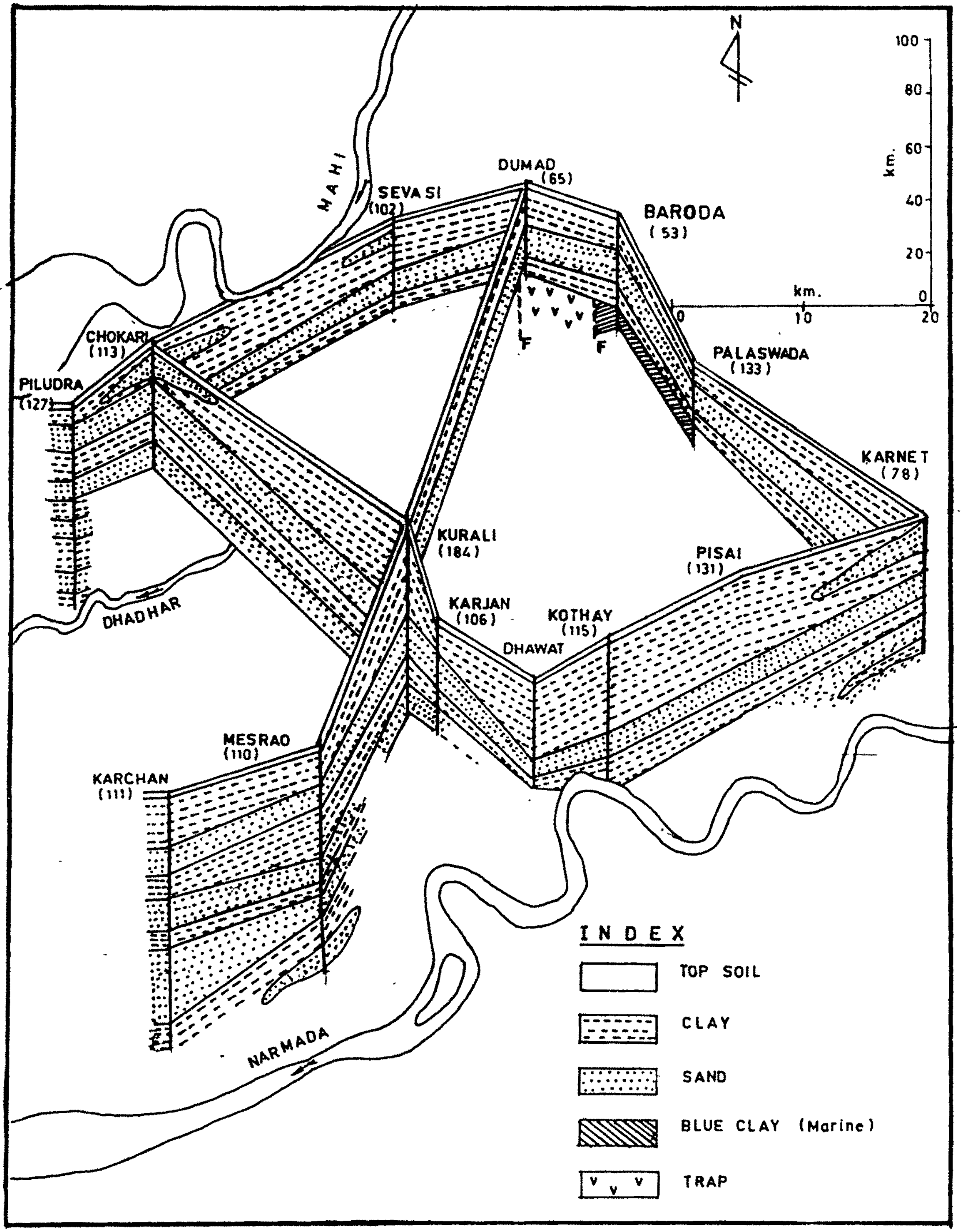
- MAJOR FAULTS
- MINOR FAULT
- TECTONIC ZONAL BOUNDARY

INDEX OF THE HYDROGEOLOGICAL MAP OF THE GUJARAT AND ADJACENT AREA lithostructrual framework and quality conditions. Accordingly, occurrence of groundwater is confined to unconfined, aquifers in unconsolidated formation of plateform margins of mainland river basins and salinity increases westwares. Datails aboout the ground water occurrence, movement potential quality etc. are available in the works of Phadtare (1988), GWRDC (1987), ORG (1985), Murthy (1975), Islam and Tiwari (1988), Tiwari and Patel (1989)etc. Having critically studied all available literature and actual field work, the author has provided a comprehensive picture of the groundwater conditions for the study area.

The sand gravel horizons in the Quaternary depositional sequence form a rich aquifer system in the area extending to a maximum depth of about 300 m in the west to aboout 30 m in the east. The tectonic activities associated with the sedimentation have affected the lateral continuity of the deposits rendering the semi-confined aquifers into a complex system. The water table aquifers extend to a depth of 10 to 30m. The aquifers have their recharge in the eastern peidmont zone. Most of the aquifers coalesce into the phreatic zone in the recharge area. However, in the central and western parts the aquifers occur under sub-artesian conditions. The distribution of aquifer system as seen in the fence diagram and profile sections is given in Fig. V-5. These are based on the tube well data at selected locations. It is seen that in the eastern parts the unconoslidated sediments are underlined by either Deccan basalts, Mesozoic sandstones or Precambrian crystallines to depth of 30 to 50 m. In fact, this area forms the recharge zone for the confined aquifers of the

FIG-V-5

FENCE DIAGRAM OF THE STUDY AREA

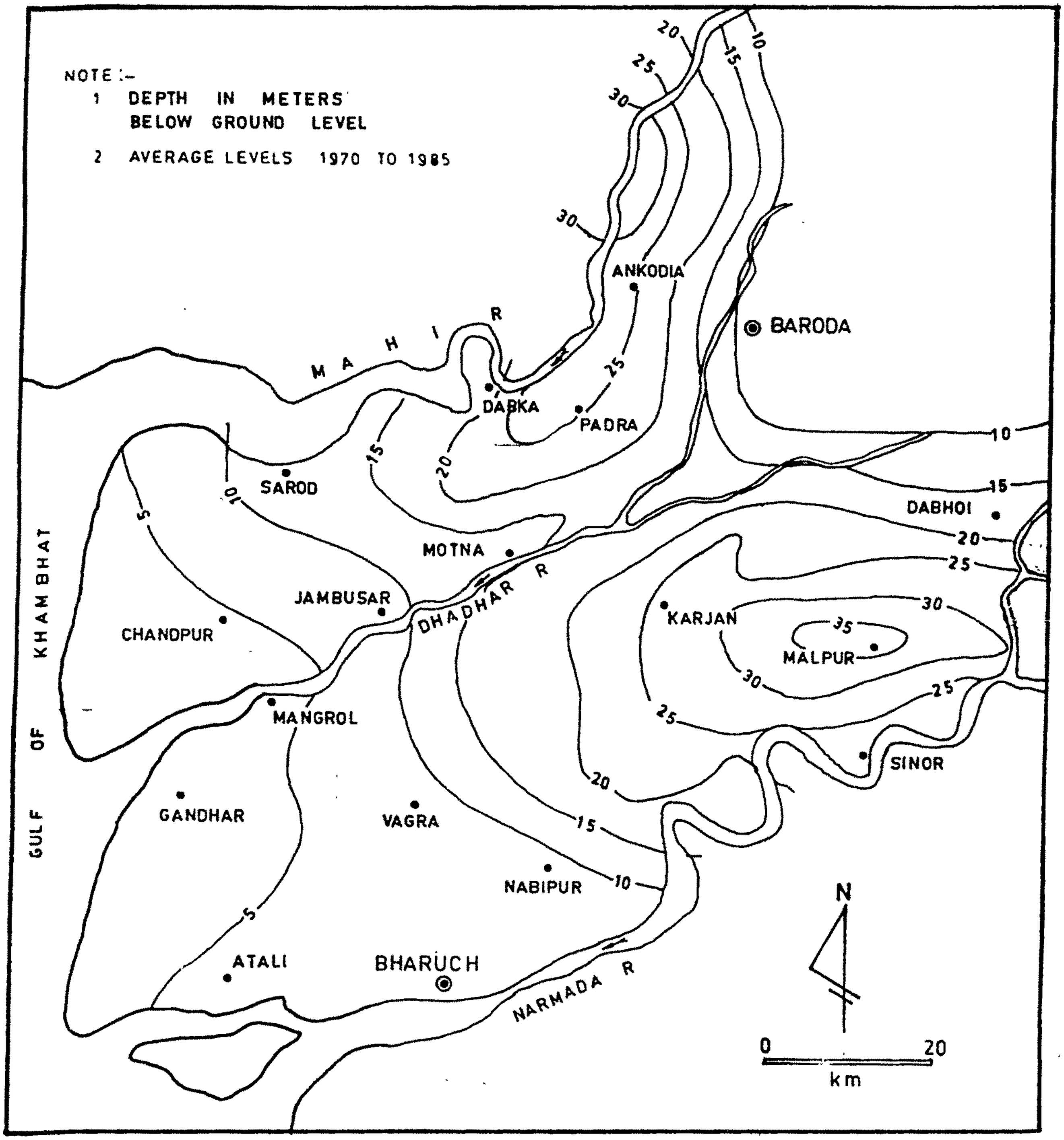


Central part. In the central part groundwater below this depth is not tapped below 200 to 300 due to increasing salinity (Plate V-4). In the coastal zone the confined aquifers being saline at shallow depth. The phreatic aquifer in this zone being less productive and of limited thickness (Plate - 5). The area suffers from groundwater supply. The aquifer system has been completely affected by the tectonic actvities as a result, there is no uniform pattern of ground water occurrence. In a b oad sense the eastern part has moderate supply from phreatic aquifer, the central part draw the confined aquifers of high yield while the coastal area has phreatic aquifers of poor yield. An interesting exception of poor yield of higher salinity has been observed in a small pocket around Dabhoi Waghodia area in the central parts due to occurrence of thick clay beds at shallow depth. This is possible on account of block faulting and uplift, the pocket does not yeild sweet water.

Water table is found to generally follow the topography. Water levels in the unconfined aquifer ranges in depth from less than 5m in western part to about 35 m in the eastern and central parts. A map showing depth to static water level is given in Fig V.6. Two pockets, one on northeast and other in southeast around Ankodia and Malpur respectively show relatively greater depths to water table. It is mainly on account of local topographic high of surface depositions. Seasonal water level fluctations are found to be within the range of 1 to 3m. (Fig. V.7). The general groundwater flow pattern in the area is from

FIG V-6

DEPTH TO WATER LEVEL MAP



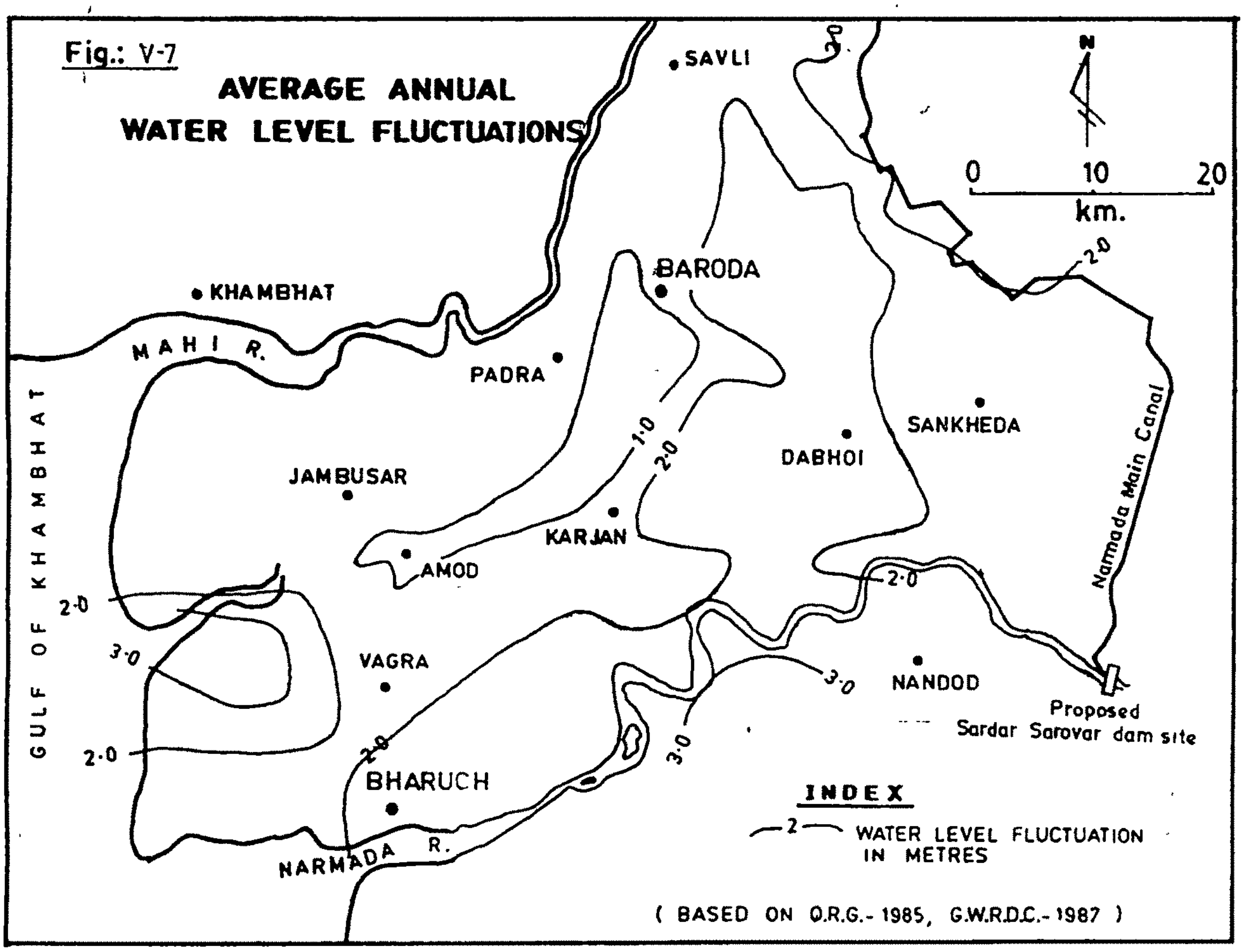


Fig.: V-7
AVERAGE ANNUAL
WATER LEVEL FLUCTUATIONS
SAVLI
KHAMBHAT
MAHI R.
PADRA
BARODA
JAMBUSAR
DABHOI
SANKHEDA
KARJAN
AMOD
VAGRA
BHARUCH
NANDOD
NARMADA R.
GULF OF KHAMBHAT
Narmada Main Canal
Proposed
Sardar Sarovar dam site
0 10 20
km.
N
1·0
2·0
3·0
INDEX
2 WATER LEVEL FLUCTUATION
IN METRES
(BASED ON O.R.G.- 1985, G.W.R.D.C.- 1987)

ENE to WSW. It is seen from from the water table map showing water level contours and direction of water flow (Fig. V.8). The general flow direction is seen locally disturbed. It is on account of high rate of pumpage. Convergence of flowlines towards Mahi and Narmada is also significant. This is possibly due to the differential depth of the confining clayey layer at the bottom of the aquifers. Water table gradient is in general steep (1:200) toward east, gentle (1:1100) in the central part and very gentle (1:2100) in the western part. It is interesting to observe that the hydraulic gradient is towards the sea and not towards the major rivers of Mahi and Narmada. Thus, the river channels are seen behaving indifferent to the groundwater flow pattern. This is on account of the Quaternary sedimentation, under strong influence of tectonism.

Aquifer Parameters :

The GWRDC (1987) has carried out extensive pumping test to determine aquifer parameters. Generalised values for the parameters of unconfined and semiconfined aquifers are given in Table V.5 and V.6.

Table VI.5 Generalised parameters for unconfined aquifers

Parameters	Unit	Central and eastern parts	Western coastal parts
1. Discharge	m^3 / min	0.18 to 3.35	0.40 to 2.10
2. Transmissi-ssibility	m^2 / day	30 to 475	65 to 320
3. Sp. Capacity	m^3 / min/m	0.03 to 1.43	0.2 to 0.8
4. Sp. Yield	%	2 to 11	2 to 10

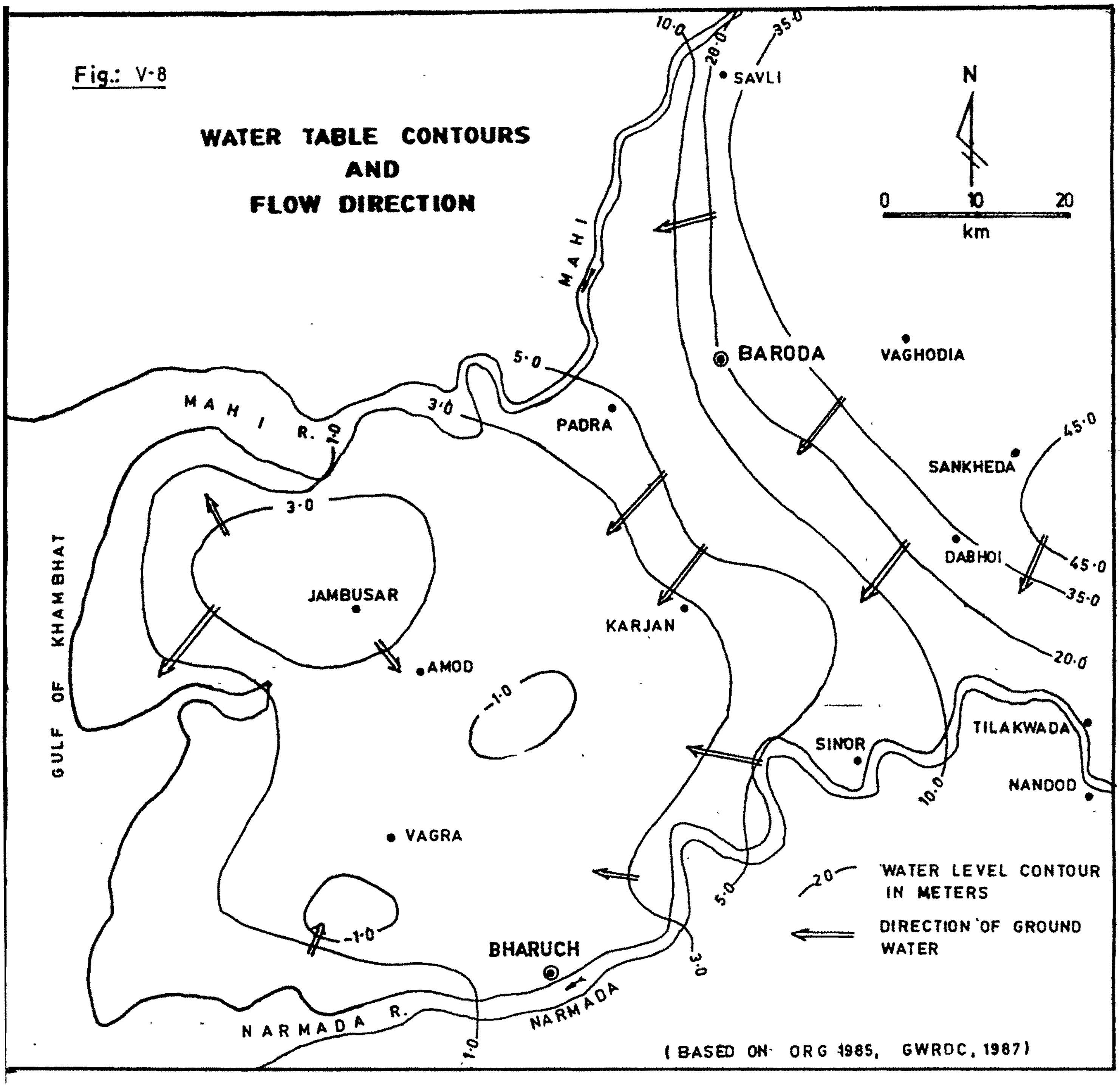


Fig.: V-8
WATER TABLE CONTOURS
AND
FLOW DIRECTION
N
0 10 20
km
10·0
28·0
35·0
SAVLI
MAHI
BARODA
VAGHODIA
5·0
3·0
PADRA
MAHI R.
1·0
45·0
SANKHEDA
3·0
DABHOI
45·0
35·0
20·0
JAMBUSAR
KARJAN
AMOD
-1·0
GULF OF KHAMBHAT
SINOR
TILAKWADA
NANDOD
10·0
VAGRA
5·0
20
WATER LEVEL CONTOUR IN METERS
DIRECTION OF GROUND WATER
-1·0
BHARUCH
3·0
NARMADA R.
NARMADA
1·0
(BASED ON ORG 1985, GWRDC, 1987)

Table V.6 Generalised Parameters for semiconfined aquifers

Parameters	Units	Central and eartern parts	Western castal parts
1. Discharge	m^3 /day	1600 to 3100	126
2. Transmiss-ibility	m^2 / day	515 to 5000	-
3. Permeability	m / day	25 to 180	-
4. Storage	-	1.003×10^{-3} to 3.43×10^{-2}	-

The leakage coefficient from unconfined to semiconfined aquifer is estimated to vary be ween 3.43×10^{-2} to 7.78×10^{-5} For the practical purposes both the unconfined and semiconfined aquifers could be collectively regarded as a compound system.

Chemical Quality :

The GWRDC (1987) has carried out extensive analysis to assess chemical quality of the ground water Fig. V.9. Number of selected analyses from different location are given in Table V.7. A location map of analysed samples is given in Fig. V.10. The water chemistry show wide range of variation. It is mainly on account of the diversity of the environment of sediments comprising the aquifer system. The lateral variation as traced from east to west and that with progressively increasing depth reflect the history of sedimentation of the aquifers in time and space. The predominnance of fluvial influence in the east and marine in west is remarkably relfected in the water chemistry.

MAP SHOWING GEOCHEMICAL TYPES OF GROUND WATER

FIG- V-9

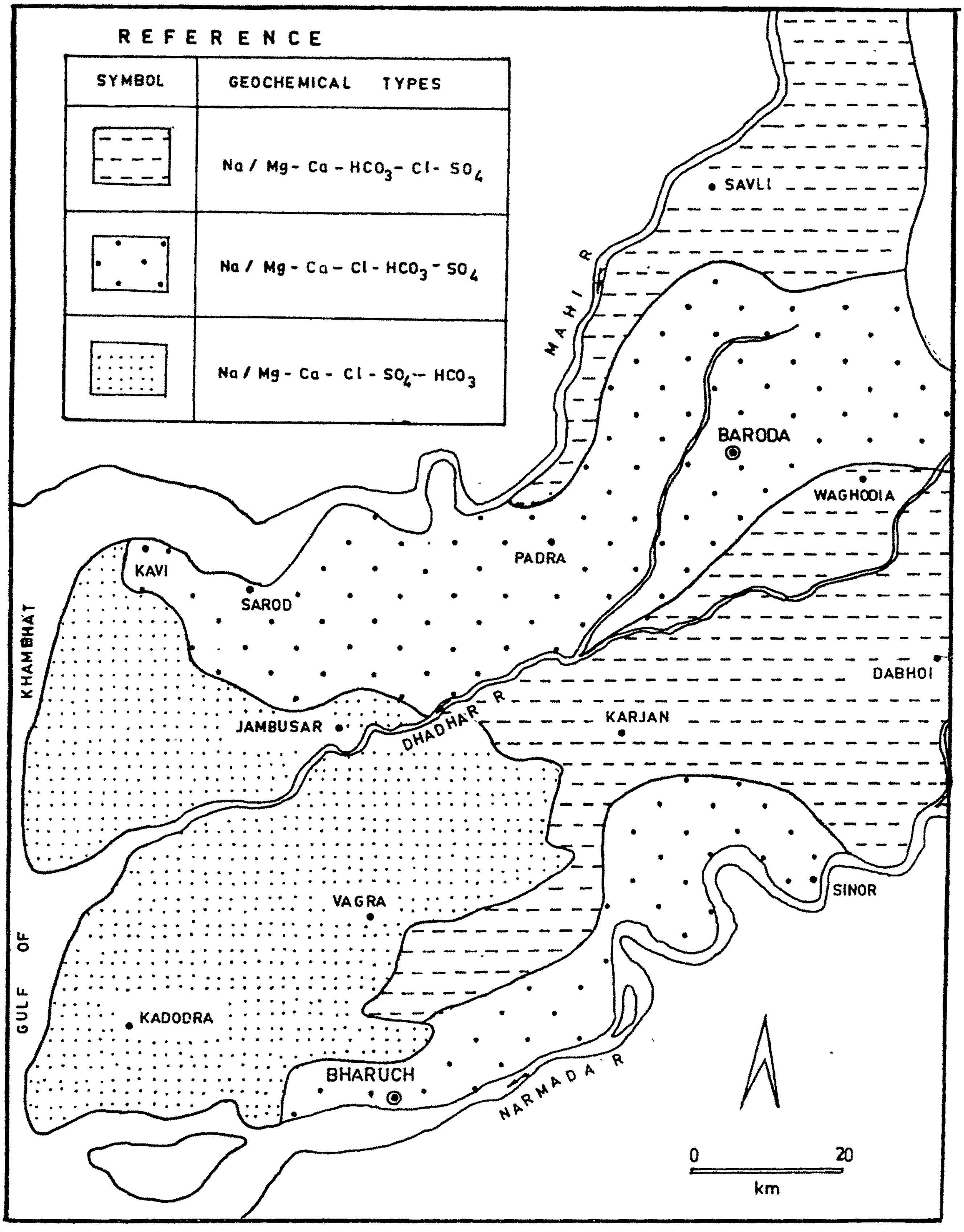


TABLE V.7 HYDROCHEMISTRY OF GROUND WATER

(Analysis May 1985, in GWRDC report 1987)

Sr	Location	pH	TDS	Cation (ppm)			Anions (ppm)		
				Ca	Mg	Na	CL	HCO3	SO4
1.	Kavi	8.0	1550	1.00	5.50	19.74	11.49	11.00	2.89
2.	Sarood	8.4	7000	0.50	8.00	118.30	84.50	30.60	11.00
3.	Sombha	8.0	4430	1.00	11.50	61.00	53.41	8.20	12.00
4.	Chandpur	7.8	17500	20.00	38.00	240.3	290.70	2.00	5.90
5.	Jambusar	8.4	1500	0.50	5.50	10.00	2.70	20.40	1.00
6.	Jaspur	8.2	12050	3.75	14.75	14.50	12.61	13.00	6.00
7.	Mangrol	8.4	9900	0.50	30.75	133.70	125.29	14.60	27.10
8.	Gandhar	8.2	15600	1.50	15.00	228.35	185.90	49.10	9.8
9.	Vagra	8.0	4400	4.75	14.75	57.30	60.00	10.00	5.00
10.	Kadodara	7.8	28000	10.50	69.25	395.05	422.66	3.00	49.16
11.	Luwara	8.4	3960	0.50	3.75	59.17	27.04	24.60	11.79
12.	Atali	8.4	7400	0.75	5.25	113.69	80.00	17.60	22.12
13.	Bharuch	7.8	1450	1.25	2.75	20.39	19.83	5.00	Nil
14.	Nabipur	7.8	400	1.25	2.75	2.60	2.70	4.00	Nil
15.	Kerala	8.0	3040	0.75	0.75	47.40	29.29	7.60	12.00
16.	Bhoesan	8.0	980	0.75	4.50	10.25	4.51	7.00	3.30
17.	Urad	7.8	930	0.75	5.0	10.00	10.14	5.60	Nil
18.	Mutar	7.8	1080	2.00	10.50	6.00	10.81	3.60	4.00
19.	Karjan	7.8	1150	1.50	8.50	10.52	13.97	4.10	2.40
20.	Karnakuva	8.0	800	0.75	1.25	10.43	2.70	9.80	Nil
21.	Dabka	8.2	3000	0.75	21.0	25.00	21.85	14.00	11.00
22.	Ankodia	8.0	1730	1.50	11.75	14.00	14.64	9.60	3.00
23.	Raika	7.8	620	1.25	6.75	3.47	4.95	6.40	Nil
24.	Savli	8.0	1450	1.25	3.00	19.85	8.11	16.00	Nil
25.	Juna Samalay	8.0	620	0.5	1.50	8.10	1.80	8.40	Nil
26.	Handi	8.2	3090	1.00	3.00	46.02	29.36	10.00	10.56
27.	Kelanpur	8.0	630	0.75	0.75	8.20	1.56	8.19	Nil
28.	Mavli	8.2	1450	0.75	2.00	20.50	8.70	10.00	3.50
29.	Alamgir	7.8	5000	1.00	5.00	60.26	49.50	8.40	8.20
30.	Itola	8.0	1490	0.75	0.75	10.50	7.43	12.60	2.00
31.	Bamangam	8.0	1470	1.00	6.50	15.60	4.20	13.00	5.00
32.	Karvan	8.0	860	0.75	2.75	10.30	4.73	9.19	Nil
33.	Shamsabad	7.8	850	1.25	5.75	8.34	8.33	7.00	Nil
34.	Makarpura	8.4	9700	3.73	35.25	106.7	117.83	13.60	14.86
35.	Timburva	7.8	650	0.75	4.75	5.00	4.05	6.53	Nil
36.	Malpur	8.0	700	1.00	4.25	6.50	5.10	6.60	Nil
37.	Chandod	7.8	530	1.50	3.50	4.00	3.60	5.40	Nil

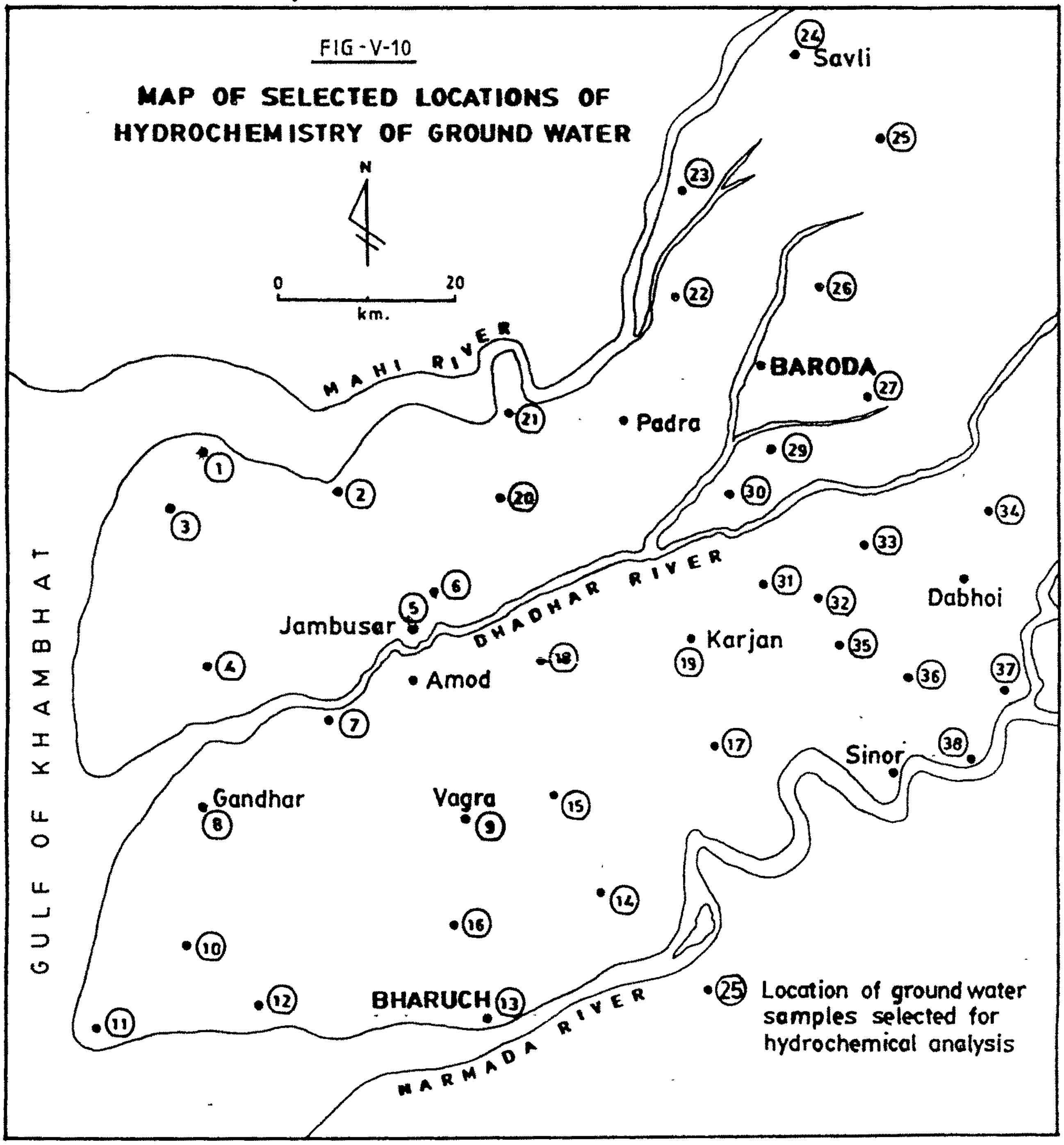


FIG - V-10
MAP OF SELECTED LOCATIONS OF HYDROCHEMISTRY OF GROUND WATER
N
0
20
km.
Savli
BARODA
Padra
Dabhoi
Karjan
Jambusar
Amod
Sinor
Gandhar
Vagra
BHARUCH
MAHI RIVER
DHADHAR RIVER
NARMADA RIVER
GULF OF KHAMBHAT
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
29
30
31
32
33
34
35
36
37
38
25 Location of ground water samples selected for hydrochemical analysis

The iso-TDS map Fig. V.11 of the area clearly shows less than 1000 ppm TDs in the the eastern part increasing to 2000 ppm TDS in the central and maximum concentration to the order of 25000 ppm in coastal aquifers. The semiconfined at depth also show increasing TDS. The chlorides also show similar trend of concentration as the total dissolved solids. Its range vary from 50 -15300 ppm.

The inherent salinity of sediments comprising the aquifers contaminates the groundwater. The ratio of chlorides v/s Carbonates + Bicarbonates indicates the presence of salts in the ground water. In case of sea water, this ratio is about 200, while for fresh water it is unity. GWRDC (1987) has observed that the ratio ranges from less than 1 to more than 15 indicating the water being fresh to injureously contaminated. A progressively increasing trend of contamination has been observes as traced from east to west. The geochemical types based on groundwater facies characters also indicate the same trend of brackishness and salinity. Piper diagram of trilinear plot showing water quality is shown in Fig. V.12. Greater concentration of the plots in the lower part of the central diamond indicates general type of water as Na-Ca-Co_3 HCO_3 -SO_4 - Cl. A plot of US salinity diagram for salinity hazard (specific conductively) against sodiumalkali harzard (Sodium Absorption Ratio - SAR) for the water samples is given in Fig. V.13. The groundwater in the eastern and southcentral part of the study area fall under C_4 S_2 and C_3 S_1 category, considered to be

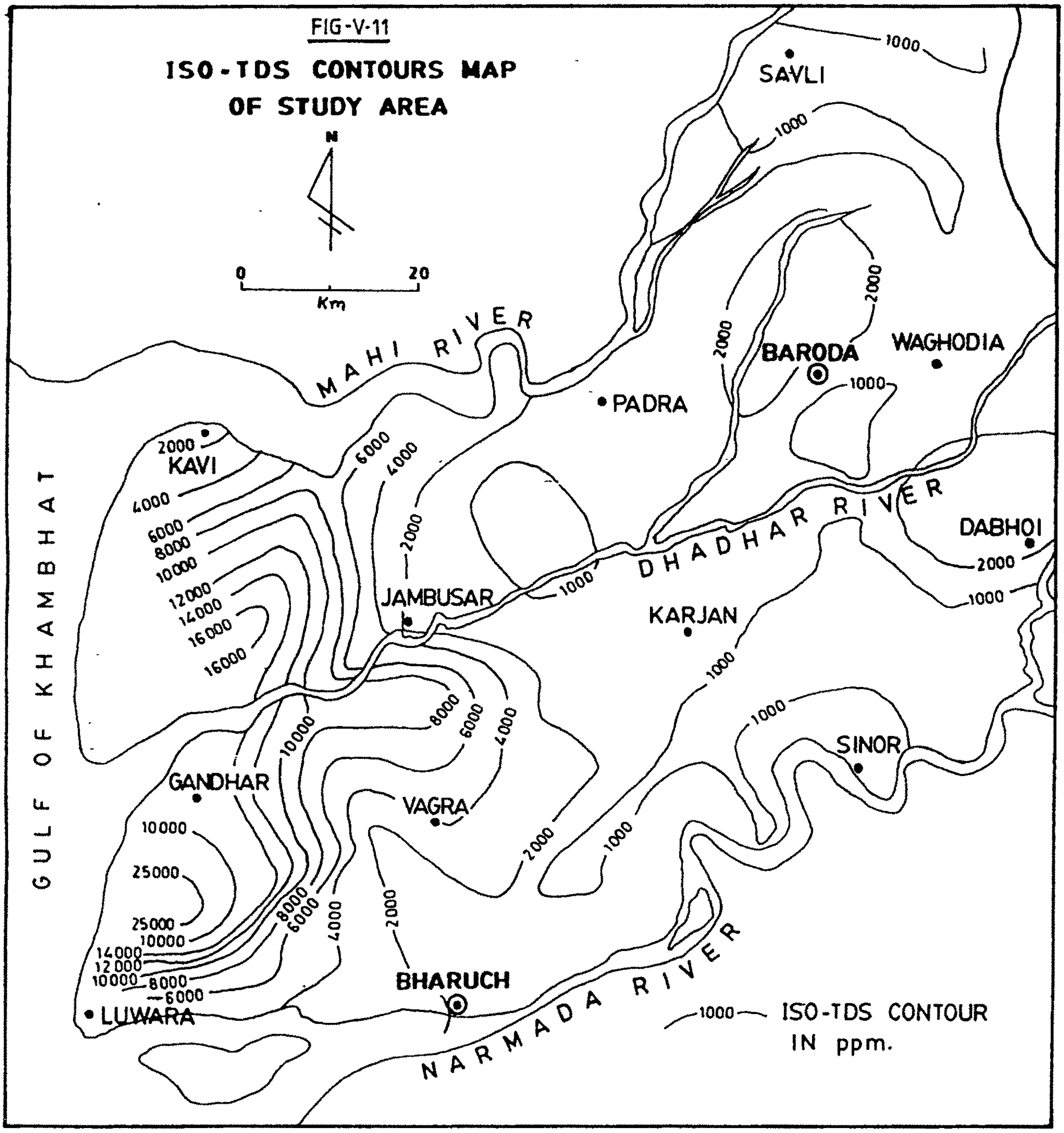
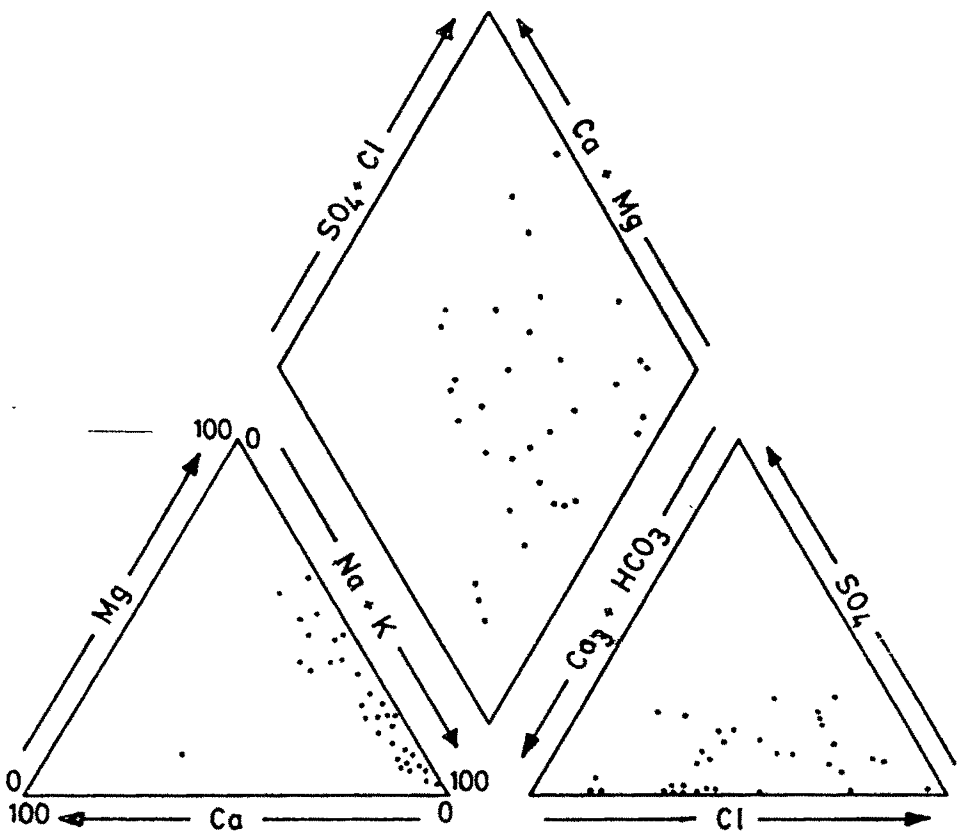


FIG-V-11
ISO-TDS CONTOURS MAP
OF STUDY AREA
N
0
20
Km
SAVLI
1000
MAHI RIVER
BARODA
WAGHODIA
PADRA
2000
KAVI
4000
6000
8000
10000
12000
14000
16000
JAMBUSAR
DHADHAR RIVER
DABHOI
KARJAN
GULF OF KHAMBHAT
SINOR
GANDHAR
VAGRA
25000
BHARUCH
LUWARA
NARMADA RIVER
1000 ISO-TDS CONTOUR
IN ppm.

FIG- V-12

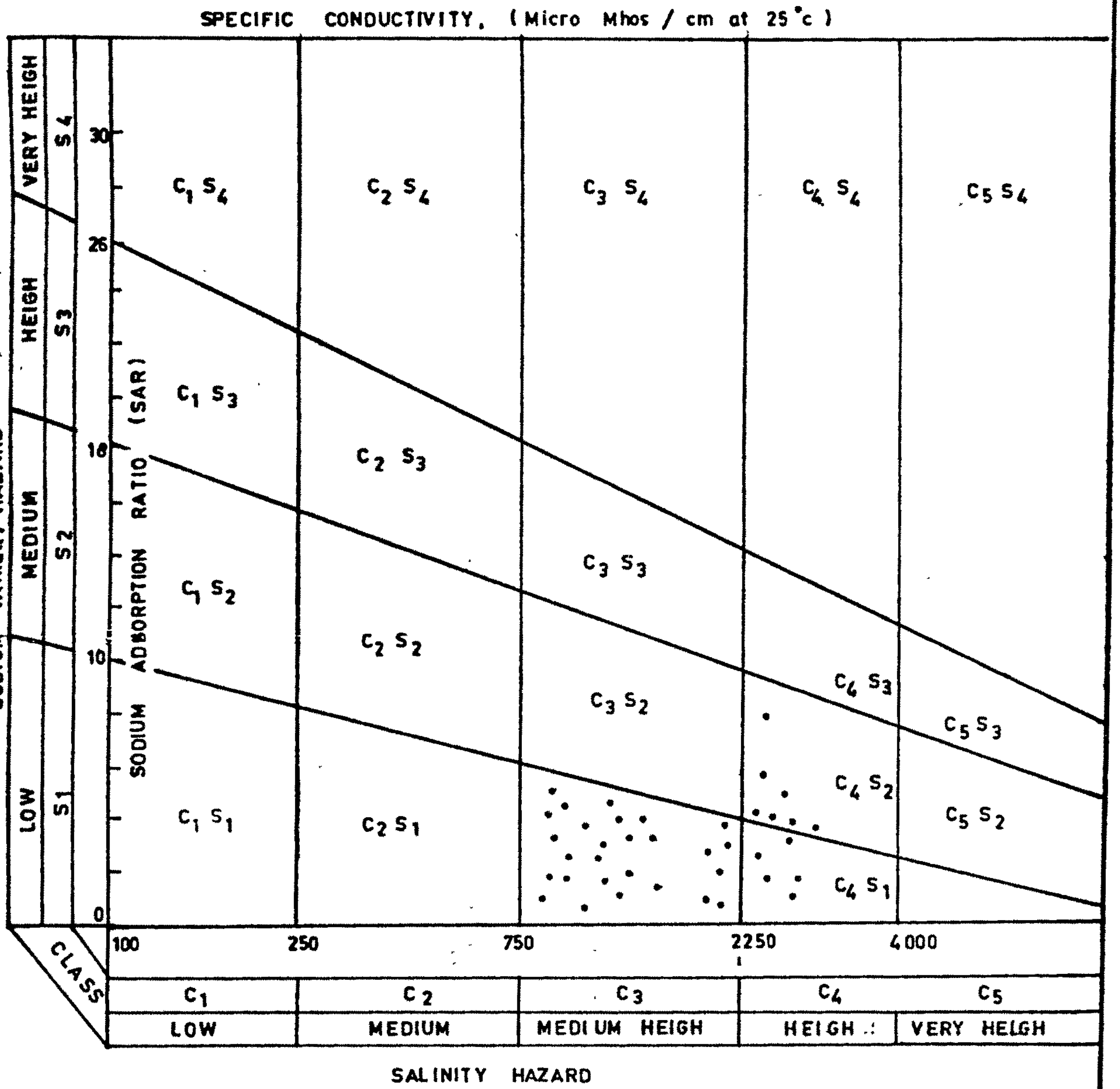


PIPER'S DIAGRAM SHOWING CHEMICAL QUALITY OF GROUND WATER FOR STUDY AREA

FIG-V-13

DIAGRAM FOR CLASSIFICATION OF GROUND WATER FOR IRRIGATION

(U. S. SALINITY LABORATORY: AFTER RICHARDS, 1954)



CLASS - I $C_2S_1 + C_3S_1$

CLASS - II $C_3S_2 + C_4S_1$

CLASS - III C_4S_2

CLASS - IV $C_4S_3 + C_4S_4$ and others

suitable for irigation in all types of soils. The plots in other catagories are unsuitable for irrigation.

Ground water Potential :

Taking into considertion, the various factors affecting the ground water recharge, GWRDC (1987) has estimated annual recharge for the Mahi-Narmada Doab are covered under the irrigation command of the Narmada Project. This area is almost covers the present study area. The annual recharge includes the following components.

Total Annual Recharge

= Recharge during monsoon + Nonmonsoon rainfall + Seepage from Canal + Return flow from Irrigation and influent rivers etc. + Recharge from Lakes etc.

Recoverable recharge

= 85% of total annual recharge

Balance ground water

= Recoverable recharge - Net Draft.

Shah and Patel (1984) have worked out talukawise ground water potential. Total 10 talukas of Baroda and Broach district comprise the study area and total of these can be regarded applicable for the area. ORG (1985) have also made estimates of the potential for the area.

The salient feature of the ground water potential estimation are given in Table V.7.

Table V.8 Groundwater Resources Estimation for the study area

(Values in MCM)

Parameters	GWRDC (1987)	ORG (1985)	Shah & Patel (1983)	Average of all
Gross recharge	978.65	1414.60	468	953.75
Utilisable recharge	831.85	1202.41	141.0	725.0
Gross abstraction	188.50	270.00	130.0	196.1
Net Abstraction	131.54	189.00	91.0	134.9
Balance Potential	700.31	1022.41	338	686.9
Development Level	18%	18%	27%	21%

It is seen that there is large amount of surplus potential available for further development. However, on account of quality problems in the Western parts, all the potential cannot be considered suitable for development.