

4

Data Collection

The coastal study area of Saurashtra is divided into following three parts for data collection and analysis.

- A) Bhavnagar to Una reach.
- B) Una to Madhavpur reach.
- C) Madhavpur to Malia reach.

4.1 Saurashtra Coast at a Glance

Sr. No.	Description	Bhavnagar to Una Reach	Una to Madhavpur Reach	Madhavpur to Malia Reach
1.	Location			
	Latitude (North)	21° 45' to 23° 35'	20° 45' to 20° 55' & 21° 15' to 21° 25'	21° 45' to 23° 35'
	Longitude (East)	70° 40' to 70° 20'	71° 15' to 69° 55'	69° 00' to 71° 00'
2.	Length of Coast	180 km	160 km	425 km
7.	Area Affected	2,49,280 Ha	1,00,000 Ha	4,60,120 Ha
8.	Population Affected	2,20,200 souls	2,80,160 souls	5,79,373 souls
9.	Wells Affected	8,800	12,562	11,388
10.	Affected Villages	166	120	248
11.	Land Reclamation	10,000 Ha	20,271 Ha	16,500 Ha
12.	Irrigation Land	33,113 Ha	19,850 Ha	65,640 Ha
13.	Check Dam	300	75	460
14.	Tidal Regulators	8	7	23
15.	Bandharas	29	10	48
16.	Afforestation	15,750 Ha	50,000 Ha	25,000 Ha
17.	Nala Plugs	20,000		45,400
18.	Recharge Wells	450	200	680
19.	Recharge Tanks	11	7	60
20.	Spreading Channels	60 km	60 km	240 km
21.	Recharge Reservoirs	22	7	21

(Report – HLC-I & II, Irri. DEPT., GOG)

Table 4.1: Details of Area Affected and Countermeasures Proposed In Brief for Different Divisions of Saurashtra Coast as per Recommendations of HLC

Refer Table 4.8 for taluka-wise detail of area affected by salinity, Fresh water area, marshy area for the year 1984 and 2007.

4.1.1 Seawater Intrusion Preventive Structures Constructed

As per the suggestions of HLCs in 1978 and 1984, following salinity control structures have been constructed. (Refer Map 4.1)

A) Tidal Regulators

Vadodara Zala	Vasoj
Meghal	Muldwarka
Panch Pipalva	Ozat
Madhuvanti	Gosabara
Medha creek	Karly
Bhogat	Bhadar

B) Bandharas

Lati	Zankharwada
Barda	Badalpur
Sodam	Khada
Shil	Somnath
Shardagram	Adri
Sheriaj	Sangawada
Nikol	Kalsar
Akwada	Samadhiyala
Jambuda	

C) Recharge Reservoirs

Vrajmi
Noli (Lambora)
Karly

D) Recharge Tanks

Ajak	Shil
Mangrol	Sodam
Gagva	Khiri

E) Check Dams: 546

F) Recharge Wells constructed in different river basins

Meghal Basin	33	Hiran Basin	15
Saraswati Basin	10	Devka Basin	05
Adri Basin	05	Shingoda Basin	15
Khari Basin	05	Somat Basin	10
Kapila Basin	10	Noli Basin	17

Netravati Basin	22	Longadi Basin	05
Khetaliya Basin	02	Malan (Una) Basin	05
Chhasi Basin	05	Raval Basin	05
Machhundri Basin	05	Rupen Basin	07
Sangavadi Basin	07	Malan (Mahuva) Basin	15
Dhatarvadi Basin	11	Maleshri Basin	11
Bhambhali Basin	11	Jholapuri Basin	11
Bagad Basin	11	Ramtila Basin	05
Garasuvo Basin	10	Ghiyal Basin	10
Manari Basin	10	Bhadrodi Basin	05
Ramdasiya Basin	05	Rupen Basin	10
Raidi Basin	10	Aji Basin	06
Sasoi Basin	15	Fulzar Basin	10
Sinhan Basin	05	Nagmati Basin	05
Ruparel Basin	10	Rangamati Basin	05

Total : 389 Nos.

G) Nala Plugs : 4,487

H) Spreading (Linking) Channels:

- Sabli – Netravati rivers (Completed) – 7.53 km
- Netravati – Noli rivers (Under Construction) 18.99 km
- Noli – Meghal rivers (Under Construction) 10.50 km
- Meghal – Adri rivers (Completed) 4.56 km
- Medha creek – Kindri creek (Under Construction)

Excavated to the length of 26.20 kms

Salient features of major salinity ingress preventive structures are given in table 4.2 to 4.7.

4.1.2 Salient Features of Various Seawater Intrusion Preventive Structures

Sr. No.	Feature	Name Of The Tidal Regulator			
		Panch Pipalva	Vasoj	Muldwarka	Vadodara Zala
1.	Name of river	Sangavadi	Creek	Shingoda	Khari
2.	Location: Village Taluka	Panch Pipalva Kodinar	Vasoj Una	Muldwarka Kodinar	Vadodara Zala Veraval
	North Latitude	20 ⁰ 46'	20 ⁰ 45'	20 ⁰ 45' 34"	20 ⁰ 48' 23"
	East Longitude	70 ⁰ 45'	70 ⁰ 48' 15"	70 ⁰ 49' 22"	70 ⁰ 32' 50"
3.	Catchment Area (Sqkm)	528.36	62.16	504.40	83.66
4.	Maximum Probable Flood (cumec)	4140.00	906.26	4350.00	1062.88
5.	Maximum Design Discharge (cumec)	4140.00	906.26	4350.00	1062.88
6.	H.F.L.	4.45	2.40	3.75	4.15
7.	F.S.L. / F.R.L.	2.50	1.80	2.25	3.50
8.	Storage at F.S.L. / F.R.L. (Mm ³)	11.11	2.60	1.63	7.93
9.	Water Spread Area (km ²)	8.86	0.55	0.92	4.643
10.	No and Size of Steel Gates	Ungated	For TR –1: 3 Gates: 5.0 x 1.0 m For TR – 2: 4 Gates: 1.65 x 1.30 m	25 Gates: 9.144 x 2.75 m	14 Gates: 9.144 x 1.50 m 4 Gates: 9.144 x 2.50 m
11.	Benefited Area Under Irrigation (Ha)	1490	500	360	1560
12.	Total Benefited Area (Ha)/Village	3815	1150	855	2400

(Source – SIPC, NWRWS DEPT., GOG)

Table 4.2: Salient Features of Various Tidal Regulators Constructed Along Saurashtra Sea Coast

Salient Features of Various seawater intrusion preventive structures.

Sr. No.	Feature	Name Of The Tidal Regulator			
		Meghal	Gosabara	Bhadar	Ozat
1.	Name of river	Meghal	Minsar	Bhadar	Ozat
2.	Location: Village	Chorvad	Gosa	Chikasa	Ratia
	Taluka	Malia (H)	Porbandar	Porbandar	Porbandar
	North Latitude	21° 14'	20° 30'	21° 27'	21° 12'
	East Longitude	70° 15'	70° 15'	70° 15'	70° 05'
3.	Catchment Area (km ²)	518.26	1295.00	7953.42	3072.00
4.	Maximum Probable Flood (cumec)	8382.90	4418.01	10761.00	3190.00
5.	Maximum Design Discharge (cumec)	8382.90	4418.01	496.00	3190.00
6.	H.F.L.	4.00	3.35	3.60	3.65
7.	F.S.L. / F.R.L.	2.50	1.93	2.45	1.50
8.	Storage at F.S.L. / F.R.L. (Mm ³)	6.00	63.90	3.88	3.04
9.	Water Spread Area (km ²)	N.A.	14.22	5.31	13.61
10.	No and Size of Steel Gates	45 Gates: 9.144 x 2.80 m 16 Gates: 9.144 x 1.50 m	20 Gates: 3.05 x 1.08 m 2 Gates: 3.05 x 2.28 m	13 Gates: 7.20 x 3.65 m	Ungated
11.	Benefited Area Under Irrigation (Ha)	4120	1250	2300	995
12.	Total Benefited Area (Ha)/Villages	4830	8 village	7 villages	5 villages

(Source – SIPC, NWRWS DEPT., GOG)

Table 4.3: Salient Features of Various Tidal Regulators Constructed Along Saurashtra Sea Coast

Salient Features of Various seawater intrusion preventive structures

Sr. No.	Feature	Name Of The Tidal Regulator		
		Madhuvanti	Karly	Medha Creek
1.	Name of river	Sabli	Minsar & Karly Creek	Medha Creek
2.	Location: Village Taluka	Pata Porbandar	Chhaya Porbandar	Miyani Porbandar
	North Latitude	21° 21'	21° 15'	21° 50' 57"
	East Longitude	69° 15'	70° 15'	69° 22' 40"
3.	Catchment Area (km ²)	802.89	1295.00	2021.48
4.	Maximum Probable Flood (cumec)	3466.00	N.A.	15064.00
5.	Maximum Design Discharge (cumec)	85.00	1416.00	15064.00
6.	H.F.L.	4.87	For K-1 – 5.30 For K-2 – 5.30	5.82
7.	F.S.L. / F.R.L.	2.83	For K-1 – 2.30 For K-2 – 1.80	2.50
8.	Storage at F.S.L. / F.R.L. (Mm ³)	0.62	44.08	49.00
9.	Water Spread Area (km ²)	1.08	50.91	38.78
10.	No. and Size of Steel Gates	12 Gates: 3.30 x 1.55 m 2 Gates: 5.50 x 2.45 m	2 Gates: 3.05 x 1.05 m	Ungated
11.	Benefited Area Under Irrigation (Ha)	800	1012	4048
12.	Total Benefited Area (Ha)/village	3 village	10 village	14 village

(Source – SIPC, NWRWS DEPT., GOG)

Table 4.4: Salient Features of Various Tidal Regulators Constructed Along Saurashtra Sea Coast

Salient Features of Various seawater intrusion preventive structures

Sr. No.	Feature	Name Of The Bandhara					
		Nikol	Samadhiyala	Khada	Sodam	Barda	Badalpur
1.	Name of river	Bhadrodi, Butio	Local Drain	Chhasi	Khari Creek	Somat	Saraswati
2.	Location: Village	Nikol	Samadhiyala	Khada	Velan	Barda	Badalpur
	Taluka	Mahuva	Rajula	Una	Kodinar	Kodinar	Veraval
	North Latitude	21° 04' 40"	21° 01' 30"	20° 46' 00"	20° 42'	20° 45' 00"	20° 53' 00"
	East Longitude	71° 50' 42"	71° 39' 00"	71° 00' 00"	70° 49'	70° 49' 00"	70° 26' 00"
3.	Catchment Area (km ²)	361.46	47.95	142.62	38.66	212.37	415.17
4.	Maximum Probable Flood (cumec)	3507	99.82	2164.74	1046.00	1753.00	2491.00
5.	Maximum Design Discharge (cumec)	3507	99.82	2164.74	1046.00	1753.00	2491.00
6.	H.F.L.	5.60	5.42	4.47	2.80	3.69	5.50
7.	F.R.L.	4.25	3.82	2.50	2.30	2.10	2.00
8.	Storage at F.R.L. (Mm ³)	24.22	1.79	8.85	10.73	4.67	0.13
9.	Water Spread Area (km ²)	13.72	638.2	6.96	5.11	9.03	0.82
10.	Length Of Spillway (m)	305.00	250.00	365.00	137.00	400.00	70.00
11.	Benefited Area (Ha)/Village	3500	300	5525	5 village	900	235

(Source – SIPC, NWRWS DEPT., GOG)

Table 4.5: Salient Features of Various Bandhara Constructed Along Saurashtra Sea Coast

Salient Features of Various seawater intrusion preventive structures

Sr. No.	Feature	Name Of The Bandhara					
		Somnath	Adri	Shardagram	Shil	Bhogat	Jambuda
1.	Name of river	Hiran	Khari	Khari – Noli	Netravati	Kalipat	Kalindri
2.	Location: Village	Patan	Adri	Sheriaj	Shil	Bhogat	Jambuda
	Taluka	Veraval	Veraval	Mangrol	Mangrol	Kalyanpur	Jamnagar
	North Latitude	20° 43' 00"	20° 57' 00"	21° 05' 00"	20° 57' 00"	21° 57' 06"	22° 32' 00"
	East Longitude	70° 23' 00"	70° 16' 00"	70° 05' 00"	70° 16' 00"	69° 11' 40"	70° 12' 00"
3.	Catchment Area (km ²)	512.35	38.40	290.56	134.67	140.67	58.50
4.	Maximum Probable Flood (cumec)	4248.00	1053.00	3762.00	1379.00	2340.6	790.71
5.	Maximum Design Discharge (cumec)	4248.00	1053.00	3762.00	1379.00	2340.6	790.71
6.	H.F.L.	6.90	3.91	5.50	6.10	5.40	24.00
7.	F.R.L.	2.60	2.50	2.20	3.10	3.50	22.75
8.	Storage at F.R.L. (Mm ³)	0.29	0.1747	2.92	1.51	6.00	0.39
9.	Water Spread Area (km ²)	0.75	0.53	1.72	0.65	4.67	0.69
10.	Length Of Spillway (m)	135.00	350	280	200.00	295.00	240.00
11.	Benefited Area (Ha)	250.00	165.00	2280.00	145.00	3179.00	2000.00

(Source – SIPC, NWRWS DEPT., GOG)

Table 4.6: Salient Features of Various Bandhara Constructed Along Saurashtra Sea Coast

Salient Features of Various seawater intrusion preventive structures

Sr. No.	Feature	Name Of The Recharge Reservoir			Name Of The Recharge Tank	
		Vrajmi	Lambora	Karly	Gagva	Khiri
1.	Name of river	Vrajmi	Noli	Minsar	Dhudkawalo vonklo	Und
2.	Location: Village	Vandarvad	Lambora	Tukda	Gagva	Khiri
		Tal: Malia (H)	Tal: Mangrol	Tal: Porbandar	Tal: Jamnagar	Tal: Jodiya
	North Latitude	28° 08' 30"	N.A.	21° 15'	22° 23' 20"	22° 26' 25"
	East Longitude	70° 24' 30"	N.A.	70° 15'	69° 49' 42"	69° 55' 20"
3.	Catchment Area (km ²)	51.84	149.96	1217.30	2.25	113.02
4.	Maximum Probable Flood (cumec)	1174.00	2609.00	16748.00	61.23	445.00
5.	Maximum Design Discharge (cumec)	1174.00	2609.00	16748.00	61.23	445.00
6.	H.F.L.	94.36	29.53	3.50	27.50	3.50
7.	F.R.L.	94.00	28.00	2.20	26.70	2.50
8.	Storage at F.R.L. (Mm ³)	10.352	3.024	22.65	0.135	0.16
9.	Water Spread Area (km ²)	2.49	2.03	40.10	0.78	0.92
10.	Length Of Spillway (m)	101.86	650.00	2600.00	65.00	88.00
11.	Benefited Area (Ha)	1070.00	2284.00	4452.00	30.00	105
				Having Radial canals of 6.0 km length and earthen dam of 11.0 km length		

(Source – SIPC, NWRWS DEPT., GOG)

Table 4.7: Salient Features of Various Recharge Reservoirs & Recharge Tank Constructed Along Saurashtra Sea Coast

4.1.3 Statement Showing Taluka-wise Variation in Area Affected by Seawater Intrusion and Freshwater Area

STATEMENT SHOWING AREAS AFFECTED BY DIFFERENT TYPES OF SALINITY IN COASTAL STRIP OF SAURASTRA AS IN 1984 AND 2007												
Sr. No.	Taluka	Area falling under investigation (in Ha)	Fresh Water area (in Ha)	Total Area Affected due to salinity (in Ha)	Area in which Groundwater is not developed due to salinity (in Ha)	Marshy Land (in Ha)	Area having Inherent Salinity (in Ha)	Area affected by seawater ingress (in Ha)	Area affected by seawater inundation (in Ha)	Area selected for reclamation (in Ha)		
			1984	2007	1984	2007		1984	2007		1984	2007
1	Bhavnagar	34536	31453	29885	3083	3779	872	1951	260	1828	1100	
2	Talaja	42096	23698	20137	18398	20995	964	16154	1280	4841		
3	Mahuva	45220	18763	12645	26457	31919	656	20217	5537	11702		
4	Rajula	32196	10731	10510	21465	15666	6020	10122	5020	5544	500	
5	Jafrabad	29136	4984	6251	24152	18381	4504	16064	3534	2317	1100	
6	Una	66096	52846	44228	13250	16593	5275	3159	4816	13434	7300	
7	Mangrol	8800			8800	8800						
8	Kutiyana	6200			6200	6200						
9	Porbandar	86570	9120	10237	77450	65333	11000	13380	17600	16483	2500	
10	Ranavav	13190	1780	2875	11410	1315	9000			1315		
11	Kalyanpur	72730	12850	8850	59880	61880	2000	49330		11550	7550	
12	Okha	70510	4556	6863	65954	60647	3000	60247		0	500	
13	Khambhaliya	71110	49890	23403	21220	33907	13800			33907	7420	1500
14	Lalpur	19760	15370	11935	4390	5125	2700			5125	1690	
15	Jamnagar	59120	31050	3986	28070	38234	16900			38234	11170	2000
16	Dhrol	9170	9170							0		
17	Jodliya	114340	25990	31617	88350	41623	41100			7133	12760	10000
18	Maliya Miyana	77000			77000	77000				0		
19	Morbi	6840			6840	6840				0		
	TOTAL	864620	302251	232592	562369	514237	117791	190624	38047	153413	40590	26500

(Report – GWRDC, NWRWS DEPT., GOG)

Table 4.8 Table showing Classification of Various Area and Change into Freshwater Area from 1984 to 2007

YEARWISE CHANGE IN AREA AFFECTED BY SEAWATER INTRUSION, FRESHWATER AREA & RAINFALL																				
Sr. No.	Year	Bhavnagar			Talaja			Mahuva			Rajula			Jafrabad			Una			
		R	FWA	SAA	R	FWA	SAA	R	FWA	SAA	R	FWA	SAA	R	FWA	SAA	R	FWA	SAA	
1	1992	348	31215	498	327	22408	2570	298	17674	6673	240	13604	2450	383	8259	309	513	46881	10781	
2	1993	612	31215	498	747	21612	3366	525	15343	9004	381	11871	4183	452	6975	1593	582	46706	10956	
3	1994	466	31046	667	683	21143	3835	677	15991	8356	753	13405	2649	655	7134	1434	696	46626	11036	
4	1995	788	30807	906	574	21074	3904	887	14058	10289	915	12548	3506	1097	7134	1434	1048	46786	10876	
5	1996	585	30807	906	360	21074	3904	297	14048	10299	370	12548	3506	543	7134	1434	874	46786	10876	
6	1997	659	30807	906	463	21074	3904	459	13692	10655	496	12237	3817	707	7128	1440	883	46417	11245	
7	1998	563	30787	926	667	21074	3904	871	13427	10920	672	11969	4085	630	7128	1440	782	46194	11468	
8	1999	770	30722	991	536	21031	3947	774	13343	11004	637	11908	4146	833	7116	1452	671	46147	11515	
10	2001	513	30697	1016	357	21233	3745	315	13232	11115	195	11851	4203	312	7024	1544	341	46108	11554	
11	2002	622	30654	1059	439	21097	3881	532	13110	11237	496	11787	4267	448	6964	1604	716	45979	11683	
12	2003	831	30624	1089	649	20880	4098	596	13021	11326	672	11421	4633	746	6845	1723	735	45683	11979	
13	2004	537	30256	1457	559	20384	4594	585	12823	11524	884	11262	4792	805	6628	1940	991	45465	12197	
14	2005	549	30040	1673	400	20246	4732	574	12655	11692	524	11035	5019	616	6538	2030	794	45178	12484	
15	2006	947	29941	1772	898	20216	4762	1157	12685	11662	1490	10629	5425	1148	6479	2089	1260	44277	13385	
16	2007	893	29885	1828	764	20137	4841	635	12645	11702	567	10510	5544	766	6251	2317	1111	44178	13484	

(Report – GWRDC, NWRWS DEPT., GOG)

Table 4.9 Table Showing Yearwise Change in Area Affected by Seawater Intrusion, Freshwater Area & Rainfall from 1992 to 2007 for Bhavnagar to Una

Notations: R – Rainfall in mm

FWA – Freshwater Area in Ha

SAA – Seawater Intrusion Affected Area in Ha

4.2 Medha Creek Tidal Regulator

The project of Medha Creek Tidal Regulator (MCTR) envisages the construction of Tidal Regulator across Medha Creek near village Miyani in Porbandar Taluka of Porbandar District.

The purpose of launching this project is twofold i.e. to stop the intrusion of tidal water deep into the land through the creek known as 'Medha Creek' as well as to store the sweet water on upstream side of the regulator. The stored water of 49.00 MCM will provide lift irrigation facility to 4048 Ha of land of surrounding 13 villages of Porbandar and Jamnagar districts. Moreover, the stored water will recharge the wells in surrounding area along the periphery of the reservoir through radial canals.

Prior to commencement of project, the fertile land of 7,290 Ha in the 13 villages of Porbandar and Kalyanpur Talukas was badly affected due to seawater intrusion. Prior to this project, shallow well was only source of irrigation water and Bajari, Jawar, Paddy & fodder were main crops of Kharif season. After completion of this project, now there is provision of lift irrigation facilities to 4048 Ha of land. Due to this benefited farmer are now turned to seed kharif cash crops like groundnut, cotton, chilly etc.

4.2.1 Salient Features of Medha Creek Tidal Regulator

- | | | | |
|------|----------------------------|---|--|
| i) | Name of Scheme | : | Medha Creek Tidal Regulator (MCTR) |
| ii) | Location A. River | : | In deltaic portion of the rivers Sani, Vartu, Sorthi, Sindhani and Kaman |
| | B. Village | : | Miyani |
| | C. Taluka | : | Porbandar |
| | D. Toposheet No. | : | 41 G and 41F |
| | E. Latitude / Longitude | : | 21° -50' -97" and 69°- 22'- 44" |
| | F. Nearest Railway Station | : | Porbandar |
| iii) | Hydrology | | |
| | A. Catchment | : | 2021.49 SqkM |
| | B. Rainfall | | |
| | Average / Max / Min | : | 503.00 mm / 1372.00 mm / 91.80 mm |
| iv) | Reservoir | | |
| | A. Full Reservoir Level | : | RL 2.50 M |
| | B. High Flood Level | : | RL 5.82 M |

C. Gross capacity at FRL : 49.00 MCM

D. Gross area under : 3878 ha

Submergence at
2.50M

v) Submergence

Culturable area : 605 Hectors
under Submergence

Nos. of villages : One (vadala) Protection bund is proposed.

vi) Command Area (Lift Irrigation)

A. Area proposed to be : 4048.77 Hectors
irrigated by lifting

B. Name of Village : Miyani, Bhavpara, Vadala, Ambarama,
Chandravada, Raval, Tankaria, Premsar,
Sanosari, Virpur, Gangadi, Ghandavi,
Ghasiana, Devalia

vii) Cost

A. Cost of the project : Rs. 15,39,61,000 /- (Year 1988)

B. B. C. Ratio : 1.14

4.2.2 Rainfall Recorded at Medha Creek TR Hydromet Station

Average Annual Rainfall = 523mm			
Year	Rainfall (mm)	% rainfall below AAR	% rainfall above AAR
1987	21.30	95.93	----
1988	449.20	14.11	----
1989	668.95	----	27.91
1990	198.20	62.10	----
1991	256.60	50.94	----
1992	433.40	17.13	----
1993	132.90	74.59	----
1994	679.00	----	29.82
1995	393.00	24.86	----
1996	151.00	28.87	----
1997	580.00	----	10.90
1998	901.00	----	72.28
1999	173.00	66.72	----
2000	447.00	14.53	----
2001	1372.00	162.33	----
2002	365.00	----	30.21
2003	890.00	70.17	----

Table 4.10: Details of Rainfall at Medha Creek Tidal Regulator Area (Refer Graph 5.13)

4.2.3 **Geology of the Area**

The Deccan Trap Basalt is continuously exposed on the right bank upper reaches of the creek but on the left bank and lower reaches of the right bank of the creek, Miliolite Limestone occurs with thin alluvium cover. In the creek portion clay is present. The geological succession in the area in its natural order of superposition is as shown in Table 4.11:

Sr. No.	Geological Formation	Age
1	Top Soil	Recent
2	Miliolite limestone	Pleistocene to Recent
3	Laterite	Eocene to recent
4	Gaj Limestone & Clay	Miocene
5	Basalt	Upper Cretaceous to Lower Eocene

Table 4.11: Geology at Medha Creek Tidal Regulator Area



Plate 4.1 : View from D/S side Medha Creek Tidal Regulator

Photograph shows down-stream of Medha Creek. A hard pan is created due to tide and ebb of seawater. Fresh water Reservoir is also created between the down-stream of TR and hard sand pan. In monsoon, during high floods some times it automatically breaks, otherwise it has to be broken manually or mechanically to dispose high floods. Road Bridge on Coastal Highway No.6 from Dwarka to Porbandar is seen on D/S side.

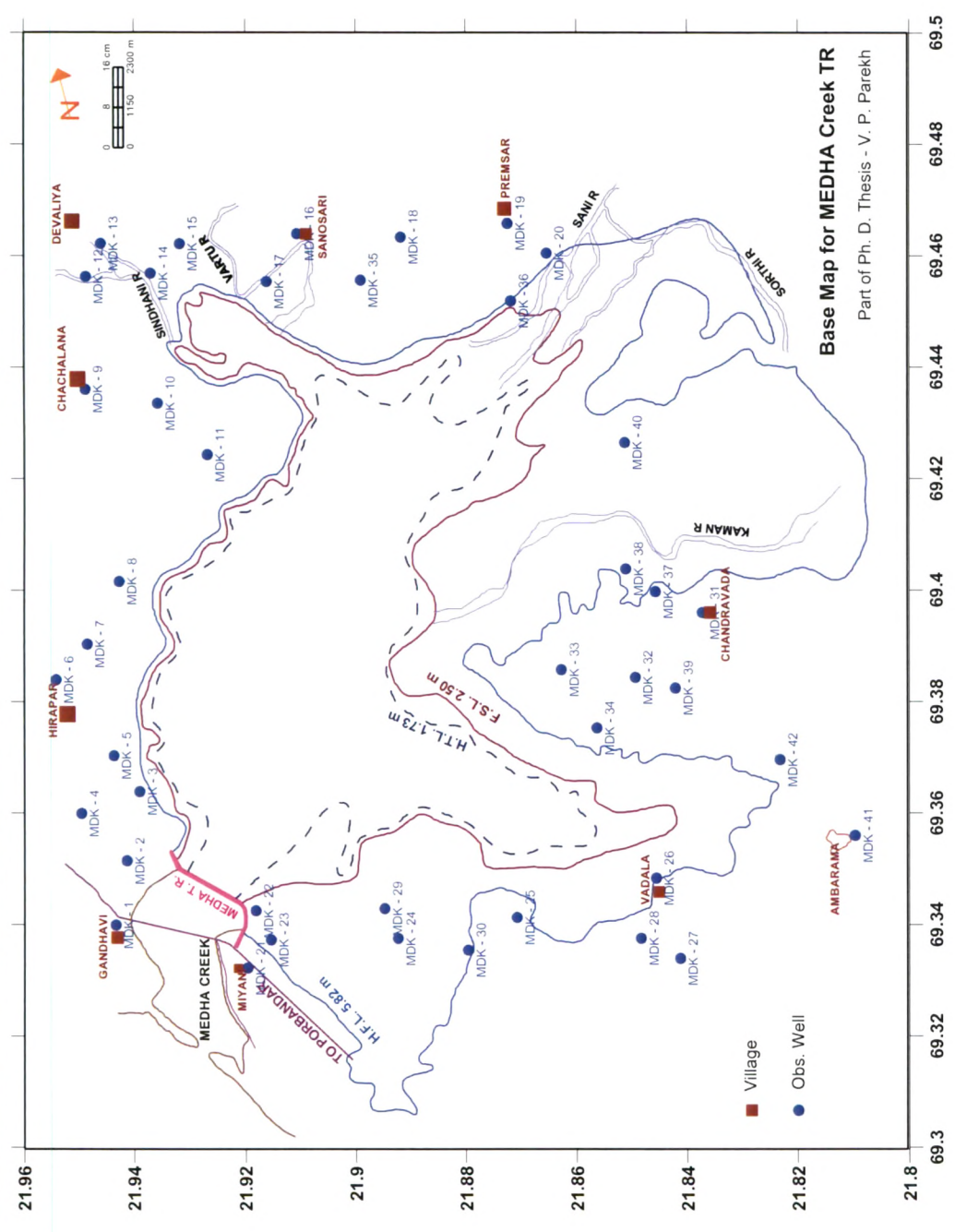


Plate 4.2: View of U/S side of Medha Creek Tidal Regulator at FRL in Monsoon Season

The up-stream of the structure shows fresh water reservoir and the down-stream of the structure shows also partially filled freshwater reservoir up to hard sandy pan.



Plate 4.3: Post Monsoon View of Dug Well in Vicinity of Medha Creek Reservoir



Map 4.2: Base Map of Medha Creek Tidal Regulator

4.2.4 Elevation, Area, Volume Stored (Capacity) & Wetted Area of Medha Creek Tidal Regulator Reservoir

Sr. No.	Ele. (m)	Area (sqm)	Cumu. Vol. (m ³)	Wetted Area (Sqgm)	Sr. No.	Ele. (m)	Area (sqm)	Cumu. Vol. (m ³)	Wetted Area (Sqgm)	Sr. No.	Ele. (m)	Area (sqm)	Cumu. Vol. (m ³)	Wetted Area (Sqgm)
1	0.00	0	0	0	28	1.35	20855028	9120000	21478280	55	2.70	45080945	56569432	46379276
2	0.05	380000	80000	392673	29	1.40	22529732	10080000	23202245	56	2.75	45955105	60000000	47277004
3	0.10	760000	160000	785213	30	1.45	24204437	11040000	24926092	57	2.80	46610289	61116730	47949402
4	0.15	1140000	240000	1177620	31	1.50	25879142	12000000	26649823	58	2.85	47265472	63485595	48621755
5	0.20	1520000	320000	1569894	32	1.55	27441333	13520000	28256615	59	2.90	47920656	65854460	49294062
6	0.25	1900000	400000	1962035	33	1.60	28899667	15000000	29757264	60	2.95	48575840	68223325	49966323
7	0.30	2300000	520000	2374693	34	1.65	30358000	16610000	31257811	61	3.00	49231024	72600000	50638539
8	0.35	2700000	640000	2787210	35	1.70	31816333	18230000	32758256	62	3.05	49884081	72968905	51308521
9	0.40	3100000	760000	3199588	36	1.75	33274667	20000000	34258599	63	3.10	50486115	75534030	51925979
10	0.45	3500000	880000	3611825	37	1.80	34733000	21950000	35758839	64	3.15	51088150	78099154	52543396
11	0.50	3900000	1000000	4023923	38	1.85	35725323	23980000	36777969	65	3.20	51690184	80664279	53160769
12	0.55	4420000	1280000	4559672	39	1.90	36084575	26020000	37146544	66	3.25	52292218	84800000	53778101
13	0.60	4940000	1560000	5095240	40	1.95	36443827	28050000	37515093	67	3.30	52894252	85794528	54395391
14	0.65	5460000	1840000	5630625	41	2.00	36803079	30000000	37883617	68	3.35	53496286	88359653	55012638
15	0.70	5980000	2120000	6165829	42	2.05	37162331	31590000	38252116	69	3.40	53971029	91634267	55498949
16	0.75	6500000	2400000	6700850	43	2.10	37521583	33180000	38620590	70	3.45	54438220	94378936	55977461
17	0.80	6880000	2432360	7091388	44	2.15	37900958	34950000	39008424	71	3.50	54905412	98000000	56455941
18	1.85	7260000	2464720	7481793	45	2.20	38321562	36350000	39439976	72	3.55	55372604	99868273	56934388
19	0.90	7640000	2497080	7872065	46	2.25	38742165	37950000	39871499	73	3.60	55839795	102612942	57412802
20	0.95	9343026	3310000	9625186	47	2.30	39162769	40160000	40302993	74	3.65	56306987	105357610	57891184
21	1.00	10667501	4000000	10989286	48	2.35	39583373	42370000	40734457	75	3.70	57182459	108284677	58789286
22	1.05	11991976	4580000	12353295	49	2.40	40003976	44118000	41165892	76	3.75	58131114	112000000	59762564
23	1.10	13316451	5290000	13717210	50	2.45	40537802	46800000	41712385	77	3.80	59079769	114204198	60735775
24	1.15	14640927	5920000	15081033	51	2.50	41446430	49000000	42645890	78	3.85	60028424	117163958	61708920
25	1.20	15965402	6560000	16444763	52	2.55	42355059	50550000	43579332	79	3.90	60977079	120123719	62681998
26	1.25	17505618	7200000	18029999	53	2.60	43263688	52272516	44512710	80	3.95	61925734	123083479	63655010
27	1.30	19180323	8160000	19754198	54	2.65	44172316	54420974	45446025	81	4.00	63000000	126400000	64757070

Table 4.12: Elevation, Area & Capacity Table for Medha Creek Tidal Regulator

4.25 Pumping & Recuperation Test at village Ambarama

To get aquifer properties Pumping & Recovery test was done at the village Ambarama, Tal. & Dist. Porbandar. The results are as follows. Graphs were developed with Cooper – Jacob's Method. Well details are mentioned on graph.

Sr. No.	Time Hr:Min:Sec	Water Level (m)	Sr. No.	Time Hr:Min:Sec	Water Level (m)
1	09:00	10.82	21	09:30	11.93
2	09:01	10.87	22	09:32	11.99
3	09:02	10.91	23	09:34	12.05
4	09:03	10.95	24	09:36	12.11
5	09:04	10.99	25	09:38	12.17
6	09:05	11.03	26	09:40	12.23
7	09:06	11.07	27	09:45	12.38
8	09:07	11.11	28	09:50	12.47
9	09:08	11.15	29	09:55	12.53
10	09:09	11.19	30	10:00	12.6
11	09:10	11.23	31	10:05	12.68
12	09:12	11.31	32	10:10	12.74
13	09:14	11.39	33	10:15	12.8
14	09:16	11.46	34	10:20	12.86
15	09:18	11.53	35	10:25	12.91
16	09:20	11.59	36	10:30	12.97
17	09:22	11.66	37	10:35	13.01
18	09:24	11.72	38	10:40	13.05
19	09:26	11.79	39	10:45	13.09
20	09:28	11.86	40	10:50	13.13

Table 4.13: Time – Water-level Data for the Pumping Test at Vill. Ambarama near Medha Creek Tidal Regulator

Sr. No.	Time Hr:Min	Water Level (m)	Sr. No.	Time Hr:Min	Water Level (m)
1	09:00	10.82	18	11:12	13.08
2	10:50	13.13	19	11:14	13.07
3	10:51	13.13	20	11:16	13.07
4	10:52	13.13	21	11:18	13.06
5	10:53	13.13	22	11:20	13.06
6	10:54	13.12	23	11:22	13.05
7	10:55	13.12	24	11:24	13.05
8	10:56	13.12	25	11:26	13.04
9	10:57	13.12	26	11:28	13.04
10	10:58	13.11	27	11:30	13.03
11	10:59	13.11	28	11:35	13.02
12	11:00	13.11	29	11:40	13.01
13	11:02	13.10	30	11:45	13.00
14	11:04	13.10	31	11:50	12.99
15	11:06	13.09	32	11:55	12.98
16	11:08	13.09	33	12:00	12.97
17	11:10	13.08	34	12:05	12.96

Sr. No.	Time Hr:Min	Water Level (m)	Sr. No.	Time Hr:Min	Water Level (m)
35	12:10	12.95	44	14:10	12.71
36	12:15	12.94	45	14:30	12.67
37	12:20	12.93	46	14:50	12.63
38	12:25	12.92	47	15:10	12.59
39	12:30	12.91	48	15:30	12.55
40	12:50	12.87	49	15:50	12.51
41	13:10	12.83	50	16:10	12.47
42	13:30	12.79	51	16:30	12.43
43	13:50	12.75	52	16:50	12.39

Table 4.14: Time – Water-level Data for the Recuperation Test at Vill. Ambarama near Medha Creek Tidal Regulator

4.2.6 Rainfall, Water Level Fluctuation & Evaporation Recorded at Medha Creek Tidal Regulator

Date	Rainfall (mm/ Week)	Water level RL. In Mt.	Evap. (cm/ week)	Date	Rainfall (mm/ Week)	Water level RL. In Mt.	Evap. (cm/ week)
23/6/99	21	1.30	-	Sep 3	5	1.85	3.5
Jun 30	Nil	1.11	5.0	10	Nil	1.74	3.5
7	3	0.96	5.0	17	Nil	1.62	3.6
14	60	1.65	-	24	Nil	1.53	3.6
21	Nil	1.50	3.7	Oct 1	Nil	1.41	3.7
28	Nil	1.37	3.9	8	Nil	1.32	3.7
Aug 4	Nil	1.25	4.0	15	Nil	1.25	3.7
11	Nil	1.13	4.0	22	Nil	1.17	3.8
18	Nil	1.04	3.9	29	Nil	1.10	3.8
25	Nil	0.96	3.8	TOTAL	467		
Sep 1	Nil	0.91	3.4				
8	15	1.35	-	14/6/01	122	0.00	-
15	Nil	1.25	3.3	15	175	1.00	-
22	Nil	1.14	3.3	16	130	3.90	-
29	5	1.05	3.1	17	70	3.00	-
Oct 6	12	1.01	2.8	18	0	2.60	-
12	37	0.98	2.5	19	0	2.55	-
TOTAL	153			20	0	2.55	-
				21	0	2.50	-
08/07/00	110	1.30	2.2	28	0	2.45	-
Jul 15	76	1.40	2.4	Jul 2	5	2.40	-
22	Nil	1.18	3.3	5	60	2.55	-
29	Nil	1.04	3.4	6	200	2.70	-
Aug 5	Nil	0.95	3.7	7	0	2.60	-
13	176	1.85	2.2	8	0	2.60	-
20	Nil	1.70	3.5	9	10	2.55	-
27	100	1.99	2.4	10	120	2.80	-

Date	Rainfall (mm/ Week)	Water level RL. In Mt.	Evap. (cm/ week)	Date	Rainfall (mm/ Week)	Water level RL. In Mt.	Evap. (cm/ week)
11	100	2.60	-	17/08/02	0	0.28	3.4
12	5	2.60	-	24	0	0.24	3.4
13	0	2.60	-	29	220	1.35	-
14	0	2.55	-	Sep 5	0	1.28	2.5
15	0	2.55	-	12	0	1.21	2.7
16	0	2.55	-	19	0	1.13	2.9
19	0	2.50	-	26	0	1.07	3.2
20	100	2.60	-	Oct 3	0	1.01	3.4
21	0	2.55	-	10	0	0.96	3.4
Jul 25	115	2.55	-	TOTAL	365		
26	0	2.55	-				
27	20	2.50	-	10/07/03	219	1.65	-
28	30	2.50	-	17	275	2.50	-
Aug 8	35	2.45	-	Aug 4	140	2.55	-
9	50	2.50	-	11	125	2.55	-
13	25	2.65	-	18	0	2.50	-
14	5	2.60	-	25	0	2.50	-
15	0	2.55	-	Sep 1	45	2.50	-
16	5	2.55	-	8	0	2.50	-
17	0	2.55	-	15	5	2.39	2.7
18	0	2.50	-	22	0	2.28	2.9
Sep 7	70	2.50	-	29	0	2.18	2.8
12	10	2.50	-	Oct 6	0	2.07	3.0
TOTAL	1372			13	0	1.97	2.9
				20	0	1.89	2.8
28/6/02	40	0.55	3.2	27	0	1.81	2.9
29	90	0.70	2.2	Nov 4	0	1.73	2.7
Jul 6	0	0.62	3.3	11	0	1.65	3.7
13	0	0.56	3.4	18	0	1.56	4.7
20	0	0.51	3.4	25	0	1.47	5.7
27	0	0.44	3.5	TOTAL	809		
Aug 3	5	0.38	3.4				
10	10	0.32	3.5				

Table 4.15: Rainfall, Water Level & Evaporation Data at Medha Creek TR – Year 1999 to 2003

4.2.7 Geohydrological & Geochemical Monitoring System Setup

To know the efficacy of the Medha Creek Tidal Regulator, 42 number of observation well surrounding the reservoir site has been monitored from May 1994 to November 2002. The observations were taken Pre-monsoon (May) and Post-monsoon (November) every year. The various parameters observed are RWL, pH, EC, TDS, Cl^- , Na^+ , SO_4^{--} , Ca^{++} , Mg^{++} , CO_3^- and HCO_3^- . To study above parameters, contour maps showing variation in different parameter values are prepared.

Obs. Well No	RL (m)	Distance from Structure (m)	Obs. Well No	RL (m)	Distance from Structure (m)	Obs. Well No	RL (m)	Distance from Structure (m)
MDK - 01	6.10	822.00	MDK - 15	5.75	5080.00	MDK - 29	3.20	1445.00
MDK - 02	8.08	690.00	MDK - 16	15.25	5210.00	MDK - 30	5.79	2190.00
MDK - 03	4.31	930.00	MDK - 17	9.14	4800.00	MDK - 31	7.92	4595.00
MDK - 04	8.90	1189.00	MDK - 18	9.15	5380.00	MDK - 32	14.02	3870.00
MDK - 05	6.59	1285.00	MDK - 19	7.47	5800.00	MDK - 33	14.63	3350.00
MDK - 06	16.04	2052.00	MDK - 20	6.09	5725.00	MDK - 34	7.92	3415.00
MDK - 07	6.86	2153.00	MDK - 21	8.57	690.00	MDK - 35	11.58	4950.00
MDK - 08	10.87	2518.00	MDK - 22	3.97	470.00	MDK - 36	6.40	5260.00
MDK - 09	9.75	4113.00	MDK - 23	3.84	675.00	MDK - 37	6.70	4340.00
MDK - 10	12.19	3845.00	MDK - 24	5.02	1615.00	MDK - 38	6.09	4250.00
MDK - 11	13.70	3414.00	MDK - 25	6.99	2535.00	MDK - 39	12.80	4130.00
MDK - 12	5.91	4945.00	MDK - 26	4.51	3670.00	MDK - 40	3.50	4875.00
MDK - 13	7.00	5156.00	MDK - 27	11.79	3915.00	MDK - 41	10.36	5315.00
MDK - 14	5.80	4875.00	MDK - 28	9.80	3555.00	MDK - 42	7.01	4787.00

Table 4.16: Details of Observation Wells surrounding Medha Creek Tidal Regulator

4.2.7.1 Data Collection for Geohydrological & Geochemical Monitoring

Month and Year	Well No	RWL (m)	EC (mmhos/cm)	TDS (ppm)	pH	Cl ⁻ (ppm)	CO ₃ (ppm)	HCO ₃ (ppm)	Ca ⁺⁺ (ppm)	Mg ⁺⁺ (ppm)	Na ⁺ (ppm)	SO ₄ (ppm)
May-96	MDK - 01	1.40	18705	11971	7.1	7040	24	110	1600	915	1230	540
May-96	MDK - 02	-1.42	6091	3898	7.8	1840	0	122	410	261	372	444
May-96	MDK - 03	-1.19	7656	4900	7.7	2440	0	110	480	369	440	468
May-96	MDK - 04	-1.50	8700	5568	7.9	2800	0	159	570	384	580	408
May-96	MDK - 05	-2.01	10005	6403	7.6	3480	0	122	865	489	440	504
May-96	MDK - 06	0.24	914	585	8.3	144	36	165	65	36	100	0
May-96	MDK - 07	-2.94	2306	1476	7.8	480	0	159	120	75	170	0
May-96	MDK - 08	-3.93	1827	1169	7.9	328	48	464	100	60	192	0
May-96	MDK - 09	-6.15	6438	4120	7.7	1920	0	134	385	300	392	432
May-96	MDK - 10	3.89	7744	4956	7.6	2360	0	134	535	360	410	468
May-96	MDK - 11	2.70	5220	3341	7.7	1200	0	110	335	222	334	336
May-96	MDK - 12	-4.69	3916	2506	7.9	1040	0	122	170	153	392	396
May-96	MDK - 13	-3.60	5481	3508	7.8	1480	0	146	390	174	400	456
May-96	MDK - 14	-1.70	9134	5846	7.8	2720	0	85	615	345	800	780
May-96	MDK - 15	-2.65	7961	5095	7.7	2400	0	85	525	423	452	528
May-96	MDK - 16	3.05	1783	1141	8.1	280	0	342	60	69	186	0
May-96	MDK - 17	-2.16	1870	1197	8.0	368	0	85	90	78	150	0
May-96	MDK - 18	-2.95	1175	752	8.2	192	0	159	30	48	150	0
May-96	MDK - 19	-1.03	3306	2116	8.1	1000	0	195	190	132	262	0
May-96	MDK - 20	1.19	17400	11136	7.6	6240	0	134	1230	840	1560	384
May-96	MDK - 21	0.17	10875	6960	7.7	3480	36	360	450	180	1470	456
May-96	MDK - 22	1.37	18270	11693	7.5	6600	0	110	1185	570	2460	576
May-96	MDK - 23	0.34	12180	7795	7.7	4000	0	85	550	342	1680	492
May-96	MDK - 24	1.22	15659	10022	7.8	5480	0	98	1105	642	1488	576
May-96	MDK - 25	0.69	15225	9744	7.8	5200	0	122	985	723	1408	636
May-96	MDK - 26	-0.79	13484	8630	7.6	4840	0	98	1280	615	816	540
May-96	MDK - 27	-2.51	6698	4287	7.8	2000	0	73	525	270	432	480
May-96	MDK - 28	-0.70	14791	9466	7.6	5280	0	73	1290	402	936	624
May-96	MDK - 29	0.80	13920	8909	7.6	4680	24	232	240	252	2772	504
May-96	MDK - 30	-0.61	12180	7795	8.0	4120	0	110	850	456	1230	540
May-96	MDK - 31	Dry	-	-	-	-	-	-	-	-	-	-

Month and Year	Well No	RWL (m)	EC (mmho s/cm)	TDS (ppm)	pH	Cl ⁻ (ppm)	CO ₃ ²⁻ (ppm)	HCO ₃ ⁻ (ppm)	Ca ⁺⁺ (ppm)	Mg ⁺⁺ (ppm)	Na ⁺ (ppm)	SO ₄ ²⁻ (ppm)
May-96	MDK - 32	-3.38	1871	1197	8.4	376	84	250	135	54	200	0
May-96	MDK - 33	4.83	3219	2060	8.2	840	48	232	185	81	340	324
May-96	MDK - 34	0.42	18705	11971	7.6	6920	0	73	1415	792	1860	744
May-96	MDK - 35	Dry	-	-	-	-	-	-	-	-	-	-
May-96	MDK - 36	-2.20	2045	1309	8.3	432	24	244	80	78	200	0
May-96	MDK - 37	-1.20	15225	9744	7.7	5360	0	146	1370	687	724	468
May-96	MDK - 38	Dry	-	-	-	-	-	-	-	-	-	-
May-96	MDK - 39	-2.60	3828	2450	8.0	1040	48	232	310	117	280	276
May-96	MDK - 40	-1.30	6308	4037	8.5	1280	444	872	0	36	1386	384
May-96	MDK - 41	-1.04	3306	2116	8.0	680	12	482	135	111	322	0
May-96	MDK - 42	-4.89	8176	5233	7.9	2440	0	122	600	327	472	468
Nov-96	MDK - 01	Dry	-	-	-	-	-	-	-	-	-	-
Nov-96	MDK - 02	-1.82	1876	1201	7.5	464	12	128	85	75	216	0
Nov-96	MDK - 03	-1.29	9572	6126	7.6	3160	12	116	865	450	452	504
Nov-96	MDK - 04	-2.10	9752	6241	7.8	3200	0	220	780	471	492	480
Nov-96	MDK - 05	-2.61	10324	6607	7.8	3480	36	140	1015	480	432	456
Nov-96	MDK - 06	-1.16	1198	767	7.9	248	12	140	95	57	124	0
Nov-96	MDK - 07	1.16	2141	1370	7.7	528	0	110	145	69	166	0
Nov-96	MDK - 08	-2.93	1866	1194	7.7	368	24	159	75	69	192	0
Nov-96	MDK - 09	-7.05	4293	2748	7.8	1240	0	146	235	201	312	300
Nov-96	MDK - 10	1.89	6890	4410	7.9	2080	0	73	365	306	382	408
Nov-96	MDK - 11	4.20	4378	2802	7.9	1320	48	159	325	225	272	0
Nov-96	MDK - 12	-4.79	4049	2591	7.8	1080	0	122	240	171	410	456
Nov-96	MDK - 13	-1.30	7388	4728	7.8	2160	0	98	665	297	452	528
Nov-96	MDK - 14	0.50	8618	5516	7.7	2680	0	73	620	312	724	672
Nov-96	MDK - 15	-3.05	6646	4253	8.0	2040	0	73	540	309	384	492
Nov-96	MDK - 16	3.35	1590	1018	8.0	288	12	165	70	78	170	0
Nov-96	MDK - 17	2.54	2979	1907	7.8	760	0	98	195	147	176	0
Nov-96	MDK - 18	-1.65	1155	739	7.7	192	24	134	55	48	138	0
Nov-96	MDK - 19	0.07	2088	1336	7.8	520	0	85	105	156	160	0
Nov-96	MDK - 20	2.29	9349	5983	7.5	3000	0	110	535	342	738	456
Nov-96	MDK - 21	0.37	9688	6200	7.5	3000	12	165	395	228	1086	432
Nov-96	MDK - 22	1.57	17161	10983	7.7	6080	0	85	1155	510	1810	552
Nov-96	MDK - 23	1.44	10462	6696	7.7	3320	0	232	490	192	1302	408
Nov-96	MDK - 24	2.52	12688	8120	7.6	4240	0	73	840	456	1116	528
Nov-96	MDK - 25	1.69	13759	8806	7.7	4640	0	122	775	630	1180	684
Nov-96	MDK - 26	0.89	14988	9592	7.8	5320	0	61	1915	414	850	612
Nov-96	MDK - 27	-1.21	7272	4654	8.0	2280	24	134	645	315	372	384
Nov-96	MDK - 28	0.10	15052	9633	7.7	5280	0	73	1360	738	768	564
Nov-96	MDK - 29	1.10	16451	10529	7.6	5280	24	207	295	348	3000	528
Nov-96	MDK - 30	0.59	7505	4803	8.1	2360	0	207	415	210	744	408
Nov-96	MDK - 31	0.12	3074	1967	7.9	800	0	122	160	153	272	0
Nov-96	MDK - 32	-2.88	1738	1112	8.0	312	72	232	60	99	200	0
Nov-96	MDK - 33	5.63	2671	1709	8.0	624	60	177	120	105	334	0
Nov-96	MDK - 34	1.02	15752	10081	7.8	5360	0	98	960	672	1760	624
Nov-96	MDK - 35	6.58	2798	1791	8.1	680	24	171	80	147	322	0
Nov-96	MDK - 36	-1.10	1728	1106	7.9	368	0	171	40	93	210	0
Nov-96	MDK - 37	-1.30	16038	10264	7.5	5720	0	85	1550	852	830	672
Nov-96	MDK - 38	-3.61	5364	3433	7.7	1600	0	85	425	228	340	372
Nov-96	MDK - 39	-3.00	3053	1954	7.8	784	0	159	150	150	246	0
Nov-96	MDK - 40	-1.10	7219	4620	8.2	1520	396	1594	45	60	1500	0
Nov-96	MDK - 41	1.06	2724	1743	8.3	608	36	226	150	141	262	0
Nov-96	MDK - 42	-4.19	6381	4084	7.9	1880	0	159	510	231	452	432
May-02	MDK - 01	1.90	11284	7222	7.6	3760	36	189	860	468	1488	588
May-02	MDK - 02	-1.52	5460	3494	7.9	1640	0	195	395	225	644	336
May-02	MDK - 03	-0.89	7826	5009	7.7	2560	24	73	595	366	840	408
May-02	MDK - 04	-0.40	9919	6348	7.7	3240	48	195	745	453	1116	456
May-02	MDK - 05	-1.94	7553	4834	7.6	2440	0	159	610	339	738	372

Month and Year	Well No	RWL (m)	EC (mmho s/cm)	TDS (ppm)	pH	Cl ⁻ (ppm)	CO ₃ (ppm)	HCO ₃ (ppm)	Ca ⁺⁺ (ppm)	Mg ⁺⁺ (ppm)	Na ⁺ (ppm)	SO ₄ (ppm)
May-02	MDK - 06	-2.46	1092	699	8.2	240	36	140	55	63	94	0
May-02	MDK - 07	-3.14	3549	2271	7.8	960	12	177	230	147	392	0
May-02	MDK - 08	-1.33	2912	1864	8.0	680	12	262	100	141	290	0
May-02	MDK - 09	1.15	6188	3960	7.7	1840	12	189	300	369	560	384
May-02	MDK - 10	3.79	10465	6698	7.6	3520	0	122	900	471	910	504
May-02	MDK - 11	2.40	7735	4950	7.7	2520	0	122	590	375	800	0
May-02	MDK - 12	1.21	2093	1340	8.1	432	0	274	60	99	246	0
May-02	MDK - 13	0.30	6279	4019	7.8	1800	36	159	490	171	764	396
May-02	MDK - 14	0.50	9737	6232	7.6	3160	0	183	560	411	1302	468
May-02	MDK - 15	-1.65	10467	6699	7.7	3440	0	110	875	474	1200	528
May-02	MDK - 16	Dry	-	-	-	-	-	-	-	-	-	-
May-02	MDK - 17	-1.56	3913	2504	7.9	1120	24	134	260	186	400	0
May-02	MDK - 18	-3.85	2639	1689	8.0	728	24	134	80	162	372	0
May-02	MDK - 19	1.87	2639	1689	8.1	640	12	152	100	120	272	0
May-02	MDK - 20	2.89	7462	4776	7.8	2320	0	146	350	312	980	432
May-02	MDK - 21	Dry	-	-	-	-	-	-	-	-	-	-
May-02	MDK - 22	1.27	11468	7340	7.6	3880	12	165	600	273	2000	516
May-02	MDK - 23	0.93	11375	7280	7.7	3720	0	146	480	234	2000	492
May-02	MDK - 24	1.92	14924	9551	7.8	5120	0	134	1105	522	2200	456
May-02	MDK - 25	0.29	15106	9668	7.6	5360	36	152	955	567	2260	576
May-02	MDK - 26	-0.39	12012	7688	7.8	4000	0	159	1085	369	1528	468
May-02	MDK - 27	-1.11	5187	3320	7.9	1640	12	128	370	258	624	348
May-02	MDK - 28	-0.60	14469	9260	7.5	4840	36	140	1225	570	1600	528
May-02	MDK - 29	0.60	12012	7688	7.8	3920	36	226	170	243	1760	456
May-02	MDK - 30	-0.71	13741	8794	7.8	4600	36	226	925	450	1904	492
May-02	MDK - 31	Dry	-	-	-	-	-	-	-	-	-	-
May-02	MDK - 32	-2.98	2184	1398	8.2	456	72	329	110	123	262	0
May-02	MDK - 33	5.93	4368	2796	8.0	1320	48	195	215	156	544	0
May-02	MDK - 34	-0.38	16380	10483	7.6	5840	0	159	1245	603	2310	588
May-02	MDK - 35	4.08	5915	3786	8.0	1840	48	232	230	273	840	384
May-02	MDK - 36	0.10	1729	1107	8.1	344	48	256	70	75	154	0
May-02	MDK - 37	-0.10	21294	13628	7.5	7600	0	146	2350	903	1808	756
May-02	MDK - 38	-0.51	10465	6698	7.7	3520	0	159	985	489	966	552
May-02	MDK - 39	-1.10	10556	6756	7.8	3480	0	134	1065	456	1086	648
May-02	MDK - 40	-0.60	2912	1864	8.3	560	192	634	95	27	544	0
May-02	MDK - 41	-0.84	3458	2213	8.1	800	120	610	175	111	410	0
May-02	MDK - 42	-1.99	8736	5591	7.8	2760	24	146	890	261	800	468
Nov-02	MDK - 01	1.50	10176	6513	7.4	3280	24	305	765	447	1428	504
Nov-02	MDK - 02	-2.12	6336	4055	7.7	2000	0	110	430	267	868	348
Nov-02	MDK - 03	-1.59	6048	3871	7.8	1880	12	140	455	297	820	408
Nov-02	MDK - 04	-2.10	7872	5038	7.6	2480	36	116	565	342	1020	384
Nov-02	MDK - 05	-3.51	7392	4731	7.8	2360	0	85	645	309	1000	360
Nov-02	MDK - 06	0.04	1152	737	8.0	168	24	195	50	72	98	0
Nov-02	MDK - 07	-2.84	2496	1597	7.6	544	0	183	130	105	250	0
Nov-02	MDK - 08	Dry	-	-	-	-	-	-	-	-	-	-
Nov-02	MDK - 09	-3.55	9216	5898	7.2	2880	0	146	745	471	900	432
Nov-02	MDK - 10	2.71	11712	7496	7.4	3800	0	110	1005	585	1500	564
Nov-02	MDK - 11	-1.80	7776	4977	7.5	2520	0	61	590	426	952	372
Nov-02	MDK - 12	-5.59	4128	2642	7.7	1120	0	195	220	192	452	312
Nov-02	MDK - 13	-2.10	7296	4669	7.6	2160	0	85	645	267	840	432
Nov-02	MDK - 14	-4.40	8640	5530	7.3	2600	0	195	750	234	1176	468
Nov-02	MDK - 15	-3.65	8352	5345	7.4	2680	0	146	775	357	1020	444
Nov-02	MDK - 16	4.75	2880	1843	7.7	592	0	159	120	174	322	312
Nov-02	MDK - 17	-3.16	3648	2335	7.6	1040	0	159	260	162	490	324
Nov-02	MDK - 18	-4.05	3072	1966	7.7	800	0	171	210	138	434	360
Nov-02	MDK - 19	-0.13	2400	1536	7.6	528	0	195	135	90	272	0
Nov-02	MDK - 20	2.59	11520	7373	7.3	3760	0	122	770	459	1640	684
Nov-02	MDK - 21	Dry	-	-	-	-	-	-	-	-	-	-

Month and Year	Well No	RWL (m)	EC (mmhos/cm)	TDS (ppm)	pH	Cl ⁻ (ppm)	CO ₃ ⁻ (ppm)	HCO ₃ ⁻ (ppm)	Ca ⁺⁺ (ppm)	Mg ⁺⁺ (ppm)	Na ⁺ (ppm)	SO ₄ ⁻ (ppm)
Nov-02	MDK - 22	1.07	13152	8417	7.4	4400	0	134	810	267	2292	588
Nov-02	MDK - 23	1.04	11808	7557	7.5	3680	0	134	560	234	2112	516
Nov-02	MDK - 24	1.52	13248	8479	7.6	4520	0	61	965	480	2040	576
Nov-02	MDK - 25	0.39	13056	8356	7.5	4320	0	110	975	258	1932	552
Nov-02	MDK - 26	-1.09	13152	8417	7.4	4360	0	195	1170	483	1740	528
Nov-02	MDK - 27	-3.71	4704	3011	7.8	1360	0	171	370	156	580	372
Nov-02	MDK - 28	-1.50	13536	8663	7.3	4680	0	73	1205	549	1680	564
Nov-02	MDK - 29	0.80	12096	7741	7.4	3960	12	207	180	243	1960	492
Nov-02	MDK - 30	Dry	-	-	-	-	-	-	-	-	-	-
Nov-02	MDK - 31	Dry	-	-	-	-	-	-	-	-	-	-
Nov-02	MDK - 32	-2.58	2304	1475	8.1	1475	12	128	110	102	290	0
Nov-02	MDK - 33	4.43	3456	2212	7.8	2212	0	146	210	102	580	336
Nov-02	MDK - 34	-0.08	12864	8233	7.4	8233	0	98	815	477	2232	624
Nov-02	MDK - 35	4.18	4032	2580	8.1	2580	12	104	160	186	544	348
Nov-02	MDK - 36	-2.00	1824	1167	8.0	1167	0	268	100	66	196	0
Nov-02	MDK - 37	-0.40	12960	8294	7.4	8294	0	146	1275	525	1904	516
Nov-02	MDK - 38	-0.31	2880	1843	7.9	1843	0	159	150	153	392	0
Nov-02	MDK - 39	-1.90	6048	3871	7.6	3871	0	134	515	210	840	396
Nov-02	MDK - 40	-0.70	2880	1843	8.7	1843	156	323	70	15	644	0
Nov-02	MDK - 41	1.16	2784	1782	8.2	1782	12	201	130	102	362	0
Nov-02	MDK - 42	-3.79	9216	5898	7.8	5898	0	85	865	318	1356	456

Table 4.17: Geohydrological & Geochemical Parameters Observed in Obs. Wells surrounding Medha Creek Tidal Regulator

4.3 Meghal Tidal Regulator

The Meghal Tidal Regulator (MTR) is the major seawater intrusion preventive structure located across the mouth of river Meghal in Malia Hatina Taluka of Junagadh District near village Chorvad on the coast of Arabian Sea.

4.3.1 Meghal Basin - Topography

The Meghal river basin situated at 20° 58' to 21° 17' North latitude and 70° 13' East to 70° 32' East longitude, originates from Kanada hill ranges and flows from Northeast to Southwest (Refer Map 4.3). The catchment area of Meghal basin is 518 km² and length of the river is 45 km. Vrajmi is one of the major tributary of Meghal (Refer Map 4.4). The river basin consists of hilly terrain region to low lying and almost flattens areas in the lower reach near the coast. The slope of basin varies from 1:1000 to 1:5000. The climate of the basin is humid and temperature ranges in between 10° C to 42° C during the year. General geological formation in its natural order of superposition is Topsoil, Miliolite limestone, Gaj limestone, Laterite and Deccan Trap basalt. Considering above succession, Miliolite limestone forms the youngest formation under the topsoil and it is cavernous in nature. (GoG, 1999; Parekh & Patel, 2002). The average annual rainfall of the Meghal basin is 800 mm, received mainly, through Southwest monsoon between June to September.

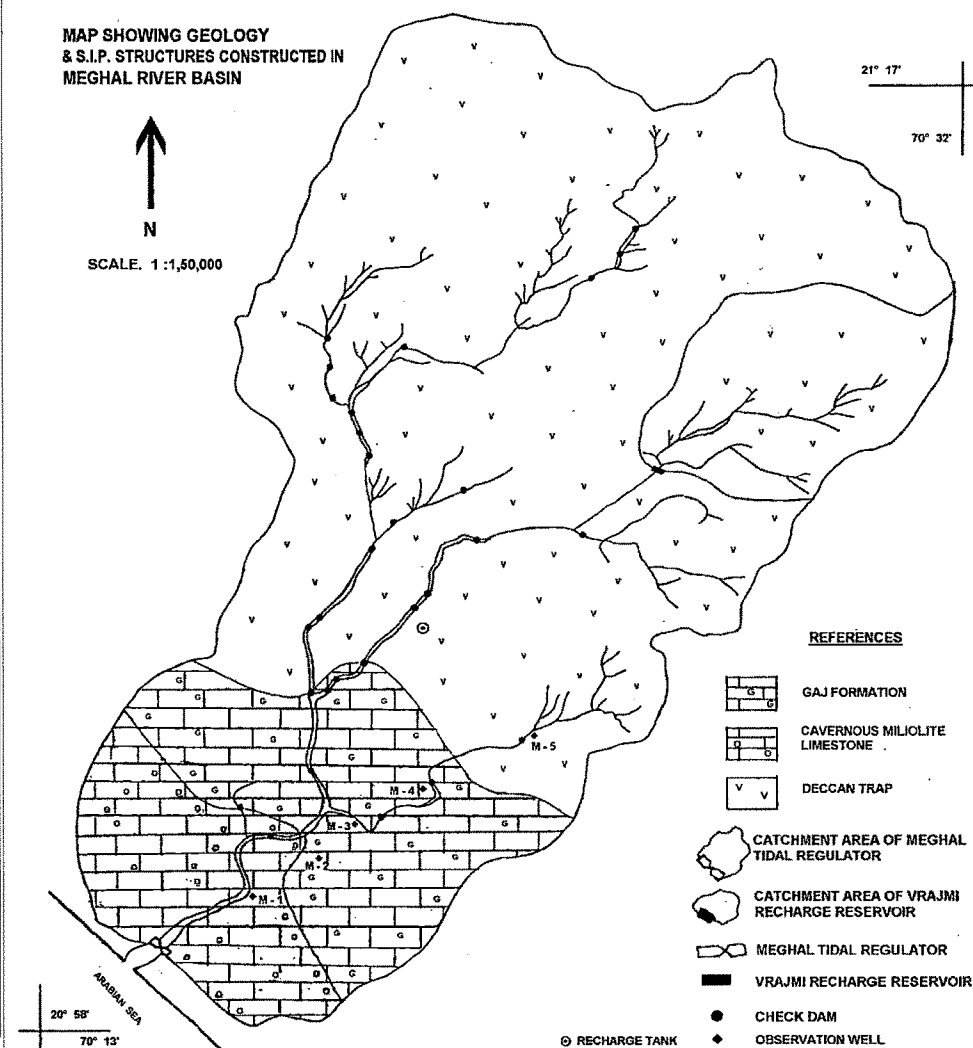
4.3.1.1 Seawater Intrusion Preventive Structures Constructed in Meghal Basin

Various seawater intrusion preventive structures constructed in the Meghal basin are listed below. (Refer Table 4.18 & Map No. 4.3)

Sr. No.	Name of the Structure	Total No. of structures proposed	Structures completed
1	Check dam	31	31
2	Meghal Tidal regulator	1	1
3	Recharge tank	1	1
4	Vrajmi Recharge Reservoir	1	1
5	Recharge well	20	20
6	Afforestation	--	1179.03 Hectare
7	Nala plugs	--	621 Nos.

(Report On MB, SIPC, GOG, 2000)

Table 4.18: Details of Seawater Intrusion Preventive structures constructed in Meghal Basin



Map 4.3: Map Showing Meghal River Basin with Geology and Location of Major Seawater Intrusion Preventive Structures

(Reference: MB, SIPC, GoG, 1999)

4.3.2 Salient Features of Meghal Tidal Regulator

i)	Location	:	Latitude 21° 14' N; Longitude 70° 15' E
ii)	Length	:	843.13m
iii)	Crest RL	:	0.00m (for Vertical Gates); 1.00m (for Godbole Gates)
iv)	Number of Gates	:	45 (Vertical); 16 (Godbole)
v)	FRL	:	2.50m
vi)	HFL	:	4.70m
vii)	HTL	:	2.50m
viii)	Length of Apron	:	13.00m
ix)	Length of Earthen Dam	:	380m
x)	Catchment Area	:	518 km ²
xi)	Designed Flood	:	8380 cumecs
xii)	Submergence Area	:	542 ha
xiii)	Storage Capacity	:	6.003 MCM

4.3.3 Rainfall Recorded at Meghal Tidal Regulator Hydromet Station

The rainfall in this area is received between June and October through the South-West monsoon. (Refer Table 4.19 & Graph 5.24)

Average Annual Rainfall = 800mm			
Year	Rainfall (mm)	% rainfall below AAR	% rainfall above AAR
1991	544.00	32.00	----
1992	1344.00		68.00
1993	523.00	35.00	----
1994	957.00	----	20.00
1995	546.00	32.00	----
1996	1090.00	----	36.00
1997	597.00	25.00	----
1998	1196.00	----	50.00
1999	227.00	71.62	----
2000	751.00	6.25	----
2001	909.00	----	13.63
2002	435.00	45.63	----
2003	866.00	----	8.25

Table 4.19: Details of Rainfall Recorded at Meghal Tidal Regulator Hydromet Station

4.3.4 Geology of the Area

The Miliolite Limestone is the youngest formation under thin soil cover. It overlies the Gaj Beds. The Miliolite Limestone is cavernous and hence it is pervious in nature. The thickness of this formation is 25m near the coast and 2m inland. Gaj beds are exposed near the village Visanvel, Gadu & Simar. Gaj beds consists of alternate layers of yellow clay and thin impure limestone beds. The general geological succession in the area in its natural order of superposition is as follows as shown in Table 4.20:

Sr. No.	Geological Formation	Age
1	Top Soil	Recent
2	Miliolite limestone	Pleistocene to Recent
3	Gaj Limestone & Clay	Upper Miocene to Pliocene
4	Laterite	Eocene to Pliocene
5	Deccan Trap	Cretaceous to Eocene

Table 4.20: Geology at Meghal Tidal Regulator Area

The aquifer characteristics of Miliolite Limestone and Gaj beds have been worked out by Open Well pump test before construction of TR. The results are as follows.

	Miliolite Limestone	Gaj Beds
Transmissibility	135.53 to 1520 m ² /day	12.04 to 85.90 m ² /day
Permeability	59.01 to 152.84 m/day	1.54 to 21.6 m/day

Table 4.21: Aquifer Properties of Geological Formation at Meghal Tidal Regulator Site



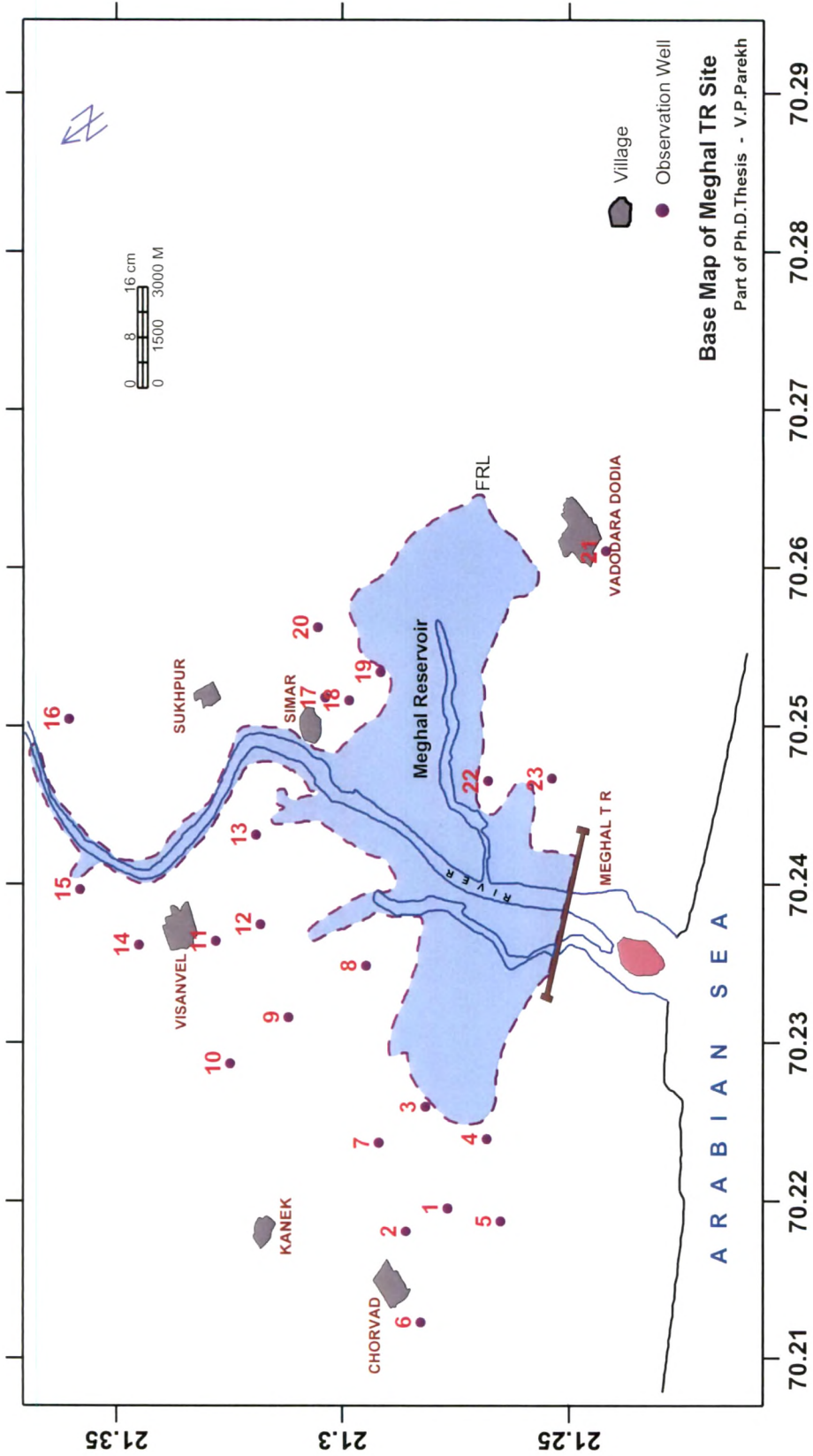
Plate 4.4: View of Meghal Tidal Regulator Hydromet Station



Plate 4.5: View of Meghal Tidal Regulator Gate – U/S & D/S of Reservoir with RL marked on Pier
(The colour difference between Fresh Water and Sea water is visualized in the same. U/S side is filled to FRL.)



Plate 4.6: View of Fresh water Reservoir created as seen from D/S side of TR
(Corrosion Machinerries on bridge portion and some part of Gates is also seen.)



Map 4.4: Base Map of Meghal Tidal Regulator

4.3.5 Elevation, Area, Volume Stored (Capacity) & Wetted Area of Meghal Tidal Regulator Reservoir

Sr. No.	Ele. (m)	Area (sqm)	Cumu. Vol. (m ³)	Wetted Area (Sqm)	Sr. No.	Ele. (m)	Area (sqm)	Cumu. Vol. (m ³)	Wetted Area (Sqm)	Sr. No.	Ele. (m)	Area (sqm)	Cumu. Vol. (m ³)	Wetted Area (Sqm)
1	-1.00	40144	0	41399	24	0.15	409697	233236	422372	48	1.35	2035218	1116000	2093006
2	-0.95	56359	2401	58114	25	0.20	424783	254096	437880	49	1.40	2230799	1222000	2293904
3	-0.90	72574	5616	74827	26	0.25	439869	275712	453384	50	1.45	2426379	1330000	2494760
4	-0.85	88788	9643	91535	27	0.30	454954	298081	468885	51	1.50	2621960	1451235	2695574
5	-0.80	105003	14482	108241	28	0.35	470040	321205	484383	52	1.55	2773507	1586104	2851082
6	-0.75	121218	20133	124943	29	0.40	485126	345083	499877	53	1.60	2925055	1728551	3006558
7	-0.70	137433	26595	141641	30	0.45	500211	369716	515369	54	1.65	3076602	1878577	3162002
8	-0.65	153648	33868	158336	31	0.50	515297	395102	530857	55	1.70	3228149	2036180	3317414
9	-0.60	169862	41953	175028	32	0.55	530383	421243	546342	56	1.75	3379697	2201362	3472794
10	-0.55	186077	50848	191716	33	0.60	545468	448139	561824	57	1.80	3531244	2374122	3628141
11	-0.50	202292	60554	208400	34	0.65	560554	475789	577302	58	1.85	3682791	2554459	3783457
12	-0.45	218507	71072	225082	35	0.70	575640	504193	592778	59	1.90	3834338	2742375	3938740
13	-0.40	234722	82400	241759	36	0.75	590726	533351	608250	60	1.95	3985886	2937868	4093991
14	-0.35	250936	94539	258434	37	0.80	605811	563264	623719	61	2.00	4137433	3126745	4249210
15	-0.30	267151	102000	275105	38	1.85	620897	593930	639185	62	2.05	4480358	3415068	4600924
16	-0.25	283366	112000	291772	39	0.90	635983	625352	654647	63	2.10	4823282	3703392	4952566
17	-0.20	299581	124000	308436	40	0.95	651068	657527	670107	64	2.15	5166207	3991715	5304134
18	-0.15	315796	134000	325097	41	1.00	666154	682949	685563	65	2.20	5509132	4280038	5655631
19	-0.10	332010	146000	341754	42	1.05	861735	721041	886751	66	2.25	5852057	4568362	6007054
20	-0.05	348225	158000	358408	43	1.10	1057315	768934	1087897	67	2.30	6194981	4856685	6358405
21	0.00	364440	175179	375831	44	1.15	1252896	826621	1289002	68	2.35	6537906	5145008	6709683
22	0.05	379526	193777	391348	45	1.20	1448476	888000	1490065	69	2.40	6880831	5433331	7060888
23	0.10	394611	213129	406862	46	1.25	1644057	966000	1691087	70	2.45	7223755	5721655	7412021
					47	1.30	1839638	1036000	1892067	71	2.50	7566680	6009978	7763081

Table 4.22: Elevation, Area & Capacity Table for Meghal Tidal Regulator (Refer Graph 5.25 to 5.27)

4.3.6 Pumping & Recuperation Test at village Visanvel

To get aquifer properties Pumping & Recovery test was done at the village Visanvel, Tal. Malia(H), Dist. Junagadh. The results are as follows. Graphs were developed with Cooper – Jacob's Method. Well details are mentioned on graph.

Sr. No.	Time Hr:Min	Water Level (m)	Sr. No.	Time Hr:Min	Water Level (m)
1	9:00	22.15	15	9:40	23.43
2	9:01	22.20	16	9:50	23.70
3	9:02	22.25	17	10:00	23.95
4	9:03	22.30	18	10:15	24.35
5	9:04	22.35	19	10:30	24.77
6	9:06	22.45	20	10:45	25.10
7	9:08	22.53	21	11:00	25.55
8	9:10	22.61	22	11:15	25.93
9	9:13	22.70	23	11:30	26.30
10	9:16	22.76	24	11:45	26.63
11	9:20	22.85	25	12:00	26.99
12	9:25	22.97	26	12:15	27.27
13	9:30	23.11	27	12:30	27.51
14	9:35	23.27	28	13:00	27.91

Table 4.23: Time – Water-level Data for the Pumping Test at Vill. Visanvel near Meghal Tidal Regulator

Sr. No.	Time Hr:Min	Water Level (m)	Sr. No.	Time Hr:Min	Water Level (m)
1	9:00	22.15	17	13:40	27.41
2	13:00	27.91	18	13:50	27.33
3	13:01	27.85	19	14:00	27.26
4	13:02	27.82	20	14:15	27.11
5	13:03	27.78	21	14:30	27.00
6	13:04	27.75	22	14:45	26.91
7	13:05	27.72	23	15:00	26.82
8	13:06	27.70	24	15:15	26.70
9	13:07	27.68	25	15:30	26.58
10	13:08	27.66	26	15:45	26.48
11	13:10	27.63	27	16:00	26.38
12	13:12	27.60	28	16:15	26.28
13	13:15	27.56	29	16:30	26.17
14	13:20	27.53	30	17:00	26.00
15	13:25	27.51	31	17:30	25.83
16	13:30	27.49	32	18:00	25.67

Table 4.24: Time – Water-level Data for the Recuperation Test at Vill. Visanvel near Meghal Tidal Regulator

4.3.7 Rainfall, Water Level Fluctuation & Evaporation Recorded at Meghal Tidal Regulator

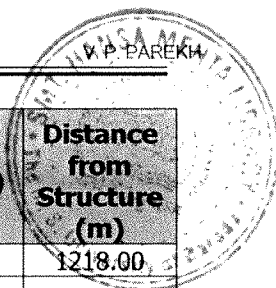
Date	Rainfall (mm/ Week)	Water level RL. In Mt.	Evap. (cm/ week)	Date	Rainfall (mm/ Week)	Water level RL. In Mt.	Evap. (cm/ week)
3/7/98	750	2.50	-	5/7/2000	286	2.50	-
Jul 10	27	2.15	3.5	Jul 15	180	2.00	6.4
17	3	2.50	-	22	3	1.71	4.4
24	2	2.50	-	29	Nil	1.50	4.6
31	43	2.50	-	Aug 5	Nil	1.34	4.7
Aug 7	18	2.50	-	11	Nil	1.20	3.8
14	3	2.50	-	13	196	2.50	-
21	3	2.50	-	20	1	2.25	4.1
28	210	2.50	-	27	64	2.06	4.2
Sep 4	23	2.50	-	Sep 3	9	1.88	4.2
11	Nil	2.50	-	10	Nil	1.70	4.3
18	1	2.50	-	17	Nil	1.54	4.3
25	4	2.50	-	24	Nil	1.38	4.2
Oct 2	18	2.50	-	Oct 1	Nil	1.23	4.3
9	23	2.50	-	8	Nil	1.08	4.1
16	41	2.50	-	15	12	0.92	4.1
23	27	2.50	-	22	Nil	0.75	4.0
30	Nil	2.50	-	29	Nil	0.59	4.0
06/11/98	Nil	2.50	-	Nov 5	Nil	0.44	3.9
13	Nil	2.50	-	TOTAL	751		
20	Nil	2.50	-				
27	Nil	2.25	3.4	16/6/01	325	2.50	-
Dec 4	Nil	2.05	3.3	23	77	2.15	4.0
12	Nil	1.87	3.1	30	4	2.00	4.5
20	Nil	1.72	3.1	Jul 7	114	1.85	3.9
27	Nil	1.60	3.2	9	130	2.50	-
3/1/99	Nil	1.46	3.3	16	31	2.50	-
10	Nil	1.34	3.3	23	13	2.50	-
17	Nil	1.22	3.4	30	22	2.50	-
24	Nil	1.10	3.5	Aug 6	2	2.50	-
Feb 1	Nil	1.01	3.7	13	68	2.50	-
8	Nil	0.89	3.9	20	13	2.50	-
15	Nil	0.77	4.0	27	21	2.50	-
22	Nil	0.64	4.1	Sep 3	26	2.50	-
Mar 1	Nil	0.52	4.2	10	2	2.50	-
TOTAL	1196			17	2	2.50	-
				24	23	2.50	-
				Oct 01	Nil	2.50	-
				8	29	2.50	-

Date	Rainfall (mm/ Week)	Water level RL. In Mt.	Evap. (cm/ week)	Date	Rainfall (mm/ Week)	Water level RL. In Mt.	Evap. (cm/ week)
15	3	2.50	-	21/07/03	445	1.20	-
22	4	2.50	-	28	46	0.90	4.8
Nov 1	Nil	2.50	-	Aug 4	13	0.65	4.7
8	Nil	2.24	3.6	8	195	2.50	-
15	Nil	2.05	3.7	15	8	2.50	-
22	Nil	1.86	3.6	22	3	2.50	-
29	Nil	1.65	3.5	29	90	2.50	-
Dec 6	Nil	1.44	3.4	Sep 5	10	2.50	-
13	Nil	1.25	3.3	12	2	2.50	-
20	Nil	1.10	3.3	19	38	2.50	-
27	Nil	0.95	3.1	26	Nil	2.50	-
03/01/2002	Nil	0.80	3.1	Oct 3	16	2.50	-
10	Nil	0.67	3.1	10	Nil	2.50	-
17	Nil	0.55	3.0	17	Nil	2.50	-
TOTAL	909			24	Nil	2.19	3.7
				31	Nil	2.00	3.7
18/6/02	12	0.00	-	Nov 7	Nil	1.79	3.5
25	9	0.00	-	14	Nil	1.61	3.5
Jul 2	123	0.00	-	21	Nil	1.42	3.4
9	Nil	0.00	-	28	Nil	1.25	3.4
17	5	0.00	-	Dec 5	Nil	1.10	3.3
23	20	0.00	-	12	Nil	0.96	3.3
30	17	0.00	-	19	Nil	0.80	3.2
Aug 6	2	0.00	-	26	Nil	0.62	3.1
13	53	0.00	-	02/01/04	Nil	0.46	3.1
20	Nil	0.00	-	9	Nil	0.32	3.1
27	188	0.90	-	16	Nil	0.18	3.0
Sep 3	5	0.55	4.2	TOTAL	866		
10	Nil	0.25	4.1				
17	Nil	0.00	4.1				
TOTAL	435						

Table 4.25: Rainfall, Water Level & Evaporation Data at Meghal Tidal Regulator – Year 1998 to 2003

4.3.8 Geohydrological & Geochemical Monitoring System Setup

To check the efficacy of the Meghal Tidal Regulator, 23 number of observation well surrounding the reservoir site has been monitored from May 1991 to November 2002. The observations were taken Pre-monsoon (May) and Post-monsoon (November) every year. The various parameters observed are RWL, pH, EC, TDS, Cl^- , Na^+ , SO_4^{2-} , Ca^{++} , Mg^{++} , CO_3^{--} and HCO_3^- . To study above parameters contour maps showing variation in different parameter values are prepared.



Obs. Well No	RL (m)	Distance from Structure (m)	Obs. Well No	RL (m)	Distance from Structure (m)	Obs. Well No	RL (m)	Distance from Structure (m)
01	5.06	1090.00	09	6.19	1197.00	17	7.37	1218.00
02	5.58	1242.00	10	7.83	1472.00	18	7.11	1134.00
03	8.97	865.00	11	8.01	1445.00	19	5.23	1100.00
04	3.53	816.00	12	6.20	1261.00	20	7.33	1389.00
05	5.14	1052.00	13	5.79	1303.00	21	6.77	1204.00
06	4.72	1483.00	14	8.31	1764.00	22	3.25	540.00
07	2.15	1085.00	15	6.58	2007.00	23	3.00	446.00
08	2.52	843.00	16	8.51	2147.00			

Table 4.26: Details of Observation Wells surrounding Meghal Tidal Regulator

4.3.8.1 Data collection for Geohydrological & Geochemical Monitoring

Month and Year	Well No	RWL (m)	EC (mmhos/cm)	TDS (ppm)	pH	Ca ⁺⁺ (ppm)	Mg ⁺⁺ (ppm)	Na ⁺ (ppm)	CO ₃ ⁻ (ppm)	HCO ₃ ⁻ (ppm)	Cl ⁻ (ppm)	SO ₄ ⁻ (ppm)
01-May-91	01	-0.70	14573	9327	7.50	970	268	1910	0	256	5080	432
01-May-91	02	-0.42	14138	9048	7.50	1135	189	1810	0	195	4920	360
01-May-91	03	3.87	11310	7238	7.40	895	267	1200	0	207	3760	228
01-May-91	04	-0.87	2697	1726	7.90	75	66	322	24	244	704	0
01-May-91	05	-1.66	10875	6960	7.50	540	216	1568	0	159	3760	396
01-May-91	06	-2.68	14138	9048	7.50	685	225	2200	0	195	4880	372
01-May-91	07	-2.85	3192	2043	8.00	155	81	300	24	281	1000	0
01-May-91	08	-2.98	11963	7656	7.40	885	282	1302	0	195	4080	372
01-May-91	09	-5.71	9353	5986	7.20	1245	133	452	0	146	3160	336
01-May-91	10	-13.77	2175	1392	7.80	95	42	210	0	317	440	0
01-May-91	11	-10.21	2001	1281	7.80	50	84	200	0	220	416	0
01-May-91	12	-2.20	7221	4621	7.40	735	186	400	0	146	2360	228
01-May-91	13	-2.71	7656	4900	7.50	355	276	784	0	220	2480	288
01-May-91	14	-16.49	2654	1699	7.70	85	105	200	0	195	680	0
01-May-91	15	Dry	-	-	-	-	-	-	-	-	-	-
01-May-91	16	-6.59	1566	1002	8.30	65	90	160	72	378	232	0
01-May-91	17	-2.03	2610	1670	7.80	160	123	186	0	85	728	0
01-May-91	18	-0.39	10223	6543	7.50	500	294	1356	0	85	3320	576
01-May-91	19	-0.27	10223	6543	7.60	535	363	1176	0	110	3480	480
01-May-91	20	-1.47	10005	6403	7.30	810	201	1230	0	85	3360	612
01-May-91	21	-0.57	11963	7656	7.50	805	240	1610	0	98	4040	552
01-May-91	22	7.74	5655	3619	7.80	205	96	1056	0	171	1640	312
01-May-91	23	-1.25	2306	1476	8.00	165	48	334	0	134	600	0
01-Nov-91	01	0.21	15360	9830	7.30	845	354	2380	0	159	5080	528
01-Nov-91	02	0.48	15360	9830	7.40	810	384	2500	0	110	5200	576
01-Nov-91	03	5.27	9120	5837	7.40	450	342	1260	0	244	3040	264
01-Nov-91	04	-0.47	4896	3133	7.90	115	108	868	0	159	1320	204
01-Nov-91	05	-1.36	15840	10138	7.40	500	480	2450	0	134	5360	588
01-Nov-91	06	-0.56	-	-	-	-	-	-	-	-	-	-
01-Nov-91	07	Dry	-	-	-	-	-	-	-	-	-	-

Month and Year	Well No	RWL (m)	EC (mmho s/cm)	TDS (ppm)	pH	Ca ⁺⁺ (ppm)	Mg ⁺⁺ (ppm)	Na ⁺ (ppm)	CO ₃ (ppm)	HCO ₃ ⁻ (ppm)	Cl ⁻ (ppm)	SO ₄ (ppm)
01-Nov-91	08	-0.48	12000	7680	7.50	705	204	1488	0	73	3960	360
01-Nov-91	09	-2.11	8832	5652	7.30	1035	510	432	0	85	3080	336
01-Nov-91	10	-2.47	4608	2949	7.30	330	216	170	0	146	1360	0
01-Nov-91	11	-1.79	2064	1321	7.60	105	72	170	0	256	456	0
01-Nov-91	12	1.80	5760	3686	7.60	410	225	392	0	110	1760	288
01-Nov-91	13	2.59	3648	2335	7.50	115	189	372	0	244	960	264
01-Nov-91	14	-0.69	2544	1628	7.50	155	90	382	0	256	664	0
01-Nov-91	15	Dry	-	-	-	-	-	-	-	-	-	-
01-Nov-91	16	2.25	-	-	-	-	-	-	-	-	-	-
01-Nov-91	17	3.37	4512	2888	7.20	260	204	340	0	195	1200	312
01-Nov-91	18	2.81	11280	7219	7.30	445	399	1680	0	171	3520	516
01-Nov-91	19	1.63	11520	7373	7.50	320	594	1528	0	61	3800	432
01-Nov-91	20	1.13	8640	5530	7.50	325	396	1200	0	110	2720	552
01-Nov-91	21	1.17	-	-	-	-	-	-	-	-	-	-
01-Nov-91	22	8.34	3552	2273	8.00	0	123	668	24	159	840	228
01-Nov-91	23	-0.40	4128	2642	7.80	130	105	600	0	146	1200	264
01-May-96	01	-0.64	12090	7738	7.50	530	153	1600	0	195	3800	444
01-May-96	02	-0.52	13485	8630	7.60	760	216	1568	0	195	4440	468
01-May-96	03	-0.60	6510	4166	7.80	215	126	738	60	189	1880	312
01-May-96	04	-0.77	4464	2857	8.00	70	75	624	0	220	1200	336
01-May-96	05	0.74	5115	3274	7.80	60	90	680	24	268	1320	360
01-May-96	06	-2.08	18135	11606	7.50	1470	357	1932	0	159	6400	468
01-May-96	07	-4.35	6510	4166	7.50	365	87	784	0	98	1920	468
01-May-96	08	Dry	-	-	-	-	-	-	-	-	-	-
01-May-96	09	-5.21	4650	2976	7.40	455	45	290	0	85	1320	456
01-May-96	10	-10.37	6882	4404	7.20	820	165	226	0	73	2200	0
01-May-96	11	-9.79	1860	1190	7.50	50	72	154	0	110	376	0
01-May-96	12	-2.70	8463	5416	7.30	760	159	560	0	85	2720	492
01-May-96	13	-2.51	9765	6250	7.40	490	300	924	0	134	3120	516
01-May-96	14	-16.69	2651	1697	7.70	75	99	226	24	134	632	0
01-May-96	15	-6.22	1349	863	7.80	35	42	128	24	85	256	0
01-May-96	16	-5.09	1721	1101	7.70	40	78	144	48	281	280	0
01-May-96	17	-5.40	3441	2202	7.50	125	153	210	0	122	920	240
01-May-96	18	-4.50	8091	5178	7.40	210	201	1000	0	146	2360	492
01-May-96	19	-1.87	8091	5178	7.50	205	207	1086	0	134	2440	468
01-May-96	20	-2.07	9300	5952	7.60	540	141	1146	0	85	2960	528
01-May-96	21	0.67	8928	5714	7.50	420	129	1146	0	85	2800	468
01-May-96	22	-1.45	6696	4285	7.90	105	138	980	0	134	1920	408
01-May-96	23	-1.40	5301	3393	7.90	65	162	800	0	146	1520	468
01-Nov-96	01	2.06	7670	4909	7.70	70	231	1000	0	207	2080	456
01-Nov-96	02	2.38	8150	5216	7.80	140	279	924	0	207	2320	516
01-Nov-96	03	3.20	4437	2840	7.90	60	114	624	48	293	1120	384
01-Nov-96	04	1.23	3303	2114	7.50	50	78	600	24	244	800	288
01-Nov-96	05	2.94	4131	2644	7.40	80	66	644	12	457	920	336

Month and Year	Well No	RWL (m)	EC (mmhos/cm)	TDS (ppm)	pH	Ca ⁺⁺ (ppm)	Mg ⁺⁺ (ppm)	Na ⁺ (ppm)	CO ₃ ⁻ (ppm)	HCO ₃ ⁻ (ppm)	Cl ⁻ (ppm)	SO ₄ ⁻ (ppm)
01-Nov-96	06	0.42	10565	6762	7.40	865	123	1230	0	207	3280	468
01-Nov-96	07	-0.15	6061	3879	7.50	300	141	820	0	110	1760	336
01-Nov-96	08	-0.38	10438	6680	7.20	750	183	1200	0	171	3280	456
01-Nov-96	09	1.69	6473	4143	7.60	755	66	434	0	268	1960	312
01-Nov-96	10	2.93	5633	3605	7.40	800	249	500	0	122	1760	288
01-Nov-96	11	5.11	2102	1345	7.50	80	45	186	0	439	352	0
01-Nov-96	12	4.00	6579	4211	7.60	535	138	500	12	274	1880	336
01-Nov-96	13	3.99	6907	4420	7.70	210	285	784	0	195	2000	348
01-Nov-96	14	3.01	2311	1479	7.80	65	96	196	0	281	504	0
01-Nov-96	15	2.18	1674	1071	7.50	55	57	166	0	293	320	0
01-Nov-96	16	3.21	1456	932	7.60	60	75	154	24	146	280	0
01-Nov-96	17	2.60	3012	1928	7.30	105	105	290	0	122	720	228
01-Nov-96	18	0.60	9655	6179	7.20	260	300	1386	0	305	2840	504
01-Nov-96	19	2.53	7981	5108	7.50	190	216	1116	0	354	2320	456
01-Nov-96	20	4.83	6880	4403	7.40	210	165	1980	0	244	1880	312
01-Nov-96	21	2.17	2797	1790	7.30	145	168	840	12	140	1560	384
01-Nov-96	22	0.75	983	629	8.00	0	54	150	48	195	160	0
01-Nov-96	23	0.80	4232	2708	7.60	0	114	744	24	232	1040	276
01-May-02	01	-0.44	6138	3928	7.80	190	87	1048	24	146	1720	384
01-May-02	02	-1.52	7812	5000	7.70	385	75	1386	0	195	2280	444
01-May-02	03	3.87	2604	1667	8.20	90	33	434	12	79	696	228
01-May-02	04	-0.87	3720	2381	8.00	80	45	624	24	207	1000	276
01-May-02	05	0.34	5580	3571	7.90	90	72	900	0	146	1520	504
01-May-02	06	-2.28	13764	8809	7.50	840	207	2292	0	73	4280	588
01-May-02	07	Dry	-	-	-	-	-	-	-	-	-	-
01-May-02	08	-6.68	10416	6666	7.90	450	222	2000	0	159	3320	468
01-May-02	09	-3.71	11625	7440	7.60	1025	201	1860	0	134	3800	504
01-May-02	10	-6.07	9765	6250	7.50	1230	150	1200	0	159	3200	372
01-May-02	11	-1.29	2139	1369	7.80	140	33	246	24	171	416	0
01-May-02	12	-17.90	6045	3869	7.60	315	63	1056	0	183	1840	444
01-May-02	13	-1.11	1860	1190	8.10	100	51	236	24	98	464	0
01-May-02	14	-23.89	6045	3869	7.90	235	123	900	0	244	1760	408
01-May-02	15	-6.02	1488	952	8.50	105	42	182	0	110	225	0
01-May-02	16	-4.39	1860	1190	8.20	60	114	170	24	171	201	0
01-May-02	17	0.57	5766	3690	7.80	285	171	816	0	85	1800	432
01-May-02	18	0.81	9672	6190	7.60	420	327	1450	0	61	3120	504
01-May-02	19	-5.67	3906	2500	8.00	145	54	580	0	98	1080	348
01-May-02	20	1.03	5859	3750	7.90	315	180	786	0	110	1760	432
01-May-02	21	-0.13	5115	3274	7.80	135	123	678	12	91	1440	408
01-May-02	22	-1.45	5273	3375	7.80	140	96	868	0	256	1560	264
01-May-02	23	-1.10	3897	2494	7.70	75	84	600	0	281	1040	216
01-Nov-02	01	0.26	6816	4362	7.80	145	213	1320	24	110	2120	444
01-Nov-02	02	-0.82	7680	4915	7.60	325	168	1500	0	110	2240	468
01-Nov-02	03	0.70	2630	1683	7.60	50	90	410	12	128	688	0

Month and Year	Well No	RWL (m)	EC (mmho s/cm)	TDS (ppm)	pH	Ca ⁺⁺ (ppm)	Mg ⁺⁺ (ppm)	Na ⁺ (ppm)	CO ₃ (ppm)	HCO ₃ (ppm)	Cl ⁻ (ppm)	SO ₄ (ppm)
01-Nov-02	04	-2.27	4992	3195	7.40	110	93	1176	12	274	1400	324
01-Nov-02	05	-0.16	2688	1720	7.80	65	84	452	24	134	688	0
01-Nov-02	06	-3.08	17280	11059	7.20	1285	25	3520	0	73	5840	780
01-Nov-02	07	Dry	-	-	-	-	-	-	-	-	-	-
01-Nov-02	08	-5.28	2208	1413	7.70	165	81	280	0	232	512	0
01-Nov-02	09	-2.01	11904	7619	7.20	1245	144	1860	0	61	3920	516
01-Nov-02	10	0.33	9792	6267	7.40	1160	216	1200	0	61	3200	396
01-Nov-02	11	-0.89	2112	1352	7.60	160	72	272	0	183	504	0
01-Nov-02	12	-3.30	9888	6328	7.20	620	237	1610	0	98	3120	564
01-Nov-02	13	Dry	-	-	-	-	-	-	-	-	-	-
01-Nov-02	14	-2.69	1920	1229	8.00	75	81	262	0	85	464	0
01-Nov-02	15	-4.02	1536	983	7.90	90	81	196	0	159	264	0
01-Nov-02	16	-3.89	1632	1044	7.80	45	141	176	0	329	216	0
01-Nov-02	17	-1.60	1248	799	7.80	0	75	210	24	268	224	0
01-Nov-02	18	-3.25	9216	5898	7.50	450	297	1500	0	134	2960	468
01-Nov-02	19	-1.67	6144	3932	7.70	105	162	936	0	183	1680	432
01-Nov-02	20	0.93	6528	4178	7.90	655	168	1146	0	73	2040	408
01-Nov-02	21	2.37	8525	5456	7.50	415	171	840	0	85	2720	432
01-Nov-02	22	2.70	6192	3963	7.80	120	144	820	12	79	1800	432
01-Nov-02	23	1.20	3734	2390	7.80	55	114	524	24	171	944	252

Table 4.27: Geohydrological & Geochemical Parameters Observed in Obs. Wells surrounding Meghal Tidal Regulator

4.4 Mul Dwarka Tidal Regulator

The Mul Dwarka Tidal Regulator is constructed near the village Mul Dwarka of Kodinar Taluka, Junagah District. The site is situated at a distance of 7 km from Kodinar where river Shingoda and Goma meets the Arabian Sea. Construction of TR was completed in 1991 at a cost of 378 lacs.

4.4.1 Salient Features of Mul Dwarka Tidal Regulator

- i) Location : Latitude 20° 45' N; Longitude 70° 48' E
- ii) Length : 748.68 m
- iii) Crest RL : -0.50 m (for Vertical Gates);
- iv) Number of Gates : 30 (Vertical)
- v) FRL / HFL : 2.25m / 3.75 m
- vi) Catchment Area : 504.40 km²
- vii) Designed Flood : 4350 cumecs
- viii) Benefited Area : 855 ha
- ix) Storage Capacity : 1.63 MCM

4.4.2 Rainfall Recorded at Mul Dwarka Tidal Regulator Hydromet Station

The rainfall in this area is received between June and October through the South-West monsoon. (Refer Table 4.28 & Graph 5.35)

Average Annual Rainfall = 800mm			
Year	Rainfall (mm)	% rainfall below AAR	% rainfall above AAR
1991	910.00	-----	13.75
1992	730.00	8.75	-----
1993	345.00	56.87	-----
1994	1029.00	-----	28.62
1995	760.00	5.00	-----
1996	1160.00	-----	45.00
1997	544.00	32.00	-----
1998	1160.00	-----	45.00
1999	432.00	46.00	-----
2000	378.00	52.75	-----
2001	568.00	29.00	-----
2002	437.00	45.37	-----
2003	1205.00	-----	50.25

Table 4.28: Details of Rainfall Recorded at Mul Dwarka Tidal Regulator Hydromet Station

4.4.3 Geology of the Area

The most of benefited area is covered by alluvial soil of recent age. Few outcrops of Miliolite Limestone occur near the site. Sand bars of about 4 to 6 m height occur along the coast. Miliolite Limestone is encountered below overburden; it is fine to medium grained having brownish grey and light pink color. It is cavernous in nature near the sea. Gaj formation occurs below Miliolite Limestone. Alternate layers of yellow clay and limestone are encountered in it.

The general geological succession in the area in its natural order of superposition is as follows as shown in Table 4.29

Sr. No.	Geological Formation	Age
1	Alluvial Soils and Sand Dunes	Recent
2	Miliolite limestone	Pleistocene to Recent
3	Gaj Limestone & Clay	Miocene
4	Deccan Trap	Upper Cretaceous to Lower Eocene

Table 4.29: Geology at Mul Dwarka Tidal Regulator Area



Plate 4.7: View of Mul Dwarka Tidal Regulator Gate from D/S Side

(On U/S side Masonry weir is visible which was constructed prior to construction of TR.)



Plate 4.8: View of Fresh water Reservoir created as seen from D/S side of TR

(U/S side is flooded to FRL. (2003) It is interesting to visualize that U/S weir is completely submerged.)



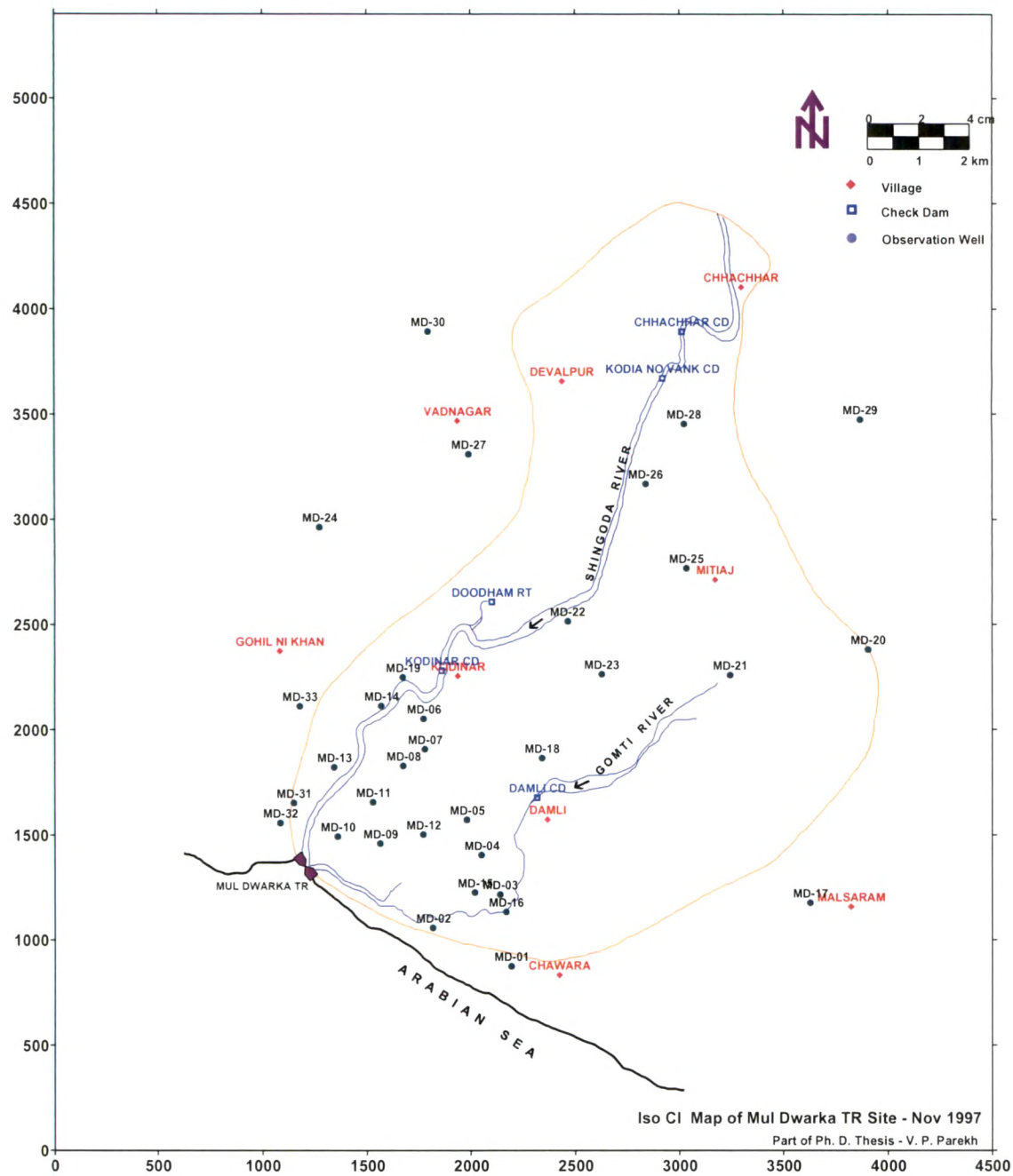
Plate 4.9: Close view of U/S Weir

(It is seen that one layer of stone masonry was laid to increase the height of weir)



Plate 4.10: View from U/S side of TR

(Because of Corrosion, the gates of TR becomes inoperative in just 10 years so adjacent to gates masonry wall has been constructed to store water on U/S side of TR. In other words the Gated structure becomes Ungated.



Map 4.5: Base Map of Mul Dwarka Tidal Regulator

4.4.4 Elevation, Area, Volume Stored (Capacity) & Wetted Area of Mul Dwarka Tidal Regulator Reservoir

Sr. No.	Ele. (m)	Area (sqm)	Cumu. Vol. (m ³)	Wetted Area (Sqm)	Sr. No.	Ele. (m)	Area (sqm)	Cumu. Vol. (m ³)	Wetted Area (Sqm)	Sr. No.	Ele. (m)	Area (sqm)	Cumu. Vol. (m ³)	Wetted Area (Sqm)
1	-1.00	951	208	982	24	0.15	160651	73356	165451	48	1.35	965026	683018	991404
2	-0.95	4290	891	4429	25	0.20	169679	82391	174730	49	1.40	998228	728675	1025407
3	-0.90	7630	1575	7875	26	0.25	178707	91427	184008	50	1.45	1031429	774331	1059403
4	-0.85	10969	2258	11320	27	0.30	187735	100462	193284	51	1.50	1064630	819988	1093392
5	-0.80	14308	2941	14764	28	0.35	196763	109498	202558	52	1.55	1109951	883189	1139820
6	-0.75	17647	3625	18208	29	0.40	205791	118533	211831	53	1.60	1155273	946391	1186239
7	-0.70	20986	4308	21651	30	0.45	214819	127568	221101	54	1.65	1200594	1009593	1232647
8	-0.65	24325	4991	25093	31	0.50	223847	136604	230369	55	1.70	1245915	1072795	1279046
9	-0.60	27665	5675	28535	32	0.55	274724	159286	282699	56	1.75	1291236	1135996	1325436
10	-0.55	31004	6358	31976	33	0.60	325601	181968	335019	57	1.80	1336558	1199198	1371816
11	-0.50	34343	6992	35416	34	0.65	376478	204649	387328	58	1.85	1381879	1262400	1418186
12	-0.45	44265	10918	45644	35	0.70	427355	227331	439625	59	1.90	1427200	1325602	1464547
13	-0.40	54188	14843	55870	36	0.75	478232	250013	491912	60	1.95	1472521	1388803	1510898
14	-0.35	64110	18769	66093	37	0.80	529109	272695	544189	61	2.00	1517842	1452005	1557240
15	-0.30	74032	22695	76315	38	1.85	579986	295377	596454	62	2.05	1554329	1488874	1594508
16	-0.25	83955	26621	86534	39	0.90	630863	318059	648709	63	2.10	1590815	1525742	1631769
17	-0.20	93877	30547	96751	40	0.95	681740	340741	700953	64	2.15	1627301	1562611	1669022
18	-0.15	103799	34472	106967	41	1.00	732617	363423	753186	65	2.20	1663787	1599479	1706267
19	-0.10	113722	38398	117180	42	1.05	765818	409079	787238	66	2.25	1700273	1636348	1743504
20	-0.05	123644	42324	127391	43	1.10	799020	454736	821284	67	2.30	1748759	1755033	1793038
21	0.00	133566	46250	137599	44	1.15	832221	500392	855322	68	2.35	1797246	1873718	1842562
22	0.05	142594	5285	146885	45	1.20	865422	546049	889353	69	2.40	1845732	1992403	1892075
23	0.10	151623	64321	156169	46	1.25	898624	591705	923377	70	2.45	1894219	2111088	1941578
					47	1.30	931825	637362	957394	71	2.50	1942705	2229773	1991071

Table 4.30: Elevation, Area & Capacity Table for Mul Dwarka Tidal Regulator (Refer Graph 5. 36 to 5.38)

4.4.5 Pumping & Recuperation Test at village Math

To get aquifer properties Pumping & Recovery test was done at the village Math, Tal. Kodinar, Dist. Junagadh. The observations are as follows. Graphs were developed with Cooper – Jacob's Method. Well details are mentioned on graph.

Sr. No.	Time H:M	Water Level (m)	Sr. No.	Time H:M	Water Level (m)	Sr. No.	Time H:M	Water Level (m)	Sr. No.	Time H:M	Water Level (m)
1	9:00	3.90	19	9:18	4.50	37	9:52	5.21	55	11:40	6.12
2	9:01	3.93	20	9:19	4.52	38	9:54	5.24	56	11:50	6.15
3	9:02	3.96	21	9:20	4.54	39	9:56	5.28	57	12:00	6.18
4	9:03	3.99	22	9:22	4.59	40	9:58	5.31	58	12:10	6.21
5	9:04	4.02	23	9:24	4.64	41	10:00	5.34	59	12:20	6.24
6	9:05	4.06	24	9:26	4.69	42	10:05	5.41	60	12:30	6.25
7	9:06	4.10	25	9:28	4.74	43	10:10	5.47	61	12:40	6.28
8	9:07	4.14	26	9:30	4.79	44	10:15	5.53	62	12:50	6.30
9	9:08	4.18	27	9:32	4.83	45	10:20	5.59	63	13:00	6.31
10	9:09	4.21	28	9:34	4.87	46	10:25	5.64	64	13:10	6.32
11	9:10	4.24	29	9:36	4.92	47	10:30	5.69	65	13:20	6.33
12	9:11	4.27	30	9:38	4.96	48	10:35	5.74	66	13:30	6.33
13	9:12	4.30	31	9:40	5.00	49	10:40	5.78	67	13:40	6.34
14	9:13	4.34	32	9:42	5.03	50	10:50	5.86	68	13:50	6.34
15	9:14	4.37	33	9:44	5.07	51	11:00	5.93	69	14:00	6.34
16	9:15	4.41	34	9:46	5.10	52	11:10	5.99			
17	9:16	4.44	35	9:48	5.14	53	11:20	6.04			
18	9:17	4.47	36	9:50	5.17	54	11:30	6.08			

Table 4.31: Time – Water-level Data for the Pumping Test at Vill. MATH near Mul Dwarka TR

Sr. No.	Time H:M	Water Level (m)	Sr. No.	Time H:M	Water Level (m)	Sr. No.	Time H:M	Water Level (m)
1	9:00	3.90	22	14:20	5.84	43	15:05	5.05
2	14:00	6.34	23	14:22	5.79	44	15:10	4.98
3	14:01	6.31	24	14:24	5.73	45	15:15	4.93
4	14:02	6.29	25	14:26	5.70	46	15:20	4.89
5	14:03	6.27	26	14:28	5.66	47	15:25	4.84
6	14:04	6.25	27	14:30	5.62	48	15:30	4.79
7	14:05	6.22	28	14:32	5.58	49	15:35	4.74
8	14:06	6.19	29	14:34	5.54	50	15:40	4.70
9	14:07	6.16	30	14:36	5.50	51	15:50	4.62
10	14:08	6.14	31	14:38	5.47	52	16:00	4.55
11	14:09	6.11	32	14:40	5.43	53	16:10	4.50
12	14:10	6.09	33	14:42	5.40	54	16:20	4.45
13	14:11	6.07	34	14:44	5.36	55	16:30	4.40
14	14:12	6.04	35	14:46	5.33	56	16:40	4.36
15	14:13	6.01	36	14:48	5.29	57	16:50	4.32
16	14:14	5.99	37	14:50	5.27	58	17:00	4.29
17	14:15	5.95	38	14:52	5.24	59	17:10	4.26
18	14:16	5.93	39	14:54	5.21	60	17:20	4.24
19	14:17	5.90	40	14:56	5.19	61	17:30	4.21
20	14:18	5.88	41	14:58	5.15	62	17:40	4.19
21	14:19	5.86	42	15:00	5.13	63	17:50	4.18

Table 4.32: Time – Water-level Data for the Recuperation Test at Vill. Math near Mul Dwarka TR

4.4.6 Rainfall, Water Level Fluctuation & Evaporation Recorded at Mul Dwarka Tidal Regulator

Date	Rainfall (mm/ Week)	Water level RL. In Mt.	Evap. (cm/ week)	Date	Rainfall (mm/ Week)	Water level RL. In Mt.	Evap. (cm/ week)
23/6/99	203	1.00	-	26/11/01	Nil	0.28	3.6
30	0	0.64	4.0	Dec 3	Nil	0.16	3.4
Jul 7	0	0.49	4.3	10	Nil	0.06	3.3
14	32	0.30	4.2	17	Nil	-0.08	3.3
21	140	0.98	3.6	24	Nil	-0.22	3.1
28	Nil	0.70	4.0	31	Nil	-0.32	3.3
Aug 4	Nil	0.57	4.0	07/01/02	Nil	-0.39	3.1
11	Nil	0.41	4.1	TOTAL	568		
18	Nil	0.24	4.0				
25	Nil	0.13	4.2	26/8/02	402	1.00	-
Sep 1	7	0.04	3.9	Sep 2	6	0.65	4.1
8	Nil	-0.10	4.0	9	Nil	0.50	4.1
15	Nil	-0.22	4.1	16	Nil	0.30	4.2
22	50	-0.30	4.1	23	29	0.15	4.1
TOTAL	432			30	Nil	0.00	4.0
				Oct 7	Nil	-0.15	3.9
18/6/01	216	1.25	-	TOTAL	437		
25	Nil	0.92	4.0				
Jul 2	10	0.73	4.1	20/6/03	264	1.55	-
9	262	1.50	-	27	Nil	1.20	4.0
16	16	2.10	-	Jul 4	21	1.00	4.1
23	Nil	1.78	3.9	11	119	1.50	-
30	7	1.64	4.1	18	64	2.25	-
Aug 6	2	1.49	4.1	25	70	2.25	-
13	29	1.35	4.0	Aug 1	29	2.25	-
20	20	2.40	-	8	388	2.25	-
27	Nil	2.25	3.9	15	15	2.25	-
Sep 3	Nil	1.95	4.0	22	3	2.25	-
10	Nil	1.79	4.0	29	77	2.25	-
17	Nil	1.62	4.1	Sep 5	55	2.25	-
24	3	1.50	3.9	12	6	2.25	-
Oct 1	Nil	1.33	3.9	19	Nil	2.25	-
8	Nil	1.19	3.8	26	Nil	2.25	-
15	3	1.05	3.9	Oct 3	94	2.25	-
22	Nil	0.90	3.8	10	Nil	2.25	-
29	Nil	0.76	3.8	17	Nil	2.25	3.5
Nov 5	Nil	0.63	3.7	Nov 7	Nil	1.85	3.4
12	Nil	0.53	3.6	14	Nil	1.60	3.4
19	Nil	0.41	3.7	21	Nil	1.38	3.7

Date	Rainfall (mm/ Week)	Water level RL. In Mt.	Evap. (cm/ week)	Date	Rainfall (mm/ Week)	Water level RL. In Mt.	Evap. (cm/ week)
28/11/03	Nil	1.20	3.6	09/01/04	Nil	0.32	3.1
Dec 5	Nil	1.02	3.4	16	Nil	0.19	3.1
12	Nil	0.81	3.3	23	Nil	0.06	3.1
19	Nil	0.67	3.3	30	Nil	-0.08	3.0
26	Nil	0.58	3.1	Feb 6	Nil	-0.22	3.0
02/01/04	Nil	0.49	3.3	13	Nil	-0.35	2.9
				TOTAL	1205		

Table 4.33: Rainfall, Water Level & Evaporation Data at Mul Dwarka TR – Year 1999 to 2003

4.4.7 Geohydrological & Geochemical Monitoring System Setup

To know the efficacy of the Mul Dwarka Tidal Regulator, 33 number of observation well surrounding the reservoir site has been monitored from May 1997 to November 2002. The observations were taken Pre-monsoon (May) and Post-monsoon (November) every year. The various parameters observed are RWL, pH, EC, TDS, Cl^- , Na^+ , SO_4^{2-} , Ca^{++} , Mg^{++} , CO_3^{--} and HCO_3^- . To study above parameters contour maps showing variation in different parameter values are prepared.

Obs. Well No	RL (m)	Distance from Structure (m)	Obs. Well No	RL (m)	Distance from Structure (m)	Obs. Well No	RL (m)	Distance from Structure (m)
MD-01	6.49	4550.00	MD-12	7.74	2500.00	MD-23	20.27	7250.00
MD-02	6.36	2750.00	MD-13	4.61	2100.00	MD-24	13.29	6800.00
MD-03	7.02	4600.00	MD-14	9.62	3500.00	MD-25	17.49	10000.00
MD-04	7.83	3650.00	MD-15	6.25	3500.00	MD-26	31.52	10350.00
MD-05	8.99	3400.00	MD-16	6.11	4250.00	MD-27	17.33	9000.00
MD-06	11.30	3875.00	MD-17	6.23	10250.00	MD-28	34.72	11750.00
MD-07	10.01	3350.00	MD-18	8.34	6000.00	MD-29	23.20	14500.00
MD-08	7.11	2800.00	MD-19	11.98	4300.00	MD-30	31.66	11100.00
MD-09	7.49	1050.00	MD-20	21.20	12250.00	MD-31	4.02	1250.00
MD-10	6.46	900.00	MD-21	18.66	9500.00	MD-32	3.19	1100.00
MD-11	7.64	1950.00	MD-22	16.20	7300.00	MD-33	5.63	3250.00

Table 4.34: Details of Observation Wells surrounding Mul Dwarka Tidal Regulator

4.4.7.1 Data collection for Geohydrological & Geochemical Monitoring

Month and Year	Well No	RWL (m)	EC mmho s/cm	TDS ppm	pH	Cl^- ppm	CO_3 ppm	HCO_3 ppm	Ca^{++} ppm	Mg^{++} ppm	Na^+ ppm	SO_4 ppm
May-97	MD-01	1.89	9746	6237	8.0	3120	0	110	325	378	1408	468
May-97	MD-02	2.46	5208	3333	8.1	1680	0	146	180	225	704	288
May-97	MD-03	3.12	5859	3750	8.0	1840	0	183	290	270	644	336
May-97	MD-04	2.63	5580	3571	7.8	1640	0	244	155	261	764	348
May-97	MD-05	1.59	5692	3643	7.9	1720	0	195	195	315	680	456
May-97	MD-06	0.90	8147	5214	7.9	2600	24	98	295	513	724	780

Month and Year	Well No	RWL (m)	EC mmho s/cm	TDS ppm	pH	Cl ⁻ ppm	CO ₃ ppm	HCO ₃ ppm	Ca ⁺⁺ ppm	Mg ⁺⁺ ppm	Na ⁺ ppm	SO ₄ ppm
May-97	MD-07	1.31	6527	4177	7.7	1920	60	421	310	306	624	468
May-97	MD-08	2.51	5738	3672	7.8	1640	84	189	185	276	704	432
May-97	MD-09	2.49	9328	5970	7.8	3000	0	159	435	579	816	648
May-97	MD-10	1.56	7859	5030	7.9	2400	0	500	195	411	1000	468
May-97	MD-11	3.04	7989	5113	8.0	2400	0	281	200	516	904	588
May-97	MD-12	2.24	9988	6392	7.8	3200	0	220	380	480	1320	732
May-97	MD-13	0.71	4092	2619	8.0	1160	0	390	150	117	524	288
May-97	MD-14	-3.08	1972	1262	7.9	304	48	537	50	120	210	0
May-97	MD-15	2.25	5766	3690	7.8	1800	24	159	225	309	560	348
May-97	MD-16	1.91	7682	4915	7.8	2480	12	91	125	384	870	432
May-97	MD-17	-1.77	8482	5428	8.0	2560	0	1059	1025	99	580	468
May-97	MD-18	-3.66	4724	3024	7.5	1320	0	390	60	279	544	336
May-97	MD-19	-5.12	930	595	7.9	152	12	250	0	99	82	0
May-97	MD-20	6.90	1776	1137	7.6	352	36	287	60	126	200	0
May-97	MD-21	-4.44	4427	2833	7.7	1200	12	396	70	147	624	228
May-97	MD-22	-1.00	698	446	8.0	88	12	213	60	33	68	0
May-97	MD-23	-1.93	884	565	7.9	88	0	293	0	87	78	0
May-97	MD-24	-5.91	1572	1005	7.9	208	96	427	65	63	196	0
May-97	MD-25	-1.51	1944	1244	7.8	408	0	268	60	93	182	0
May-97	MD-26	20.52	1153	738	8.0	176	0	299	0	102	186	0
May-97	MD-27	-6.97	995	637	8.0	128	48	232	30	51	118	0
May-97	MD-28	21.52	1339	857	8.2	192	0	287	35	72	166	0
May-97	MD-29	15.50	3674	2351	7.6	960	24	268	70	99	668	268
May-97	MD-30	11.56	1153	738	7.9	192	0	244	45	54	114	0
May-97	MD-31	0.52	6473	4143	7.8	1920	12	504	75	375	904	468
May-97	MD-32	1.09	11365	7274	7.9	3320	24	268	415	555	1680	936
May-97	MD-33	-3.17	4724	3023	8.0	1360	36	189	140	147	868	348
Nov-97	MD-01	3.79	5885	3766	8.1	1800	0	110	220	246	624	372
Nov-97	MD-02	3.16	5896	3773	8.0	1800	0	134	210	264	600	348
Nov-97	MD-03	5.22	8456	5412	7.9	2760	0	183	370	465	840	504
Nov-97	MD-04	4.33	5579	3571	8.0	1640	12	116	145	267	668	384
Nov-97	MD-05	4.39	5620	3597	7.9	1680	12	128	130	342	580	444
Nov-97	MD-06	5.00	8486	5431	7.8	2720	0	159	260	546	668	528
Nov-97	MD-07	5.01	3856	2468	8.0	1040	36	116	85	204	392	408
Nov-97	MD-08	3.91	3978	2546	7.8	912	48	293	60	198	492	432
Nov-97	MD-09	5.49	4702	3009	7.9	1320	12	165	95	264	524	348
Nov-97	MD-10	4.56	4519	2892	8.0	1240	12	177	75	270	544	396
Nov-97	MD-11	3.74	7160	4582	7.8	2120	12	165	185	441	580	444
Nov-97	MD-13	3.11	3386	2167	8.1	960	36	201	85	93	452	252
Nov-97	MD-14	0.42	1795	1149	8.2	288	156	348	0	114	236	0
Nov-97	MD-15	4.25	8395	5373	7.9	2640	12	67	315	435	738	552
Nov-97	MD-16	3.11	2366	1514	7.8	608	48	122	25	159	300	0
Nov-97	MD-17	-0.37	8803	5634	8.0	2800	0	73	830	258	784	492
Nov-97	MD-18	0.54	5049	3231	7.7	1440	24	183	110	255	560	348
Nov-97	MD-19	-2.12	826	529	7.9	104	48	268	55	66	92	0
Nov-97	MD-20	13.50	1683	1077	8.1	344	12	189	70	93	196	0
Nov-97	MD-21	3.46	4427	2833	7.8	1160	48	342	90	141	668	408
Nov-97	MD-22	8.10	622	398	8.4	56	60	226	50	45	60	0
Nov-97	MD-23	3.17	796	509	8.1	88	72	207	35	42	92	0
Nov-97	MD-24	0.49	1724	1103	8.1	256	108	372	30	144	182	0

Month and Year	Well No	RWL (m)	EC mmho s/cm	TDS ppm	pH	Cl ⁻ ppm	CO ₃ ppm	HCO ₃ ppm	Ca ⁺⁺ ppm	Mg ⁺⁺ ppm	Na ⁺ ppm	SO ₄ ppm
Nov-97	MD-25	4.29	1989	1273	8.0	392	72	268	85	126	182	0
Nov-97	MD-26	26.21	979	627	8.1	152	36	177	45	63	128	0
Nov-97	MD-27	-2.37	1061	679	8.0	168	24	207	50	60	114	0
Nov-97	MD-28	29.72	1030	659	8.3	160	12	238	45	57	134	0
Nov-97	MD-29	18.00	3539	2265	7.9	880	36	238	55	132	544	432
Nov-97	MD-30	19.66	1081	692	7.9	176	60	152	35	72	72	0
Nov-97	MD-31	1.82	6171	3949	7.9	1840	60	213	75	549	784	672
Nov-97	MD-32	0.99	11822	7566	7.8	3520	12	91	425	480	1568	984
Nov-97	MD-33	1.73	4284	2742	8.1	1040	12	213	70	156	580	384
May-99	MD-01	1.75	8463	5416	8.1	2720	0	244	220	354	1000	432
May-99	MD-02	2.10	8556	5476	8.1	2840	0	98	350	333	1000	408
May-99	MD-03	3.22	9300	5952	8.0	3080	12	91	325	471	924	396
May-99	MD-04	0.63	4836	3095	8.3	1440	12	201	125	201	544	372
May-99	MD-05	0.29	6975	4464	7.9	2200	0	256	265	321	880	384
May-99	MD-06	-0.70	7719	4940	8.0	2400	12	91	405	417	840	432
May-99	MD-07	-0.59	6882	4404	8.1	2200	0	390	195	273	704	408
May-99	MD-08	0.91	6603	4226	7.9	2000	0	366	225	324	764	480
May-99	MD-09	3.69	4464	2857	8.0	1240	12	431	135	219	524	336
May-99	MD-10	2.46	4371	2797	8.2	1280	12	250	160	168	524	384
May-99	MD-11	0.74	6882	4404	8.0	2200	12	128	145	498	680	552
May-99	MD-12	0.14	6603	4226	8.1	2120	0	220	200	354	704	456
May-99	MD-13	-0.19	3534	2262	8.3	952	12	348	0	159	524	264
May-99	MD-14	-5.18	1674	1071	8.7	288	60	445	0	99	200	0
May-99	MD-15	2.35	9300	5952	7.9	3000	0	195	335	459	900	444
May-99	MD-16	2.21	8835	5654	8.0	2760	0	232	235	327	1176	468
May-99	MD-17	-2.07	9207	5892	7.9	2920	0	146	825	195	870	528
May-99	MD-18	-1.86	4464	2857	8.2	1240	12	299	125	165	492	396
May-99	MD-19	-5.72	1023	655	8.7	168	60	213	0	105	78	0
May-99	MD-20	7.20	1860	1190	8.5	384	12	262	75	66	200	0
May-99	MD-21	-3.34	4464	2857	8.4	1280	72	354	90	147	668	312
May-99	MD-22	0.50	716	458	8.5	72	24	293	50	39	50	0
May-99	MD-23	-5.75	1618	1036	8.3	312	36	311	70	154	154	0
May-99	MD-24	-5.51	1535	982	8.7	224	108	384	75	60	166	0
May-99	MD-25	-13.01	2306	1476	8.0	536	24	354	65	144	186	0
May-99	MD-26	17.72	846	542	8.6	96	36	236	0	144	144	0
May-99	MD-27	-10.67	2418	1548	8.6	496	60	399	75	96	290	0
May-99	MD-28	19.52	958	613	8.3	104	0	354	0	150	150	0
May-99	MD-29	14.70	3255	2083	8.3	696	60	348	55	69	600	324
May-99	MD-30	10.66	902	577	8.7	112	12	387	0	33	138	0
May-99	MD-31	-1.08	5301	3393	8.7	1640	24	232	0	285	668	336
May-99	MD-32	0.49	9765	6250	8.2	2850	0	220	405	381	1260	888
May-99	MD-33	-3.47	4650	2976	8.4	1240	12	201	80	162	784	468
May-02	MD-01	2.19	12558	8037	7.5	4120	0	171	550	471	1810	456
May-02	MD-02	1.66	12649	8095	7.4	4200	0	183	580	471	2100	432
May-02	MD-03	2.32	8736	5591	7.6	2800	0	317	360	363	1200	408
May-02	MD-04	-1.47	7189	4601	7.7	2120	0	293	225	303	952	348
May-02	MD-05	-1.81	4641	2970	8.0	1360	24	98	45	264	524	312
May-02	MD-06	0.20	9737	6232	7.8	3120	0	207	285	525	1116	504
May-02	MD-07	-0.99	9737	6232	7.6	3040	0	195	310	492	1200	480
May-02	MD-08	-1.09	7826	5009	7.6	2240	0	366	210	357	936	456

Month and Year	Well No	RWL (m)	EC mmhos/cm	TDS ppm	pH	Cl ⁻ ppm	CO ₃ ⁻ ppm	HCO ₃ ⁻ ppm	Ca ⁺⁺ ppm	Mg ⁺⁺ ppm	Na ⁺ ppm	SO ₄ ⁻ ppm
May-02	MD-09	1.49	8554	5475	7.7	2320	0	281	355	540	816	984
May-02	MD-10	-0.04	8645	5533	7.7	2240	0	268	335	549	816	816
May-02	MD-11	-0.16	6734	4310	7.6	1880	0	329	155	312	764	456
May-02	MD-12	1.74	6643	4252	7.5	1960	12	274	120	321	820	432
May-02	MD-13	-4.89	4459	2854	8.2	1240	60	128	0	210	624	348
May-02	MD-14	-6.38	2002	1281	8.5	432	84	311	0	132	400	0
May-02	MD-15	1.25	8554	5475	7.8	2640	12	140	160	447	1020	456
May-02	MD-16	1.81	10283	6581	7.7	3400	0	110	375	477	1500	492
May-02	MD-17	-13.67	11375	7280	7.8	3760	0	61	1350	168	1680	526
May-02	MD-18	-9.56	3279	4019	8.5	1784	12	335	250	276	900	408
May-02	MD-19	-12.22	1209	774	8.4	256	48	183	0	117	68	0
May-02	MD-20	1.90	1869	1196	8.6	408	36	201	0	99	246	0
May-02	MD-21	-13.34	4450	2848	8.4	1160	72	342	25	156	680	324
May-02	MD-22	-1.80	534	342	8.8	64	48	146	0	66	50	0
May-02	MD-23	-8.73	863	553	8.2	120	24	183	30	48	66	0
May-02	MD-24	-7.31	2120	1357	8.3	296	216	476	30	132	262	0
May-02	MD-25	-13.51	1958	1253	8.2	368	36	262	0	123	182	0
May-02	MD-26	11.52	890	570	8.2	136	12	213	40	45	74	0
May-02	MD-27	-8.67	1302	833	8.5	192	36	165	0	108	200	0
May-02	MD-28	7.72	979	627	8.1	128	24	268	35	54	100	0
May-02	MD-29	9.50	2790	1786	8.4	528	60	272	0	72	462	288
May-02	MD-30	12.56	874	559	8.0	120	36	177	30	33	114	0
May-02	MD-31	0.02	10647	6814	7.8	3360	12	128	165	435	1640	696
May-02	MD-32	0.19	3913	2504	8.0	880	48	281	120	159	560	504
May-02	MD-33	-2.57	6825	4368	7.8	1800	24	159	135	267	900	528

Table 4.35: Geohydrological & Geochemical Parameters Observed in Obs. Wells surrounding Mul Dwarka Tidal Regulator



Plate 4.11: View of Mixing of Crop in the Farm Located just on D/S of Structure

4.5 Barda Bandhara

The Barda Bandhara (BB) is one of the seawater intrusion preventive structures constructed across the mouth of the river Somat. River Somat meets Arabian Sea at about 10 km SSW of Kodinar Taluka of Junagadh District. This structure prevents the seawater to intrude further into the low lying area of 105 ha of Barda and Dhamlej Villages of Kodinar Taluka. The Bandhara was completed in 1985 at a cost of 140.74 lacs. It is located at a distance of about 6 km from Mul Dwarka Tidal Regulator.

4.5.1 Topography

The Somat River originates from Gir Forest. The length of the river is 27.50 Kms. The Somat river basin comprises an area of 212.37 Sqkm. The river basin is confined between East Longitude $70^{\circ} 38'$ and $70^{\circ} 44'$ and North Latitude $20^{\circ} 44'$ and $20^{\circ} 82'$. The topography of the area near the structure is almost flat with discontinuous sand bars of varying heights on the coast. The gradient of the area varies from 1:100 to 1:575 but it is undulating in upper portion with hilly configuration near the point of origin.

4.5.2 Salient Features of Barda Bandhara (BB)

i)	Location	:	Latitude $20^{\circ} 45' N$; Longitude $70^{\circ} 49' E$
ii)	River	:	Somat
iii)	Length	:	400 m
iv)	FRL	:	2.10 m
v)	HFL	:	3.69 m
vi)	Catchment Area	:	212.37 km ²
vii)	Designed Flood	:	1753 cumec
viii)	Benefited Area	:	900 ha
ix)	Storage Capacity	:	4.67 MCM

4.5.3 Rainfall

The rainfall for this structure is recorded at Mul Dwarka Tidal Regulator hydromet station as they are neighboring structures. (Refer Table 4.28)

4.5.4 Geology of the Area

The entire benefited area is covered with alluvial soils of recent age. Sand bars and limestone occur along the coast. The normal height of sand bar is about 5.0m. The geological succession of the area in its natural order of superposition is as follows. Cavernous Miliolite Limestone is encountered below overburden.



Plate 4.12: View of Barda Bandhara from U/S Side
(On U/S side Silting is visible nearly upto height of Bandhara.)



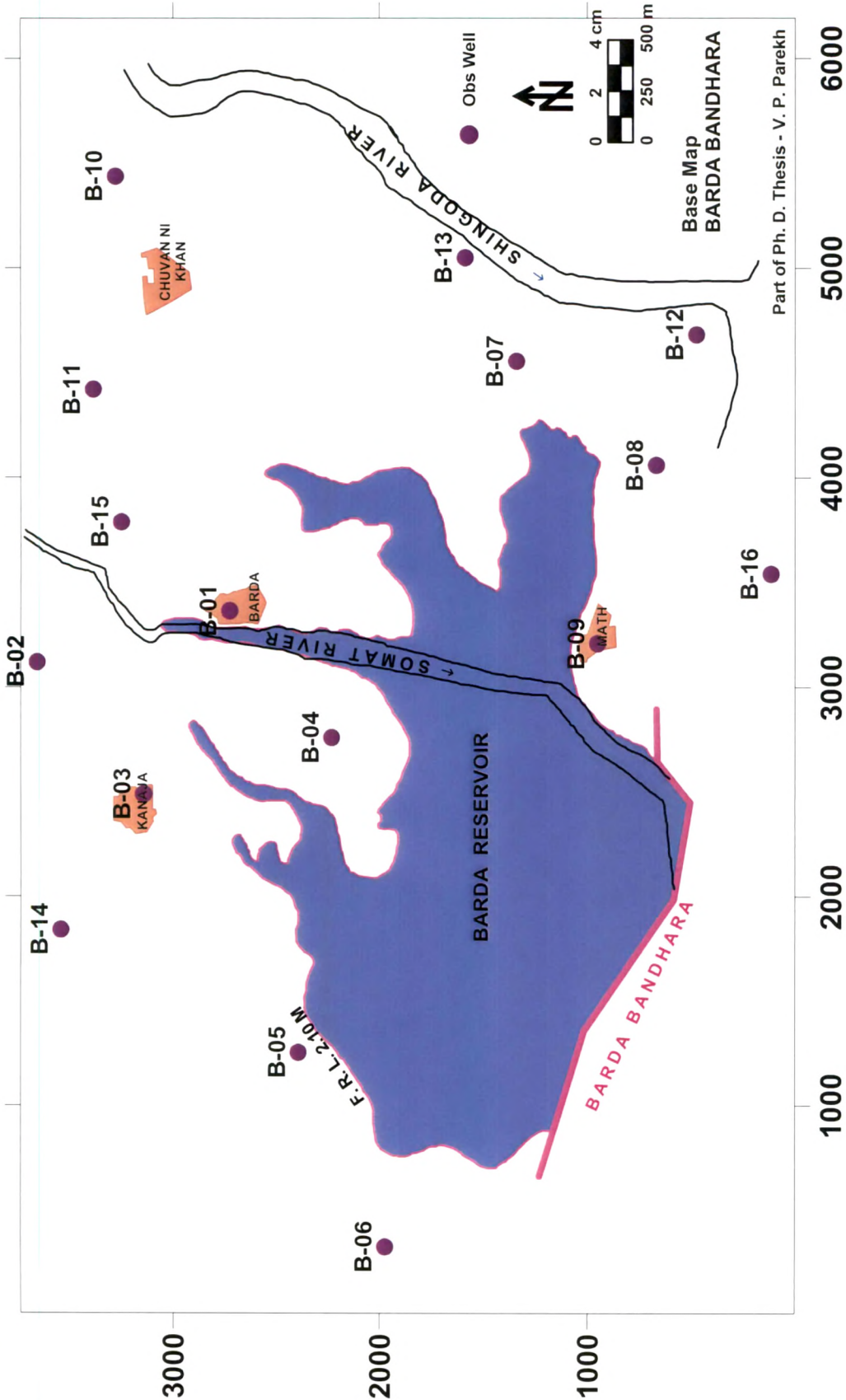
Plate 4.13: View of Barda Bandhara from D/S Side
(D/S side is flooded to with seawater in month of March & U/S of weir is completely dried.)



Plate 4.14: View of Cotton Crop at a stage of Harvesting just U/S Weir



Plate 4.15 Close View of Cavernous Miliolite Limestone found in study area



Map 4.6: Base Map of Barda Bandhara

4.5.5 Elevation, Area, Volume Stored (Capacity) & Wetted Area of Barda Reservoir

Sr. No.	Ele. (m)	Area (sqm)	Cumu. Vol. (m ³)	Wetted Area (Sqm)	Sr. No.	Ele. (m)	Area (sqm)	Cumu. Vol. (m ³)	Wetted Area (Sqm)	Sr. No.	Ele. (m)	Area (sqm)	Cumu. Vol. (m ³)	Wetted Area (Sqm)
1	-1.50	339	748	351	26	-0.25	124084	68502	127817	52	1.05	1468584	428701	1508726
2	-1.45	3712	1303	3834	27	-0.20	129053	74664	132922	53	1.10	1656128	522930	1701221
3	-1.40	7084	1858	7317	28	-0.15	134022	80826	138026	54	1.15	1843672	617159	1893676
4	-1.35	10456	2414	10798	29	-0.10	138991	86989	143129	55	1.20	2031216	711388	2086091
5	-1.30	13828	2969	14279	30	-0.05	143961	93151	148231	56	1.25	2218760	805617	2278467
6	-1.25	17201	3524	17759	31	0.00	148930	99313	153332	57	1.30	2406304	899846	2470803
7	-1.20	20573	4079	21238	32	0.05	197409	108800	203223	58	1.35	2593848	994075	2663099
8	-1.15	23945	4634	24716	33	0.10	245887	118287	253104	59	1.40	2781392	1088304	2855355
9	-1.10	27317	5190	28193	34	0.15	294366	127774	302974	60	1.45	2968936	1182533	3047571
10	-1.05	30690	5745	31669	35	0.20	342845	137261	352834	61	1.50	3156480	1276762	3239748
11	-1.00	34062	6300	35145	36	0.25	391324	146748	402684	62	1.55	3344024	1370991	3431885
12	-0.95	40580	9439	41864	37	0.30	439802	156235	452523	63	1.60	3531568	1465220	3623982
13	-0.90	47097	12578	48582	38	0.35	488281	165722	502352	64	1.65	3719112	1559449	3816039
14	-0.85	53615	15717	55297	39	0.40	536760	175208	552171	65	1.70	3906656	1653678	4008057
15	-0.80	60132	18856	62011	40	0.45	585238	184695	601980	66	1.75	4094200	1747907	4200035
16	-0.75	66650	21995	68726	41	0.50	633717	194182	651778	67	1.80	4581950	2165701	4699908
17	-0.70	73167	25134	75438	42	0.55	698449	208211	718281	68	1.85	5069700	2583496	5199677
18	-0.65	79685	28273	82150	43	0.60	763182	222240	784770	69	1.90	5557450	3001290	5699343
19	-0.60	86202	31412	88860	44	0.65	827914	236269	851246	70	1.95	6045200	3419084	6198905
20	-0.55	92720	34551	95568	45	0.70	892646	250298	917708	71	2.00	6532950	3836878	6698364
21	-0.50	99237	37690	102276	46	0.75	957379	264327	984156	72	2.05	7020700	4254673	7197720
22	-0.45	104206	43852	107386	47	0.80	1022111	278356	1050591	73	2.10	7508450	4672467	7696972
23	-0.40	109176	50015	112495	48	0.85	1086843	292385	1117012	74	2.15	7888163	4877899	8085382
24	-0.35	114145	56177	117604	49	0.90	1151575	306414	1183419	75	2.20	8267875	5083332	8473712
25	-0.30	119114	62339	122711	50	0.95	1216308	320443	1249812	76	2.25	8647588	5288764	8861961
					51	1.00	1281040	334472	1316192	77	2.30	9027300	5494196	9250130

Table 4.36: Elevation, Area & Capacity Table for Barda Bandhara (Refer Graph 5.46 to 5.48)

4.5.6 Pumping Test at village Math

To get aquifer properties Pumping & Recovery test was done at the village Math, Tal. Kodinar, Dist. Junagadh. It is described with Mul Dwarka Tidal Regulator.

4.5.7 Rainfall, Water Level Fluctuation & Evaporation Recorded at Barda Bandhara

Date	Rainfall (mm/ Week)	Water level RL. In Mt.	Evap. (cm/ week)	Date	Rainfall (mm/ Week)	Water level RL. In Mt.	Evap. (cm/ week)
23/6/99	203	1.30	-	29/10/01	Nil	-0.50	3.8
30	0	1.03	4.0	Nov 5	Nil	-0.65	3.7
Jul 7	0	0.70	4.3	12	Nil	-0.78	3.6
14	32	0.40	4.2	TOTAL	568		
21	140	1.00	3.6				
28	Nil	0.50	4.0	26/8/02	402	1.10	-
Aug 4	Nil	0.20	4.0	Sep 2	6	0.79	4.1
11	Nil	0.06	4.1	9	Nil	0.39	4.1
18	Nil	-0.10	4.0	16	Nil	0.10	4.2
25	Nil	-0.25	4.2	23	29	-0.05	4.1
Sep 1	7	-0.36	3.9	30	Nil	-0.25	4.0
8	Nil	-0.49	4.0	Oct 7	Nil	-0.40	3.9
15	Nil	-0.65	4.1	TOTAL	437		
22	50	-0.77	4.1				
TOTAL	432			20/6/03	264	2.10	-
				27	Nil	1.90	4.0
18/6/01	216	1.30	-	Jul 4	21	1.78	4.1
25	Nil	1.05	4.0	11	119	1.85	-
Jul 2	10	0.75	4.1	18	64	2.20	-
9	262	1.40	-	25	70	2.05	4.0
16	16	1.75	-	Aug 1	29	1.95	5.0
23	Nil	1.45	3.9	8	388	2.30	-
30	7	1.25	4.1	15	15	2.30	-
Aug 6	2	1.09	4.1	22	3	2.30	-
13	29	0.95	4.0	29	77	2.30	-
20	20	1.40	-	Sep 5	55	2.30	-
27	Nil	1.18	3.9	12	6	2.30	-
Sep 3	Nil	1.02	4.0	19	Nil	2.30	-
10	Nil	0.62	4.0	26	Nil	2.30	-
17	Nil	0.32	4.1	Oct 3	94	2.30	-
24	3	0.11	3.9	10	Nil	2.30	-
Oct 1	Nil	0.00	3.9	17	Nil	2.30	-
8	Nil	-0.13	3.8	24	Nil	2.30	-
15	3	-0.25	3.9	31	Nil	2.09	3.4
22	Nil	-0.38	3.8	Nov 7	Nil	1.98	3.7

Date	Rainfall (mm/ Week)	Water level RL. In Mt.	Evap. (cm/ week)	Date	Rainfall (mm/ Week)	Water level RL. In Mt.	Evap. (cm/ week)
14/11/03	Nil	1.87	3.6	09/01/04	Nil	0.22	3.1
21	Nil	1.77	3.7	16	Nil	0.07	3.1
28	Nil	1.56	3.6	23	Nil	-0.05	3.1
Dec 5	Nil	1.36	3.4	30	Nil	-0.20	3.0
12	Nil	1.18	3.3	06/02/04	Nil	-0.33	3.0
19	Nil	1.05	3.3	13	Nil	-0.45	2.9
26	Nil	0.75	3.1	TOTAL	1205		
02/01/04	Nil	0.45	3.3				

Table 4.37: Rainfall, Water Level & Evaporation Data at Barda Bandhara – Year 1999 to 2003

4.5.8 Geohydrological & Geochemical Monitoring System Setup

To know the efficacy of the Barda Bandhara, 13 number of observation well surrounding the reservoir site has been monitored from May 1994 to November 2002 and 3 wells surrounding the reservoir site has been added for monitoring from May 1997. The observations were taken Pre-monsoon (May) and Post-monsoon (November) every year. The various parameters observed are RWL, pH, EC, TDS, Cl^- , Na^+ , SO_4^{2-} , Ca^{++} , Mg^{++} , CO_3^{--} and HCO_3^- . To study above parameters contour maps showing variation in different parameter values are prepared.

Obs. Well No	RL (m)	Distance from Structure (m)	Obs. Well No	RL (m)	Distance from Structure (m)
B-01	6.81	2198	B-09	5.26	713
B-02	7.26	3089	B-10	5.91	3802
B-03	6.83	2435	B-11	5.63	3208
B-04	5.45	1604	B-12	4.61	1901
B-05	3.89	2317	B-13	9.62	2435
B-06	1.47	2554	B-14	8.98	3029
B-07	4.02	2020	B-15	5.01	2851
B-08	3.19	1544	B-16	5.07	1069

Table 4.38: Details of Observation Wells surrounding Barda Bandhara

4.5.8.1 Data collection for Geohydrological & Geochemical Monitoring

Month and Year	Well No	RWL (m)	EC mmhos /cm	TDS ppm	pH	Cl^- ppm	CO_3 ppm	HCO_3 ppm	Ca^{++} ppm	Mg^{++} ppm	Na^+ ppm	SO_4 ppm
May-94	B-01	1.51	3393	2172	8.4	840	48	220	35	96	544	264
May-94	B-02	-2.24	8448	5407	7.6	2680	0	110	660	219	764	336
May-94	B-03	-1.17	12000	7680	7.3	4200	0	415	695	198	1736	288
May-94	B-04	0.75	8640	5530	7.5	2800	0	159	670	204	764	312
May-94	B-05	-1.11	6816	4362	7.6	1760	0	305	465	165	744	336
May-94	B-06	-3.33	7200	4608	7.6	2280	0	232	465	165	744	216

Month and Year	Well No	RWL (m)	EC mmhos /cm	TDS ppm	pH	Cl ⁻ ppm	CO ₃ ⁻ ppm	HCO ₃ ⁻ ppm	Ca ⁺⁺ ppm	Mg ⁺⁺ ppm	Na ⁺ ppm	SO ₄ ppm
May-94	B-07	-0.58	7008	4485	8.2	2040	48	171	35	294	1302	384
May-94	B-08	0.19	6528	4178	8.0	1840	0	110	270	315	668	612
May-94	B-09	0.86	6528	4178	7.9	1800	0	281	325	291	624	456
May-94	B-10	-6.09	6000	3840	8.0	1800	24	195	115	321	644	288
May-94	B-11	-3.57	5520	3533	8.1	1440	48	183	50	219	800	312
May-94	B-12	-1.79	6000	3840	8.3	1800	0	171	95	264	764	360
May-94	B-13	-2.88	1680	1075	8.6	200	168	561	50	99	200	0
May-97	B-01	0.71	4213	2696	8.0	1080	12	311	105	135	784	312
May-97	B-02	0.26	7115	4554	7.8	2240	0	183	510	174	820	504
May-97	B-03	-0.57	12103	7746	7.6	3840	36	482	665	144	1320	516
May-97	B-04	0.45	7245	4637	7.8	2320	0	61	415	246	840	384
May-97	B-05	-2.11	4762	3048	7.9	1440	24	110	335	117	600	336
May-97	B-06	-3.43	3553	2274	7.9	1040	12	104	150	96	544	228
May-97	B-07	0.52	6473	4143	7.8	1920	12	504	75	375	904	468
May-97	B-08	1.09	11365	7274	7.9	3320	24	268	415	555	1680	936
May-97	B-09	1.16	3925	2512	7.8	1040	0	390	110	135	492	408
May-97	B-10	-3.19	5003	3202	8.0	1400	36	421	205	270	600	444
May-97	B-11	-3.17	4724	3023	8.0	1360	36	189	140	147	868	348
May-97	B-12	0.71	4092	2619	8.0	1160	0	390	150	117	524	288
May-97	B-13	-3.08	1972	1262	7.9	304	48	537	50	120	210	0
May-97	B-14	-18.08	5282	3381	8.1	1640	0	110	330	183	600	348
May-97	B-15	-4.99	4399	2815	7.5	1120	0	244	60	147	600	312
May-97	B-16	0.97	1386	887	8.0	272	12	177	0	90	154	0
May-99	B-01	-0.29	3441	2202	8.5	880	36	238	45	105	524	336
May-99	B-02	-1.24	2883	1845	8.5	760	12	226	0	123	410	276
May-99	B-03	Dry	-	-	-	-	-	-	-	-	-	-
May-99	B-04	-1.35	3255	2083	8.1	880	36	177	0	102	500	288
May-99	B-05	-3.11	6882	4404	8.2	2200	0	73	450	198	868	348
May-99	B-06	-4.33	5952	3809	8.1	1920	0	110	395	138	820	408
May-99	B-07	-1.08	5301	3393	8.7	1640	24	232	0	285	668	336
May-99	B-08	0.49	9765	6250	8.2	2850	0	220	405	381	1260	888
May-99	B-09	1.26	5487	3512	8.6	1680	48	183	0	294	668	348
May-99	B-10	-3.69	5580	3571	8.5	1760	24	159	80	228	704	384
May-99	B-11	-3.47	4650	2976	8.4	1240	12	201	80	162	784	468
May-99	B-12	-0.19	3534	2262	8.3	952	12	348	0	159	524	264
May-99	B-13	-5.18	1674	1071	8.7	288	60	445	0	99	200	0
May-99	B-14	-3.02	6603	4226	7.8	2200	0	110	415	231	868	456
May-99	B-15	-3.99	13720	2381	8.4	960	24	171	75	102	544	432
May-99	B-16	1.37	1116	714	8.5	176	12	238	0	90	83	0
Nov-01	B-01	-0.19	5880	3763	8.1	1760	12	116	175	222	924	384
Nov-01	B-02	-2.24	8428	5394	7.8	2640	0	146	655	225	1500	468
Nov-01	B-03	Dry	-	-	-	-	-	-	-	-	-	-
Nov-01	B-04	0.45	2704	1731	8.5	688	36	426	50	129	312	434
Nov-01	B-05	-4.81	8330	5331	7.8	2680	0	49	650	225	1500	432
Nov-01	B-06	-7.03	9408	6021	7.7	3080	0	110	660	168	1736	528
Nov-01	B-07	2.02	9800	6272	7.9	3120	48	288	200	390	1488	588
Nov-01	B-08	0.69	8036	5143	8.0	2120	24	366	325	372	1120	936
Nov-01	B-09	0.76	3724	2383	8.2	920	12	128	125	168	472	384
Nov-01	B-10	-4.79	3920	2509	8.4	1080	48	183	80	192	432	324
Nov-01	B-11	-3.07	6568	4204	8.0	1680	24	329	115	267	1002	552

Month and Year	Well No	RWL (m)	EC mmhos/cm	TDS ppm	pH	Cl ⁻ ppm	CO ₃ ppm	HCO ₃ ppm	Ca ⁺⁺ ppm	Mg ⁺⁺ ppm	Na ⁺ ppm	SO ₄ ppm
Nov-01	B-12	1.71	813	520	8.7	120	60	201	65	60	74	0
Nov-01	B-13	0.42	2646	1693	8.7	616	96	244	0	195	272	0
Nov-01	B-14	0.62	2288	1464	8.7	488	84	360	50	138	352	0
Nov-01	B-15	-4.49	3816	2442	7.9	1040	12	226	150	120	524	324
Nov-01	B-16	2.07	1526	977	8.4	272	12	165	135	51	160	0
May-02	B-01	-4.19	7007	4484	7.9	2200	0	61	180	315	1002	408
May-02	B-02	-4.74	8736	5591	7.8	2760	0	134	600	264	1500	468
May-02	B-03	Dry	-	-	-	-	-	-	-	-	-	-
May-02	B-04	-1.55	7735	4950	7.7	2400	12	79	190	345	1020	396
May-02	B-05	-2.85	7917	5067	7.6	2480	0	159	475	147	1470	432
May-02	B-06	-4.83	8099	5183	7.8	2600	0	61	605	246	1386	468
May-02	B-07	-0.88	10647	6814	7.8	3360	12	128	165	435	1640	696
May-02	B-08	0.19	3913	2504	8.0	880	48	281	120	159	560	504
May-02	B-09	1.36	2366	1514	7.9	432	24	207	95	57	280	324
May-02	B-10	-10.29	4641	2970	8.0	1320	24	232	50	243	544	348
May-02	B-11	-10.87	6825	4368	7.8	1800	24	159	135	267	900	528
May-02	B-12	-4.89	4459	2854	8.2	1240	60	128	0	210	624	348
May-02	B-13	-6.38	2002	1281	8.5	432	84	311	0	132	400	0
May-02	B-14	11.10	10324	6607	7.7	3200	0	220	690	216	1848	480
May-02	B-15	9.90	4836	3095	7.8	1272	36	152	40	204	624	348
May-02	B-16	4.00	1860	1190	8.2	312	0	256	0	120	160	0

Table 4.39: Geohydrological & Geochemical Parameters Observed in Obs. Wells surrounding Barda Bandhara

4.6 Shardagram Bandhara (SGMB)

The Shardagram Bandhara is a seawater intrusion preventive structure constructed at the mouth of River Noli (Khari) near the village Sheriaj of Mangrol Taluka of Junagadh District where river Noli meets the Arabian Sea. Construction of Bandhara was completed in 1992 at a cost of 207 lacs. (Refer Map 4.9)

The Bandhara is of 2.80 m high Ogee shaped non-gated structure which stores 2.92 MCM fresh water. The Catchment area of Shardagram Bandhara is 290.56 Sqkm. In the catchment area of Shardagram Bandhara there are 7 check dams constructed across river Noli and another 8 check dams constructed across the river Longadi, tributary of Noli, making a total of 15 check dams. In addition to above check dams 1 recharge reservoir is also constructed near the village Lambora on river Noli. (Refer Map 4.7)

4.6.1 Salient Features of Shardagram Bandhara

- i) Location : Latitude 21° 05' N; Longitude 70° 05' E
- ii) Length : 280.00 m
- iii) Crest RL : 2.50 m
- iv) FRL : 2.50m

- v) HFL : 5.50m
- vi) Catchment Area : 290.56 km²
- vii) Designed Flood : 3762 cumecs
- viii) Benefited Area : 2280 ha
- ix) Storage Capacity : 2.92 MCM

4.6.2 Rainfall Recorded at Sheriaj Hydromet Station

The rainfall in this area is received between June and October through the South-West monsoon. (Refer Table 4.40 & Graph 5.54)

Average Annual Rainfall = 800mm			
Year	Rainfall (mm)	% rainfall below AAR	% rainfall above AAR
1980	1521	90.13	-----
1981	1069	33.63	-----
1982	618	-----	22.75
1983	1794	124.25	-----
1984	712	-----	11.00
1985	375		53.13
1986	510		36.25
1987	55		93.13
1988	1259	57.38	-----
1989	786	-----	1.75
1990	875	9.38	-----
1991	492	-----	38.50
1992	1272	59.00	-----
1993	385	-----	51.88
1994	908	13.50	-----
1995	609	-----	23.88
1996	1078	34.75	-----
1997	447	-----	44.13
1998	1052	31.50	
1999	315	-----	60.63
2000	664	-----	17.00
2001	771	-----	3.63
2002	241	-----	69.88
2003	690	-----	13.75
Avg of Last 24 Years = 770.75		9 times above AAR	15 times below AAR

Table 4.40: Details of Rainfall Recorded at Sheriaj Hydromet Station

4.6.3 Geology of the Area

The top layer consists of top soil and coastal sands. Coastal sand is deposited in the form of sand dunes, occurring along the sea-coast which extends upto Khodada - Nes village on left bank of the bandhara. The Miliolite Limestone is the major geological formation encountered in the vicinity either as exposures exposed or underlying the thin soil cover and the sand dunes. It is a yellowish to buff coloured, fine to coarse grained & cavernous in nature having very high permeability. The thickness of this rock reduces towards inland.

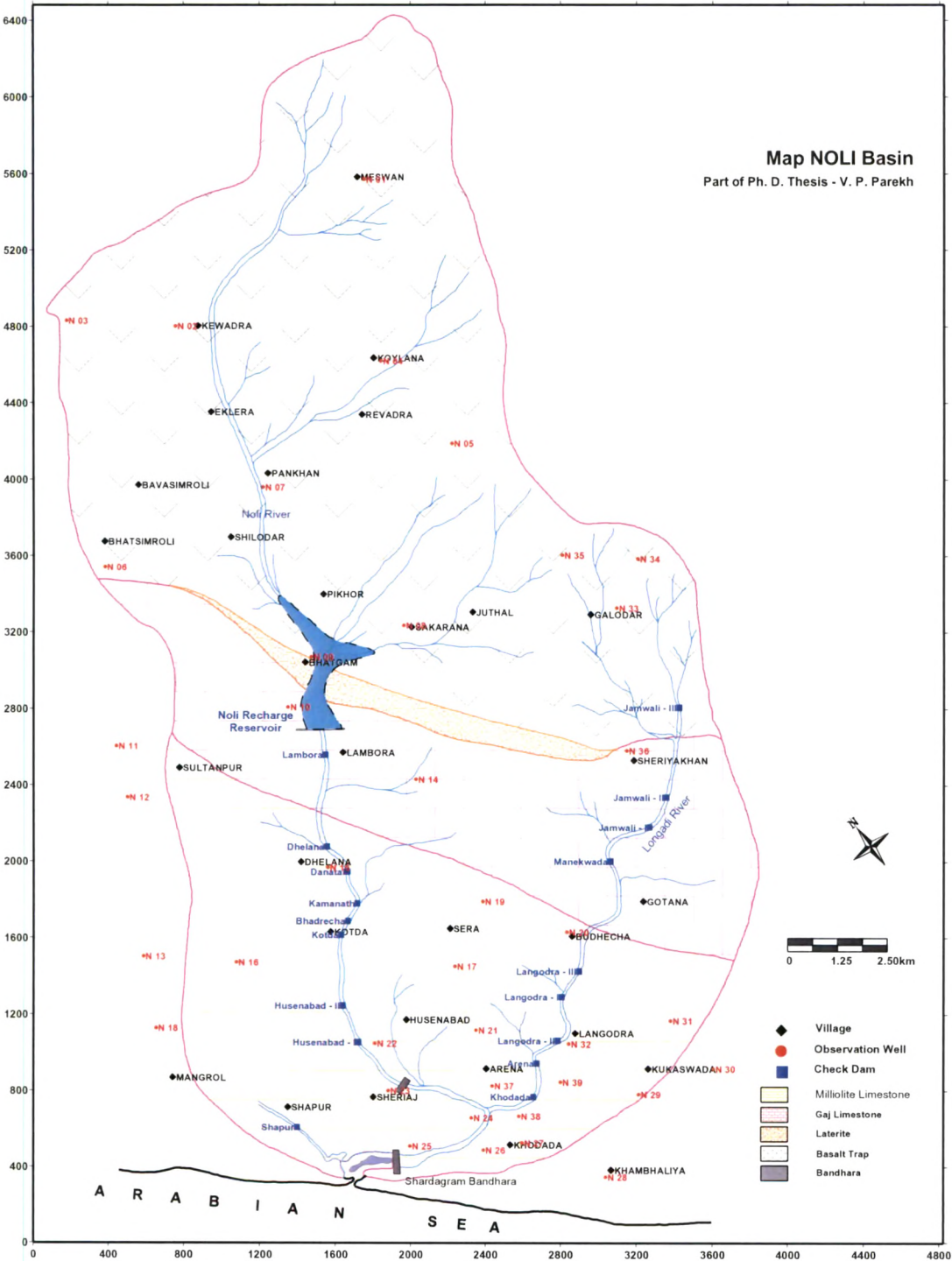
The aquifer characteristics of Miliolite Limestone have been worked out by Open Well pump test before construction of Bandhara. The results are as follows.

	Miliolite Limestone
Transmissibility	239 to 644 m ² /day
Permeability	0.00065 to 0.0024 cm/sec

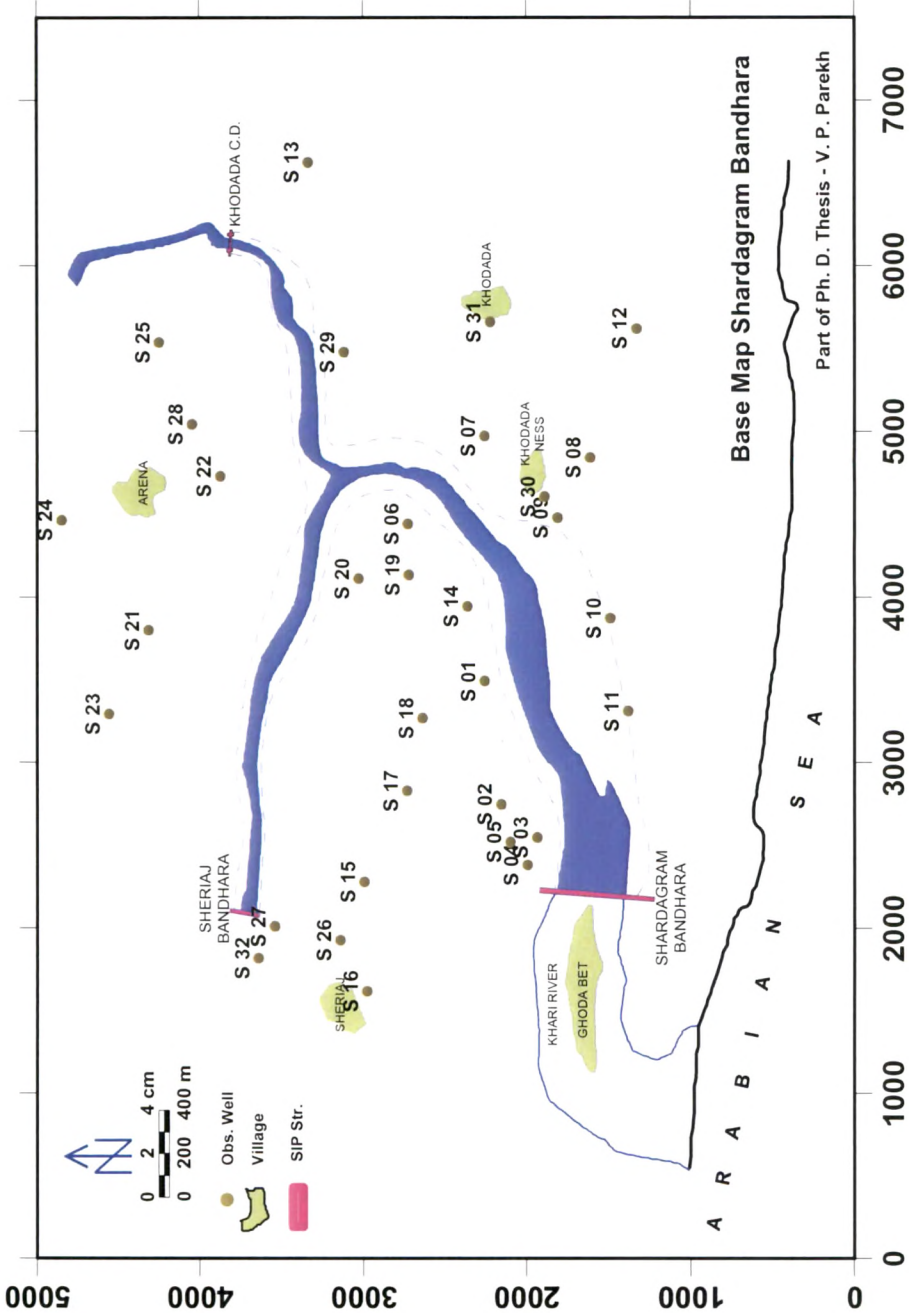
Table 4.41: Aquifer Properties of Geological Formation at Shardagram Bandhara Site



Plate 4.16: View of Shardagram Bandhara from U/S Side
(On U/S side Pumping Masonry Tower is visible to supply water directly from reservoir to Farm)



Map 4.7: Base Map of Noli Basin Showing Geology and Location of Seawater Intrusion Preventive Structures



Map 4.8: Base Map of Shardagram Bandhara

4.6.4 Elevation, Area, Volume Stored (Capacity) & Wetted Area of Shardagram Bandhara Reservoir

Sr. No.	Ele. (m)	Area (sqm)	Cumu. Vol. (m ³)	Wetted Area (Sqm)	Sr. No.	Ele. (m)	Area (sqm)	Cumu. Vol. (m ³)	Wetted Area (Sqm)	Sr. No.	Ele. (m)	Area (sqm)	Cumu. Vol. (m ³)	Wetted Area (Sqm)
1	-0.50	18908	366000	50622	21	0.50	120744	950000	211277	41	1.50	600000	1740000	771375
2	-0.45	19855	390100	56194	22	0.55	133078	988000	229908	42	1.55	647000	1792000	831714
3	-0.40	20802	414200	61764	23	0.60	145411	1026000	248534	43	1.60	694000	1844000	892040
4	-0.35	21748	438300	67333	24	0.65	157745	1064000	267157	44	1.65	741000	1896000	952354
5	-0.30	22695	462400	72900	25	0.70	170078	1102000	285776	45	1.70	788000	1948000	1012655
6	-0.25	23642	486500	78466	26	0.75	182412	1140000	304392	46	1.75	835000	2000000	1072944
7	-0.20	24589	510600	84031	27	0.80	194746	1178000	323003	47	1.80	882000	2052000	1133220
8	-0.15	25536	534700	89594	28	0.85	207079	1216000	341611	48	1.85	929000	2104000	1193484
9	-0.10	26482	558800	95155	29	0.90	219413	1254000	360214	49	1.90	976000	2156000	1253735
10	-0.05	27429	582900	100715	30	0.95	231746	1292000	378814	50	1.95	1023000	2208000	1313974
11	0.00	28376	607000	106274	31	1.00	244080	1330000	397410	51	2.00	1070000	2260000	1374201
12	0.05	37613	641300	116783	32	1.05	279672	1371000	434841	52	2.05	1135500	2325000	1413868
13	0.10	46850	675600	127290	33	1.10	315264	1412000	472265	53	2.10	1201000	2390000	1453528
14	0.15	56086	709900	137794	34	1.15	350856	1453000	509681	54	2.15	1266500	2455000	1493179
15	0.20	65323	744200	148295	35	1.20	386448	1494000	547089	55	2.20	1332000	2520000	1532821
16	0.25	74560	778500	158797	36	1.25	422040	1535000	584489	56	2.25	1397500	2585000	1572456
17	0.30	83797	812800	169297	37	1.30	457632	1576000	621882	57	2.30	1463000	2650000	1612082
18	0.35	93034	847100	179796	38	1.35	493224	1617000	659267	58	2.35	1528500	2715000	1651700
19	0.40	102270	881400	190292	39	1.40	528816	1658000	696644	59	2.40	1594000	2780000	1691310
20	0.45	111507	915700	200785	40	1.45	564408	1699000	734013	60	2.45	1659500	2845000	1730912
										61	2.50	1725000	2910000	1770506

Table 4.42: Elevation, Area & Capacity Table for Shardagram Bandhara (Refer Graph 5.55 to 5.57)

4.6.5 Pumping Test at village Langodra

To get aquifer properties pumping test was done at the village Langodra, Tal. Mangrol, Dist. Junagadh. The observations are as follows. Graphs were developed with Cooper – Jacob's Method. Well details are mentioned on graph.

Sr. No.	Time H:M	Water Level (m)	Sr. No.	Time H:M	Water Level (m)
1	10:10	10.82	17	10:32	11.66
2	10:11	10.87	18	10:34	11.72
3	10:12	10.91	19	10:36	11.79
4	10:13	10.95	20	10:38	11.86
5	10:14	10.99	21	10:40	11.93
6	10:15	11.03	22	10:42	11.99
7	10:16	11.07	23	10:44	12.05
8	10:17	11.11	24	10:46	12.11
9	10:18	11.15	25	10:48	12.17
10	10:19	11.19	26	10:50	12.23
11	10:20	11.23	27	10:55	12.38
12	10:22	11.31	28	11:00	12.53
13	10:24	11.39	29	11:05	12.68
14	10:26	11.46	30	11:10	12.83
15	10:28	11.53	31	11:15	12.98
16	10:30	11.59	32	11:20	13.13

Table 4.43: Time – Water-level Data for the Pumping Test at Vill. Langodra near Shardagram Bandhara

4.6.6 Rainfall, Water Level Fluctuation & Evaporation Recorded at Shardagram Bandhara

Date	Rainfall (mm/ Week)	Water level RL. In Mt.	Evap. (cm/ week)	Date	Rainfall (mm/ Week)	Water level RL. In Mt.	Evap. (cm/ week)
17/8/98	1052	2.50	-	30/11/98	Nil	-0.05	4.0
Aug 24	Nil	1.85	5.4	Dec 7	Nil	-0.10	4.0
31	Nil	1.50	5.3	14	Nil	-0.15	4.1
Sep 7	Nil	1.20	5.0	21	Nil	-0.19	4.0
14	Nil	1.00	3.7	28	Nil	-0.23	4.2
21	Nil	0.80	4.2	4/1/99	Nil	-0.26	3.9
28	Nil	0.65	4.2	TOTAL	1052		
Oct 5	Nil	0.52	4.3				
12	Nil	0.40	4.3	12/7/00	475	2.50	-
19	Nil	0.31	4.2	Jul 19	5	1.80	5.0
26	Nil	0.22	4.3	26	Nil	1.40	5.4
Nov 2	Nil	0.15	4.0	Aug 2	Nil	1.10	5.4
9	Nil	0.10	4.3	9	Nil	0.90	5.3
16	Nil	0.05	4.2	16	119	1.70	-
23	Nil	0.01	4.1	23	Nil	1.30	5.0

Date	Rainfall (mm/ Week)	Water level RL. In Mt.	Evap. (cm/ week)	Date	Rainfall (mm/ Week)	Water level RL. In Mt.	Evap. (cm/ week)
30/08/00	65	1.05	4.5	19/11/01	Nil	0.12	4.6
Sep 6	Nil	0.85	4.2	26	Nil	0.06	5.6
13	Nil	0.70	4.3	Dec 3	Nil	0.01	6.6
20	Nil	0.58	4.3	10	Nil	-0.05	7.6
27	Nil	0.48	4.2	17	Nil	-0.11	8.6
Oct 4	Nil	0.37	4.1	24	Nil	-0.16	9.6
11	Nil	0.29	4.0	31	Nil	-0.20	10.6
18	Nil	0.22	4.0	TOTAL	664		
25	Nil	0.15	4.1				
Nov 1	Nil	0.09	4.0	8/8/03	603	2.50	-
08/11/00	Nil	0.04	4.2	15	Nil	2.50	-
15	Nil	0.00	3.9	22	Nil	2.00	4.1
22	Nil	-0.05	4.0	29	17	1.65	3.9
29	Nil	-0.10	3.9	Sep 5	30	1.40	4.1
Dec 6	Nil	-0.14	3.9	12	Nil	1.20	4.1
13	Nil	-0.17	3.8	19	22	1.05	4.0
TOTAL	664			26	Nil	0.90	4.2
				Oct 3	18	0.78	4.1
18/6/01	418	2.50	-	10	Nil	0.65	4.0
25	Nil	1.90	5.0	17	Nil	0.53	3.9
Jul 2	18	1.50	4.1	24	Nil	0.43	3.8
9	92	2.50	-	31	Nil	0.35	3.7
16	36	2.00	4.0	Nov 7	Nil	0.27	3.7
23	Nil	1.60	3.9	14	Nil	0.21	3.6
30	Nil	1.33	4.1	21	Nil	0.15	3.7
Aug 6	Nil	1.10	4.1	28	Nil	0.10	3.6
13	135	2.50	-	Dec 5	Nil	0.05	3.4
20	8	2.10	3.9	12	Nil	0.01	3.3
27	Nil	1.68	3.9	19	Nil	-0.04	3.3
Sep 3	40	1.45	4.0	26	Nil	-0.09	3.1
10	Nil	1.20	4.0	02/01/04	Nil	-0.13	3.3
17	5	1.02	4.1	9	Nil	-0.17	3.1
24	8	0.88	3.9	16	Nil	-0.20	3.1
Oct 1	Nil	0.74	3.9	TOTAL	690		
8	6	0.63	3.8				
15	5	0.53	3.9				
22	Nil	0.42	3.8				
29	Nil	0.33	3.8				
Nov 5	Nil	0.25	3.7				
12	Nil	0.18	3.6				

Table 4.44: Rainfall, Water Level & Evaporation Data at Shardagram Bandhara – Year 1998 to 2003

4.6.7 Geohydrological & Geochemical Monitoring System Setup

To know the efficacy of the Shardagram Bandhara, 32 number of observation well surrounding the reservoir site has been monitored from May 1997 to November 2002. The observations were taken Pre-monsoon (May) and Post-monsoon (November) every year. The various parameters observed are RWL, pH, EC, TDS, Cl^- , Na^+ , SO_4^{2-} , Ca^{++} , Mg^{++} , CO_3^{--} and HCO_3^- . To study above parameters, contour maps showing variation in different parameter values are prepared.

Obs. Well No	RL (m)	Distance from Structure (m)	Obs. Well No	RL (m)	Distance from Structure (m)	Obs. Well No	RL (m)	Distance from Structure (m)
S-01	4.80	1238	S-12	5.70	2871	S-23	8.39	2723
S-02	4.52	693	S-13	7.00	3960	S-24	11.63	3366
S-03	4.54	455	S-14	3.69	1624	S-25	7.22	3614
S-04	4.29	446	S-15	9.83	1287	S-26	10.07	1406
S-05	4.26	554	S-16	8.95	1337	S-27	6.92	1723
S-06	3.31	2129	S-17	9.50	1188	S-28	6.42	3267
S-07	4.50	2376	S-18	7.09	1287	S-29	6.00	3029
S-08	5.00	2198	S-19	3.20	1950	S-30	4.45	2079
S-09	3.20	1901	S-20	3.39	2039	S-31	9.38	2970
S-10	2.80	1386	S-21	7.27	2723	S-32	5.89	1683
S-11	2.80	941	S-22	7.24	2901			

Table 4.45: Details of Observation Wells surrounding Shardagram Bandhara

4.6.7.1 Data collection for Geohydrological & Geochemical Monitoring

Month and Year	Well No	RWL (m)	EC mmhos/cm	TDS ppm	pH	Cl^- ppm	CO_3 ppm	HCO_3 ppm	Ca^{++} ppm	Mg^{++} ppm	Na^+ ppm	SO_4 ppm
May-97	S-01	-2.60	6724	4303	7.5	2120	48	183	275	216	820	324
May-97	S-02	-0.38	5394	3452	7.6	1560	0	195	85	132	744	360
May-97	S-03	-0.46	2957	1892	7.7	712	12	250	55	75	490	252
May-97	S-04	-0.31	6557	4196	7.5	1960	0	195	135	159	1000	312
May-97	S-05	-0.54	6566	4202	7.4	2040	0	171	225	141	924	336
May-97	S-06	-1.29	9719	6220	7.4	3160	0	183	315	183	1386	408
May-97	S-07	-1.30	7347	4702	7.5	2280	0	220	120	186	1086	300
May-97	S-08	-1.40	8928	5714	7.4	2960	0	159	510	201	1116	432
May-97	S-09	-1.50	4883	3125	7.5	1440	0	244	115	135	704	288
May-97	S-10	-1.10	9560	6118	7.3	3120	0	403	215	234	1260	312
May-97	S-11	-1.00	12062	7720	7.6	4000	0	220	290	396	1600	456
May-97	S-12	-0.80	10983	7029	7.6	3720	0	171	525	273	1360	432
May-97	S-13	-1.10	3199	2047	7.9	920	60	214	155	102	340	0
May-97	S-14	-0.71	11709	7494	7.6	4120	0	244	200	315	1488	312
May-97	S-15	-0.27	9235	5910	7.7	2680	0	146	320	198	1320	288
May-97	S-16	Dry	-	-	-	-	-	-	-	-	-	-
May-97	S-17	0.20	10900	6976	7.5	3600	0	232	515	219	1470	288
May-97	S-18	-0.21	7738	4952	7.6	2440	0	183	185	204	1086	276
May-97	S-19	-1.20	8835	5654	7.5	2800	0	183	295	252	1116	252

Month and Year	Well No	RWL (m)	EC mmhos/cm	TDS ppm	pH	Cl ⁻ ppm	CO ₃ ppm	HCO ₃ ppm	Ca ⁺⁺ ppm	Mg ⁺⁺ ppm	Na ⁺ ppm	SO ₄ ppm
May-97	S-20	-1.41	9198	5887	7.6	2880	0	207	325	189	1146	228
May-97	S-21	-2.33	13020	8333	7.7	4480	0	207	1140	219	1176	288
May-97	S-22	0.84	4548	2911	7.8	1360	0	244	350	138	312	0
May-97	S-23	-2.11	13904	8899	7.5	4680	0	317	730	558	1288	504
May-97	S-24	-2.07	7635	4886	7.8	2440	0	159	825	114	492	372
May-97	S-25	-2.58	9970	6381	7.5	3400	0	122	955	237	648	408
May-97	S-26	-0.43	13522	8654	7.3	4520	0	220	545	297	1736	288
May-97	S-27	0.02	7580	4851	7.5	2320	0	244	75	228	924	264
May-97	S-28	-2.28	14081	6012	7.5	4880	12	116	1505	156	1600	564
May-97	S-29	-1.90	10194	6979	7.7	3600	0	73	510	186	1528	504
May-97	S-30	-0.65	2585	1654	7.9	600	12	116	170	139	226	0
May-97	S-31	-0.42	1278	818	8.1	248	60	231	0	90	176	0
May-97	S-32	-1.01	8649	5535	7.7	2600	0	268	375	114	116	336
Nov-98	S-01	-1.70	7448	4767	8.0	2280	12	128	115	198	1320	432
Nov-98	S-02	1.72	1568	1004	8.7	280	72	305	50	48	290	0
Nov-98	S-03	2.44	1372	878	8.6	296	12	140	35	54	186	0
Nov-98	S-04	0.64	1176	753	8.6	224	48	146	50	30	182	0
Nov-98	S-05	0.56	588	376	8.7	80	24	134	60	15	78	0
Nov-98	S-06	0.21	1372	878	8.4	320	24	122	40	69	170	0
Nov-98	S-07	-0.70	8428	5394	8.1	2640	12	189	225	147	1386	468
Nov-98	S-08	-0.70	2842	1819	8.3	640	24	281	50	90	476	336
Nov-98	S-09	-0.80	2646	1693	8.2	664	24	183	60	78	382	286
Nov-98	S-10	-0.60	4802	3073	8.4	1400	48	183	75	141	784	384
Nov-98	S-11	-0.30	2940	1882	8.6	768	36	226	65	81	500	276
Nov-98	S-13	Dry	-	-	-	-	-	-	-	-	-	-
Nov-98	S-14	1.90	2156	1380	8.3	576	0	146	90	66	340	0
Nov-98	S-15	0.29	5194	3324	8.1	1480	36	238	85	126	924	408
Nov-98	S-16	1.03	5194	3324	8.3	1600	12	165	195	75	880	444
Nov-98	S-17	0.75	17270	11053	7.9	3640	0	110	585	159	1808	504
Nov-98	S-18	2.10	3822	2446	8.2	1160	0	134	120	102	624	336
Nov-98	S-19	1.29	9114	5833	7.7	2840	48	122	270	168	2000	468
Nov-98	S-20	-0.50	1568	1004	8.7	320	48	244	105	45	216	0
Nov-98	S-21	-0.01	1568	1004	8.5	328	0	220	80	54	246	0
Nov-98	S-22	2.87	3430	2195	8.2	1000	0	146	255	57	452	372
Nov-98	S-23	Dry	-	-	-	-	-	-	-	-	-	-
Nov-98	S-24	3.39	12054	7715	7.4	3960	12	116	990	186	1760	576
Nov-98	S-25	4.03	1372	878	8.1	328	0	98	200	30	114	0
Nov-98	S-26	2.62	2156	1380	8.1	488	0	134	145	36	196	0
Nov-98	S-27	0.97	4998	3199	8.2	1360	0	256	165	78	840	516
Nov-98	S-28	3.72	5292	3387	8.0	1520	0	183	185	114	784	468
Nov-98	S-29	2.02	2142	1371	7.8	488	12	262	140	72	250	0
Nov-98	S-30	0.80	9690	6202	7.6	3000	0	207	450	60	1500	504
Nov-98	S-31	0.25	2856	1828	8.2	800	0	134	75	54	312	312
Nov-98	S-32	0.08	2040	1306	8.6	416	48	244	0	81	290	0
May-99	S-01	-2.00	10058	6437	7.7	3160	24	220	380	168	1810	444
May-99	S-02	0.32	7332	4692	7.9	2280	12	140	195	147	1356	408
May-99	S-03	0.54	7520	4813	7.8	2200	12	299	225	120	1356	456
May-99	S-04	-0.31	4982	3188	8.0	1400	12	165	50	81	980	516
May-99	S-05	-0.41	5170	3309	8.2	1600	24	159	70	72	1000	492
May-99	S-06	-0.79	8084	5174	8.1	2560	12	85	210	210	1408	504

Month and Year	Well No	RWL (m)	EC mmhos /cm	TDS ppm	pH	Cl ⁻ ppm	CO ₃ ppm	HCO ₃ ppm	Ca ⁺⁺ ppm	Mg ⁺⁺ ppm	Na ⁺ ppm	SO ₄ ppm
May-99	S-07	-1.90	11220	7181	7.9	4040	0	61	595	303	2000	636
May-99	S-08	-1.00	6016	3850	8.0	1840	0	122	265	111	1000	408
May-99	S-09	-0.20	5452	3489	8.0	1640	0	122	250	150	924	432
May-99	S-10	-0.60	5264	3369	8.1	1640	0	122	105	192	880	408
May-99	S-11	-0.30	5546	3549	8.2	1720	12	91	170	144	980	456
May-99	S-12	-0.10	6016	3850	7.9	1840	0	85	210	153	1000	408
May-99	S-13	-0.40	13160	8422	7.8	4480	0	61	985	474	1860	684
May-99	S-14	-0.21	8460	5414	8.1	2600	36	201	275	174	1470	408
May-99	S-15	-2.77	11844	7580	7.7	3840	0	195	560	246	2000	636
May-99	S-16	-1.25	10716	6858	7.7	3400	0	268	365	213	1700	504
May-99	S-17	1.40	11750	7520	7.8	3880	0	146	505	270	1960	492
May-99	S-18	0.49	10528	6738	8.0	3440	0	110	320	243	1848	432
May-99	S-19	-1.20	7614	4873	8.0	2360	0	73	225	201	1302	384
May-99	S-20	-1.81	9870	6317	7.9	3120	0	146	300	252	1680	528
May-99	S-21	-2.33	12878	8242	7.8	4240	0	146	820	210	2000	564
May-99	S-22	Dry	-	-	-	-	-	-	-	-	-	-
May-99	S-23	-1.41	12972	8302	7.8	4320	0	110	765	291	2050	588
May-99	S-24	-2.67	13536	8663	7.6	4640	0	73	990	411	1810	528
May-99	S-25	-3.78	9306	5956	7.8	3080	0	73	950	270	904	492
May-99	S-26	-0.23	12314	7881	7.6	4000	0	210	480	264	2000	492
May-99	S-27	1.02	12220	7821	7.8	4000	0	110	505	225	2000	456
May-99	S-28	-2.08	10509	6726	7.1	3600	0	220	610	396	1500	624
May-99	S-29	-1.90	9579	6131	7.6	3120	0	317	460	114	1680	480
May-99	S-30	-0.15	2883	1845	7.8	640	12	396	155	30	668	312
May-99	S-31	-0.32	2651	1696	7.8	688	12	348	140	63	410	276
May-99	S-32	1.02	12220	9821	7.8	4000	0	110	505	225	2000	456

Table 4.46: Geohydrological & Geochemical Parameters Observed in Obs. Wells surrounding Shardagram Bandhara

4.7 Change in Crop Production

Because of construction of various Seawater Intrusion Preventive structures, the additional surface and subsurface freshwater storage has been created at basin level. Moreover because of availability of freshwater soil condition and fertility is also improved. Due to this an increase in the yield of crop has come up. The effect of crop production cannot be studied at individual structure level so basin level is considered. Table 4.47 throws some light on change in crop production.

Crop	Noli Basin			Meghal Basin			Shingoda Basin		
	Year		%	Year		%	Year		%
	1992	2003	Change	1988	2003	Change	1988	2003	Change
Coconut	50	85	70	50	90	80	-	-	-
Groundnut	15	25	67	11.2	27	141	9.88	11.5	16
Wheat	10	21	110	20	40	100	18.7	31	66
Millet	-	-	-	17.9	29	62	8.64	14.5	68
Sugarcane	-	-	-	-	-	-	422.3	550	30

Table 4.47: Change in Crop Production for Noli, Meghal & Shingoda Basin

- Production of Coconut is in Number/Tree/Year
- All other crop production is measured in Qtl/Ha.

4.8 Mining of Limestone in the Coastal Belt

Major chemical constituents of limestone are calcium, magnesium, silicon oxides of various metals (Aluminum, Iron, Titanium etc.). Cement grade limestone requires high calcium (minimum 45%) and chemical grade requires lesser percent of calcium (minimum 35%). Majority of limestone deposits in Gujarat are good for cement industries.

Deposits	Districts	As major mineral		As minor mineral	
		No of leases	Lease area (ha)	No of leases	Lease area (ha)
Pleistocene Miliolite Limestone	Amreli	14	1297.84	58	30.28
	Bhavnagar	6	123.83	2	3
	Jamnagar	44	2257.81	66	68.52
	Junagadh	247	5720.01	527	400.09
	Surendranagar	1	47	7	8.05
	Rajkot	3	101.13	29	17.72
Total		315	9547.62	689	527.66

(Source:DGM 1989)

Table 4.48: Position of Limestone Mining Lease in Saurashtra

Several major agencies are mining Miliolite Limestone of Saurashtra coast. Majority of cement plants are operating in Saurashtra. A major part of limestone (around 65%) is, however, being mined by these plants. (Table 4.49)

Agency	Number of Lease	Lease area
Narmada Cement Co. Ltd	5	810.6592
Digvijay Cement Ltd.	9	1064.4516
Tata Chemicals	49	1502.9819
Saurashtra Chemicals	15	525.1036
Ambuja Cement	1	272.00
Total	78	4175.1963

(Source:DGM 1987, 1989)

Table 4.49: Major Mining Agencies of Limestone in Saurashtra