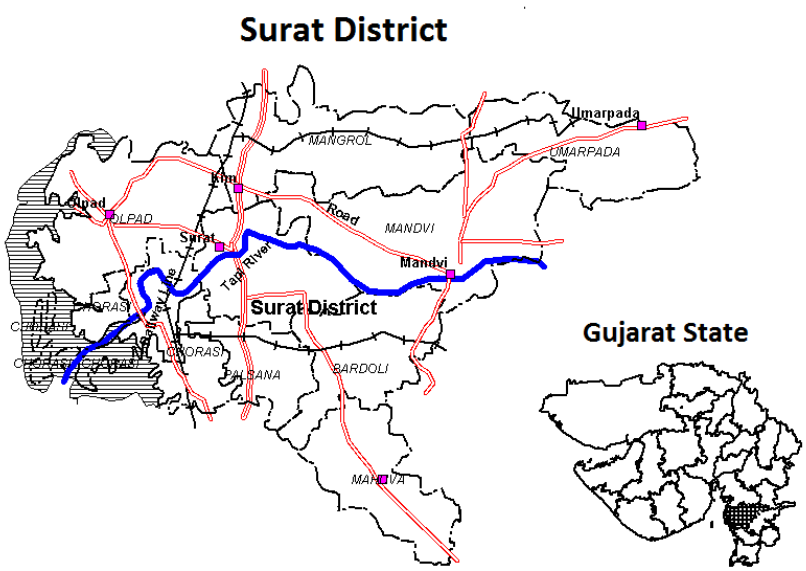
Government of India
Ministry Of Water Resources
Central Ground Water Board

DISTRICT GROUND WATER BROCHURE

SURAT DISTRICT,

GUJARAT STATE



By
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West Central Region

Ahmedabad

December -2013

SURAT DISTRICT AT A GLANCE		
Sl.No.	Items	Statistics
1	General Information	
	i) Geographical area as per state territory/as per village papers (Sq. Km)	**4109**
	ii) Administrative Divisions (As on 3/2012) **Number of Talukas** **Number of Villages** **Number of Towns**	 **09** **713** **22**
	iii) Populations (As on 2001 census)	**6079231**
	iv) Normal Annual Rainfall (mm) (1951to 1980) IMD **V) Average Annual Rainfall(mm)**	**1209.4** **1394**
2.	GEOMORPHOLOGY	
	Major Physiographic Units: hilly areas, piedmont slopes, alluvial plains (main land) & coastal alluvial plains.	
	Major Drainages: Kim river, Tapti river, Purna river, Khapari river.	
3.	MAJOR SOIL TYPES: **saline (khar) soils, light coloured soils and garot soils & black cotton soils.**	
4.	PRINCIPAL CROPS): **Rice, Jowar, Bajra, Wheat, Maize, cereals, Gram and other pulses. Other food crops are Ground nut, Seasam, mustard, oil seeds and sugarcane.**	
5.	NUMBERS OF GROUND WATER MONITORING WELLS **OF CGWB (As on 31-03-2012)** **No of Dug Wells** **No of Piezometers**	 **18** 4
6.	PREDOMINANT GEOLOGICAL FORMATIONS: **Deccan trap basalt with dykes, Tertiary formations include ferruginous sandstone (Gaj beds Nummulitic lime stone Gypseous shale, Laterite and Lateritic clays (Bauxite pockets), older alluvium (Quaternary) fine, light coloured argillaceous loam with nodular lime concretions (Kankar). Younger alluvium river & stream deposits, Dunes of blown sand abundant in coastal areas fluvio-marine deposits abundnant in tidal flats and estuaries.**	
7.	HYDROGEOLOGY	
	➢ **Major Water Bearing Formations: Deccan trap basalt with dikes, Tertiary formations (ferruginous sandstone, Laterite Nummulitic lime stone, inland alluvium &coastal alluvium.** ➢ **Pre- monsoon depth to water level (May 2012) 2.48m (Palsana) to 17.75 m (Mahuva2) Post- monsoon depth to water level (November 2012) 1.39m (Palsana) to 16.55 m (Mahuva2)** ➢ **Annual fluctuation rise -0.81 (Olpad2) 7.53m (Mandvi2)** ➢ **Long term water level trend in 10 yrs premonsoon (May 2003 to May 2012) Rise 0.0331m/yr (Nogama) to 0.338 m /yr (Sachin Town) and Fall 0.0037m/yr (Mandvi2) to 0.4293 m/yr (Palkhanda)** ➢ **Long term water level trend in 10 yrs post monsoon (Nov./2003-Nov./2012) Rise 0.0002 m/yr (Juna Umarpada) to 0.447 m/yr (Sachin town) and Fall 0.0058 m/yr (Madhi) to 0.0.6439 m/yr (Kathore)**	

8.	GROUND WATER EXPLORATION BY CGWB (As on 31-03-2012)	
	No of wellsdrilled (EW, OW, Pz, SH, Total) EW 08+ ,OW 5+, PZ 4	
	Depth Range(m)	**25.36 to 611**
	Discharge (Litres per minute)	**8 to 720 lpm**
	Storativity (S)	-
	Transmissivity (m^2/day)	**104-2965 m^2/day**
	Specific capacity lps/m of dd	**19- 1658 m^3/day/m**
9.	GROUND WATER QUALITY (3/2012)	
	Presence of chemical constituents more than permissible limit) Na and K	
	Type of waters: Fresh and Saline	
10.	DYNAMIC GROUND WATER RESOURCES (3/2009)- in ha.m	
	Annual Replenisible Ground Water Resources	112093.73
	Net Annual Ground Water Availability	103440.91
	Projected Demand for Domestic and industrial Uses upto 2025	83669.00
	Stage of Ground Water Development	**40.39%**
11.	AWARENESS AND TRAINING ACTIVITY	
	Mass Awareness Programmes organized (March 2007) Date Place No of Participants	3/ 2012 Netrang 250
	Water Management Training Programmes organized (3/07) Date Place No of Participants	 3/ 207 Netrang 30
12.	EFFORTS OF ARTIFICIAL RECHARGE & RAINWATER HARVESTING(31/3/2007)	
	Projects completed by CGWB (No & Amount spent)	NIL
	Projects under technical guidance of CGWB (Numbers)	NIL
13.	GROUND WATER CONTROL AND REGULATION (3/2009)	
	Number of OE Talukas	NIL
	Number of Critical Talukas	NIL
	Number of Semi-Critical Talukas	NIL
14.	**Number of Talukas notified**	NIL
	MAJOR GROUND WATER ISSUES i) Case study for ground water quantity & ground water quality ii) Excess run off due to rugged topography iii) Heterogeneity of aquifer iv) Unplanned construction of ground water structures v) Pumping pattern vi) Optimum use of water vii) water conservation viii) Rain water harvesting and roof top rain water harvesting ix) Feasible artificial recharge projects	

DISTRICT GROUND WATER BROCHURE
SURAT DISTRICT, GUJARAT

1.0 INTRODUCTION

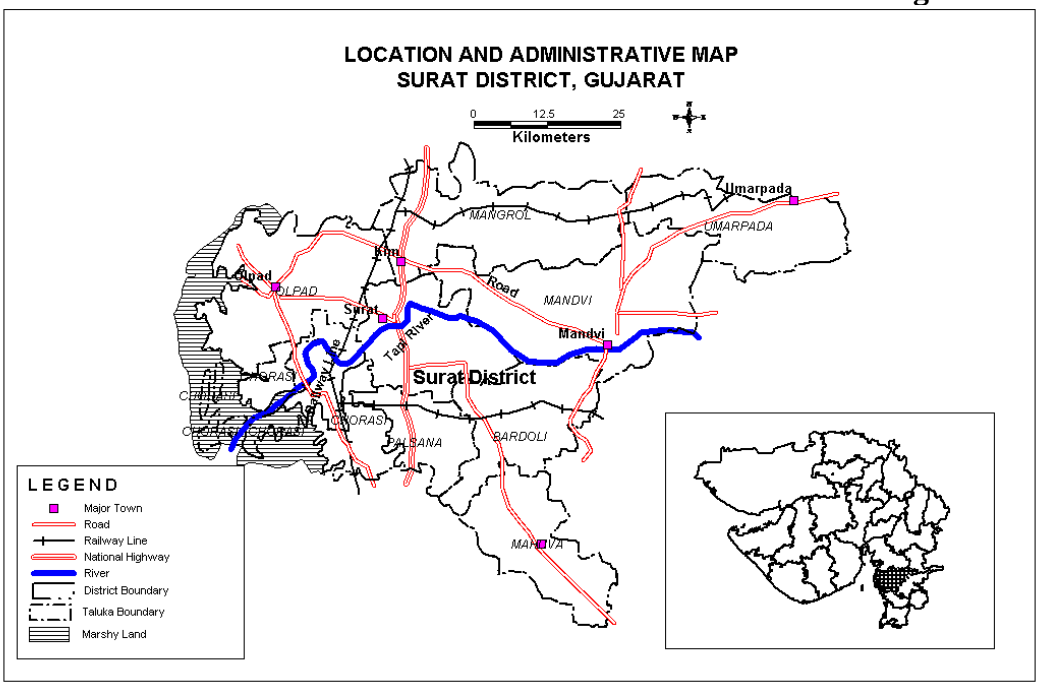
Surat district lying between 20°30': 21°35'N and 72°35':74°20' E has a total geographical area of 4109.74 sq. km. The district is situated in the southern part of the state. It is bounded by the Arabian Sea on the west, Bharuch in the North, the Valsad district in the south, The Dangs district in the south-east, and the Tapi district of the in the east. The district has been divided into nine talukas namely Bardoli, Choryasi, Kamrej, Mahuva, Mandvi, Mangrol, Olpad, Palsana and Umarpada.

Table :-I Geographical Area

S. No	Taluka	Geographical Area (Sq. Km.)
1	Bardoli	399.09
2	Choryasi	396.95
3	Kamrej	377.60
4	Mahuva	267.02
5	Mandvi	829.02
6	Mangrol	526.45
7	Olpad	598.09
8	Palsana	202.26
9	Umarpada	513.26
	Total	**4109.74**

The district comprises of 09 Talukas, i.e., Bardoli, Choryasi, Kamrej, Mahua, Mahuva, Madvi Magrol, Palsana and Umarpada . The administrative divisions of the district have been reconstituted recently by bifurcating Surat district as shown above in Figure-1 Location and Administrative Map of the Surat District.

Figure-1



2.0 HYDROMETEOROLGY

The district has the meteorological station in the district town Surat . therefore, the climatological data of Surat IMD station is discussed here.

There are many rain gauge stations being monitored by different state government agencies. The Water Resources Investigation Circle (WRI) under the department of Narmada Water Resources, Govt. of Gujarat, monitors most of the rain gauges stations and also collects and compiles the rainfall data collected by different agencies.

Long term mean monthly climatological parameters (IMD 1951-80) like maximum and minimum temperatures, relative humidity, wind speed and rainfall are given in Table-II and depicted in Figure- 2

Table:- II IMD Climatological Data

Month	Max Temp	Min Temp	Humidity	Wind Speed	Sunshine	PET	Rainfall
	(°C)	(°C)	(%)	Km/h	(Hours)	(mm/d)	(mm)
January	31.5	14.3	52.0	4.70	9.7	3.9	0.0
February	33.5	16.1	47.5	4.83	10.3	4.7	0.4
March	36.2	20.1	48.0	5.10	9.9	5.7	1.5
April	37.7	23.7	52.0	5.65	10.5	6.6	0.3
May	36.4	26.4	61.5	8.10	10.3	6.9	7.3
June	33.8	26.6	74.5	9.19	7.4	5.5	249.3
July	31.0	25.4	83.5	8.58	4.0	3.9	417.7
August	30.6	25.0	84.0	7.48	4.3	3.8	299.4
September	32.2	24.4	78.0	5.38	6.2	4.2	190.7
October	35.9	23.0	60.5	4.22	9.4	4.8	27.2
November	35.3	19.3	52.0	4.49	9.7	4.3	13.0
December	32.9	16.1	54.0	4.90	9.5	3.9	2.6
Total	**-**	**-**	**-**		**-**	**-**	**1209.4**
Average	**33.9**	**21.7**	**62.3**	**6.05**	**8.4**	**4.8**	**-**

General climate of the district is sub-tropical and is characterised by three well-defined seasons, i.e. summer - from April to June, monsoon - from July to September, and winter - from October to March.

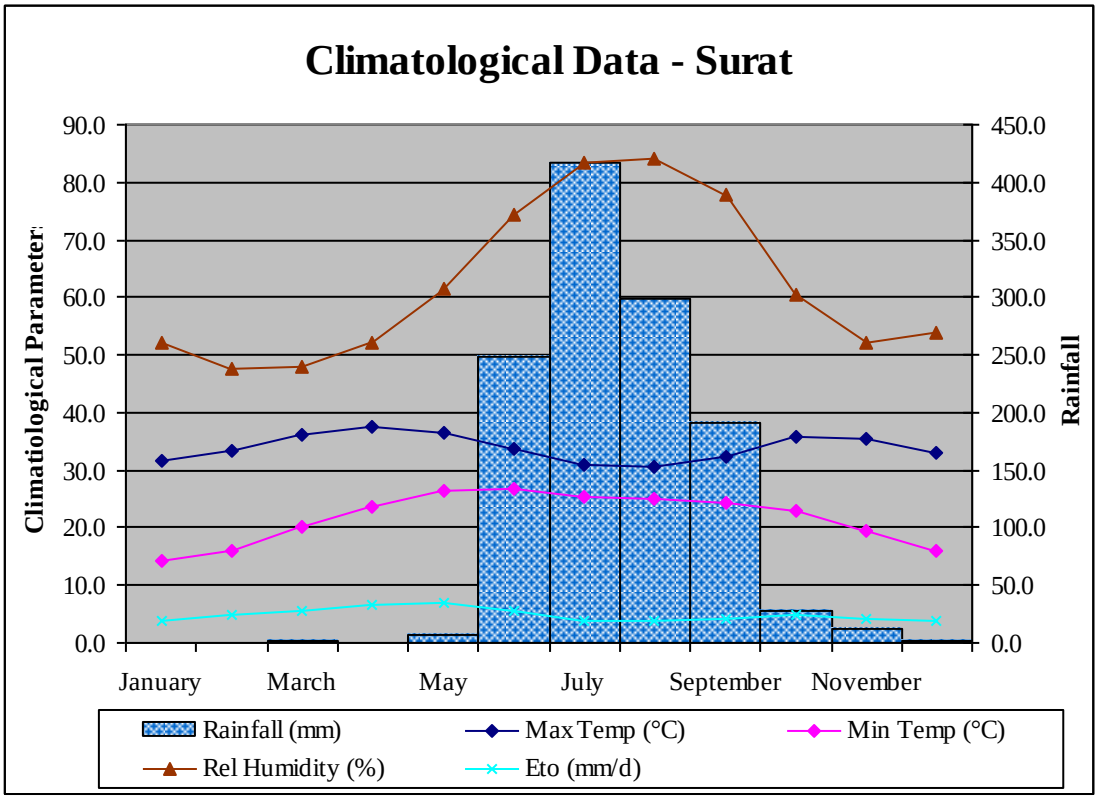
2.1 Rainfall

Long term normal rainfall (1951-80) for the SURAT IMD station is about 1210 mm for stations monitored by Govt. of Gujarat. The rainfall data for other stations falling in the district is available for the period between 1963 to 2012. It is seen that the average annual rainfall varies between 901.29 mm at Olpad and 1483.3.mm at Mahuva. The minimum recorded rainfall during these years varied between 378 mm (Bardoli -1996) and 542 mm (Mahuva –2011). The maximum recorded rainfall varied from 1939 mm (Olpad –1976) to 3529 mm (Mahuva –1970). The Statistical Analysis of Rainfall Data (1963-2008) is given in table-III.

Table:-III Statistical Analysis of Rainfall Data (1963-2012)

Taluka/ Stations	No of Years	Average Rainfall	Stand Dev	C V %	Min. Rainfall	Years	Max. Rainfall	Years
		(mm)			(mm)		(mm)	
Bardoli	47	1466.1	558.53	38.096	378	1996	3146	1994
Kamrej	49	1313.2	556.42	42.371	495	1996	2543	1988
Mahuva	48	1483.3	561.49	37.854	542	2011	3529	1970
Mandvi	46	1475.4	577.16	39.119	438	1987	2899	1976
Mangrol	49	1192.5	475.53	39.878	349	1996	2640	1976
Olpad	47	901.29	368.62	40.899	409	1987	1939	1976
Choryasi	49	1232.2	519.12	42.128	528	2002	2806	1983
Palsana	46	1406.1	509.55	36.239	451	1996	2743	1970
Umarpada	47	1300.42	561.981	43.2154	349	1996	2877	2006

Figure- 2



3.0 GEOMORPHOLOGY

3.1 Physiography

Geographically, the district belongs to the western coastlands of the Deccan peninsula. The main Sahyadri scarp is a little outside the limits of the district towards east, but it gives the district its orientation, landscape features and drainage pattern. Distinct zones, viz., hilly areas, piedmont slopes, alluvial plains and coastal plains.

Hilly areas: The north-eastern parts of the district fall in this category. Here the general elevations are more than 100m amsl. The topography is rugged with low to moderate high hills and steep hill slopes. These parts are poorly populated and are infested by dense jungle of teak and bamboo.

Piedmont slopes: East-central parts of the district fall in this category. Here the elevations range between 60 and 100m.amsl. These parts show a gentle slope towards west. Topography is mainly plain with moderate to deep cutting river valleys and occasional hillocks.

Alluviual plains: Alluvial plains towards situated in the central parts of the district are characterized by flood plains of the Tapi, Kim and Purna rivers. Tapi has a meandering channel entrenched fairly deep and has cut deep terraces. The topography is generally plain with gentle slope towards west. The general elevations are below 60 m.amsl, the lowest elevation being 45m.amsl near Madhi.

Coastal Plains: The alluvial plains towards west merge into a dry barren sandy coastal plain fringed by marshy shore line. All the rivers form estuarine mouths. There are sand bars and spits near the shore.

3.2 Drainage

The Tapi is the major river which passes through the central parts of the district and flows towards the west. The river is perennial in nature. It originates in Madhya Pradesh near Betul and has about 62225 sq. Km. of catchment area. The average width of the river upstream of Kathor bridge in about 500m. Downstream of the bridge the average being about 700m. Pickup weir was constructed on the Tapi River in 1954 at Kakarapar about 56km west of Surat. Ukai dam, constructed in 1965, is situated about 25km upstream of Kakarapar weir. Other prominent rivers draining the district are Kim, and Purna.

3.3 Soil Type

The basaltic lava flows are covered by black clayey to loamy soil. It is in general ranges in thickness up to one meter. The colour of the soil turns brown due to high iron content at places. In the piedmont slope area the soil is shallow to moderately deep, moderate to severely eroded and non calcareous in nature. The texture is silt clay loam to clay loams. The clay content varies from 30 to 60%. The water holding capacity of the soil is moderate. In the midland and flood plain areas, the soil is deep to very deep, light greyish to yellowish brown in colour. The texture is fine clay loam to sandy loam. The clay content varies from 25 to 60%. In coastal region the soil is deep to very deep dark grey to black colour. The texture is clay loam to silty loam. The area is affected by tide as well as leaching of salts from up land forming saline alkali soils. The content of clay in this is high and permeability is low (mud flats).

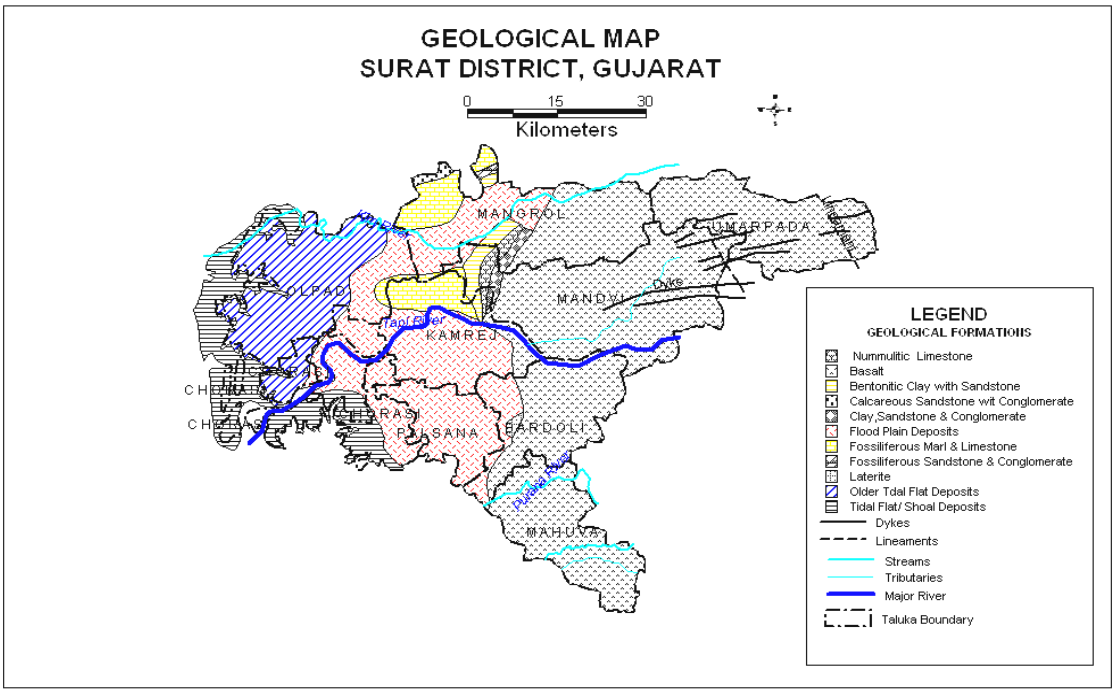
4.0 GEOLOGY

Major geological formations exposed in the district are Quaternary alluvium, Tertiary limestone and sandstones and Deccan Trap basalt. Figure -3 shows the geology of the district and the succession of geological formations in the district, as given by Geological survey of India in their brochure titled '' Know Your District-Surat'' is as follows.The geology of the district is depicted in Figure-3

Geological Succession

Era	Period	Epoch /Series	Description
Cenozoic	Quaternary	Holocene	Soil, Younger alluvium Blown and Fluvio-marine deposits.
	Tertiary	Pleistocene	Older alluvium, conglomerate
		Miocene	Ferruginous sandstone (Gaj)
		Eocene	Numulitic limestone
		Palaeocene	Sub-Numulitic limestone, gypseous shale,Supra- Trappean sediments lateritised and having bauxite pockets.
Mesozoic	Lower Tertiary to Upper Cretaceous	Early Eocene To Upper	Deccan Trap basalt with dykes

Figure-3



5.0 HYDROGEOLOGY

5.1 Aquifer System

The hydrogeological frame work of the area is essentially governed by geological setting, distribution of rainfall fall and facilities of circulation and movement of water through inter connected primary and secondary porosity of the geological units forming the aquifers.

The major aquifers in the district are formed by alluvium and Deccan Trap basalt with Tertiary formations occupying a small patch. The alluvium occurs in the western part of the district and along the streams whereas in eastern parts weathered and fractured basalt form aquifers. hydrogeological units:

1. Fissure Formations:
2. Porous Formation:

Fissure Formations

Deccan Traps from the aquifers in north-eastern, eastern and south eastern parts of the district comprising Mangrol, Mandvi, Vyara, Valod Mahuva, Songadh, Uchchhal and Nizar talukas. The ground water occurs in unconfined to semi-confined conditions. The occurrence and movement of ground water is governed by the thickness and extent of weathered zone and presence of fractures and joints. At places, dykes act as ground water barriers and restrict the flow of ground water. On the other, at places, the dykes themselves from good aquifers owing to deeper levels of weathering in them.

Depths of dug wells in Deccan traps ranges from less than 2m to 25m with maximum number of wells, about 80%, being 5 to 15m deep. The depths to water levels in the dug wells range from 1 to 20m. However, in 90% of the wells, the water levels are less than 10m. bgl. Yields of the dug wells are low to moderate in central parts whereas they are low to very low on the hill slopes. The dug wells generally sustain pumping for 4 to 5 hours at the yields of 50 to 150 m^3/day. Recuperation of water levels is generally slow.

Alluvium

The western and north western parts of the district comprising Choryasi, Olpad, Kamrej, Palsana and parts of Bardoli talukas is covered by Alluvium. This aquifer can broadly be demarcated into two zones namely newer alluvium and older alluvium. The newer alluvium is present along the river courses and comprises fine to coarse grained sand trap wash with cay intercalations. The sand is unconsolidated but shows some degree of cohesion at places. Water levels are in general deeper in newer alluvium. Older alluvium is present in inter river plains and comprises sand, clay, kankar, grave and silt. The ground water occurs mostly under unconfined conditions but at places semi-confined conditions are also observed, probably due to presence of clay lenses.

The depths of the wells in alluvium generally range from 3.0 to 30.0m with some of the wells having bores down to 50m below bottom of the wells. The maximum number of wells, about 80% are 5 to 20m deep. Depths to water levels in the wells range from 0.5 to 15m bgl about 90% wells shows water levels less than 10m bgl. Yields of the dug wells and dug-cum- bored wells range between 100 and 450 m^3/day.

5.2 Aquifer Parameters

The aquifer parameters data available with CGWB from the exploration carried out in different parts of the district was taken into the consideration.

In Alluvial areas the depth of the tube wells range from 36 to 169m with piezometric levels varying between 2 to 10m. The specific capacity of the wells ranges from 19 to 1658 m^3/day/m. The transmissivity values obtained at these tube wells ranges from 104 (Kosad) to 2965m^2/day (Vihan).

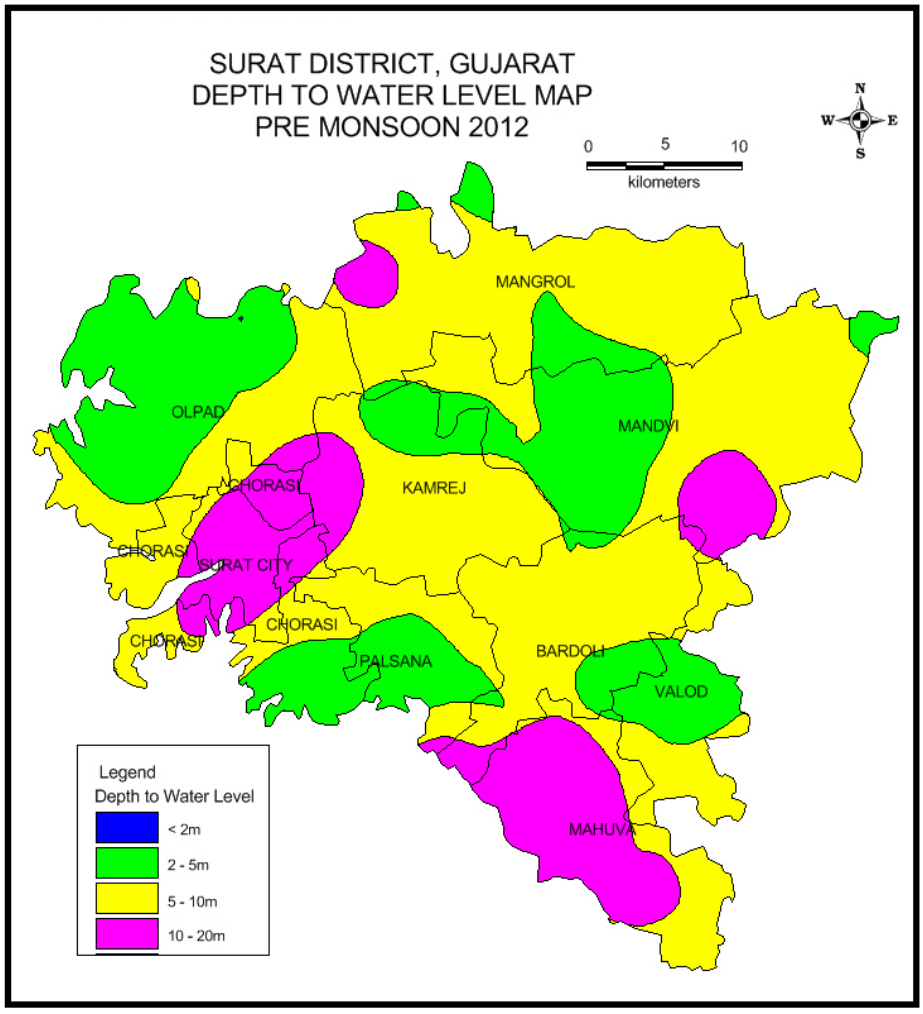
5.3 Behaviour of Water Levels

The behaviour of water levels was studied based on the water level data collected from the National Network of Hydrograph Stations (NNHS). There are a total number of 23 monitoring stations in the district. Their data has been used for preparation of various hydrogeological maps. The water level data for year 2012 of NHS established in the district is given in Annexure-II.

5.3.1 Depth to Water Level

The map depicting the depth to water level (Figure 4 & 5) has been prepared based on water level data for May and November 2012 collected from NNHS.

Figure-4

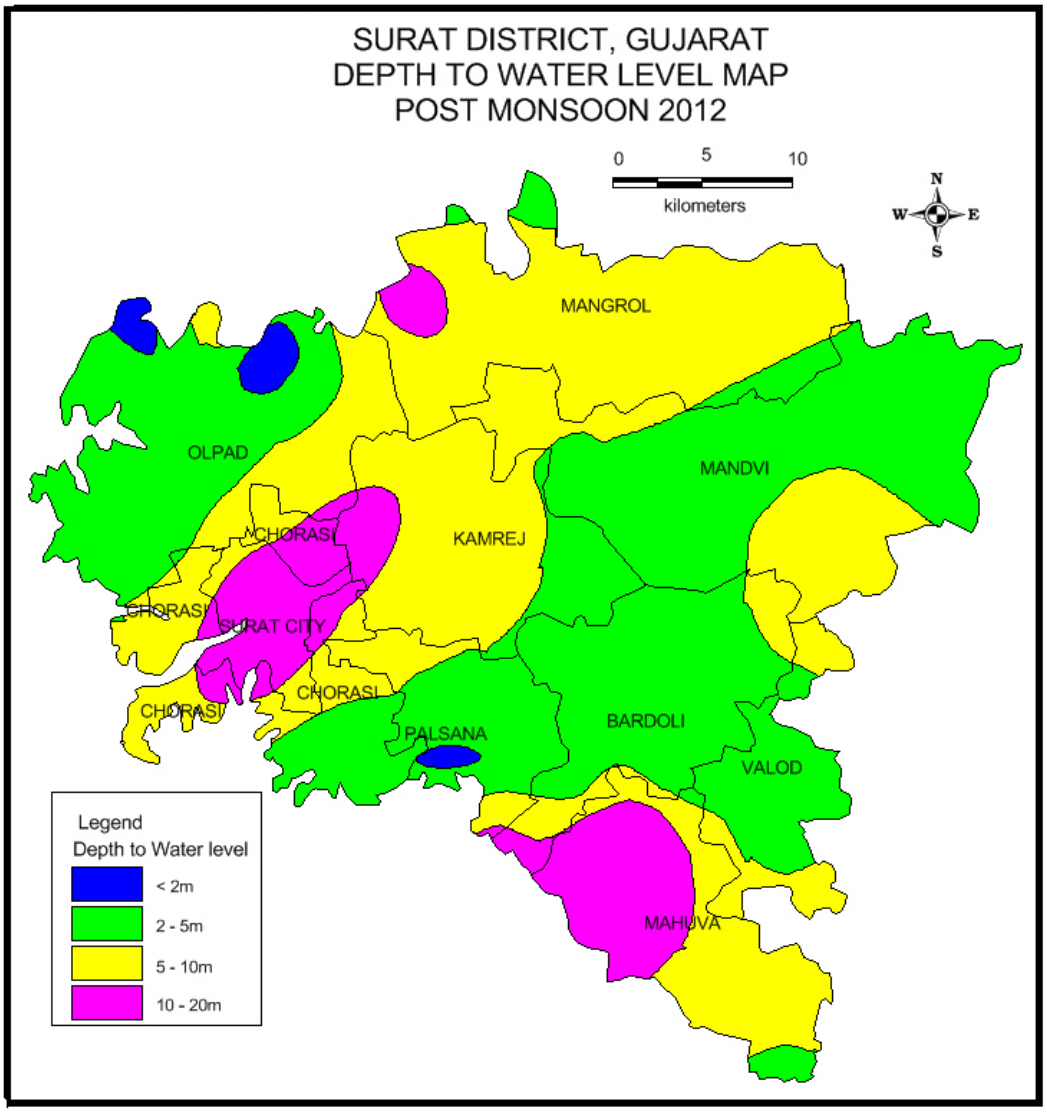


The depth to water level ranges from 2.48m (Palsana) to 17.75m (Mahuva 2) during May2012. Spatially, the depth to water level in the district ranges between 2m to 20m during May 2012. The major area of the district is covered by the water level of 5m to 10m bgl . There are seven isolated pockets in the district which shows the water level ranging between 2 to 5m. Similarly, there are four isolated pockets in the district which shows the

water level ranging between 10 to 20m. There is no area where the water level of less than 2m and more than 20 meter seen (Figure -4).

The depth to water level ranges from 0.1.39m (Palsana) to 16.55m (Mahuva2) during November2012. Spatially, the depth to water level in the district ranges between less than 2m to nearly 20m during November 2012. In the major part of the district the water level ranges between 2 m and 5 m bgl. The water level ranging between 5m and 10 m bgl is found in considerably in larger part of the district. There are three isolated and pockets in the district where the water level of less than 2 m is also observed. Similarly water level ranging between 10 to 20m is seen in three isolated pockets in the district (Figure-5).

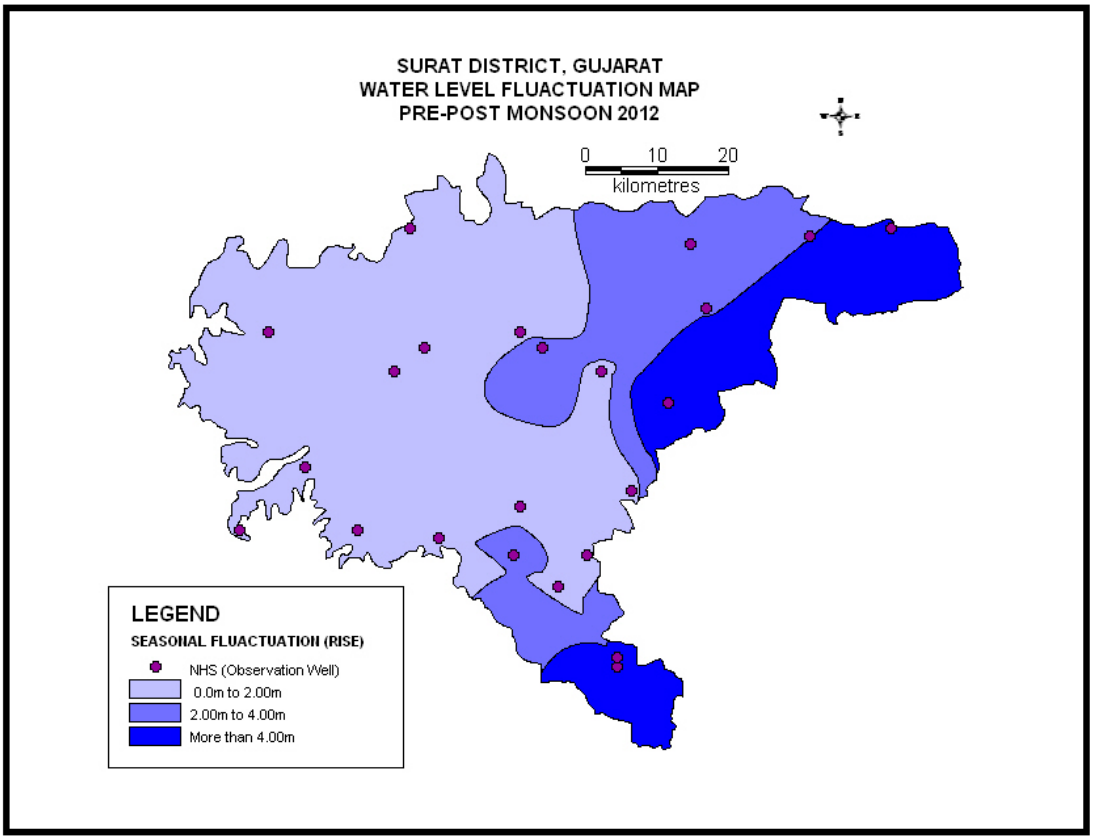
Figure -5



5.3.2 Rise And Fall In Water Levels.

Rise and fall in water levels between May 2012 and November 2012 has been shown in Figure -6. The whole district shows the rise of water level of different ranges. In major part covering nearly 59% of the district shows the rise of water level up to 2m. Nearly 23% of the district shows the rise of water level between 2m to 4 m. Whereas 18% of the area of the district shows the rise of water of more than 4m as shown in Figure-6

Figure-6



5.4 Changes in Ground Water Scenario over the years

Long term water level data is available for 24 NNHS since 2003 and data was analysed for the period between January 2003 to November 2012 and water level trend for various period (pre-monsoon and post-monsoon period trend) is shown in table -IV

Pre-monsoon water level trend shows that 22% of the hydrograph stations indicate a rise of water level ranging from 0.0331 m/year to 0.338m/year where as 78% of the hydrograph stations indicate a decline of water level ranging from 0.0037 m/year to 0.4293 m/year. During post- monsoon period water level trend shows that 39 % of the hydrograph stations indicate a rise of water level ranging from 0.0202 m/year to 0.447 m/year where as 61% of the hydrograph stations indicate a decline of water level ranging from 0.0058 m/year to 0.6439 m/year as tabulated below:-

Table :-IV Long Term Trend of Water level
(Period 1st Jan. 2003 to 30th Nov. 2012)

S No	Location	Pre-monsoon		Data Points	Post-monsoon		Data Points
		Rise (m/yr)	Fall (m/yr)		Rise (m/yr)	Fall (m/yr)	
1	Allu		0.1968	20		0.0802	18
2	Asarma		0.1064	9		0.2194	7
3	Chavada	0.0579		14	0.055		17
5	Jhankhavav		0.0433	17		0.0903	18
6	Juna umarpada		0.0543	18	0.0002		19
7	Kasal		0.0398	20		0.033	20
8	Kathor		0.2302	20		0.6439	20
9	Madhi		0.0388	15		0.0058	20
10	Mahuva2		0.0492	16		0.2277	19
11	Malda	0.1563		18	0.1983		19
12	Mandvi2		0.0037	19		0.1569	20
13	Navi pardi		0.0764	20		0.2293	20
14	Nogama	0.0331		19	0.0133		20
15	Olpad2		0.198	20		0.1407	20
16	Palsana		0.0242	20		0.0599	20
17	Pankheda		0.4293	10		0.1418	9
18	Puna1		0.1363	20		0.22	19
19	Sachin town	0.338		20	0.447		20
20	Sarbhon	0.1198		20	0.0627		20
21	Sultanabad		0.1379	19		0.0245	18
22	Ten-bardoli		0.1643	20	0.0431		19
23	Ushker		0.0188	20	0.0574		18
24	Wadoli		0.1297	19	0.0212		17
	Percentage Rise/Fall	**21.739**	**78.261**	**-**	**39.130**	**60.870**	**-**

5.5 Ground Water Resources

The Ground Water Resources and Irrigation Potential of the district were calculated as on March 2009 in collaboration with the Government of Gujarat using the methodology suggested by "Ground Water Estimation Committee (GEC-97). These resources were computed after reorganisation of the districts. The ground water resources for different Talukas of the district are given in the Table –V& VI.

The annual ground water recharge varies from 1196.67 ha m. in Umarpada Taluka to 17167.38 ha m. in Olpad Taluka and total gross recharge for the district is 112093.77 ha m. The net available recharge, after leaving natural discharge for non monsoon period varies from 1077.07 (Umarpad) to 16888.01 ha m. (Olpad), the recharge for district is 103440.91 ha m.

5.5.1 Ground Water Draft

The Table –III also shows the Draft from Irrigation and Domestic/Industrial sources. The gross draft in the district is 41777.90 ha m. and varies from 309.0 ha m. (Umarpada) to 8950.0 ha m. (Kamrej).

5.5.2 Ground Water Balance for Irrigation

The irrigation potential available for future use for ground water has been computed leaving the ground water projected for allocation for the domestic and industrial requirements (Next 25 years) for all the talukas. The ground water available for future irrigation varies from 718.07 ha m. in Umarpada Taluka to 12889.5 ha m. in Olpad Taluka and total ground water balance for irrigation for the district is 59271.01 ha m.

5.5.3 Level of Ground Water Development & Stage

The level of Ground Water Development varies from 20.14% (Olpad Taluka) to 77.72% (Choriyasi Taluka.) and overall Level of Development for the district is 40.39 %. The overall category of the district is also "Safe"

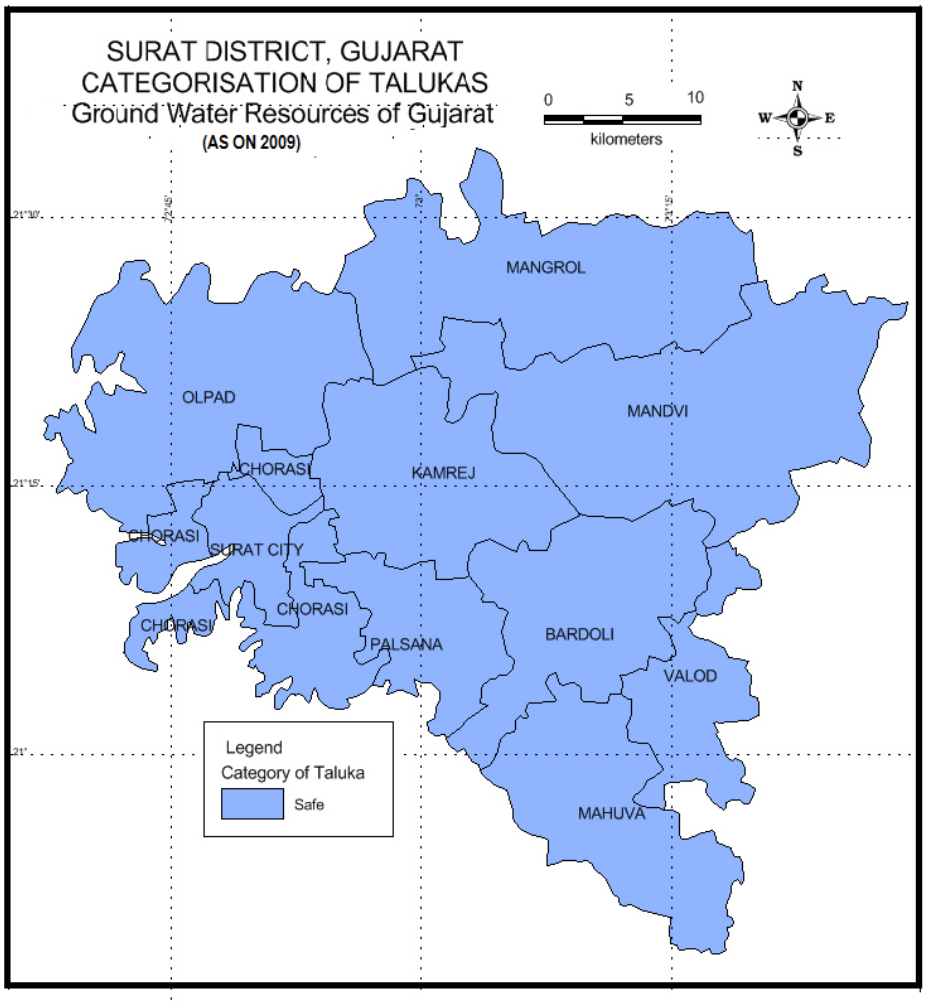
Table :-V Ground Water Resources Potentials as on 2009

S. No	Taluka	Annual Ground Water Recharge	Natural Discharge During Non-Monsoon	Net Annual Available Ground Water (3-4)	Existing Draft for Domestic and industrial Water Supply	Ground Water Draft for Irrigation	Existing Gross Draft For All Uses (6+7)
		(Ha m)	(Ha m)	(Ha m)	(Ha m)	(Ha m)	(Ha m)
1	2	3	4	5	6	7	8
1	Olpad	17167.38	858.37	16309.01	336.00	2948.50	3284.50
2	Choriyasi	10134.66	506.73	9627.93	3702.00	3780.50	7482.50
3	Mangrol	14277.13	713.86	13563.27	313.00	1413.00	1726.00
4	Umarpada	1196.67	119.67	1077.07	123.00	186.00	309.00
5	Mandvi	13845.31	1384.53	12460.78	337.00	2676.00	3013.00
6	Palsana	9551.89	477.59	9074.30	215.00	5225.50	5440.50
7	Bardoli	18765.34	1876.53	16888.81	381.00	7176.00	7557.00
8	Kamrej	15944.88	1594.49	14350.39	312.00	8638.00	8950.00
9	Mahuva	11210.39	1121.04	10089.35	258.00	3757.40	4015.40
	Total	**112093.73**	**8652.82**	**103440.91**	**5977.00**	**35800.90**	**41777.90**

Table :- VI Stage of Ground Water Development

S. No.	Taluka	Net Annual Available Ground Water	Allocation for Domestic and Industrial Requirement (Next 25 Years)	Net Ground Water Availability for future Irrigation	Level of Ground Water Development	Stage of Development
		(Ha m)	(Ha m)	(Ha m)	(%)	
1	2	9	10	11	12	13
1	Olpad	16309.01	471.00	12889.51	20.14	Safe
2	Choriyasi	9627.93	5188.00	659.43	77.72	Safe
3	Mangrol	13563.27	431.00	11719.27	12.73	Safe
4	Umarpada	1077.07	173.00	718.07	28.69	Safe
5	Mandvi	12460.78	472.00	9312.78	24.18	Safe
6	Palsana	9074.30	301.00	3547.80	59.96	Safe
7	Bardoli	16888.81	535.00	9177.81	44.75	Safe
8	Kamrej	14350.39	437.00	5275.39	62.37	Safe
9	Mahuva	10089.35	361.00	5970.95	39.80	Safe
	Total	**103440.91**	**8369.00**	**59271.01**	**40.39**	**Safe**

Figure-7



6.0 GROUND WATER QUALITY

6.1 Quality of Shallow Ground Water

The quality of ground water in the shallow aquifer has been studied based on the chemical analysis of water samples collected from NHS during May 2012. Data for a total number of 15 samples (including Alluvium/Soft Rock and Deccan trap) are available. The analysis of water samples indicates that the ground water is relatively more saline in coastal part comparing to other parts of the district. Statistical analysis of these are presented in Table - VII

Table:- VII Statistical Analysis of Chemical Constituents

Constituents	(Shallow Aquifer)			
	Number	Min	Max	Average
pH	15	7.8	8.6	8.2
EC (µS/cm)	15	510	3754	1283
TDS	15	342	2515	860
CO3	15	0	72	5
HCO_3 (mg/l)	15	24	734	368
Cl (mg/l)	15	21	1172	198
NO_3 (mg/l)	15	4	145	30
SO_4 (mg/l)	15	7	242	76
F (mg/l)	15	0	2	1
Alkalinity	15	140	602	309
Ca (mg/l)	15	24	260	67
Mg (mg/l)	15	19	171	54
TH (mg/l)	15	200	1350	413
Na (mg/l)	15	26	380	129
K (mg/l)	15	0.20	81.40	13.19
Fe	15	0.14	0.86	0.27
SAR (mg/l)	15	0.69	8.79	2.87

6.1.1 Quality of Water from Deeper Aquifers

The quality of ground water for the deeper aquifers is available form the Exploratory wells and piezometers drilled by CGWB during ground water exploration in Surat district. Statistical Analysis of Chemical Constituents (Deeper Aquifers) is in the table below:-

Table -VIII Statistical Analysis of Chemical Constituents (Deeper Aquifers)

Hard Rock			
Constituent	**Number**	**Min**	**Max**
EC (µS/cm)	09	590	1530
Cl (mg/l)	09	50	383

The ground water quality data for the basaltic areas of Surat district indicates that the electrical conductivity ranges from 590 µS/cm to 1530 µS/cm.

7.0 GROUND WATER DEVELOPMENT AND MANAGEMENT

7.1 Ground Water Development

1. Primary sources of irrigation in the district are dug wells and canals. No area is irrigated by tanks and ponds. In 2002-2003, 21053 dug wells were being used for irrigation. As reported by the agricultural department of Govt. of Gujarat, there is no tube wells in the district.

2. All the geological formations occurring in the district form the aquifer, however, the Deccan Trap are the most extensive aquifers in the district. Deccan traps are found in north-eastern, eastern and south-eastern parts of the district comprising of Mangrol, Mandvi, Vyara, Valod, Mahuva, Songadh, Uchchhal and Nizar talukas. The ground water occurs in phreatic to semi-confined conditions. According to hydrogeological survey carried out in this area the depth of dug well in Deccan traps range between less than 2m to 25 m. The majority of the dug (nearly 80%) wells have depth range between 5m and 15m. The depth to water level in these wells ranges between 1m and 10m. However, in 90% of wells the water level of less than 10m is recorded. The yield of these well varies from $50m^3$/day to $150m^3$/day with the maximum sustainable pumping of 4 to 5 hours.

3. The ground water in the deeper aquifers occur under semi-confined to confined conditions. The hydrogeological data and aquifer parameters of some of the tube wells/ piezometers reveals that the deepest exploratory borehole was drilled down to the depth of 304.86m at Koshamada. However, the production tube wells in the district are constructed at shallow depth because of the salinity existing at the deeper levels. The depth of the tube ranges between 36m and 169m with the piezometer surface varying between 2 to 10 m. The specific capacity of the tube well ranges between 19 to 1658 m^3/d/m. The value of Coefficient of Transmissivity obtained at these tube wells ranges between 104 (Kosad) to 2965 m^2/day (Vihan).

4. The annual ground water recharge varies from 1196.67 ha m. in Umarpada Taluka to 17167.38 ha m. in Olpad Taluka and total gross recharge for the district is 112093.77 ha m. The net available recharge, after leaving natural discharge for non monsoon period varies from 1077.07 (Umarpad) to 16888.01 ha m. (Olpad), the recharge for district is 103440.91 ha m. The Draft from Irrigation and Domestic/Industrial sources. The gross draft in the district is 41777.90 ha m. and varies from 309.0 ha m. (Umarpada) to 8950.0 ha m. (Kamrej). The ground water available for future irrigation varies from 718.07 ha m. in Umarpada Taluka to 12889.5 ha m. in Olpad Taluka and total ground water balance for irrigation for the district is 59271.01 ha m.

5. The level of Ground Water Development varies from 20.14% (Olpad Taluka) to 77.72% (Choriyasi Taluka.) and overall Level of Development for the district is 40.39 %. The overall category of the district is also “Safe”

7.2 Water Conservation & Artificial Recharge

1. In the eastern part of the district, in the Deccan trap area, the yield of wells are comparatively poor. Since the rain fall in these part is generally high, suitable measures

to augment the ground water resource may be adopted. Such measures could be contour bunding, gully plugging, small, check dams and bhandaras.

2. The surplus ground water potential may be utilized by construction of different ground water exploitation structures in favorable areas. Favorable locations for ground water structure are valley floors, valley fill area, large plateaus, amphitheatrical valleys meeting point of two or more nalas. Also where there is convergence of valley lines or where the drainage from different dimensions in the surrounding region turned into a narrow catchment, the area can be favorable site for ground water structure.
3. In urban areas roof top rain water structures should be constructed on mandatory ground. In the higher plateau areas, rain water harvesting structures associated with storage tank can be constructed for domestic purpose since other sources would not be feasible .
4. During monsoon period all the irrigation wells can be recharged by diverting monsoon runoff of each agricultural plots to the irrigation wells by constructing water channels. Recharge wells can be constructed in all the public parks and monsoon runoff can be diverted to these wells.

7.3 Ground Water Related Problems

1. The deeper aquifers in the alluvial parts of the district are saline (The deepest exploratory borehole was drilled down to the depth of 304.86m at Koshamada.).The production tube wells in the district are constructed at shallow depth because of the salinity existing at the deeper levels. The depth of the tube ranges between 36m and 169m with the piezometer surface varying between 2 to 10 m.
2. However, there is a chance that excessive withdrawal water from tube wells may result from salinity ingress which may deteoriate the ground water quality particularly in area adjoining the sea coast.

8.0 Recommendations

1. In the eastern part of the district, in the Deccan trap area, the yield of wells are comparatively poor. Since the rain fall in these part is generally high, suitable measures to augment the ground water resource may be adopted. Such measures could be contour bunding, gully plugging, small, check dams and bhandaras.

2. The surplus ground water potential may be utilized by construction of different ground water exploitation structures in favorable areas. Favorable locations for ground water structure are valley floors, valley fill area, large plateaus, amphitheatrical valleys meeting point of two or more nalas. Also where there is convergence of valley lines or where the drainage from different dimensions in the surrounding region tunned into a narrow catchment, the area can be favorable site for ground water structure.

3. In urban areas roof top rain water structures should be constructed on mandatory ground. In the higher plateau areas, rain water harvesting structures associated with storage tank can be constructed for domestic purpose since other sources would not be feasible .

4. During monsoon period all the irrigation wells can be recharged by diverting monsoon runoff of each agricultural plots to the irrigation wells by constructing water channels. Recharge wells can be constructed in all the public parks and monsoon runoff can be diverted to these wells.

5. The deeper aquifers in the alluvial parts of the district are saline (The deepest exploratory borehole was drilled down to the depth of 304.86m at Koshamada.).The production tube wells in the district are constructed at shallow depth because of the salinity existing at the deeper levels. However, there is a chance that excessive withdrawal water from tube wells may result from salinity ingress which may deteriorate the ground water quality particularly in area adjoining the sea coast. It is therefore, recommended that rate discharge from these area may be maintained in such a way that relationship/cushion between fresh and saline water may not be disturbed.

Annexure-I

RAIN FALL DATA AND ITS ANALYSIS

	Bardoli	Kamrej	Mahuva	Mandvi	Mangrol	Olpad	Choryasi	Palsana	Umarpada
	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)
Year	1	2	3	4	5	6	7	8	9
1963	1404	1545	1743	1965	1480	978	1220	1361	1480
1964	2244	1679	2050	2637	1513	1490	2084	1061	1513
1965	1067	856	1011	1469	942	530	931	1033	942
1966	1339	870	1154	1456	986	801	1008	1254	986
1967	1198	944	1360	1047	1062	720	1095	1022	1062
1968	1248	1993	925	1058	923	733	968	1351	923
1969	1135	751	1357	1420	934	464	876	1214	934
1970	2363	1871	3529	2807	1764	1399	1151	2743	1764
1971	1309	887	1630	1465	1329	779	918	1360	1329
1972	855	736	802	932	625	599	565	1046	625
1973	1406	1254	1392	1598	1758	1025	1209	1555	1756
1974	619	678	1182	761	527	533	626	599	527
1975	1742	1384	1862	1842	1362	903	1662	1685	1362
1976	2698	2524	1999	2899	2640	1939	2299	2501	2640
1977	1735	1202	1487	1592	1040	853	1155	1771	1040
1978	1103	922	943	1191	1225	636	1215	1029	1225
1979	1621	1235	1368	1412	1035	1066	1512	1812	1035
1980	985	971	938	1023	986	864	1018	1174	986
1981	1597	1946	1771	1570	1127	806	1260	1840	1127
1982	958	871	1056	992	711	485	1158	1241	711
1983	2286	1986	2254	1917	1816	1279	2806	2337	1816
1984	1173	1084	1194	1179	829	678	1027	1066	829
1985	874	551	931	711	814	538	806	1160	814
1986	918	1093	1241	778	763	605	722	1020	763
1987	1550	773	774	438	554	409	616	707	554
1988	2338	2543	2176	1887	1934	1522	2298	2361	1934
1989	1068	1055	1254	916	1008	560	671	1092	1008
1990	1349	1224	1370	1170	1172	553	1043	1176	1172
1991	739	745	954	1162	776	552	734	809	776
1992	1637	1218	1564	700	2198	920	2169	1927	2198
1993	1466	1386	1611	1569	1492	848	986	1483	1492
1994	3146	2180	1699	1964	1892	1415	1797	2142	1892
1995	1352	935	1121	1148	688	645	1311	1294	688
1996	378	495	545	1039	349	422	659	451	349
1997	1362	1067	1151	1881	1062	651	1029	1046	1062
1998	1501	1158	1639	1719	1306	1032	1095	1309	1306
1999	1059	982	1252	1728	1070	627	1442	1042	1070
2000	981	680	917	1072	913	495	940	833	913

2001	1454	933	1815	2365	1142	695	1006	1258	1142
2002	738	900	1175	588	1042	869	528	952	1042
2003	1883	1795	2437	2165	1736	1124	1755	1804	1736
2004	1947	1518	2002	2123	1268	1255	1676	1817	1268
2005	2362	2476	2605	2012	1680	1421	1999	2326	1650
2006	1691	2356	1997	2024	2041	1266	1333	1535	2877
2007	1425	2342	1639	1353	1432	1477	1640	1457	1968
2008	1687	1501	1644	1641	1311	1320	1244	1565	2018
2009	1450	1618	1871	959	933	988	1328	1464	2396
2010	1933	1612	1750	-	991	1493	1797	-	1720
2011	-	1497	542	-	995	-	543	-	-
2012	-	838	-	-	447	-	682	-	-
Avrg	**1466.1**	**1313.2**	**1483.3**	**1475.4**	**1192.5**	**901.29**	**1232.2**	**1406.1**	**1300.42**
Min	**378.00**	**495.00**	**542.00**	**438.00**	**349.00**	**409.00**	**528.00**	**451.00**	**349.00**
Max	**3146**	**2543**	**3529**	**2899**	**2640**	**1939**	**2806**	**2743**	**2877**
St Devi	**558.53**	**556.42**	**561.49**	**577.16**	**475.53**	**368.62**	**519.12**	**509.55**	**561.981**
C-Va	**38.096**	**42.371**	**37.854**	**39.119**	**39.878**	**40.899**	**42.128**	**36.239**	**43.2154**

Note: Avrg= Average; Min= Minimum; Max= Maximum; St Dev= Standard Deviation and C-Va = Coefficient of variation

Annexure-II

DEPTH TO WATER LEVELS PRE & POST MONSOON PERIOD (2012)

S No	Location	Pre-monsoon	Post-monsoon	Fluctuation (m)
		DTW (m) bgl.	DTW (m) bgl.	
1	Allu	4.06	2.75	1.31
2	Chavada	4.30	1.76	2.54
	Jhankhavav	9.50	5.09	4.41
5	Jhankhavav	7.40	5.03	2.37
6	Juna umarpada	5.96	2.00	3.96
7	Kasal	5.99	2.62	3.37
8	Kathor	12.83	11.00	1.83
9	Madhi	5.43	3.78	1.65
10	Mahuva2	17.75	16.55	1.20
11	Malda	6.15	2.25	3.90
12	Mandvi2	13.89	6.36	7.53
13	Navi pardi	3.75	1.97	1.78
14	Nogama	3.66	1.94	1.72
15	Olpad2	2.67	1.86	0.81
16	Palsana	2.48	1.39	1.09
18	Puna1	10.20	6.00	4.20
	Purna	12.81	8.38	4.43
19	Sachin town	3.59	2.71	0.88
20	Sarbhon	5.61	2.19	3.42
21	Sultanabad	5.84	5.00	0.84
22	Ten-bardoli	6.77	3.65	3.12
23	Ushker	5.26	3.97	1.29
	Max	17.75	16.55	7.53
	Min	2.48	1.39	0.81