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Technical Report Series

GROUNDWATER BROCHURE

BHAVNAGAR DISTRICT

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Profile of Bhavnagar District – Gujarat State

Sr No.	Particular / Items	
1	**General Information** i. Geographic Area (Sq km) : 9980.9 Sq Km ii. Administrative Units : 11Taluaka – Bhavnagar, Botad, Gadhada, Sihor, Umarana, Gariyadhar, Palitana, Mahuva, Talaja, Ghogha&Vallbhipur iii. No of Villages / Towns :793 Villages ; 10 Statutory Towns and 11 Census Towns. iv. Population (2011 Census) : 28,77,961 ; 14,90,465Males&13,87,496Females ; Decennial Growth Rate of population 16.53 % v. Climate : Semi-arid vi. Normal Rainfall : 598.40 mm	
2	**Physiographic Features** i. Physiographic Zones :Coastal marshes ,sandy areas,hilly upland area ,hill ranges,inland Plain & Coastal Plain ii. Drainage :Shetrunji, Ranghola and Kaludhar	
3	**Agriculture & Irrigation** i. Area Reported for Land Use : 857945 ha ii. Gross cropped area: 582001 ha iii. Forest: 26924 ha iv. Irrigation Sources(surface water) a. Canal Network Length : 310.58 km b. Irrigation schemes : 1 major, 14 medium and 53 mino c. Area : 12,9615 ha	
4	**Geology & Hydrogeology** i. Major Geological Formation : Deccan Trap & Alluvium ii. Aquifer System: Both Unconfined & Semi to Confined system in Deccan Trap and Alluvium Formation iii. Groundwater Monitoring : 36 Open wells &12 Piezometers iv. Depth to water level : 1.99 to 30.10 m bgl(Pre monsoon) and 1.37 to 21.76 m bgl (Post monsoon) v. Groundwater Quality : Fresh to saline vi. Groundwater Exploration : Exploration up to 94 m at 67 locations; 42 Exploration Wells ,16 Observation Wells , 9 Piezometers vii. Groundwater Resources : a. Total Annual Ground Water Recharge : 942.7954 mcm b. Net Annual Ground Water Availability : 895.6557 mcm c. Gross Annual Draft : 573.7140 mcm	

	d. Stage of Ground Water Development 64.06 % - Safe Category i. Bhavnagar : 69.72 % - Safe Category ii. Botad : 65.71 % - Safe Category iii. Gadhadha : 69.13 % - Safe Category iv. Gariyadhar : 54.00 % - Safe Category v. Ghogha : 68.02 % - Safe Category vi. Mahuva: 63.87%-Safe Category vii. Palitana:68.33%- Safe Category viii. Sihor: 66.25%- Safe Category ix. Talaja : 61.36%- Safe Category x. Umrala: 68.41%- Safe Category xi. Vallabhipur: 40.74%- Safe Category	
5	Awareness & Training Activity of CGWB i. Mass Awareness Program Organized : 1 ii. Water Management Training Program Organized : 1	
6	Artificial Recharge Work i. Project /Work Undertaken : Nil ii. Feasibility of AR Work : potential for construction of various recharge structures like check dams, recharge shaft, subsurface dam ; percolation tanks and recharge through dug wells / tube wells.	
7	Groundwater Development Regulation i. Notified Area / Blocks : Nil ii. Measures Required : a. Regulation for further development in eastern& southern part – coastal zone having limited thickness of fresh quality aquifer b. Specific Monitoring Network to ascertain impact of development activity and extent of pollution	
8	Major Groundwater Related Issues i. Uneven distribution and development of ground water resources ii. Quality constraint in alluvium areas and variable yield constraint in hard rock areas. iii. Coastal zone aquifer having limited thickness of fresh quality ground water iv. Possibility of groundwater pollution due to industrial effluent of the district	

INTRODUCTION

Bhavnagar district is one of the most developed districts of Saurashtra region of Gujarat State. Its district headquarter is located in Bhavnagar city. Bhavnagar was founded by BhavsinhjiGohil (1703-64 AD) in 1723 AD near the Gulf of Khambhat, on a carefully chosen strategic location having potential of maritime trade. Bhavnagaris bordered by Ahmedabad and Surendranagar districts in the North, the Gulf of Cambay in the East and South, and Amreli and Rajkot districts in the West.

LOCATION

Bhavnagar district has the area of 9980.9 Sq km and is located in southern part of the Saurashtra Region of Gujarat State. It lies between north latitude $21^{o}18^{'}$ and $22^{o}18^{'}$ and east longitudes $71^{o}15^{'}$ and $72^{o}18^{'}$.It falls in the Survey of India (SOI) degreesheets 41O and 46 C. District Bhavnagar is bounded by Surendranagar and Ahmedabad districts of Gujarat in the north, Rajkot and Amreli districts of Gujarat in the west, Arabian Sea and part of Amreli district in the south and the Gulf of Cambay (Gulf of Kambhat) in the east. Administratively, the district is divided into eleventalukas viz., Bhavnagar,

DEMOGRAPHY

According to the 2011 census the total population of Bhavnagar district is 2,877,961persons,Out of this,1,490,465 are males and 1,387,496 are females. The density of population is 288 souls per sq.km and the decadal growth ratefor 2001-11 is 16.53%. The literacy rate has gone up from 78.02% (2001) to 86.15% (2011) for males and 53.73% (2001) to 66.92% (2011) for females.

LAND USE PATTERN

As per *Seasons & Crops Record*,8,57,945hectares of land, excluding all type of forest & hilly terrain areas, is accounted for land use record. Brief accountof land use classification forBhavnagardistrict,is given in table

Details of Land Use – Bhavnagar District Source : Agriculture Directorate Govt of Gujarat

Sr No	Land Use Classification	Area in Hectare
1	Geographic Area	857945
2	Forest Area	26924
3	Barren and uncultarabale land	98557
4	Land put to nonagricultural uses	59782
5	Permanent pasture and other grazing land	61188
6	Culturable waste	601394
7	Current fallows	61940
8	Net sown area	548535
9	Area sown more than once	33466
10	Gross cropped area	582001

IRRIGATION & AGRICULTURE

The irrigated area is broadly classified into four classification namely irrigation by (a) canal, (b) tank, (c) well (including tubewell) and (d) other sources (like Khettalavadi ,Boribandh, Checkdam etc.). The area irrigated and cropping intensity of the Bhavnagar Disrtict is given in table below. It is seen that the gross irrigated area in Bhavnagar District is 194087 Hectares which is 64.10 percent of the gross cultivated area. Groundwater is the main source of irrigation. Dugwells and tubewells are the major source of draft. It is interesting to note that the talukawise cropping intensity and intensity of irrigated cropping is more than 100% for every taluka of the district.The crop is divided into two major parts for statistical purpose namely Food and Non-Food crops. The main food crops of the district are Bajra, Wheat and Maize. The main non-food crops are Cotton, Groundnut, Til and Fodder.

Industries

There are 112 medium and large scale industries locatedin Bhavnagar district. The industries includediamond cutting & polishing, cement &gypsum, inorganic salt-based and marine chemicals, shipbuilding,ship-repairs, oxygen, foundry, re-rolling, ceramics,fabrication and food processing industries. Some salient features of Industries in Bhavnagar is as follows

- Bhavnagar stands second in diamond cutting & polishing industry after Surat in India, with 6,000 unitsoperating from the district and employing more than 3 lakh people
- Bhavnagar is the largest producer of salt, with 34,500 tons of salt being produced annually in the district

- Bhavnagar manufactures FRP (Fiberglass Reinforced Plastic) boats and steel vessels at ship buildingfacility of Alcock Ashdown (Gujarat) Ltd
- At Alang, Bhavnagar houses the largest ship breaking yard in the world
- Bhavnagar has about 150 units manufacturing plastic monofilaments, and more than 400 unitsmanufacturing plastic cloth, twine, ropes, films, and multifilament yarn
- There are 10 industrial estates located in Bhavnagar and are listed as follows

Industrial Estate		Area in Hectare
1	Vallabhipur	0.75
2	Dhasa	0.93
3	Botad	6
4	Vithalwadi	9
5	Sihor 1	12
6	Sihor 2	18.73
7	Palitana	33.95
8	Mahuva	18
9	Vartej	73.58
10	Chitra	174.71

Source: Gujarat Industrial Development Corporation, Government of Gujarat, 2007

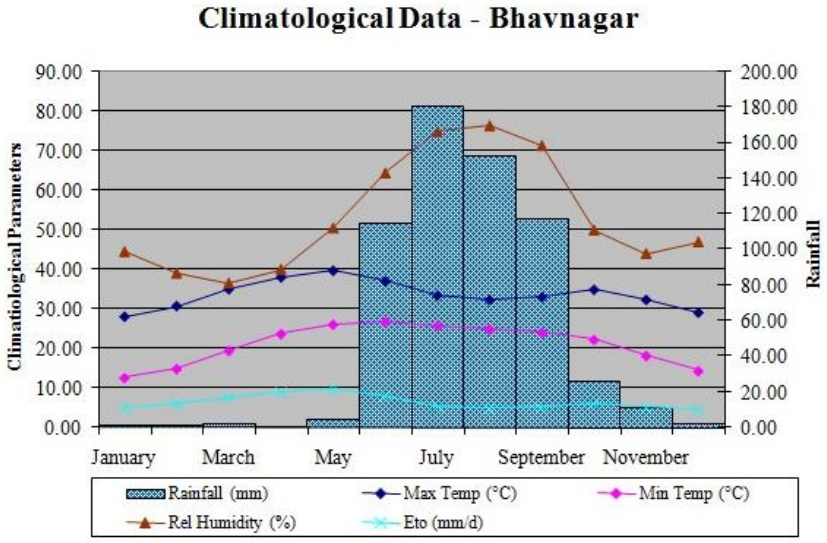
Climate

The district is characterized by a tropical climate with general dryness, except in the coastal areas. There are four seasons in a year, viz., hot season from March to May, monsoon season from June to September, post-monsoon season from October to November and cold season from December to February.

Details of climatological data as recorded at IMD, Bhavnagar is given in following table and same is depicted graphically.

Climatological Data of IMD Station , Bhavnagar

Month	**Max Temp (°C)**	**Mini Temp (°C)**	**Humidity (%)**	**Wind Spd. Kmpd**	**Sunshine (Hours)**	**Solar Rad. (MJ/m2/d)**	**Eto (mm/d)**	**Rainfall (mm)**
January	28.00	12.60	44.50	233.80	9.00	17.34	4.86	1.20
February	30.70	14.90	39.00	249.10	9.20	19.60	6.01	1.50
March	35.00	19.50	36.50	274.70	9.80	22.72	7.70	2.40
April	38.10	23.80	40.00	307.10	10.40	25.20	9.04	0.40
May	39.80	26.20	50.50	385.60	10.80	26.23	9.86	4.60
June	37.10	26.90	64.50	441.90	7.60	21.34	7.86	114.90
July	33.40	25.90	75.00	395.90	4.40	16.48	5.36	180.50
August	32.30	25.00	76.50	329.30	4.20	15.88	4.76	152.90
September	33.00	24.10	71.50	267.90	6.30	18.08	5.17	117.40
October	34.90	22.30	50.00	223.50	7.90	18.51	5.97	26.10
November	32.30	18.20	44.00	203.10	8.00	16.52	5.12	10.80
December	29.00	14.30	47.00	203.10	8.90	16.50	4.46	2.00
Total	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**614.70**
Average	**33.63**	**21.14**	**53.25**	**292.92**	**8.04**	**19.53**	**6.35**	**-**



Rainfall

The normal rainfall in the district is 598.4 mm (IMD data) and 90% of the total annual rainfall is received during the monsoon season with average of 31 rainy days in a year.

PHYSIOGRAPHY

The physiography of the district varies from place to place. It ranges from the coastal marshes and sandy areas fringing the Gulf of Cambay (Khambhat) to the hilly areas of Palitana and Sihor in the south and southeast and Botad andGadhada in the northwest. In the north-western parts of the district, hilly upland area ranges between 100 and 296 m above mean sea level (amsl) and the regional slope of the district is towards east in this parts. The height of the hill ranges in the south and southwest covering Palitana and Sihortalukas generally range from 305 and 457 m amsl. The Shetruji hills lying southwest of Palitana have the highest elevation (501 m amsl) in the district. These hill ranges lies almost parallel to the coast in a southwest - northeast direction and covers the south central part of the district of Bhavnagar. The regional slope is towards east and southeast. The regional slope of the land is towards south in the area lying south of the hill ranges upto the coast in the southern part of the district covering major part of the Muhavataluka, resulting in the river flow direction towards south in this part.

Apart from the above hill ranges of the northwest and south central parts of the district, there are two distinct physical regions in the district, namely (1) the coastal plain including the adjacent sand banks and (2) the inland plains. The coastal plains is broken with rocks and hillocks featured by several creeks along the coast while the plains in the interior are flat in places and undulating and broken by hills in other places. The hills near Chamardi (109 m amsl) and Shogadh (86 m amsl) in the northern plain raises abruptly above the plain breaking its monotony

DRAINAGE

Bhavnagar district is drained by a number of rivers, namely Shetrunjiriver and its tributiries viz., Kalubhar, Ghelo, Vagad, Kalbi, Padala, Keri, Goma, Utavli, Dhantarvadi, Surajvadi, Melan and Bagad. Most streams are ephemeral. The drainage is southeasterly except in Mahuvataluka, where it is drained by southerly flowing

streams.Shetrunji is the main river that flows towards Southeast and meets with the Arabian Sea.TheriverShetrunji drains the south-central of the district covering Gariadhar, Palitana and Talajatalukas. Originating in the Dundhi hills in the Gir, it enters the district about 1.5 km north of Karjala and flows almost towards east and northeast to east of Palitana and takes a southeasterly turn afterward and debouches in the Gulf of Cambay near Sultanpur. The total length of the river is the district is about 98 km.

The other important rivers that drain the central and northern part of the districts include the Kalubhar, Ghelo, Vagad etc. The above rivers have generally easterly and southeasterly flow and debouch in the marshy land adjoining the Gulf of Cambay in the north-eastern part of the district. The Kalubhar has a total flow length of 45 km, the Ghelo 72 km and the Vagad 38 km in the district.

A number of rivers/streams originate and flow in a southerly direction in the southern part of the district south of Shetrunji basin-divide and debouches in the Gulf of Cambay. Important among them are Dhantarvadi, Nadhi, Surajvadi, Nandh, Malan Nadi and BagadNadi.

SOILS

The soils of the district may be broadly classified into following categories

i) Medium black soils
ii) Alluvial soils
iii) Alkaline soils.

Medium black soils are wide spread and are found in all the talukas of the district, They are more productive and are rich in lime, magnesium and alumina and poor in phosphorous, nitrogen and organic matters. They can retain considerable moisture and are much suitable for agriculture.

Alluvial soils are found along the Shetrunjiriver covering parts of Gariyadhar and Palitanataluka. Soils in this area are less productive as they are saline. Alkaline soils are found in the parts of Gariyadhartaluk. They consist of both productive and non productive soils.

GEOLOGY

Geologically, 80% of the area is covered by Basalts and the remaining 20 % by alluvial formation and mudflats.The generalized geological succession is given in the following table:

Geological Succession

Era	Age	Formation	Lithology
Quaternary	Recent to Sub-Recent	Surface Soil/ Alluvium	Thick beds of calcareous clay, intercalated with layers of trap sand.
--Unconformity--			
Tertiary	Lower Eocene to Upper Cretaceous	Deccan trap	Basalt as stratified lava flows comprising amygdaloidal basalt, fine grained porphyritic basalt and basaltic/dolerite dykes.

Deccan Trap

The Deccan trap encompasses all the intrusive and extrusive acid and basic volcanic formations belonging to upper cretaceous to Paleocene (lower Eocene) age. Deccan traps form highly rugged, undulating to hilly topography and are exposed in the highest reaches, in the western and northern parts. In the plain terrain, 1 – 2 m of soils and weathered part cover these formations.

Deccan traps in this area are represented by basalts, both massive and amygdoidal or vesicular type, dolerite flows, ash beds, basaltic and dolerite dykes. Massive basalt is dark grey or steel grey in colour, very fine grained and compact.

Dykes

The district is characterized by numerous dykes that cut across the prominent feature of the landscape. These dykes vary in thickness/width from less than a meter to more than 15 meters. Number of dykes are traceable for very long distances and are both straight linear and arcuate type and seams to follow well defined fractures. Fedden (1984) concluded that majority of basaltic flows were derived from fissure eruption, now represented by dykes.

Major part of the district, about 82%, is covered by Deccan Trap lava flows. The trap rock is mostly basalt and dolerite, though, trachytes are also found. The Deccan Trap occurs in the form of lava flows with thickness of individual flows ranging from few meters to more than 30 m. Each individual lava flow can be sub divided into three distinct units - (1) grayish red clay and reddish clayey vesicular basalt, (2) vesicular and amygdaloidal basalt and (3) jointed and massive basalt.

The top of the individual flow is often marked by grayish red to reddish brown clayey material. The thickness of this horizon varies from few centimeters to few meters, at places clayey horizons up to 20 m thickness have also been observed. These horizons are insitu product of weathering and baking of basalt representing a time gap between two successive lava flows. The Vesicular/Amygdaloidal horizons range in thickness from few meters to as much as 10 m. Vesicles were formed due to escape of gas bubbles from the upper part of the flow during cooling of lava. The vesicles are generally filled with secondary minerals like calcite, zeolites and quartz. The lower most horizon of each flow is represented by jointed and massive basalt. This horizon is fine to medium grained, compact dark greenish to grey in colour and forms 60 to 70% of the flow unit. The upper part of this horizon is often jointed and fractured. At places, the massive basalt is underlain by thin amygdaloidal unit. The lava flows are generally horizontal in disposition. However, in at places, they are found to be dipping by about 7° towards SSE and SSW direction.

The Deccan Trap lava flows have been intruded by a large number of basic and acidic dykes. The basic dykes are generally composed of basalt and dolerite, whereas, the acidic dykes are generally composed of rhyolite and felsite. The dolerite dykes are generally porphyritic in nature, the dykes generally 2 to 5m thick, but dykes of as much as 250m thickness are also encountered. These dykes appear to be structurally controlled and are generally oriented in three main directions, i.e., ENE-WSW, E-W and NE-SW.
The joints in Deccan traps are also quite well developed at places. Columnar jointing is also quite common. Principal joint directions observed are N-S, E-W, NE-SW, and NW-SW. The Faults are generally not seen within the basalt out crops, however, there are indications that several faults are lying below the overlying formations. An east-west trending faults has been observed south of Shetrunji River near trap-alluvium contact.

Quaternary Formations

The Quaternary formations in the area are represented by clays fuller's earth), marls, limestones. This formation overlies deccan traps.

Recent to Sub-Recent Formations

The recent and sub-recent formations in the district are sand dunes, coastal & beach sands, tidal mud flats, coral reefs occurring in the coastal areas and fresh water alluvium occurring mainly along the rivers and streams.
The alluvium mainly occurs in the central parts of the district along the Shetrunji River. Here it has a thickness ranging from few meters to about 50 m. The alluvium which primarily rests on the basalt mainly comprise of the sand and clays along with the carbonate nodules (kankar) and weathered pieces of basalt. Weathering of basalt has also given rise to black cotton soils and generally it is difficult to distinguish between insitu weathering product of basalt and alluvium**.**

Hydrogeology

The Deccan trap and Quaternary formations form the aquifer within the district. Groundwater occurs under water table and semi confined conditions. Dug and dug cum bore well are common structures used for groundwater extraction.

Quaternary formation

The area around Panvi in the east has shallow to moderately thick quaternary formation (Post – Miocene) overlying thick Deccan trap. It

constitutes about 5 % of the total area covered and consists of clays, marl, chert and sand gravel.

Groundwater in these formations occurs under unconfined conditions. The occurrence and movement of groundwater is controlled by primary as well as secondary porosity.

The yield of the dugwells rangesfrom 170 m3/day to 800 m3/day. Lateral bores are also drilled in the dugwells to enhance the yield.

Dykes/ lineament

The presence of many dykes and lineaments in the district are suggestive of large scale tectonic disturbances experienced in the past. Dykes generally form linear hills and are demarcated due to relief. The subsurface dykes and fracture do appear in the form of lineament. The dykes in general do not form the aquifer, unless highly fractured and thus mostly act as groundwater barrier. The associated fracture zone and the basaltic formation adjacent to dykes have comparatively higher porosity.

Deccan Trap

Deccan trap basalt occupies a major part of the district and forms the most extensive aquifer system. It generally forms a poor aquifer due to compactness and poor primary porosity. However, the upper weathered parts, which at places are up to 20 m thick, form good aquifer in the district. At deeper levels, the secondary porosity developed as a result of tectonic activities, in the form of joints, and fractures, shear zones, form repository of groundwater at many places. Amygdaloidal horizons within basalt also form potential aquifers at places.

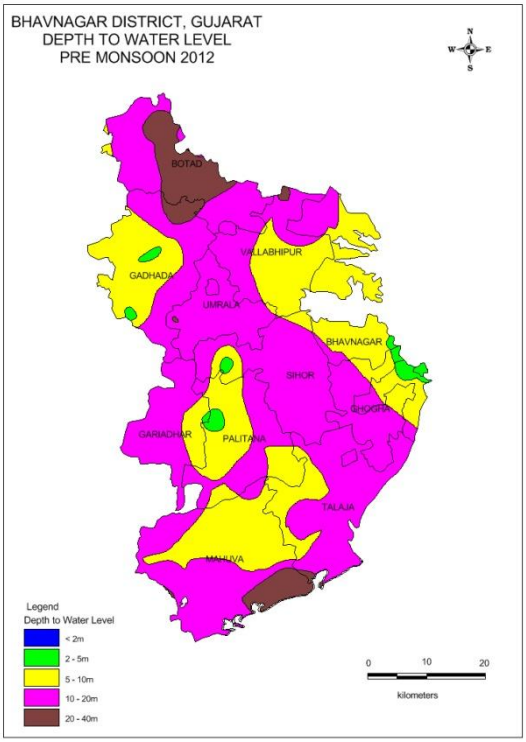
The groundwater in basalt occurs under phreatic to confined conditions. The groundwater is generally tapped through dug wells varying in depth from 5 to 30 m. At places, dug-cum-bored wells are also constructed by drilling bores below the bottom of dug wells. The yield of dug wells and dug-cum-bored wells in basalt generally range from 100 to 500 m^3/day. During Rabi (post monsoon) season these wells sustain intermittent pumping of 15 minutes to 12 hours, however, during summer, the yield of these wells is considerably low. The vesicular & amygdaloidal horizons within basalt at places may have yields of up to 1000 m^3/day.The dykes occurring in the district form aquifers at places wherever they are highly fractured. The wells in such dykes range in depth between 5 to 25 m and the yield of wells range between 15 and 600 m^3/day.

Alluvium

The alluvium forms very potential aquifer, particularly in the central part. The wells in alluvium range in depth from 4 to 50 mbgl. Drilling of horizontal bores in the wells to increase the yields is quite common practice. Such horizontal bores generally have diameter of 2.5 to 5 cm and extend laterally to 10 to 15 m. The yield of wells ranged between 10 and 820 m^3/day.

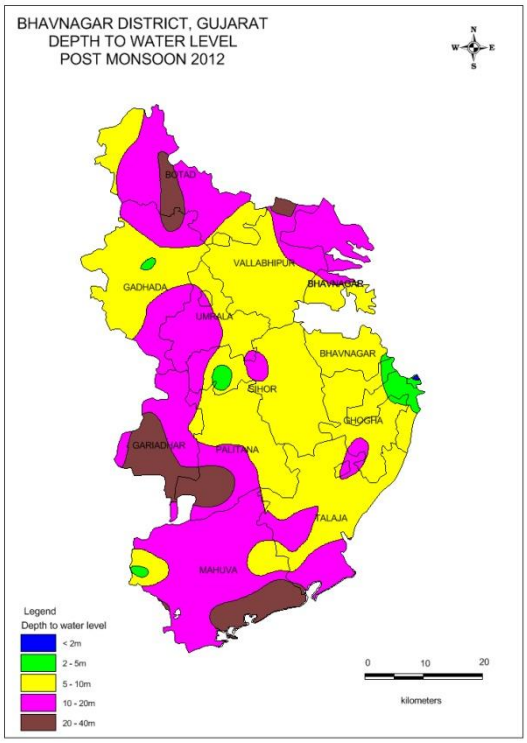
GROUNDWATER REGIME MONITORING

Ground water regime monitoring is the basic component of groundwater management, and it is carried out in Bhavnagar district four times a year, during January, May, August and November through 48 National Hydrograph Network Stations (NHS). Depth to water level map of pre monsoon and post monsoon period and annual fluctuation of water level are prepared with data of NHS for year 2012. The water level map of the district of pre monsoon 2012 (May) is as follows



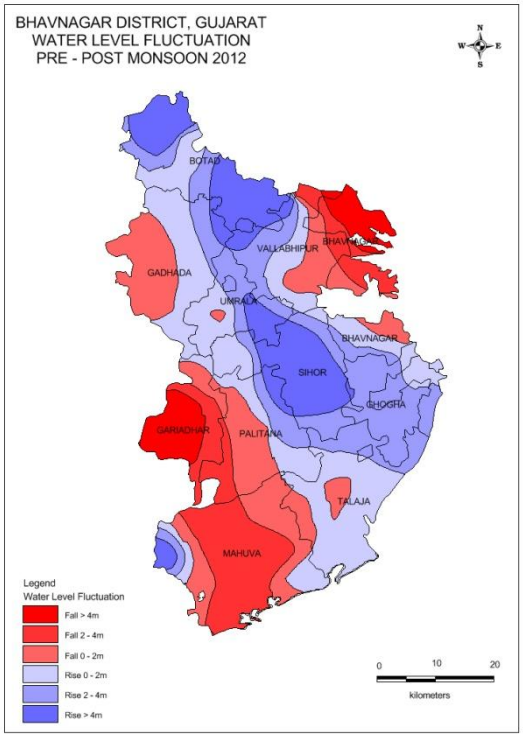
In most of the district the water level during pre monsoon lies within a range of 10 to 20 meters below ground level, whereas in some part of North West and South East the water level is within a range of 20 to 40 meters.

During the post monsoon the water level map for the November 2012 is as follows



The water level during post monsoon is less than 20 meters in most of the district, however the water level is more than 20 meters in North West ,South East and South West part of the district.

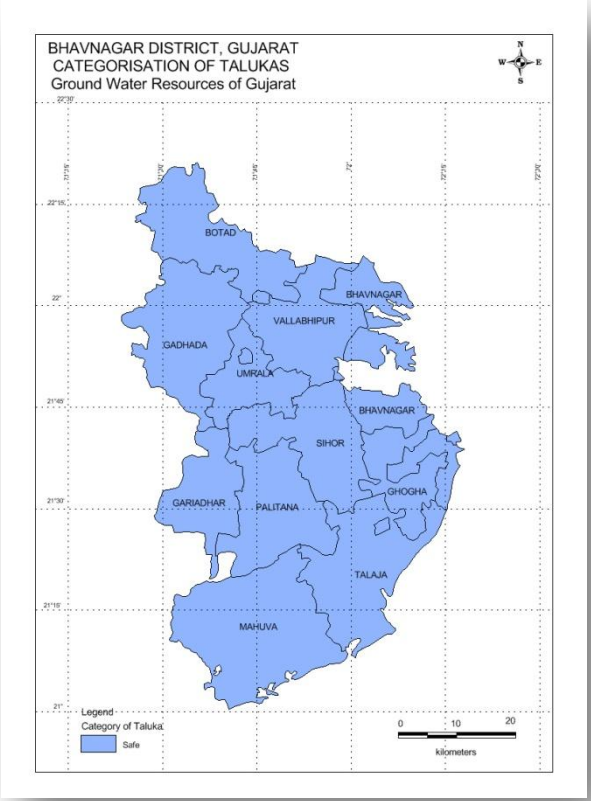
The map showing fluctuation between May 2012 and Nov.2012 is as below



In major part of district there is rise in water level after rainfall but in South West part adjoining Amreli district there is fall in water level also there is fall in North East corner of the district.

GROUND WATER RESOURCES

Annual ground water recharge of Bhavnagar district, (GWRE 2011), is 942.79 MCM and keeping provision of 47.13MCM for environmental /runoff purposes, net annual ground water availability is worked out to be of 895.65 MCM. The gross annual ground water draft in the district comes out to be 573.71 MCM out of which 517.33 MCM per year is due to irrigation while remaining 56.38 MCM is accounted for domestic and industrial uses.



The stage of ground water development at year 2011, for all the talukas of the Bhavnagar district computed range from 40.74 % to 69.72 % and all units of assessment (talukas) have been categorized as *Safe*, based on the stages of ground water development and the long-term trend of pre and post monsoon ground water levels. The average for district is 64.06 %. Taluka wise ground water resources and categorization for each assessment unit is shown below

Stage of Groundwater Development (2011) - Bhavnagar district

Name of Taluka	Available Ground Water Recharge in MCM / Year	Existing Gross Ground Water Draft for all uses in MCM / Year	Stage of Ground Water Development (%)	Category
Bhavnagar	50.27	33.29	69.72	Safe
Botad	110.86	69.20	65.71	Safe
Gadhada	108.34	71.15	69.13	Safe
Gariyadhar	72.12	36.99	54.00	Safe
Ghogha	47.45	30.66	68.02	Safe
Mahuva	141.18	85.66	63.87	Safe
Palitana	94.22	61.16	68.33	Safe
Sihor	92.25	58.06	66.25	Safe
Talaja	123.33	71.88	61.36	Safe
Umarala	60.30	39.18	68.41	Safe
Vallabhipur	42.42	16.42	40.74	Safe
Total	942.79	573.71	64.06	Safe

HYDROCHEMISTRY

Majority of water samples collected from the monitoring wells of CGWB in a major part of the District fall under desirable or permissible category and hence are suitable for drinking purposes. However, a small percentage of well waters are found to have concentrations of some constituents beyond the permissible limits. Such waters are not fit for human consumption and are likely harmful to health on continuous use. Based on the results it is found that groundwater in the District is mostly of **calcium bicarbonate type** when the Electrical conductivity is below 750uS/cm. They are of mixed cation and mixed anions type when the electrical conductance is between 750 and 3200 uS/cm and waters with electrical conductance more than 3200 uS/cm are of sodium chloride type.

In general in most parts of the District the EC value is found to be very high i.e. 3200uS/cm to 15000uS/cm and more. It was observed that out of 24water samples, 7 samples show EC value more than 3200 uS/cm, which indicates the gravity of salinity problem in the area.

Nitrate value varies from Nil to 460mg/L. **High Nitrate** > 100mg/L, have been found in four number of samples out of 24 total number of samples analyzed indicating high nitrate pollution due to use of nitrogen containing fertilizer, domestic and agriculture waste and man made anthropogenic activities. Nitrate value as high as 460mg/L at Ghogha, 380mg/LatTansa, 340mg/L at Tatum, 110mg/L at Khijadiya, have been observed in the District. Further, seven water samples in the range of 45mg/L- 100mg/L representing desirable limit of nitrate content and alternate source of drinking water may be used in High nitrate content area. In most of other places having nitrate < 45mg/L there is no problem with respect to nitrate pollution.

Range of Fluoride value varies from 0.20mg/L to 2.50mg/L .High Fluoride>1.5mg/L, which is mainly attributed due to geogenic conditions, have been observed in 4 water samples out of 24 water samples analyzed. Fluoride values to the extent of 2.50mg/L at Vallabhipur, 2.00mg/L at lonjdhara, 1.74mg/L at Jalia and

1.70mg/L at Tardhera have been observed indicating prominence of fluoride problem in these areas. Apart from above locations there is no problem with respect to fluoride contamination.

GROUND WATER RELATED ISSUES &MEASURES

i) In Bhavnagar district, the overall stage of groundwater development is moderate (68.04 %), however, there is constraint of quality in the coastal areas and low yield in inland hard rock areas. Rapid urbanization and concurrent industrial activities are affecting ambient hydrogeological regime lately.

ii) District receives monsoon rainfall of 580 mmduring SW monsoon, large number of artificial recharge structure are present in the district. The structures need maintenance at regular interval so as to reap the benefit for Time to come.

iii) There is relatively high ground water development along coastal zones, which also have limited thickness of good quality aquifer system. Sustainable groundwater management strategy to conserve existing resources and preventive actions to controlcontamination of freshwater resources are essential. Periodic monitoring of ground water should be mandatory.