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Technical Report Series

GROUNDWATER BROCHURE

DAHOD DISTRICT

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PROFILE OF DAHOD DISTRICT

SL No.	Items	Statistics
1	General Information	
	i) Geographical area as per state territory/as per village papers (Sq. Km)	3655/3712
	ii) Administrative Divisions (As on 3/2011) Number of Talukas Number of Villages	 7 696
	iii) Populations (As per 2011 census)	2126558
	iv) Average Annual Rainfall (mm)	745
2.	GEOMORPHOLOGY	
	Major Physiographic Units : undulating plain, highly dissected plateau and hills	
	Major Drainages: Non-perenial river - Panam, Hadap, Goma, Kharod, Anas, Kali, Khan, Machchhan and Chibota are tributary of Mahi river.	
3.	LAND USE (Sq. Km) (2006-07)	
	a) Forest area b) Net area sown c) Cultivable area	884 2145 3090
4.	MAJOR SOIL TYPES: Sandy soils, Yellowish brown & black soils, Black cotton soils	
5.	AREA UNDER PRINCIPAL CROPS (Hectare) (2006-07) Rice-47, Wheat-50, Maize-106, Cereals-204, Gram-49, Other Pulses-30, Total Pulses-78, Total food grains-282, Ground Nut-2, Sesamum-1, total oil seeds-18.	
6.	IRRIGATION BY DIFFERENT SOURCES (Areas in Sq Km and numbers of structures)	
	Dug wells	471/38443
	Tube wells/Bore wells	12/52
	Tanks/Ponds/Water conservation structures	48
	Canals	63
	Other Sources	61
	Net Irrigated area (sq. km.) (2006-07)	545
	Gross Irrigated area (sq. km.) (2006-07)	594
7.	NUMBERS OF GROUND WATER MONITORING WELLS OF CGWB (As on 31-03-2011) No of Dug Wells No of Piezometers	23 17 6
8.	PREDOMINANT GEOLOGICAL FORMATIONS: Phyllite, schist, meta-quartzite, dolomite, granite, pegmatite, gneiss, ortho-quartzite, sandstone, limestone, Deccan trap basalt and alluvium.	
9.	HYDROGEOLOGY	
	Major Water Bearing Formation: Groundwater occur in unconfined to semi-confinrd condition in phyllite, schist & quartzite and under unconfined condition in deccan trap formation, Granite and gneiss and alluvium along river courses, valley fills, flood plain & abandoned Palaeochannel deposits occur under unconfined conditions.	

Depth to water Level during 2011-12				
Period	Phreatic Aquifer (DTW)		Semi-confined Aquifer (PZ head)	
	Min	Max	Min	Max
Pre Monsoon	2.88 (Varamkheda)	14.09 (Fatehpur)	NA	NA
Post Monsoon	1.42 (Varamkheda)	10.72 (Khandania)	NA	NA
Long Term (10 Years) Water Level Trend (2003 to 2012)				

	Trend	Pre-Monsoon	Post- Monsoon
	Rise (m/Yr)	0.021 (Khandania) to 0.084 (Devgarhbaria)	0.0028 (Dadhela) to 0.106 (Devgadh Baria)
	Fall (m/Yr)	0.018 (Jhalod) to 0.468 (Dhanpur)	0.0215 (Limkheda) to 0.4109 (Dhanpur)

10.	GROUND WATER EXPLORATION BY CGWB (As on 31-03-2011)	
	No of wells drilled (EW, OW, Pz, SH, Total)	EW :33,OW: 06, PZ:0, SH :0, Total:39
	Depth Range(m)	25-200
	Discharge (Litres per minute)	60-300
11	GROUND WATER QUALITY	
	Presence of chemical constituents (more than permissible limit)	Fluoride and Nitrate at few locations
	Type of water	In general potable
12.	DYNAMIC GROUND WATER RESOURCES (As on 2011)	
	Annual Replenishable Ground Water Resources (MCM)	372.54
	Net Ground water Availability (MCM)	353.92
	Projected Demand for Domestic and industrial Uses upto 2025 (MCM)	55.47
	Stage of Ground Water Development (%)	49.87
13	AWARENESS AND TRAINING ACTIVITY (as on 3/2012)	
	Mass Awareness Programmes organized No of Participants	Nil
	Water Management Training Programmes organized (No of Participants)	01 (30)
14	EFFORTS OF ARTIFICIAL RECHARGE & RAIN WATER HARVESTING (31-3-2011)	
	Projects completed by CGWB (No & Amount spent)	
	Projects under technical guidance of CGWB (Numbers)	
15	GROUND WATER CONTROL AND REGULATION (3/2009)	
	Number of OE Blocks	Nil
	Number of Critical Blocks	Nil
	Number of Semi Critical Blocks	Nil
	Number of Safe Blocks	07
	Number of Saline Blocks	Nil
	No. Of Blocks Notified by CGWA	Nil
16	MAJOR GROUND WATER PROBLEMS AND ISSUES	
	i) Increasing depth of tube wells ii) Increasing instances of high fluoride iii) Groundwater contamination due to unplanned construction and poor technical design of tube wells iv) Awareness amongst villagers on water conservation techniques v) Demand supply management	

Contents

GROUNDWATER BROCHURE OF

DAHOD DISTRICT

1. INTRODUCTION

Dohad, situated in the eastern part of main peninsular shield of Indian subcontinent. It is the most important district of Gujarat state. The area forms part of Mahi basin. The Mahi river is one of main rivers of Guajrat state. The Mahi river is flowing due southwest. The district has major occupation being agriculture and animal husbandry. The present report deals with the salient features of hydrogeological conditions in the district and also outlines the ground water development vis-à-vis the water requirements for irrigation and domestic needs. The district is tribal and drought prone. Dohad district has a geographical area of about 3655 sq.km (as per state territory) and about 3712 sq. km as per village papers.

The location of Dohad district in Gujarat is shown in Figure 1. It is bounded by Madhya pradesh state, Rajasthan state and other districts of Gujarat viz. Vadodara & Godhra. The district has fairly good network of roads and all taluka head quarters are connected with all weathered roads. The district headquarter, Dohad, is connected with Ahmedabad through a state highway. Broad gauge railway line passes through the district (central railways).

The district was a part of Panchamahal district in 1999. The administrative divisions of the district have been reconstituted recently. The district comprises of seven talukas viz. Devgad Baria, Dhanpur, Dohad, Fatehpura, Garbada, Jhalod & Limkheda. The Fatehpura taluka is created from Santrampur taluka. Jhalod taluka remained as such. The Dohad and Garbara talukas are created from Dohad taluka. The Limkheda and Dhanpur talukas are created from Limkheda taluka. The Devgad Baria taluka remained with reduced area and No. of villages. Total No of villages of the district are 696. The map of Dohad district showing administrative subdivisions is shown in Figure 1.

1.1. DEMOGRAPHY

According to the 2011 census, the total population of Dahod district is 21,26,558 persons. The density of population is 582 souls per sq km. The district had a population of 16,35,374 in 2001 and decadal growth of district 2001 to 2011 is 29.95%. Dahod has a sex ratio of 986 females for every 1000 males and a literacy rate of 60.6%.

1.2. CLIMATE

Dahod district is located in east of Gujarat,comes under heavy rainfall areas in Gujarat, having sub-tropical climate with moderately low humidity. The main seasons prevailing in the district are (a) monsoon - mid of June to October, (b) winter - November to February, and (c) summer – March to June.

The maximum daily temperature during the year ranges from 27.7 °C in January to 39.7 °C in May while minimum temperature ranges from 11.9 °C in January to 25.6°C in May. Maximum humidity ranges from 98.2 % to 79.6 % while minimum range is from 28 to 83.5 %. The wind speed ranges from 105.2 to 479.6 km/day, where as evapo - transpiration ranges from 3.4 to 11.1 mm/day.

Table 01: Climatological Data								
Station:	Idar				District:	Panchmahal		
Altitude:		m AMSL			HA	13	**0.7187828**	
Latitude:	22°45'57"		N		Longitude:	73°36'29"		E
Month	**Max Temp (Deg.C)**	**Min Temp (Deg.C)**	**Humidity (%)**	**Wind Spd. (Kmpd)**	**Sunshine (Hours)**	**Solar Rad. (MJ/m2/d)**	**Eto (mm/d)**	**Rainfall (mm)**
January	27.7	11.7	41.0	138.0	9.6	17.7	3.8	0.0
February	30.6	14.1	33.5	169.1	10.2	20.6	5.2	0.0
March	35.0	19.1	27.5	220.8	9.3	21.8	7.1	0.0
April	38.6	23.7	28.0	293.3	10.0	24.5	9.3	0.0
May	39.7	25.6	38.0	438.2	10.6	25.9	11.1	0.0
June	35.8	24.8	60.5	479.6	8.8	23.2	8.4	0.0
July	30.8	23.6	79.0	405.4	4.6	16.8	4.7	168.0
August	28.9	22.7	83.5	351.9	4.3	16.0	3.9	637.0
September	30.6	22.2	75.0	265.7	6.7	18.5	4.7	136.0
October	33.7	20.0	50.5	132.8	9.5	20.4	4.9	0.0
November	31.6	16.2	42.5	105.2	9.7	18.3	3.9	0.0
December	28.7	12.9	44.0	112.1	9.5	16.8	3.4	0.0
Total	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**941.0**
Average	**32.6**	**19.7**	**50.3**	**259.3**	**8.6**	**20.1**	**5.9**	**78.4**

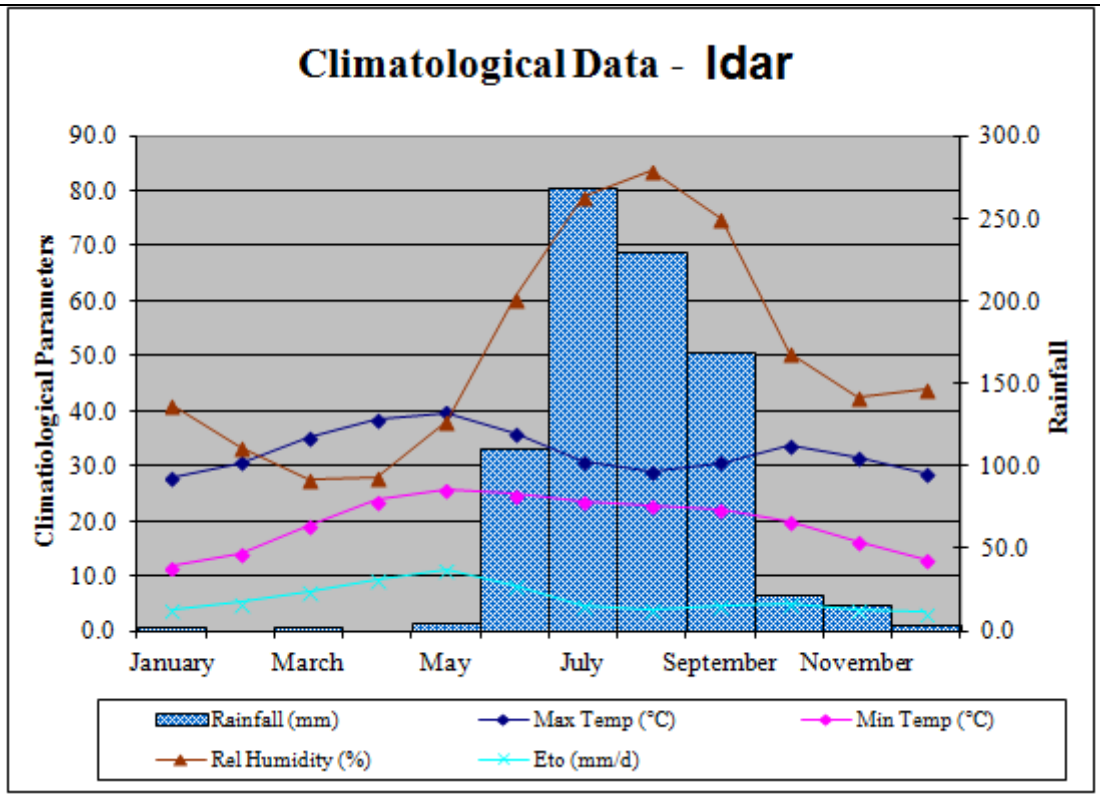

Fig 02: Climatological data analysis of Dahod district

1.3. Rainfall

Dahod district receives much of its rainfall from the south-west monsoon during the period between June & October; its maximum intensity being in the month of July & August. Total rainy days ranges from 30 to 40 days/year. Long term annual rainfall data of the district from year 1982-2011 are statistically analyzed and the average annual rainfall is 745mm as presented in table No 2. The distribution of annual rainfall over the Dahod district as given in table 2.

Table 02 - Statistical Analysis of Rainfall Data (Rainfall in mm)

No of Years	Average Annual RF
2004	1041
2005	560
2006 (Highest RF - Year)	1104
2007	872
2008	590
2009 (Lowest RF - Year)	377
2010	546
2011	575
2012	692
1982 – 2011	745

1.4. STUDIES / ACTIVITY BY CGWB

Systematic hydrogeological survey were carried out by different officers of CGWB between 1975 – 76 to 1980 – 81.

1. Doshi S.K. & Bhatnagar G.C. 1974 – 75
2. Bhatnagar G.C. 1975 – 76
3. Venkatraman S. 1976 – 77
4. Sharma V. 1977 – 78
5. Venkatraman S. 1978 – 79
6. Arun Kumar 1980 – 81
7. P.K.Jain, P.R.Gupte, A.B.Kawade 1988 – 89

The findings of the report during these investigations are summarised as follows:

a. Major part of the district is underlain by hard rocks.
b. Mainly the groundwater is developed by dugwells
c. The hard rock formation forms most extensive aquifers in the district.
d. The yield of the wells in the hard rock depends mainly on the thickness of weathered mantle and degree of fracturing.
e. In isolated patches, particularly in the vicinity of the rivers, valley fills, palaeochannel deposits forms potentials aquifers.
f. Later on groundwater exploration work also carried out as part of the AAP during 1985 – 86, 1987 – 88, 1988 – 89, 2002 – 03, 2003 – 04, 2007 – 08, 2008 – 09, 2009 – 10 and 2010 – 11.

2. Geomorphology

2.1. PHYSIOGRAPHY

Dohad district is situated in the western part of peninsular shield of Indian subcontinent. The elevations in the district are more than 400m AMSL. The district has varied topography of undulating plain to rugged topography of quartzite (above 400m amsl). Flat topped and highly dissected plateau of Deccan trap basalt occurring in the central part and northern parts. The development of geomorphic units is the manifestation of diverse geological processes, may be structural, tectonic, erosion & denudation. The quartzite ridges occur in western part of the district. The regional geomorphic units are pediplains and dissected hills of phyllites & mica schists occur in the western and eastern part of the district and having gentle to moderate slope. The curvilinear ridges of phyllite, schist and quartzite have steep slope one side and gentle slope on the other side. The phyllite, schist and quartzite have identifiable structural trends. Pediplain has cover of weathered, unconsolidated and medium to coarse-grained material. Dissected hills of granite and gneiss occur in the southern part of the district. The granitic and gneissic dissected hills have high relief and steep slopes. Scattered alluvial deposits include flood plains, valley fills and abandoned river channel deposits occur at many places in district. The alluvial deposits are composed of clay, silt, sand, gravel and lime kankar & have gentle slope. The area has complex folding, faulting, tectonic history and has large shear zones, quartz reefs and pegmatitic intrusives. The area has high altitudes in western and southern part and low altitudes in eastern part. The surface water bodies have topographic control. The high relief areas and low relief areas can be identified on toposheets.

2.2. DRAINAGE

The district is drained by main tributaries of Mahi river on left bank. They are Panam, Hadap, Goma, Kharod, Anas, Kali, Khan, Machchhan and Chibota. Mahi river originates out side the district and follows southwest course and enters adjoining Panchmahal district near Kadana. Futher south-west it debauches in the Gulf of Khambhat. Mahi river is perennial and all its tributaries are ephimeral in nature. The drainages are easterly and westerly flowing. The dissected hills and moderately dissected plateau of Deccan Trap have identifiable drainage pattern. The phyllitic and schistose pediplain also has identifiable drainage pattern. The dissected hills of granitic and gneissic area in the south also have identifiable drainage pattern. The regional fault pattern and local fault pattern also has identifiable drainage pattern. The western hilly area has lithological and structural control over drainage. The eastern low-lying area has lithological, structural and tectonic control over drainage. The drainage in the area is sparsely developed. The surface water divide can be inferred from topography and runs almost north to south. The flow of the water in the rivers is more during the rainy season. The drainage is dendrite to sub-dendrite type.

2.3. SURFACE WATER RESOURCES

There is one major irrigation project on Mahi river, namely Kadana reservoir project (Santrampur – Lunawada talukas) and medium projects such as (i) Machchan Nala project (Jhalod) on Machchan Nala river, (ii) Palla dam project (Devgadh Baria) on Karod river, (iii) Patadungri Tank project (Dahod) on Khan river, (iv) Walkeswar Project (Devgadh Baria) on Walkeswar stream, a tributary of Panam river.

2.4. SOILS

The soil of the district can be divided broadly into three categories depending upon the source rock, namely the phyllite, granites and basalts. The granite normally gives rise to sandy soil but where weathering is intense, sandy loam is produced. The phyllite produced yellowish brown light soils but where weathering is deep, black soil produced. The basaltic rock gives rise to variegated soil depending upon the degree of weathering. The first stage of weathering produce light soil with splinters of morum where as in the second stage medium soil od light brown to brownish black colour are produced. These medium soils are more than a meter depth. The black cotton soils produced by intense weathering of basalts are however deep, heavy and become sticky when saturated. They have high fertility value.

2.5. LANDUSE PATTERN

The data on land utilisation and irrigated are shows that, the land brought under cultivation and sowing in the Dahod district covers 3090 Ha, where area sown more than once covers 945 Ha. Forest area covers in the district about 884 Ha. The details Geographical area covers 3655 sq km where forest area cover 884 Ha. The Fallow land covers 72 Ha.

3. HYDROGEOLOGY

3.1. GEOLOGY

Geologically, Dahod district is the manifestation of diverse geological extension from Archaeans to Recent with different rock types such as granitic to basalt and limestone to alluvium. The stratigraphy of Dahod district is presented in table 9. The oldest formation in the area is Archaean rock presenting Granite gneiss and biotite gneiss in the southern part of the district. Aravallis Supergroup comprises of various meta-sediments belongs to Lower Proterozoic. The post-Delhi intrusive, Godhra granite and gneisses were intruded into older Archaeans. Both Aravallis and granite-gneiss have undergone many orogenic movement. They are overlain at places by Lower cretaceous fluvial and marine sequences, namely Bagh beds and Lametas. Lower Cretaceous rocks are overlain by Deccan basalts, extrusive rock formation; occur as sporadic exposure in the form of cappings over older rocks. The youngest formation is the alluvium; occur as pediments, sand dunes, valley fills and flood plain along the river courses as isolated patches. (Fig 03: Geological map of Dahod district)

Archaeans: The oldest rock type comprises of Granite gneiss and biotite gneiss exposed in the southern part of the district. The Archaeans Granite gneiss has been intruded by the Godhra Granites as found in the southern part of the district.

Aravallis Supergroup: It comprises of meta sediments has been categorized under Lunawada group.Lunawada group of rocks comprises of Phyllite, mica schist, metasubgraywacke, chlorite schist, phyllite quartzite, protoquartzite and minor bands of dolomite cover maximum parts of the districts. Infratrappean Bagh and Lameta group of rocks consisting of Limestone, shale, sandstone and conglomerate, exhibit presence of marine and freshwater fossils. Dinosaurian egg and bone fossils are found in the Lameta group.

Basalts and rhyolite comprises the Deccan volcanic exposed at central part in Dahod and Jhalod taluka.

Table 03: Stratigraphy of Dahod District

Geological Age	Supergroup	Group	Formation	Lithology
Holocene				Alluvium - Sand, Kankar and Clay
Cretaceous to Eocene		Deccan Traps		Basalts
Upper Cretaceous		Bagh/Lameta Group		Infra - Trappeans - Lameta Beds, Limestone, Nodular marls and Sand stones
Upper Proterozoic		Godhra Granites		Granite
Lower Proterozoic	Aravallis Super Group	Lunavada Group		Phyllites, mica schist, metasubgraywacke and chlorite schist, quartzite & Phylitic quartzite, quartz - mica schist, protoquartzite, dolomite.
Archaean				Granite gneiss, biotite gneiss

3.2. OCCURRENCE & DISTRIBUTION OF GROUND WATER

The groundwater in Dahod district occurs under confined and unconfined condition. Unconsolidated shallow alluvium and weathered, jointed and fractured rock support unconfined aquifers whereas interflow zones of basalts, inter trappean beds, encountered at depth, deep seated fractures and shear zones give rise to confined conditions. All the geological formations occurring in the district form aquifers, however, the phyllite, schist & quartzite are the most extensive aquifers in the district. The deccan trap formation is second most extensive aquifer in the district. Granite and gneiss also form aquifer in small area in the south part of the district. Alluvium forms a potential but limited aquifer and occurs as scattered isolated patches along river courses, valley fills, flood plain & abandoned Palaeochannel deposits.

Generally, water level follows topographic configuration. As part of the hard rock, phyllites, quartzites, schists, basalts, sandstone and limestones are forming aquifers. Alluvium and valley fills materials form potential aquifers in the vicinity of rivers and piedmont zone but their distribution is patchy with limited extension, rarely exceeding a few square kilometer in area.

a) Phyllites, Schist and Quartzites as aquifer: Groundwater occurs under unconfined conditions. The groundwater restricted to weather mantle and fractured/sheared zones. Quartz veins act as good barriers and prevent groundwater subsurface flow. The depth to weathering normally doesnot extend below 10m. The fracture and joints are wide near surface or just below the weathered mantle and are effective as groundwater conduits only for 0 to 20m below which they tend to be only like hair cracks. Intense weathering of phyllites and schists results in production of impervious clayey matrix where as quartzites produces sandy materials. However, weathering in quartzites is very rare on account of their uniform and resistant nature. The discharge in the exploratory wells varies from 0.1 to 3 lps with observed heavy drawdown. The depth to water level vary with in 3 to 20m.

b) Basalts: The basalts form aquifer in the central part and northeastern part of the district. Groundwater occurs under unconfined and confined condition in the weathered mantle, joints, fractures and interflow zones. Inter trappean sediments often carry granular sediments which form good aquifer locally. The water level vary with in 4 to 13m with an discharge of 1 to 4 lps. The exploratory well at Rupapura have a discharge of 4.4 lps.

c) Granite and gneisses: Groundwater occur under unconfined to confined condition. The aquifer materials is weathered/fractured granite. The thicknesses of weathered zone vary from 0 to 20m. Quartz and feldspar being major constituents, it produces granular sandy materials. The depth of dugwell vary from 6 to 20m. The dug cum borewells extended to a maximum depth of 26m. The gneisses form aquifer in the south-western part of the Devgadh Baria taluka. The weathering nature of gneisses is same as that of granite but the dark bands with mafic materials are prone to I intense weathering and often produces less pervious materials. The depth wells vary from 10 to 17m. The water level in granitic area vary with in 3 to 15m with an discharge of 8 to 110 m^3/day.

3.3. GROUNDWATER REGIME MONITORING

Ground water regime monitoring is the basic component of groundwater management and it is carried out in parts of Dahod district through National Hydrograph Network Stations (NHNS or NHS). NHSs are observation wells, comprising of dug wells and purpose built bore wells – known as piezometers. There are 17 NHS and 6 piezometers as part of the 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. With available data of systematic and reappraisal hydrogeological surveys carried out in the district. The water level of the district is described bellows. Figure 07: Hydrogeological map of Dahod district

Depth to Water Level (May 2012)

The figure 04 shows depth to water level map of Dahod district, prepared on the basis of NHS data of May 2012. In major part of the district, the water level ranged in between 5 to 10m, western part of the Limkheda, Jhalod and DEvgadh Baria taluka has the water level range in between 10 to 20m. On the northern part, Fatehpura taluka also range in between 10 to 20 m bgl of water level. On the eastern part, water level range in between 2 to 5m bgl. (Figure 04: DTW May 2012 map of Dahod district.)

Depth to Water Level (Nov 2012)

The figure 05 shows depth to water level map of November 2012. The major part of the district have water level in range of 0 to 5m bgl while northern part of the Fatehpura taluka, western part of Jhalod and Limkheda and Devgadh Baria talukas and southernpart of Dhanpur taluka of the district ranged within 5 to 10m bgl. (Figure 05: DTW November 2012 map of Dahod district.)

Water Level Fluctuation (May - Nov 2012)

The figure 06 shows water level fluctuation map of the district for May- November 2012 period. In the fluctuation map, it shown rise in water level in all parts of the district in the range of less than 2m to more than 4m. (Figure 06: Annual water level fluctuation May to November 2012 map of Dahod district.)

Water Level Trend (2003 - 2011)

From the analysis of the water level trend of the Dahod district from 2003 to 2012, it is observed that, during pre-monsoon, the water level has a rise of 0.0213 m/yr (Khandania) to 0.084 m/yr (Devgadh Baria) and also has a fall of 0.018 m/yr (Jhalod) to 0.4679 m/yr (Dhanpur). Similarly from the analysis of the post-monsoon data of 2003 to 2012, the rise shown by water level is vary from 0.0028 m/yr (Dadhela) to 0.1060 m/yr (Devgadh Baria) and also has a fall of 0.0215 m/yr (Limkheda) to 0.4109 m/yr (Dhanpur). Hence, from the analysis it is observed that, at Dhanpur, during both pre-monsoon and post-monsoon has a trend of falling water level.

3.4. GROUNDWATER EXPLORATION

The boreholes drilled by CGWB as a part of Ground Water Exploration work, in various parts of Dahod district have indicate that the sub surface geological formation in the district comprises of layered sequences of Deccan Trap lava down to 250 m of explored depth. The yield of bore wells varies widely from few lps to more than 20 lps. Overall, deep ground water quality is suitable for both irrigation and domestic uses. Map showing location of exploration is shown in figure 02 in Geological map of Dahod district.

The depth range of exploration varies from 38 to 295.15m. The minimum depth of drilling 38m at Fatehpura Karadiya of Fatehpur taluka and the maximum depth of drilling 295.15m at Motibara of Fatehpur taluka. In total, from 1987 – 88 to 2009 – 10, 39 well drilled in the districts.
The perusals of exploratory drillings data and hydrogeological sections reveal that, Aravalli group of rocks form the basement in the area. Aravalli encountered at 15m at Chauki.

Both Aravallis and post-Delhi intrusive are overlain by Lower Cretaceous fluvial and marine sequence namely Bagh beds and Lametas at Tarkhanda, Pavagadh and Chauki. They comprises of a sequences of shale, sandstone and limestones. Shale vary in colour (buff white to dark pink colour). Sandstone is medium to very coarse grained, conglomeratic at places and in general cherty. The light pink shale formation, of this group is exposed around Tarkhanda. The thickness of these groups varies from few meters to 42.5, as observed in lithology of various bore holes.

Lower Cretaceous rocks are overlain by basalts. Basalts area observed as sporadic exposures in the form of cappings. They interbedded by intertrappean sediments at some places. Intertrappeans are of localized nature and have variable composition and thickness. Each flow of basalts is separated by intertrappean sediments or red bole. Six flows of basalts were recorded at Rupapura up to a depth of 79m while at Khajuri, three flows were recorded down to a depth of 90m. The red bole bed represents zones of palaeo weathering and subsequent baking of soil as formed.

4. HYDROCHEMISTRY

The Dahod district has mainly consisting of hard rock types hydrogeological provinces. In the hard rock, it is constituted of granite and gneisses, meta sediments and Deccan traps. Groundwater of the district originates as rainwater that infiltrates through soil into flow system in the underlying geologic material. In Dahod district, higher plateau and hill zones of central part and southern part constitute as recharge areas, which is underlain by deccan basalts and granitic rocks. Major part of the area covered by meta sediments. As groundwater moves along flowlines from recharge areas to discharge areas, the chemistry of groundwater is altered by the effects of variety of geochemical processes. The range analytical result of major ions of representative samples collected during various surveys and exploration works along with NHS data are compiled and the range of major constituents and parameters are given below in table 12.

Table 04: Summarised chemical data of Dahod district

Chemical Parameter	Min	Max	Chemical Parameter	Min	Max
pH	7.6	8.02	F	0.6	6.7
EC	597	4430	Alk	240	590
TDS	400	2968	Ca	16	88
CO_3	0	0	Mg	22	190
HCO_3	293	720	TH	250	980
Cl	28	880	Na	43	572
NO_3	2	430	K	1.2	33.7
SO_4	7.26974	86.2605	Fe	0	7.7

*All values are in mg/l except pH and EC in µS/cm at 25°C

4.1. Ground Water Quality

Variation in chemical quality of ground water is due to hydrogeological factors controlled by rock types, depicting aerial distribution of various water quality features. In terms of electrical conductance (EC), measure of total dissolved salts in ground water is vary in between 597 to 4430 µS/cm during May 2012. The chloride content of the district also vary with in 28 to 880 mg/l. Nitrate content in the district is very high varying within 2 to 430 mg/l. At six places, namely Dahod (45mg/l), Dadhela (47 mg/l), Sukhsar (47 mg/l), Wadia (85 mg/l), Dhanpur (100 mg/l), Garbara (430 mg/l), where found above 45 mg/l is unsuitable drinking and domestic purpose. Similarly, fluoride content is varying within 0.6 to 6.7 mg/l. At Khandania (1.5 mg/l), Dahod (2.5 mg/l) and Garbara (6.70 mg/l) are found above the maximum permissible limit and not suitable for the drinking purpose. Iron is the heavy metal that found in the groundwater of the district is varying from 0 to 7.7 mg/l. The maximum value found at Jhalod is 7.70 mg/l and also found the maximum permissible limit, unsuitable for drinking and domestic purpose (BIS 2012: IS10500). At Sukhsar (0.75 mg/l), Dhanpur (0.88 mg/l) and Wadia (2.20 mg/l) are also found above the maximum permissible limit of 0.3 mg/l and unsuitable for drinking purpose comparing to BIS 2012: IS10500. In other chemical ion, total hardness in terms of $CaCO_3$, is found above the BIS maximum permissible limit of 600 mg/l at Garbara (980 mg/l) found unsuitable for drinking and domestic purpose. In other area, TH varies within 250 to 460 mg/l with a value of more than 200 mg/l found at 12 places.

2.1. WATER POLLUTION

Dahod district has a number of medium and small scale industries set up in the Dahod and Devgadh Baria talukas focusing mainly on the agriculture and minerals industries. 4000 metric tonnes of quartz produces annually to support the ceramic, cement and glass industries. Major small scale industries are deals in the sector such as rubber and plastic products, food products, engineering, readymade garments and minerals. Dahod and Devgadh Baria taluka have maximum number of industrial units in the district such as 875 and 541 units respectively. No major chemical quality problem reported so far, but looking at the quality problems in other parts of the Gujarat due industrial set up, enforcing regulatory measures mandatory before releasing of industrial effluents only after due treatment in ETPs and solid waste disposal at designated sites.

Table 05: Chemical quality of groundwater for drinking and domestic purpose in Dahod district

Sl.No	Chemical Parameter	BIS – 2012 (IS 10500)		Variation of chemical data during May 2012		No of sample exceeding the HDL	No of sample exceeding the MPL
		Highest Desirable Limit	Maximum Permissible Limit	Min	Max		
1	pH	6.5 to 8.5	No Relaxation	7.6	8.02	Nil	No Relaxation
2	Total Dissolved Solids	500	2000	400	2968	9	1
3	Total Hardness (as CaCO3)	200	600	250	980	12	1
4	Calcium	75	200	16	88	Nil	Nil
5	Magnesium	30	200	22	190	11	Nil
6	Sodium	-	200	43	572	-	2
7	Potassium	-	12	1.2	33.7	-	1
8	Bicarbonate	-	-	293	720	-	-
9	Chloride	250	1000	28	880	2	Nil
10	Sulphate	200	400	7.3	86.3	Nil	Nil
11	Nitrate	45	No Relaxation	2	430	6	No Relaxation
12	Fluoride	1	1.5	0.6	6.7	3	3
13	Alkalinity	200	600	240	590	13	Nil
14	Iron as Fe (mg/l)	0.3	No Relaxation	0	7.7	4	No Relaxation

*Except pH all values are in mg/l

Table 06: Medium and large scale industrial estates in Dahod district

Industrial Estate	Size (in Hectare)
Dahod I	4
Dahod II	5.3
Devgadh Baria	6.07

3. GROUND WATER RESOURCES

Annual ground water recharge of Dahod district, (GWRE 2011), is 3720.53 MCM and after natural discharge of 18.63 MCM due to environmental / runoff purposes, net annual ground water availability is worked out to be of 353.9 MCM. The gross annual ground water draft in the district is 176.5 MCM out of which 132.6 MCM per year is due to irrigation while remaining 43.9 MCM is accounted for domestic and industrial uses.

The stage of ground water development at year 2011, for all the talukas of the Dahod district computed range from 33.98% to 56.94% 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 stage of groundwater development for district is 49.87%. Taluka wise ground water resources and categorization for each assessment unit is presented in table 09.

4. Mass Awareness and workshop Programme in Dahod District

One Water Management Training Programme conducted at Dahod in the year 2011.

5. CONCLUSION AND RECCOMENDATION

a. The Dahod district having an area of 3655 sq km forms a border district in the eastern part of the Gujarat and comes under the tribal and drought prone area.

b. The district in general poses an undulating topography with an elevation of morethan 400m a msl. The central and southern part of the district is marked by hill ranges.

c. District receives medium intensity monsoon rainfall of 372 to 1104 mm during SW monsoon with an average of 745 mm. It will be good to harness the available monsoon rainfall runoff for artificial recharge to the ground water through construction of check dams, recharge shaft, percolation tanks, site specific recharge bore wells / dug wells, etc. All such measures can augment groundwater resources at local levels and can make drinking water supply schemes efficient and sustainable in long term.

d. In Dahod district, the overall stage of groundwater development is moderate (49.87%), all the seven talukas have been categorized as safe. However, there is low yield in inland hard rock areas. With strategy of conjunctive use and multidisciplinary approach for ground water development in hard rock terrain, sustainable development of water source can be accomplished.

Table 07: Taluka wise groundwater development in Dahod district (2011)

Sl.No	Talukas	Annual Ground Water Recharge	Natural Discharge	Net ground Water Availability	Annual Ground Water Draft			Projected demand for domestic & industrial uses up to 2025	Ground Water Availability for future irrigation	Stage of Ground Water Development	Category
					Irrigation	Domestic & Industrial uses	Total				
1	Devgadh Baria	55.17	2.76	52.41	22.5	6.3	28.8	8.39	21.52	54.95%	Safe
2	Dhanpur	39.24	1.96	37.28	16.56	3.99	20.55	4.99	15.73	55.13%	Safe
3	Dahod	49.46	2.47	46.99	15.42	6.97	22.39	8.72	22.85	47.65%	Safe
4	Fatehpura	44.87	2.24	42.63	18.65	5.62	24.27	7.01	16.97	56.94%	Safe
5	Garbada	32.4	1.62	30.78	6.16	4.3	10.46	5.39	19.23	33.98%	Safe
6	Limkheda	64.32	3.22	61.10	23.98	7.24	31.22	9.06	28.06	51.09%	Safe
7	Jhalod	87.07	4.35	82.72	29.28	9.53	38.81	11.91	41.53	46.92%	Safe
District Total		372.53	18.63	353.90	132.55	43.95	176.5	55.47	165.88	49.87%	Safe

Compute by RIF method

All values are in MCM except stage of GW development

e. Major part of the districts is underlain by hardrock formations of Aravalli Super Group and Granie and Gneisses. Deccan trap and Infratrappean are also observed at the central part and northern part. Hard rock formations in general have vertical to sub-vertical joints. Alluvial deposits occur in the vicinity of the river and in intermontane valleys. The thickness and extent of alluvial formation is however very limited.

f. Sustainable groundwater management strategy to conserve existing resources and preventive actions to control contamination of freshwater resources are essential.

g. Strategy for regular monitoring for planned development and pollution control with adequate enforcement directive is essential to prevent occurrence of pollution incident in future.

h. The Dahod and Devgadh Baria talukas are highly industrialized. Periodic monitoring of ground water along with quality should be mandatory.

i. The Central Ground Water Board has conducted only one 'Water Management Training Program' in the district. Taking into consideration of tribal domination and drought prone area, mass awareness programs in regular basis can be arranged in the district for awareness on the depletion of groundwater resources and quality problems.

j. Water Management Training Programme for capacity building measures for technical officers / officials & Vos/NGOs working in the field of ground water development and management may be trained to create awareness among the people for consequent ground water resources depletion and quality problems.

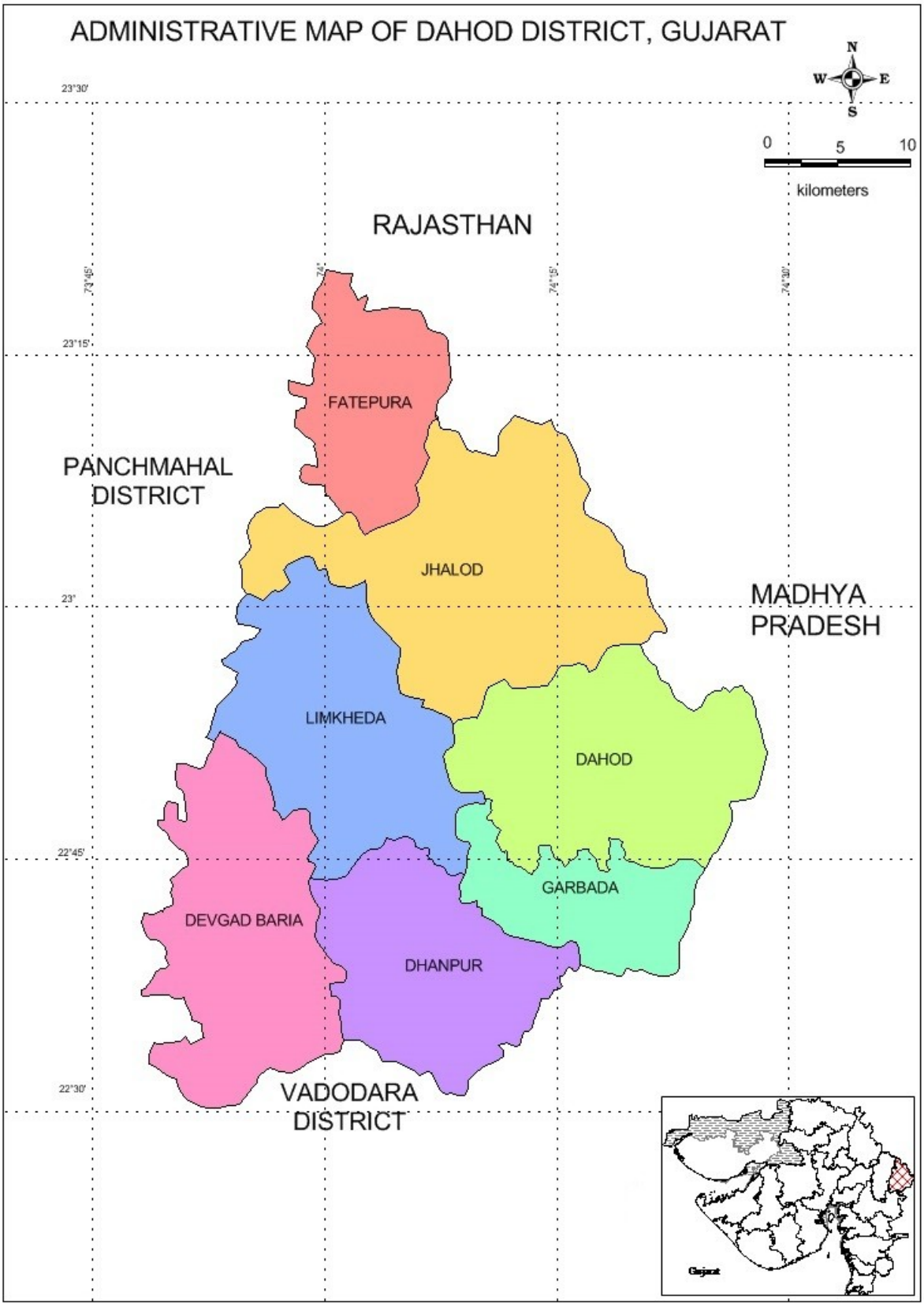

Fig 01: Administrative map of the Dahod district

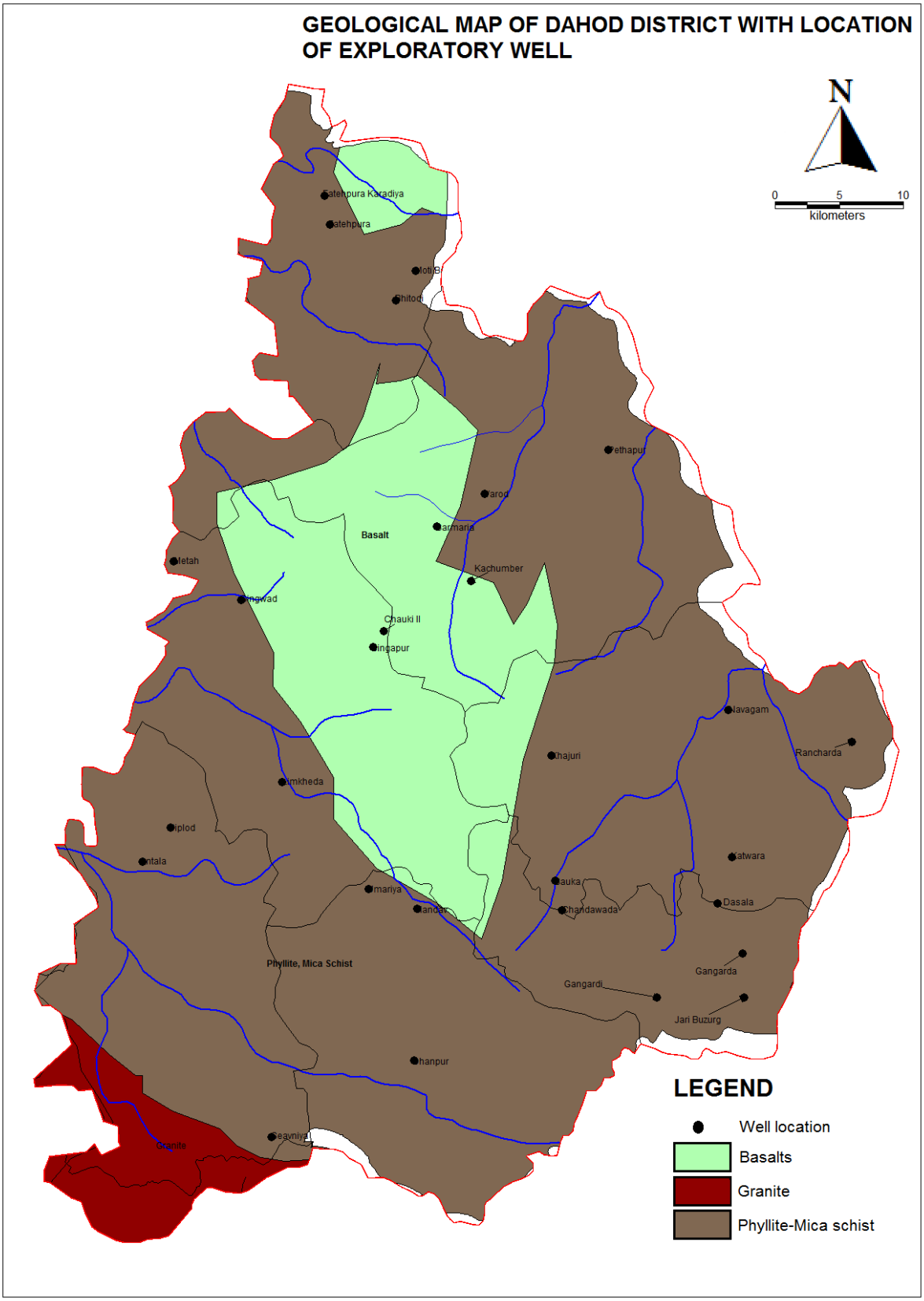

Fig 03: Geological map of Dahod district alongwith EW location.

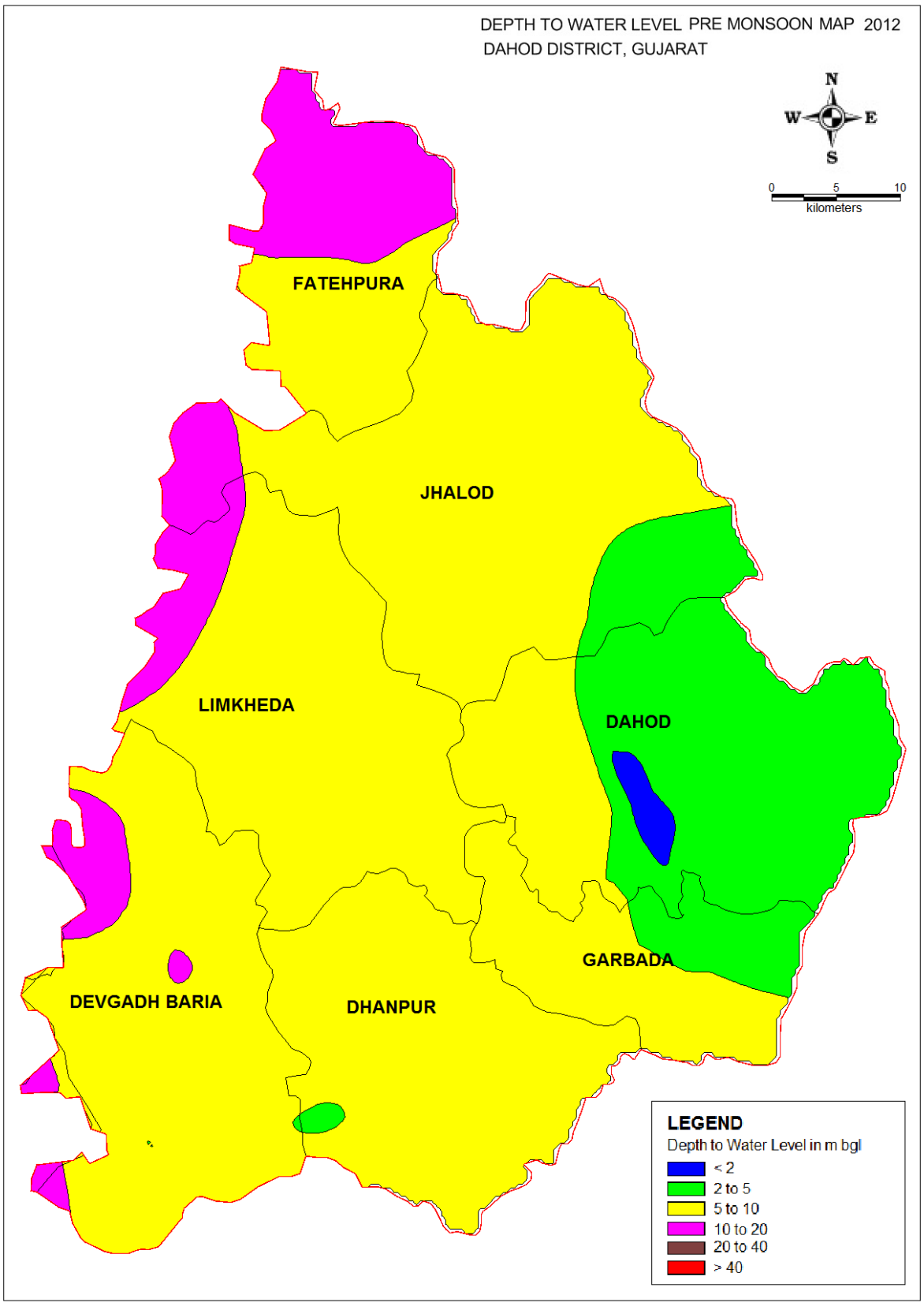

Fig 04: Depth to water level map of Dahod district during May 2012

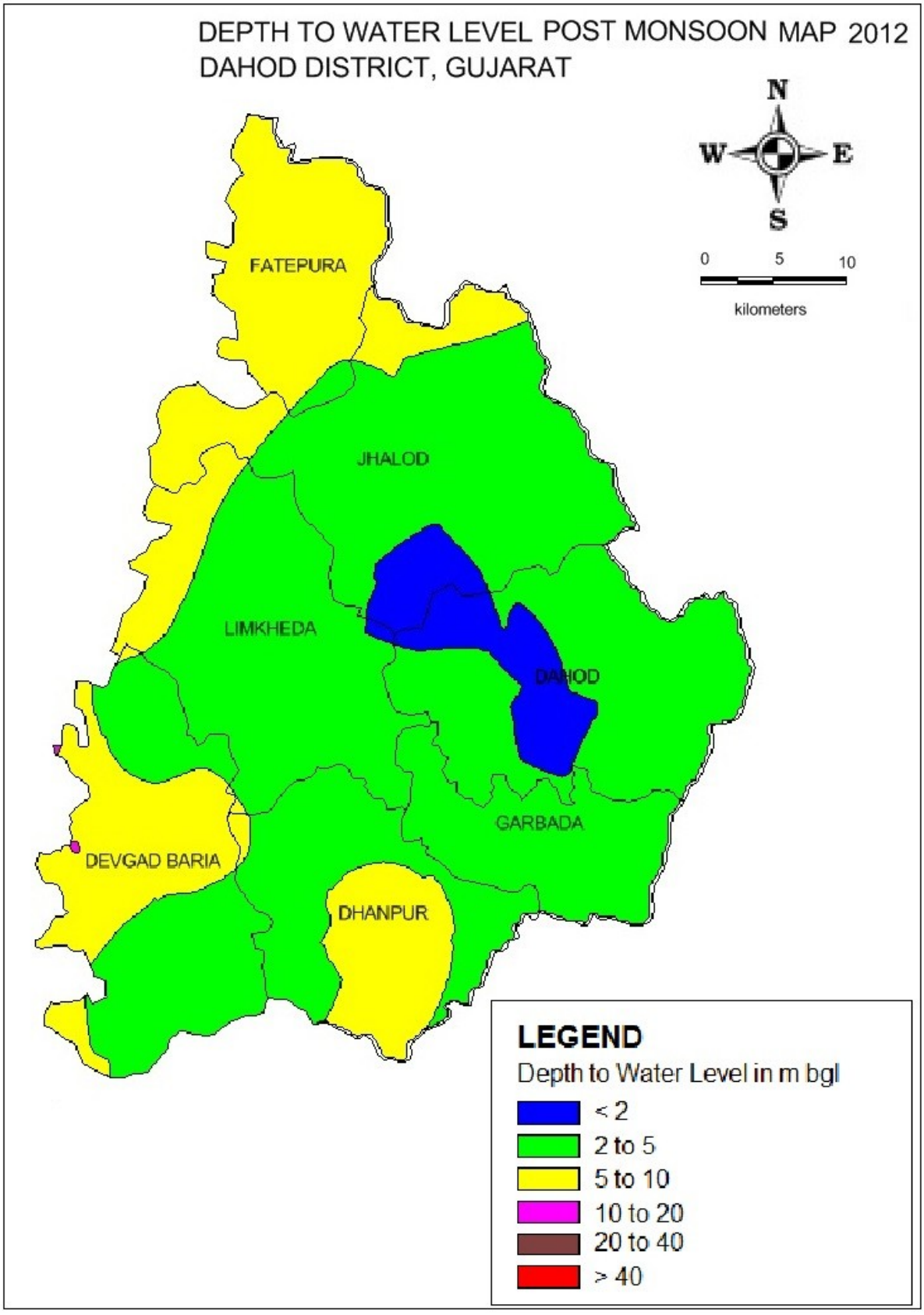

Fig 05: Depth to water level map of Dahod district during Nov 2012

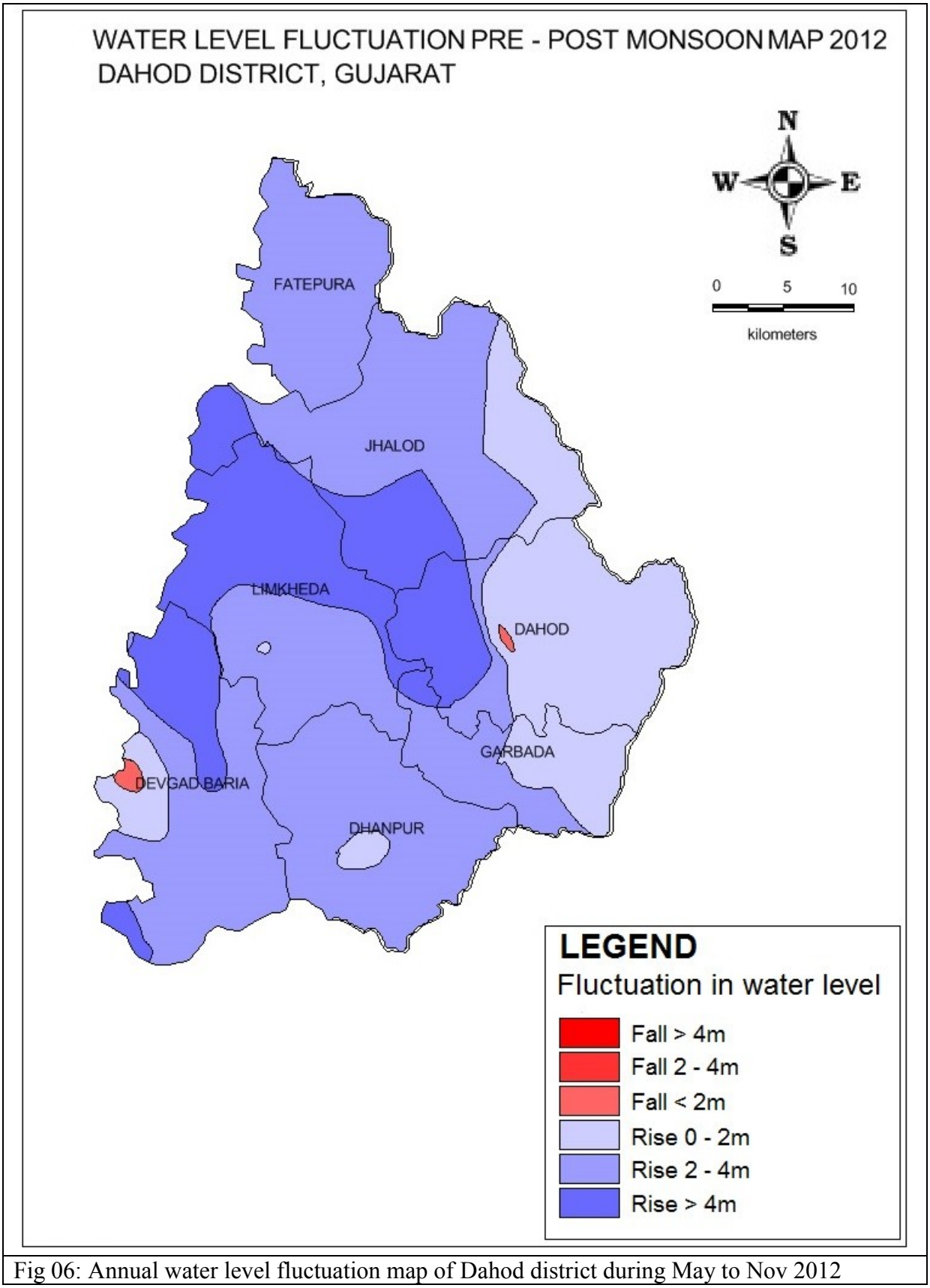

Fig 06: Annual water level fluctuation map of Dahod district during May to Nov 2012

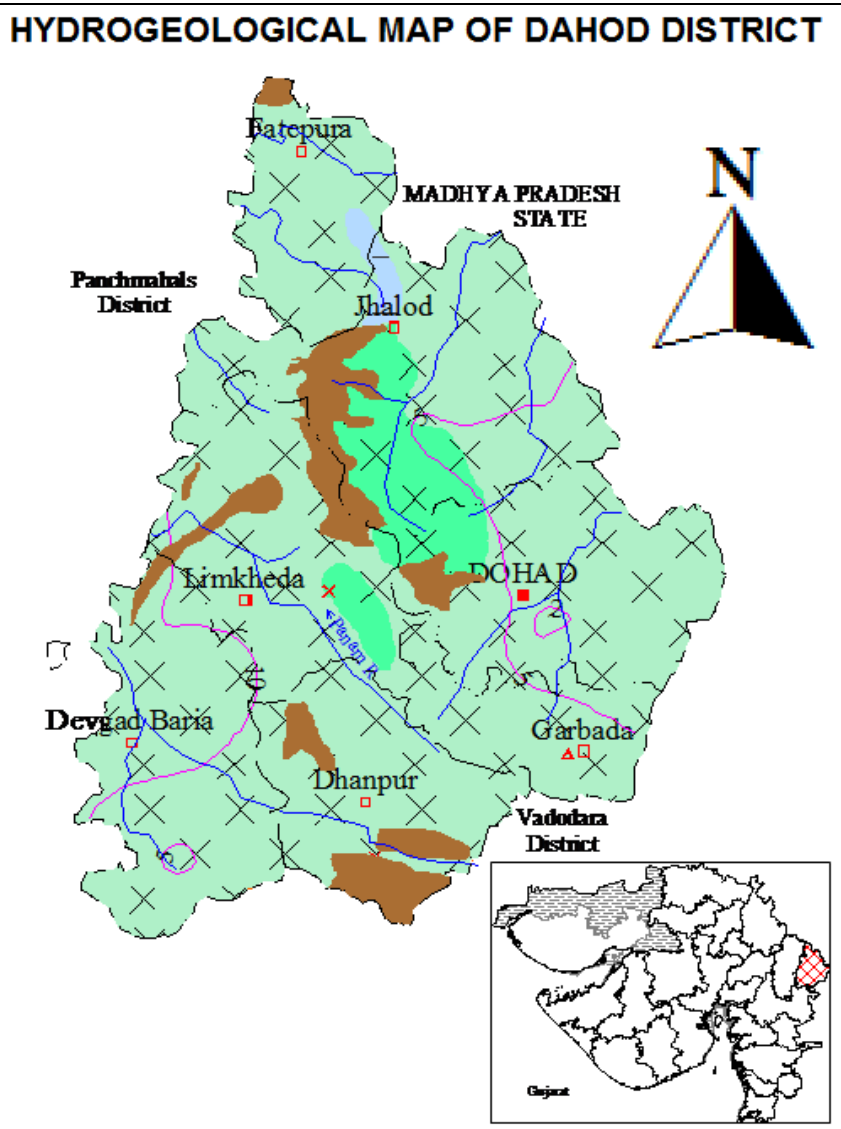

Fig 07: Hydrogeological map of Dahod district

Legend

Rock type	Wells Feasible	Rigs Suitable	Depth of Well (m)	Discharge (lpm)	Artificial Recharge Structure Suitable
Soft Rock Aquifer	Dug Well	Manual	10-25	200-300	Percolation Tanks/ Ponds, Recharge Wells,
Hard Rock Aquifer	Dug Well Borewell	Manual Down the Hole Hammer (DTH)	10-25 50-100	60-100 60-150	Percolation Tanks/ Ponds, Recharge Wells, Check Dams, Nalla Bunds.
Hard Rock Aquifer	Dug Well Borewell	Manual Down the Hole Hammer (DTH)	10-25 100-200	80-150 100-300	Percolation Tanks/ Ponds, Recharge Wells, Check Dams, Nalla Bunds.
Hilly Areas	Not Suitable				Check Dam, Nalla Bund, Gully Plug
20	Pre-monsoon Decadal mean (1993-2000) Depth to Water Level (mbgl)		2000	Electrical Conductivity (µS/cm at 25° C)	
	Fluoride > Maximum Permissible Limit (1.5 mg/l)			Nitrate > Maximum Permissible Limit (100 mg/l)	
	Drainage			District/Taluka HQ	