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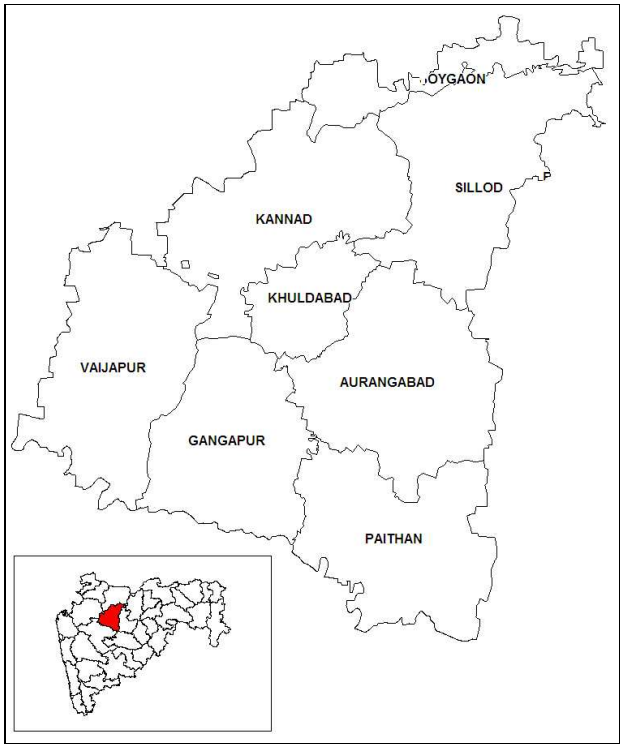
भारत सरकार
जल संसाधन मंत्रालय
केंद्रीय भूजल बोर्ड

GOVT OF INDIA
MINISTRY OF WATER RESOURCES
CENTRAL GROUND WATER BOARD

महाराष्ट्र राज्य के अंर्तगत औरंगाबाद जिले की भूजल विज्ञान जानकारी

GROUND WATER INFORMATION
AURANGABAD DISTRICT
MAHARASHTRA



By
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द्वारा
संदीप द वाघमार
सहाय्यक भूजलवैज्ञानिक

मध्यवर्ती क्षेत्र
नागपुर
CENTRAL REGION
NAGPUR
2010

AURANGABAD DISTRICT AT A GLANCE

1. GENERAL INFORMATION

Geographical Area	:	10,107 sq. km.
Administrative Divisions	:	Taluka-9; Aurangabad, Kannad, Soygaon, Sillod, Phulambri, Khultabad, Vaijapur, Gangapur, Paithan
Villages	:	1344
Population (2001)	:	28,97,013
Average Annual Rainfall	:	500 to 840 mm

2. GEOMORPHOLOGY

Major Physiographic unit	:	3; Satmala hill range, Ajanta hill range and Godavari plain
Major Drainage	:	2; Godavari and Purna

3. LAND USE (2005-06)

Forest Area	:	814.15 sq. km.
Net Area Sown	:	7150.55 sq. km.
Cultivable Area	:	8135.57 sq. km.

4. SOIL TYPE

: Deep and Medium black cotton soil

5. PRINCIPAL CROPS (2005-06)

Wheat	:	2381.70 sq. km.
Jowar	:	2301.33 sq. km.
Cotton	:	1329.16 sq. km.
Pulses	:	1189.30 sq. km

6. IRRIGATION BY DIFFERENT SOURCES (2000-01) - Nos. / Potential Created (ha)

Dugwells	:	78680 / 331942
Tubewells/Borewells	:	1438 / 3796
Tanks/Ponds	:	266/ 39791
Other Minor Surface Sources	:	14/2748
Net Irrigated Area	:	170569 ha

7. GROUND WATER MONITORING WELLS (As on 31/05/2007)

Dugwells	:	19
Piezometers	:	06

8. GEOLOGY

Recent	:	Alluvium
Upper Cretaceous-Lower Eocene	:	Deccan Traps Basalt

9. HYDROGEOLOGY

Water Bearing Formation	:	(Deccan Traps) Basalt weathered, vesicular fractured, jointed. Under phreatic semi-confined to and confined conditions.
Premonsoon Depth to Water Level (May-2007)	:	4.82 to 16.70 m bgl
Postmonsoon Depth to Water Level (Nov.-2007)	:	1.85 to 16.00 m bgl
Premonsoon Water Level Trend (1998-2007)	:	Rise: 0.01 to 0.68 m/year Fall: 0.03 to 0.79 m/year
Postmonsoon Water Level Trend (1998-2007)	:	Rise: Negligible to 0.41 m/year Fall: 0.01 to 0.97 m/year

10. GROUND WATER EXPLORATION (As on 31/03/07)

Wells Drilled	:	EW-64, OW-07, Total -71
Depth Range	:	16.25 to 200.00 m bgl
Discharge	:	Traces to 25.50 lps
Drawdown	:	0.80 to 72.10 m

11. GROUND WATER QUALITY

The potability is affected due to high concentration of nitrate, TDS and TH at many places. The quality of ground water is generally alkaline and suitable for drinking and irrigation purpose.

Type of Water : Ca-Cl and Ca-HCO_3

12. DYNAMIC GROUND WATER RESOURCES- (March 2004)

Net Annual Ground Water Availability	:	1146.19 MCM
Annual Ground Water Draft (Irrigation+Domestic)	:	632.72 MCM
Allocation for Domestic and Industrial requirement up to next 25 years	:	53.74 MCM
Stage of Ground Water Development		55.20 %

13. MAJOR GROUND WATER PROBLEMS AND ISSUES

An area of about 61,300 ha falling in canal command of major and minor irrigation projects in Paithan, Sillod, Aurangabad talukas is showing rising trend of water levels. The ground water quality is adversely affected at many places due to high concentration of some parameters especially nitrate.

Ground Water Information
Aurangabad District

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Ground Water Information
Aurangabad District

1.0 Introduction

Aurangabad district is situated in the north central part of Maharashtra between North Latitude 19° 15' and 20° 40, and East Longitude 74° 37' and 75° 52'. It covers an area of 10,107 sq. km falling in parts of Survey of India Toposheet No. 46 L & P and 47 I & M. The district is bounded by Jalgaon district in north by Nashik district in West, Ahmadnagar and Beed districts in south and Parbhani and Buldhana districts in east. The world famous Ajanta and Ellora caves are situated in Aurangabad district. There are also a few caves near Aurangabad City. Other monuments of national fame are Bibi-ka-Maqbara and Daulatabad fort.

The district headquarter is located at Aurangabad City. For administrative convenience, the district has been divided in 9 talukas viz., Aurangabad, Kannad, Soygaon, Sillod, Phulambri, Khuldabad, Vaijapur, Gangapur and Paithan talukas. The district has geographical area of 10,107 sq.km. out of which 814.15 sq.km is occupied by forest whereas cultivable area is 8135.57 sq.km and net area sown is 7150.55 sq.km in 2005-06. Agriculture is the main occupation of the rural people.

Central Ground Water Board has taken up several studies in the district and the list of studies conducted in the district is presented in Table-1.

Table 1: Studies undertaken by CGWB (March 2007).

S. No.	Officer	AAP	Type of Survey/Study	Area Covered
1.	V.V Rane	1969-70	SHS	Toposheet No. 47 M/6 and M/7.
2.	V.V Rane	1970-71	SHS	Toposheet No. 47 M/1 and M/5.
3.	K. Shrinivasan	1972-73	SHS	Toposheet No. 46 P/11 and P/12.
4.	M.R. Kulkarni	1974-75	SHS	Extreme southern part.
5.	V.V Rane and M.R. Kulkarni	1975-76	SHS	Toposheet No. 46 P/4, 47 M/1 and M/2.
6.	Dr. S. Shrihari Rao	1975-76	SHS	Toposheet No. 47 I/9, 10, 13 and 14.
7.	M.R. Kulkarni	1976-77	SHS	Toposheet No. 47 M/9, 10, 13 and 14 (Parts).
8.	M.R. Kulkarni	1978-79	SHS	Toposheet No. 46 P/3, 4, 7 and 8.
9.	D.Y. Sirsikar	1981-82	SHS	Extreme southern part.
10.	S. K. Bhatnagar	1992-93	RHS	Northern part.
11.	A. Suresha	1992-93	RHS	Northern part.
12.	B. K. Kallapur	1992-93	RHS	Southern part.
13.	K.B Sahoo	2000-01	RHS	Southern and south western parts.
14.	S.K Jain	2001-02	RHS	Urban Hydrogeology of Aurangabad city

Ground water exploration in the district has been taken up in different phases since 1985-86. The ground water exploration has been done in hard rock areas occupied by Deccan Trap Basalt and disconnected alluvial patches. A total of 57 exploratory wells (EW) and 7 Observation Wells (OW) have been constructed till March 2007.

Table-2: Salient Features of Ground Water Exploration (March 2007).

S. No.	Taluka	Forma-tion	Wells		Depth (m bgl)	SWL (m bgl)	Discharge (lps)	Draw-Down (m)	Zones (m bgl)
			EW	OW					
1	Aurangabad	Basalt	10	1	70.00-200.00	5.00-17.80	Traces to 1.86	6.50-15.70	6.50-13.50, 30.70-34.80
2	Kannad	Basalt	9	2	36.70-200.00	3.50-8.00	Traces to 0.78	2.95-30.90	3.50-6.50, 124.00-148.00
3	Soygaon	Basalt	2	1	98.00-200.00	5.60	3.17-25.50	16.32-34.45	15.00-18.10, 90.0-107.10
4	Sillod	Basalt	7	1	125.50-200.00	5.25-16.50	0.02-3.17	1.88 to 72.10	3.10-6.20, 95.90-93.00
5	Phulambri	Basalt	4	0	200.00	5.25-10.00	Traces to 1.73	3.22 to 21.82	5.50-9.70, 41.00
6	Khultabad	Basalt	2	0	200.00	5.60-18.10	0.38-0.78	14.80-15.70	19.60-28.80
7	Vaijapur	Basalt	8	1	183.50-200.00	5.60-10.40	Traces to 9.84	0.80 to 25.50	3.50-12.70, 76. 40
		Alluvium	3	2	16.25-25.50	10.00 to 15.00	0.20 to 4.50	-	13.00 -16.00, 21.00-23.50
8	Gangapur	Basalt	9	0	200.00	4.50 to 19.00	Traces to 1.80	5.40 to 48.70	7.40 to 10.40, 56.20-59.30
		Alluvium	4	1	24.40-28.50	8.00 to 18.00	0.01 to 1.73	-	17.50 -18.50, 24.00-25.00
9	Paithan	Basalt	6	1	26.00 - 200.00	5.60-9.00	Traces to 4.43	6.90 to 10.40	7.00 - 27.10
	Sub-Total	Basalt	57	7	36.70 – 200.00	3.50-19.00	Traces to 25.50	0.80 – 72.10	3.10 – 148.00
	Sub-Total	Alluvium	7	3	16.25-28.50	8.00 to 18.00	0.01 to 4.50	-	13.00 – 25.00
	Total		**64**	**10**	**16.25 – 200.00**	**3.50 – 19.00**	**Traces to 25.50**	**0.80 – 72.10**	**3.10 – 148.00**

In Basalt 57 exploratory wells were drilled and their depth ranged from 183.50 to 204.75 metres below ground level (m bgl). The discharge from these wells varied from 0.14 to 25.50 litres per second (lps). The static water levels (SWL) ranged from 3.50 to 19.00 m bgl. The potential aquifer zones have been encountered from 3.10 to 148.00 m bgl.

Apart from this, 7 shallow EW and 3 OW were constructed in Shivna alluvial area in the depth range of 16.25 to 28.50 m bgl in disconnected alluvial patches occurring along the Godavari and its tributaries. The phreatic and semi-confined aquifers tapped in these EW in the depth range of 13-25 meters have yielded 0.01 to 4.50 lps of discharge. The static water levels in these wells ranged between 8.00 and 18.00 m bgl.

2.0 Climate and Rainfall

The climate of the district is characterized by a hot summer and a general dryness throughout the year except during the south west monsoon season, which is from June to September while October and November constitute the postmonsoon season.

The winter season commences towards the end of November when temperatures begin to fall rapidly. December is the coldest month with the mean maximum temperature of 28.9° C, while the mean minimum temperature is 10.3°C. From the beginning of March, the daily temperature increases continuously. May is the hottest month with the mean maximum temperature of 39.8°C and the mean minimum temperature of 24.6° C. With the onset of the south-west monsoon by about the second week of June, the temperature falls appreciably.

Except during the southwest monsoon season, when the relative humidity is high, the air is generally dry over the district. The summer months are the driest when the relative humidity is generally between 20 and 25 % in the afternoon. Winds are generally light to moderate with increase in speed during the latter half of the hot season and in the monsoon season. The winds flow predominantly from directions between west and north during the hot season. They are mostly from directions between south west and northwest during the south west monsoon season. They blow mostly from the directions between northeast and southeast during the rest of the year becoming southwesterly to north westerly in January and February.

The normal annual rainfall over the district varies from about 500 mm to about 840 mm. It is minimum in the western part of the district around Vaijapur (510.6 mm). This increases towards east and reaches a maximum in the central part of the district around Khuldabad (835 mm) and in the north eastern part of the district around Soygaon (810 mm). The study of negative departures of the annual rainfall over normal reveals that extreme western parts around Vaijapur and Southern parts around Paithan and Chikalthana experienced moderate and severe drought conditions for more than 20 % of years. Hence these parts can be categorized as “Drought Area”.

The average annual rainfall for the period 1998 to 2007 varies from 504 mm (Vaijapur) to 756 mm (Soygaon) and the same is presented in Table-3. Thus it is clear that the average rainfall in the district during the period has decreased as compared to normal rainfall.

Taluka	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average
Aurangabad	1024.0	674.2	848.5	637.9	629.0	792.7	711.6	677.2	937.4	552.4	748.5
Gangapur	731.3	784.4	539.1	695.1	440.3	203.3	657.4	499.9	918.2	619.8	608.9
Kannad	800.6	699.7	412.8	567.5	594.7	440.8	496.2	506.4	971.1	537.7	602.7
Khuldabad	1192.0	750.0	309.8	513.6	932.9	761.3	717.9	481.1	963.8	562.9	718.5
Paithan	930.7	685.3	285.6	615.6	586.9	578.6	787.6	512.3	873.2	545.1	640.1
Phulambri	1025.0	-	190.2	572.2	497.0	603.2	445.4	494.2	681.8	627.9	570.8
Sillod	924.5	465.6	338.6	440.2	758.6	648.9	624.7	482.2	1085.6	644.5	641.4
Soygaon	997.8	695.5	310.6	668.6	814.2	1035.3	694.6	651.2	1010.4	682.9	756.1
Vaijapur	754.0	666.6	258.8	394.7	405.0	255.0	484.4	445.8	843.1	538.0	504.5

3.0 Geomorphology and Soil Types

Geomorphologically, the district comprises of varied topographic features and landscape consisting of high hills and plains and low lying hills. Most of the hill ranges are located in the northern part of the district. The Satmala hills and Ajanta hills extend from east to west. The hills near Verul in Khulabad taluka are part of these ranges which extend to Chawaka ranges and Aurangabad hills. The Satmala range encompasses several hills overlooking the Tapi valley. From west to east they are Antur (826 m amsl), Satonda (552 m amsl), Abasgand (671 m amsl) and Ajantha (578 m amsl). The Satmala hill (493 m amsl) from which name of the range is derived, is situated north to Kannad town.

The district is a part of the Deccan Plateau. In general the slopes in the district are towards south and southeast. The average elevation of the district is in the order of 500 m amsl. Within it are flat topped hill ranges extending over wide area and also hills separated by broad valleys.

Major part of the district falls in Godavari basin with a small area in north eastern parts falling Tapi Basin. The major river in the district is the Godavari with its tributaries namely; Purna, Dudhna and Shivna rivers. The other important tributaries are Sukna, Khelna, Kham, Gulathi, Shivbhadra and Girija rivers. Depending on the drainage and geomorphology, the district has been divided into 52 watersheds.

Soil plays a very important role in the agricultural activities and forest growth of the area. The fertility of the soil from agricultural point of view depends upon the texture and structure which controls the retaining and transmitting capacity of moisture and various nutrients such as nitrogen, phosphorous and potassium present in the soil. The formation of the soil in the area is influenced by the climate, geology, vegetation and topography. The major part of the district is covered by black cotton soil or ‘Regur’ formed by the weathering of Deccan Trap Basalt. It is rich in plant nutrients such as lime, magnesia, iron and alkalies on which cotton and dry crops like Jowar, Bazra and tur etc flourish. It swells and becomes sticky on watering while on drying is contracts and develops many cracks. The soil varies both in texture and depth. In northern portion of the district the soils are shallow and relatively poor while in south they become deep and fairly rich in nutrients.

4.0 Ground Water Scenario

4.1 Hydrogeology

The major part (95%) of the district constitutes a sequence of basaltic lava flows (Deccan Trap) while alluvium occupies a small portion. There are two distinct hydrogeological units in the district i.e. fissured formations (different units of basaltic lava flows) and porous formations (isolated patches of alluvial deposits). The occurrence and movement of ground water is controlled by variation in water bearing properties of these formations.

4.1.1 Hard Rock Areas

4.1.1.1 Deccan Trap Basalt

Deccan traps are a thick pile of basaltic flows, horizontally disposed and apparently more or less uniform in composition. Each individual flow is a typical section, which varies from porous weathered base to a massive middle unit,

becoming increasingly vesicular towards the top. The ground water occurs under water table and semi confined to confined conditions in Deccan Trap Basalt. The vesicular units in different trappean flows range in thickness from 2-8 meters and have primary porosity. However, the nature and density of the vesicles, their distribution, interconnection between the vesicles, depth of weathering and topography of the area are the decisive factor for occurrence and movement of ground water in these units. Since the zeolitic units in vesicular traps are highly susceptible to weathering, the vesicular units comprising weathered zeolitic traps occurring in topographic lows are the main water bearing formation in hard rock terrain of the district.

In massive unit of Deccan Trap Basalt, ground water occurs in soil cum weathered mantle, joints, cracks and other weaker zones. The upper portion of the massive traps show persistent spheroidal weathering and exfoliation which helps in retaining more ground water in these rocks in comparison to compact massive unit. The storage of ground water in compact massive unit totally depends upon the presence of joints and their nature, distribution and interconnection. The average depth range of dugwells is 12.00 m to 15.00 m and that of borewells is 50.00 to 60.00 m in hard rock areas, whereas the yields ranges from 0.60 to 3.10 lps.

4.1.2 Soft Rock Areas

4.1.2.1 Alluvium

The ground water in isolated alluvial pockets in the Godavari, Shivna, Purna and their tributaries occur under both water table and semi-confined conditions. The exploration of shallow alluvial area of the Shivna basin reveals that the saturated thickness of the alluvial material comprising silty clay, sand and gravel ranges from 1-7 meters. The depth to basement ranges between 16.25 to 26.45 m bgl. The aquifer horizons were encountered as coarse sand mixed with clay and silt between 15.00 and 26.00 m bgl, which constitute the potential aquifer in the area with discharge of up to 4.50 lps. The dugwells are generally down to 20 m depth and yields varying between 0.5 and 0.8 lps.

4.2 Water Level Scenario

Central Ground Water Board monitors 21 National Hydrograph Network Stations (NHNS) stations in the Aurangabad district, four times a year i.e. in January, May (Premonsoon), August and November (Postmonsoon).

4.2.1 Premonsoon Depth to Water Level (May-2007)

The depth to water levels in the district during May 2007 ranges between 4.82 m bgl (Ajanta) and 16.00 m bgl (Paithan). The depth to water levels during premonsoon (May 2007) has been depicted in **Figure-3**. Shallow water levels within 2 to 5 m bgl are seen in northern parts of the district in parts of Soygaon and Sillod talukas. Water levels within 5 to 10 m bgl are seen almost in entire district occupying entire Khuldabad taluka and major parts of Aurangabad, Gangapur, Kannad and Sillod talukas. The NHNS located at Ajanta, Chauka, Chikhltana, Fardapur, Hatnur, Khamgaon, Khandala, Kinnal, Limbe Jalgaon, Patri and Walur Tanda are showing this particular range of water level. The water levels in the range of 10 to 20 m bgl are seen in the form of 4-5 patches scattered in the district occupying major parts of Paithan and Vaijapur talukas and small parts of Aurangabad, Sillod and Kannad talukas. The NHNS at Bidkingaon,

Borgaon Bazar, Kannad and Mahalgaon are falling in this range.

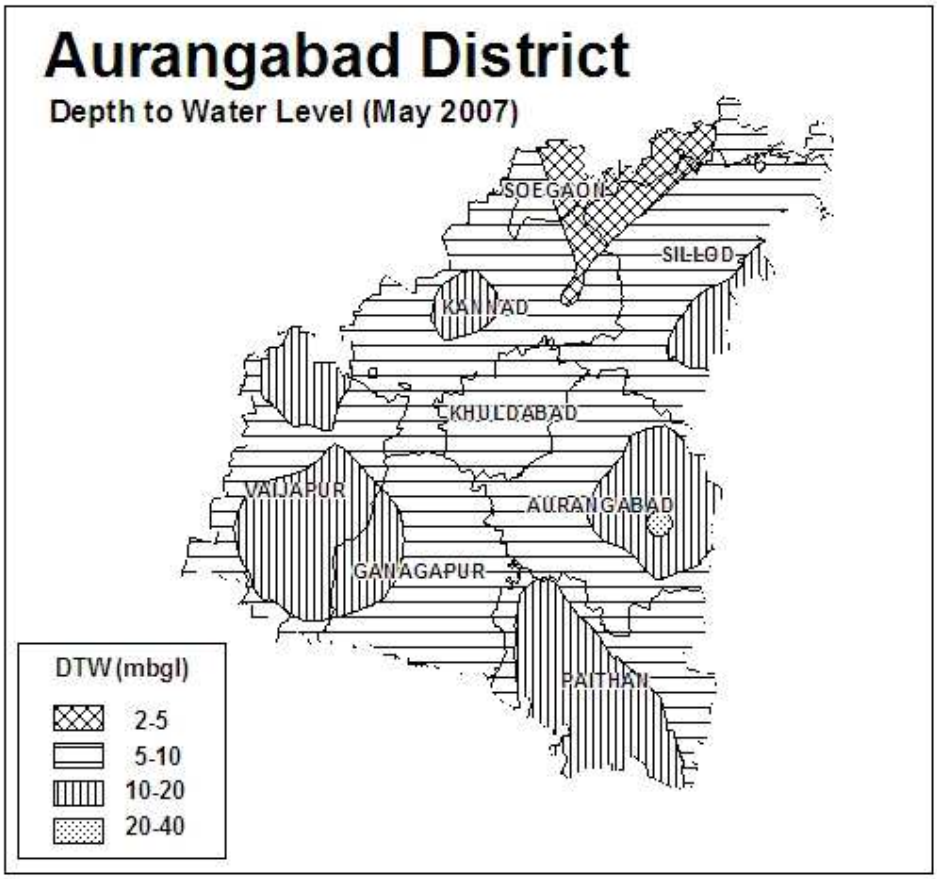

Figure-3: Premonsoon Depth to Water Level Map (May-2007)

4.2.2 Postmonsoon Depth to Water Level (Nov.-2007)

The depth to water levels during postmonsoon (Nov. 2007) ranges between 1.85 (Chauka) and 16.00 (Paithan). The spatial variation of the postmonsoon (November 2007) depth to water levels is shown in **Figure 4**. Shallow water levels within 5 m bgl are observed in north-south extended patch along eastern side of the district occupying parts of Soygaon, Kannad, Silod and Gangapur talukas and almost entire Aurangabad taluka. The NHNS located at Apatgaon, Chauka, Hatnur, Kaigaon, Kinnal, Limbe Jalgaon, Patri and Walur Tanda fall in this category. Water levels within 5 to 10 m bgl are observed in major part of the district in western, southern and north eastern parts of the district, occupying almost entire Vaijapur, Paithan, Kannad and Sillod talukas and parts of Khuldabad and Gangapur talukas. The NHNS located at Adul, Fardapur, Kannad, Khandala, Mahalgaon, Rotegaon and Tunki are showing this particular range of water level. The water levels in the range of 10 to 20 mbgl are seen in the form of 2 patches, one in Paithan taluka and another in the central part of the district. The NHNS located at Borgaon Bazar, Khuldabad and Paithan fall in these range.

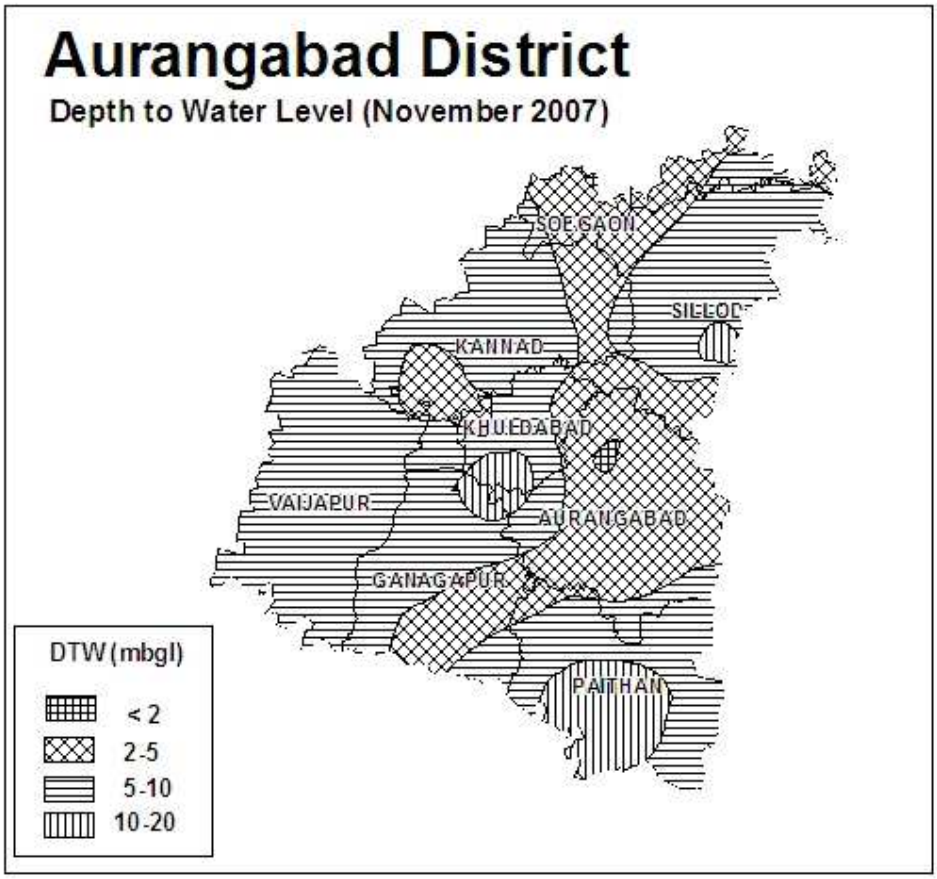

Figure-4: Postmonsoon Depth to Water Level Map (November-2007)

4.2.3 Seasonal Water Level Fluctuation (May-Nov. 2007)

The water level fluctuation in the district ranges from 0.00 (Adul) to 7.90 m (Limbe Jalgaon). The water level fluctuation in the range of 0 to 2 m is observed in major part of the district in northern and southern parts occupying almost entire Soygaon, Sillod, Kannad, Paithan and parts of Gangapur talukas. The NHNS showing this range are located at Borgaon Bazar, Fardapur, Hatnur, Paithan, Rotegaon. The water level fluctuation of 2 to 4 m is observed in central part of the district covering parts of Khuldabad, Aurangabad and Gangapur talukas. The NHNS showing this range are located at Chauka, Khandala, Limbe Jalgaon, Walur Tanda. The water level fluctuation of more than 4 m is observed in 2 scattered patches occupying eastern part of Aurangabad taluka and parts of Vaijapur and Gangapur talukas. The NHNS showing this range are located at Kinnal, Mahalgaon, Paithan, Tunki.

4.2.4 Water Level Trend (1998-2007)

Trend of water levels of 16 NHNS for pre-monsoon and of 18 NHNS for post-monsoon periods for last ten years (1998-2007) have been computed.

Analysis of trend indicates that during premonsoon period, rise in water levels has been recorded at 4 stations and it ranges between 0.01 (Ajanta) and 0.68 m/year (Khamgaon). Fall in water levels has been observed at 12 stations and it ranges between 0.03 (Rotegaon) and 0.79 m/year (Kannad). During postmonsoon period rise in water levels has been recorded at 6 stations and it

ranges from negligible at few stations to 0.41 m/year (Kinnal), whereas at 12 stations, fall in water levels ranging between 0.01 (Adul) and 0.97 m/year (Khamgaon) is observed. Thus in major part of the district, both during pre and postmonsoon periods declining trends have been observed.

The premonsoon trend map was also prepared and the same is presented in Figure-5. The perusal of the map shows that rising trends of up to 0.20 m/year are restricted to northern, south eastern and central western parts of the district occupying almost entire Soygaon taluka and parts of Sillod, Aurangabad, Paithan, Vaijapur and Kannad talukas. It also shows that in major parts of the district falling water level trend is observed in southern, south western and central parts occupying almost entire Paithan, Gangapur, Vaijapur and Khuldabad talukas and parts of Kannad and Sillod talukas. Thus the future water conservation and artificial recharge structures needs to be prioritized in these areas.

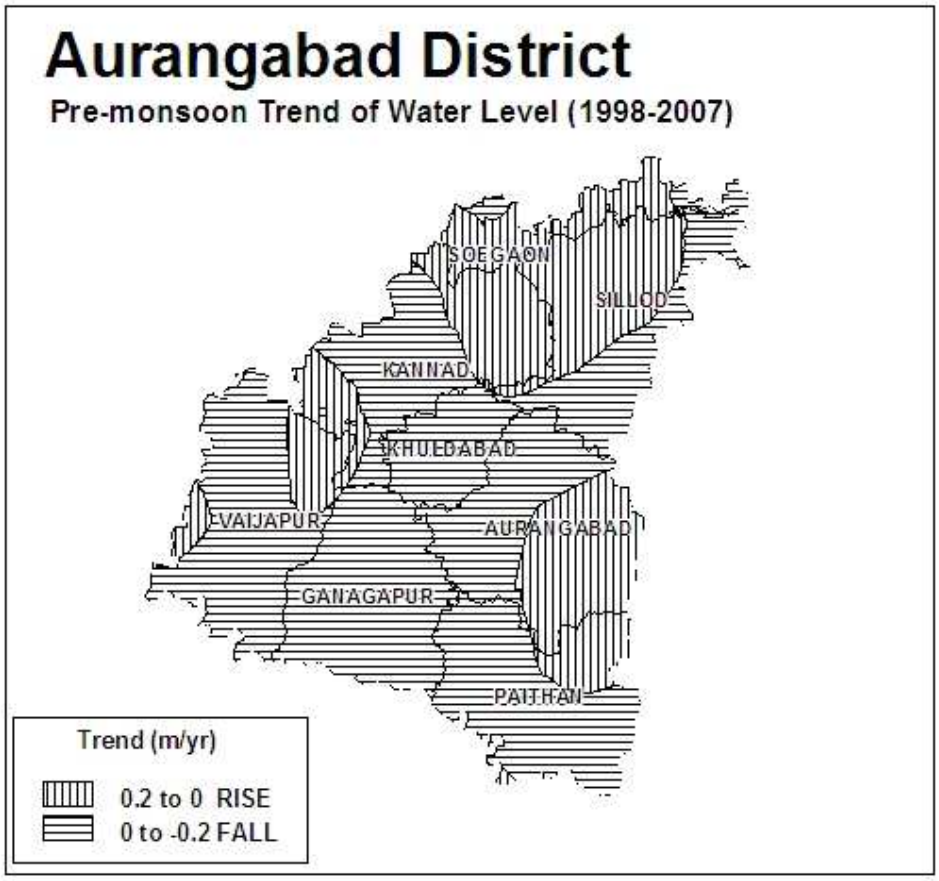

Figure 5: Premonsoon Water Level Trend (May 1998-2007)

4.3 Yield of Wells

The yields of the wells are function of the permeability and transmissivity of aquifer encountered and it varies with location, diameter and depth of wells etc. There are mainly two types of ground water abstraction structures in the district i.e., dugwells and borewells/tubewells, however the yield of wells also vary according to nature of formation tapped and its saturated thickness. Therefore, the dugwells located in the topographic lows, morphological depressions and on

or near the lineaments yield comparatively more water than the located elsewhere, which is particularly true in basaltic terrain. The yield of dugwell also varies depending on the season. The yields of dugwells for different formations are presented in Table-4.

Table-4: Yield of Wells

S. No.	Formation	G.W Structures	Depth Range (m bgl)	Yield Range (lps)
1	Alluvium (Porous)	Dugwell Tubewell	7-20 20-30	0.5-0.8 0.1-4.5
2	Basalt (Fissured)	Dugwell DCB Borewell	12-15 12-40 50-60	1.5-3.1 0.6-3.0 0.6-2.4

4.4 Aquifer Parameters

Aquifer parameters are available from ground water exploration carried out in the alluvial area of the district as well as from the pumping tests carried out on dugwells in Basaltic and Alluvial terrain. The transmissivity of shallow basaltic aquifers in the district is generally less than 80 m^2/day. The specific capacity of well also gives an idea about the productivity of well and is controlled by diameter and depth. In basaltic formation the specific capacity of dugwells is generally less than 200 lpm/m of drawdown with an average of 110 lpm/m of drawdown. In Alluvium it ranges from 130-2043 lpm/m of drawdown. The pumping tests conducted on 2 shallow exploratory wells of Alluvium indicates that transmissivity ranges from 369 to 757 m^2/day, storativity ranges from 3.3×10^{-5} to 1.7×10^{-3} whereas specific capacity ranges between 0.7 and 3.2 lps/m of drawdown.

4.5 Ground Water Resources

Central Ground Water Board and Ground Water Survey and Development Agency (GSDA) have jointly estimated the ground water resources of the district based on GEC-97 methodology as on March 2004. The same are presented in Table 5, whereas graphical representation is presented in Figure-6. Ground water resources estimation was carried out for 9821.56 sq. km. area out of which 1523.45 sq. km. is under command and 8298.11 sq. km. is non-command.

As per the estimation, the total annual ground water recharge is 1208.25 MCM with the natural discharge of 62.06 MCM, thus the net annual ground water availability is 1146.19 MCM. The annual gross draft for all uses is estimated at 632.72 MCM with irrigation sector being the major consumer having an annual draft of 605.84 MCM. The allocation domestic and industrial water requirement is at 53.74 MCM/year for next 25 years. The net annual ground water availability for future irrigation is estimated at 459.72 MCM.

Stage of ground water development varies from about 26% (Soygaon) to about 68% (Gangapur). The overall stage of ground water development for the district is about 55% and it falls under “Safe” category. The watershed wise resource estimation was also done and it indicated that 47 watersheds out of 52 fall under “Safe” category. The 4 watersheds that fall under “Semi-Critical category” are GV-34B, GP-11, GP-15 and GP-17 whereas 2 watershed i.e., GV-41 and GV-9 fall under “Critical” category. In all these watersheds, future ground water development is not recommended without adhering to the precautionary measures i.e., artificial recharge to ground water resources and adoption of

ground water management practices.

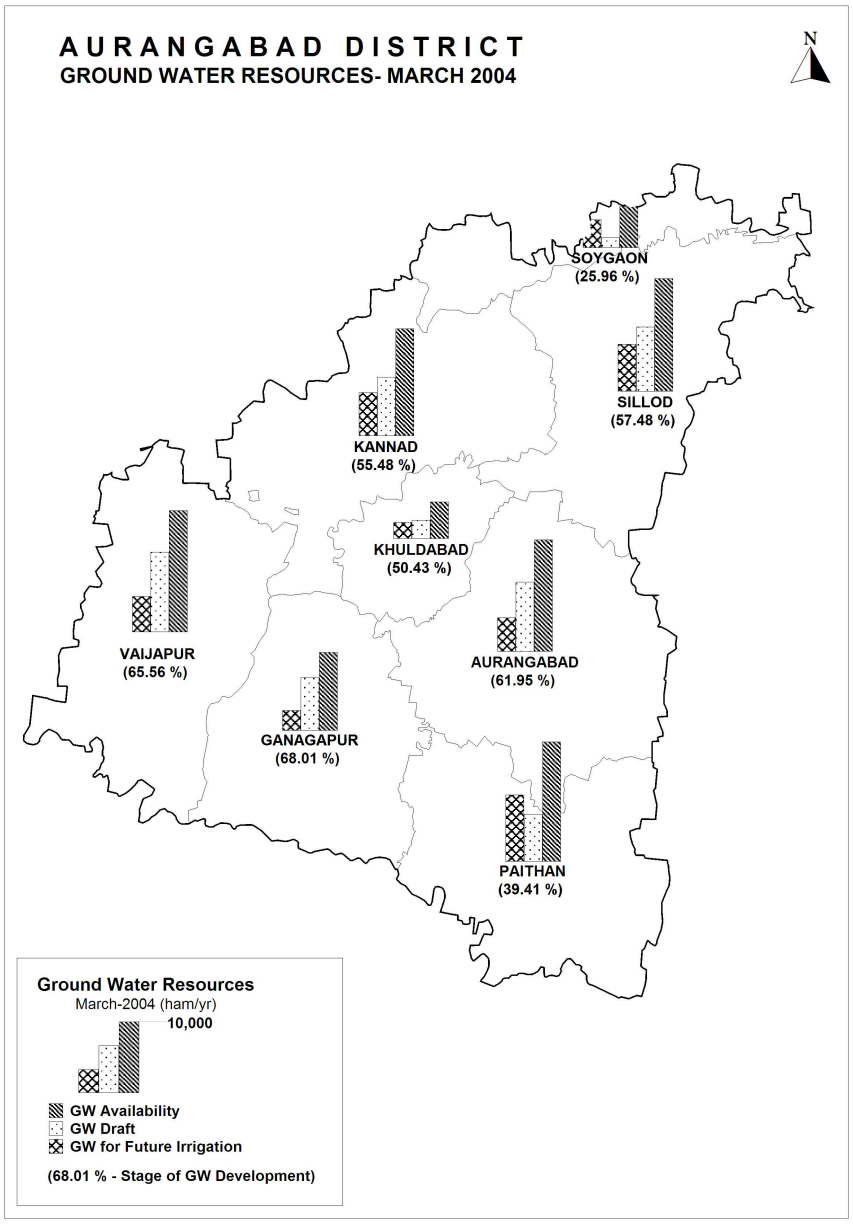

Figure-6: Ground Water Resources (March 2004)

4.6 Ground Water Quality

Central Ground Water Board monitors the ground water quality of the district through its National Hydrograph Network stations (NHNS), which mainly consist of the dugwells representing shallow aquifer. The objective behind the monitoring is to develop an overall picture of the ground water quality in the district. During the year 2007, CGWB carried out the ground water quality monitoring of 14 NHNS.

Table-4 Taluka wise Ground Water Resources (March 2004).

Taluka	Area type	Net annual ground water availability (ham/yr.)	Annual ground water draft (ham/yr.)			Allocation for domestic & industrial requirement supply up to next 25 years (ham/yr.)	Ground water availability for future irrigation (ham/yr.)	Stage of ground water develop-ment (%)	Category
			Irrigation	Domestic & industrial uses	Total				
Aurangabad	C	6059.46	1866.63	104.93	1971.56	95.39	761.71	32.54	Safe
	NC	11458.39	8519.67	360.64	8880.31	794.85	4562.48	77.50	
	Total	17517.85	10386.30	465.58	10851.87	890.24	5324.19	61.95	
Paithan	C	7144.46	1422.77	124.04	1546.81	196.73	2327.56	21.65	Safe
	NC	11677.37	5558.41	311.91	5870.32	678.96	8149.71	50.27	
	Total	18821.83	6981.18	435.95	7417.13	875.69	10477.27	39.41	
Sillod	C	3414.26	1012.55	22.42	1034.96	37.18	540.57	30.31	Safe
	NC	14373.15	8902.38	286.13	9188.51	610.68	6897.72	63.93	
	Total	17787.40	9914.92	308.55	10223.48	647.87	7438.29	57.48	
Soyegaon	C	2862.16	181.51	32.33	213.84	20.13	465.56	7.47	Safe
	NC	3720.93	1415.47	79.65	1495.11	200.79	3934.57	40.18	
	Total	6583.09	1596.98	111.98	1708.96	220.92	4400.14	25.96	
Vaijapur	C	7013.50	4447.57	160.84	4608.41	314.85	2003.88	65.71	Safe
	NC	12091.36	7624.40	292.31	7916.71	591.19	3670.85	65.47	
	Total	19104.86	12071.97	453.15	12525.12	906.04	5674.73	65.56	
Kannad	C	3365.30	1824.04	54.11	1878.15	61.14	577.12	55.81	Safe
	NC	13412.34	7091.73	338.11	7429.83	712.96	6243.37	55.40	
	Total	16777.64	8915.76	392.22	9307.99	774.10	6820.49	55.48	
Khuldabad	C	1038.58	525.03	20.88	545.91	24.49	136.16	52.56	Safe
	NC	4778.40	2254.39	133.36	2387.76	286.54	2449.47	49.97	
	Total	5816.98	2779.43	154.25	2933.67	311.02	2585.63	50.43	
Gangapur	C	3831.37	2018.83	107.30	2126.13	182.82	1229.29	55.49	Safe
	NC	8378.28	5919.60	258.34	6177.94	565.93	2022.38	73.74	
	Total	12209.66	7938.43	365.64	8304.07	748.74	3251.67	68.01	
District Total	C	34729.08	13298.93	626.85	13925.78	932.72	8041.85	40.10	
	NC	79890.22	47286.05	2060.46	49346.51	4441.90	37930.54	61.77	
	Total	114619.30	60584.98	2687.31	63272.29	5374.62	45972.40	55.20	

Here C-Command, NC-Non-Command.

The chemical analysis results show that the ground water in the district is alkaline in nature, while the EC and TDS values show that the ground water in the area is mineralized to medium extent. The concentrations of the major ions indicate that among the cations, the concentration of magnesium ion is highest followed by calcium and sodium while among anions, the concentration of chloride ion is highest followed by bicarbonate and sulphate ions. The results also show that the concentration of nitrate ions in the ground is significant and appearing as major ion.

The geochemical classification of ground water in the area was carried to see the dominance of ions in ground water. In the district, 14 samples were collected all representing Deccan Trap Basalt. The epm percentage of alkaline earths (Ca+Mg), alkali metals (Na+K), weak acids (CO_3+HCO_3) and strong acids (CI+SO_4NO_3), in the ground water samples were calculated and samples were broadly classified into 4 classes as given in Table-5.

Table-5: Geochemical Classification of Ground Water Samples.

Sr. No.	Classification	Type	No. of Sample	% of Sample
1	Alkaline earths (Ca+Mg > 50%) exceeds alkali metals and weak acids (CO_3+HCO_3 > 50%) exceeds strong acids.	Ca-HCO_3	2	14
2	Alkaline earths (Ca+Mg > 50%) exceeds alkali metals and strong acids (Cl+SO_4+NO_3 > 50%) exceeds weak acids.	Ca-Cl	12	86
3	**Total**		**14**	**100**

As all the samples are from Basaltic aquifer, the type of water present in these samples should be of Ca-HCO_3 type. But the perusal of Table-5 shows that 86% of samples are having Ca-CI type of water, indicating that the type of water in these samples has been changed from Ca-HCO_3 type to Ca-CI type. This may be because of percolation of waste and wastewater containing high concentration of strong acid ions (CI+NO_3+SO_4) to ground water.

4.6.1 Suitability of Ground Water for Drinking Purpose

The suitability of ground water for drinking purpose is determined keeping in view the effects of various chemical constituents in water on the biological system of human being. The classification of ground water samples was carried out based on the desirable and maximum permissible limits as given by BIS for drinking water in IS-10500-91, Revised 2003 standards for the parameters viz., TDS, TH, Ca, Mg, Cl, SO_4 and NO_3 is given in Table 6.

Table-6: Classification of Ground Water Samples based on BIS Drinking Water Standards (IS-10500-91, Revised 2003)

Parameters	DL	MPL	Samples with conc. < DL	Samples with conc. in DL-MPL	Samples with conc. >MPL
TDS (mg/L)	500	2000	3	9	2
TH (mg/L)	300	600	1	10	3

Ca(mg/L)	75	200	9	4	1
Mg(mg/L)	30	100	0	12	2
Cl (mg/L)	250	1000	12	2	0
SO_4 (mg/L)	200	400	11	2	1
NO_3 (mg/L)	45	No relaxation	3	-	11
F (mg/L)	1.0	1.5	14	0	0

(Here, DL- Desirable Limit, MPL- Maximum Permissible Limit)

The perusal of Table-6 shows that concentration of TDS, TH, Ca, Mg and SO_4 is above desirable limit but below maximum permissible limit in most of the cases. However, the concentration of nitrate is found more than MPL at 11 locations (78%) indicating high influence of anthropogenic activity in the vicinity of the wells, causing nitrate contamination.

Therefore, it can be concluded that the ground water quality in most of the monitored wells is not suitable for drinking purpose due to high nitrate concentration.

4.6.2 Suitability of Ground Water for Irrigation Purpose

The water used for irrigation is an important factor in productivity of crop, its yield and quality of irrigated crops. The quality of irrigation water depends primarily on the presence of dissolved salts and their concentrations. Sodium Absorption Ratio (SAR) and Residual Sodium Carbonate (RSC) are the most important quality criteria, which influence the water quality and its suitability for irrigation.

4.6.2.1 Sodium Absorption Ratio (SAR)

Sodium Absorption Ratio (SAR) is an expression pertaining to cation make up of water and soil solution and is used for characterizing the sodium hazard of irrigation water.

SAR value is used to calculate the degree to which irrigation water tends to enter into cation exchange section in the soil. The main problem with high sodium concentration is its effect on soil permeability. Sodium also contributes directly to the total salinity of the water and may be toxic to sensitive crops such as fruit trees. The higher value of SAR indicates soil structure damage.

4.6.2.2 Residual Sodium Carbonate (RSC)

Residual Sodium Carbonate (RSC) is considered to be superior to SAR as a measure of sodicity particularly at low salinity levels. The classification of ground water samples based on SAR and RSC values for its suitability for irrigation purpose is shown below in Table-7.

The Table-7 shows that, all the samples have SAR values below 10 indicating that the possibility of sodium hazard is low if the water is used for irrigation purpose. The RSC values of all the samples collected from the wells located in the district is also less than 1.25.

Overall, the ground water quality in the wells monitored is good for irrigation purpose and there is a less possibility of developing sodium hazard.

Table 7: Classification of Ground water for Irrigation based on SAR and RSC.

SAR	**<10**		**10-18**		**18-26**		**>26**	
Category	**Good**		**Good to**		**Doubtful**		**Unsuitable**	
Total Samples	No. of Samples	%	No. of Samples	%	No. of Samples	%	No. of Samples	%
14	14	100	NIl	Nil	Nil	Nil	Nil	Nil
RSC	**<1.25**		**1.25-2.50**		**>2.50**			
Category	**Good**		**Doubtful**		**Unsuitable**			
Total Samples	No. of Samples	%	No. of Samples	%	No. of Samples		%	
14	14	100	--	--	Nil		Nil	

4.7 Status of Ground Water Development

Ground water development depends on many factors viz., availability, crop water requirement, socio-economic fabric and on the yield of the aquifers existing in that area.

The ground water is predominantly used for irrigation, as it is the major ground water utilising sector. The minor irrigation census data (2000-01) indicates that area irrigated by ground water is 1223.38 sq.km., whereas surface water accounts for 482.31 sq.km. of area and net irrigated area stands at 1705.69 sq.km. Thus it is clear that 71% of irrigation is done by ground water and surface water accounts for only 29%, thereby laying more stress on limited pristine ground water resources. There are about 78680 dugwells in the district which create an irrigation potential of about 3319 sq.km., out of which 1603 sq.km. of irrigation potential was utilised. In addition to this 16 sq.km of irrigation potential is utilised through 1438 borewells/tubewells during 2000-01.

The State Government has drilled large number of borewells/tubewells fitted with hand pumps and electric motors for rural drinking water purposes in the district. In all G.S.D.A, Government of Maharashtra, in the year 2006-07 was successfully operating 4997 borewells/tubewells fitted with hand pumps and 300 borewells/tubewells fitted with electric pumps for rural water supply in the district.

5.0 Ground Water Management Strategy

Ground water has special significance for agricultural development in the district as 71% of irrigation is ground water based. The ground water development in some parts of the district has reached a critical stage resulting in decline of ground water levels. There is thus a need to adopt an integrated approach of development of ground water resources dovetailed with ground water augmentation to provide sustainability to ground water development.

5.1 Ground Water Development

The present stage of ground water development in the district is 55.20%. Thus there is scope for further ground water development in the district. However, in two talukas i.e., Vaijapur and Gangapur, the stage of ground water development is between 65-70 % hence cautious approach for future ground water development is required in these talukas. 2 watersheds i.e., GV-41 and GP-9 fall in “Critical” category, whereas 4 watersheds i.e., GV-

34B, GP-11, GP-15 and GP-17 fall under “Semi-Critical” category. Further ground water development in these watersheds falling is not recommended, without adhering to the precautionary measures i.e., artificial recharge to augment the ground water resources and adoption of ground water management practices.

5.2 Water Conservation and Artificial Recharge

CCT, nala bunding, gabion structures, vegetative bunds, terracing etc are suitable for the Satpuda hill range. In the Basaltic area, the artificial recharge structures feasible are check dams, gully plugs, percolation tanks, nala bunds, etc. Existing dugwells can also be used for artificial recharge; however, the source water should be properly filtered before being put in the wells. The artificial recharge structures suitable for Alluvial areas are percolation tanks and recharge wells/shafts. The most feasible artificial recharge structures suitable for alluvial area, are shallow recharge wells/shafts on the river bed of the tributaries. These sites need to be located where the hydrogeological conditions are favourable, i.e., where sufficient thickness of de-saturated/unsaturated aquifer exists and water levels are more than 5 m deep. Such areas are available throughout the district except in Soygaon taluka, where water levels are shallow.

6.0 Ground Water Related Issues and Problems

In major parts of the district falling water level trend is observed in southern, south western and central parts occupying almost entire Paithan, Gangapur, Vaijapur and Khuldabad talukas and parts of Kannad and Sillod talukas. Thus the future water conservation and artificial recharge structures needs to be prioritized in these areas. Although a considerable area in Aurangabad district is under canal command of various major and minor irrigation projects but major parts the district is showing declining trend of water levels due to exploitation of ground water for irrigation and other purposes at a faster rate. There is not much scope for conjunctive use in such areas. But an area of about 61,300 ha falling under canal command of major and minor irrigation projects in Paithan, Sillod and Aurangabad talukas is showing rising trend. The conjunctive use of water is recommended in this area.

Ground water quality is adversely affected at many places due to high concentration of some parameters especially nitrate. Adequate sanitary protection to the wells may be provided to control the nitrate contamination.

7.0 Areas Notified by CGWA/SGWA

As per ground water resource estimation all the talukas fall under ‘Safe’ category, hence till March 2007 no area has been notified either by CGWA or SGWA.

8.0 Recommendations

1. Before deciding to develop ground water potential of Aurangabad district it is of prime importance to consider the stage of ground water development so that the system is not damaged and no side effects like over development, deterioration of water quality etc., are encountered.

2. The design of ground water structures depends upon geological formation. In basaltic area dugwells of 5-6 meter diameter and 12-15 m depth, and borewells of 50-60 meters depth are recommended while in alluvial area, the dugwells of 2-4 meter diameter and 7-20 m depth and shallow tubewells of 20-30 meters depth are recommended to be constructed.

3. Major part of the district is underlain by Deccan Trap Basalt, where only dugwells are the most feasible structures for ground water development.

4. The sites for borewells need to be selected only after proper scientific investigation. Borewells generally tap deeper fractures, which may not be sustainable. Besides, the borewells should only be used for drinking water supply and not for irrigation.

5. The present stage of ground water development in the district is about 55%. Thus there is scope for ground water development in the district. However, in two talukas of the district i.e., Vaijapur and Gangapur, the stage of ground water development is between 65 and 70% hence cautious approach for future ground water development is required in these talukas. The 2 watersheds i.e., GV-41 and GP-9 fall in “Critical” category, whereas 4 watersheds i.e., GV-34B, GP-11, GP-15 and GP-17 fall under “Semi-Critical” category. Further ground water development in these watersheds falling is not recommended, without adhering to the precautionary measures i.e., artificial recharge to augment the ground water resources and adoption of ground water management practices.

6. The concentration of nitrate is found more than MPL at 11 locations (78%) indicating high influence of anthropogenic activity in the vicinity of the wells, causing nitrate contamination. It may cause toxic effect on young infants. Ground water from these areas may be used only after proper treatment or demineralization. Adequate sanitary protection to the wells may be provided to control nitrate contamination.

7. CCT, nala bunding, gabion structures, vegetative bunds, terracing etc are suitable for the Satpuda hill range. In the Basaltic area, the artificial recharge structures feasible are check dams, gully plugs, percolation tanks, nala bunds, etc. Existing dugwells can also be used for artificial recharge; however, the source water should be properly filtered before being put in the wells. The artificial recharge structures suitable for alluvial areas are percolation tanks and recharge wells/shafts.

8. The existing village ponds/tanks need to be rejuvenated to act both as water conservation and artificial recharge structures.

9. An area of about 61,300 ha is falling under canal command of major and minor irrigation projects in Paithan, Sillod and Aurangabad talukas is showing rising trend. The conjunctive use of surface and ground water is recommended in this area.