Report on

RISING WATER LEVEL PROBLEMS IN JODHPUR CITY AREA, RAJASTHAN

CENTRAL GROUND WATER BOARD
Western Region
Jaipur

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Introduction

Jodhpur is the second largest town of Rajasthan State. It is most important cultural heritage city of western Rajasthan popularly known as “Suncity” and is more than 540 years old. The city had unique medieval rainwater harvesting and water management system which enabled city to survive in arid desertic climate with frequent droughts.

Jodhpur City, founded by Rao Jodhaji in the year 1459 AD, is a historic city of great importance. It was capital of the princely state Jodhpur until the merger of the state after independence into Rajasthan. The old city is well fortified, protected by high stone wall which is about 10 km. long and has eight gates in various directions. Within this, on the hill comprising of rhyolites and sandstone, stands the prominent Jodhpur fort ,the famous 'Mehrangarh' overlooking the city. The fort hill is about 125 m. above the surrounding plains. The city expanded beyond old walls with growing population and urbanization. Walled city area is active trading cum residential center presently.

Jodhpur city is located between latitude 26°15’ N to 26°20’ N and longitude 73°0’E to 73°4’E (Figure 1). The standard urban area of Jodhpur town is 208.31 Sq.km comprising 78.60 Sq.Km area of urban component and 120.71 km sq. area of rural component. The Jodhpur Urban/Metropolitan area includes Jodhpur, Kuri Bhagtasani, Mandore Industrial Area, Nandri, Pal Village and Sangariya. The city is well connected by road, meter gauge and broad gauge line of the Railways and by air to other parts of the country.

The population of Jodhpur city as per Census of India (2011) is 10,53,191 souls, which includes 5,55,37 male and 5,00,820 Female. The population of the city as per 2001 census was 8,60,818. The population growth rate during 2001-2011 has been 22.35%.

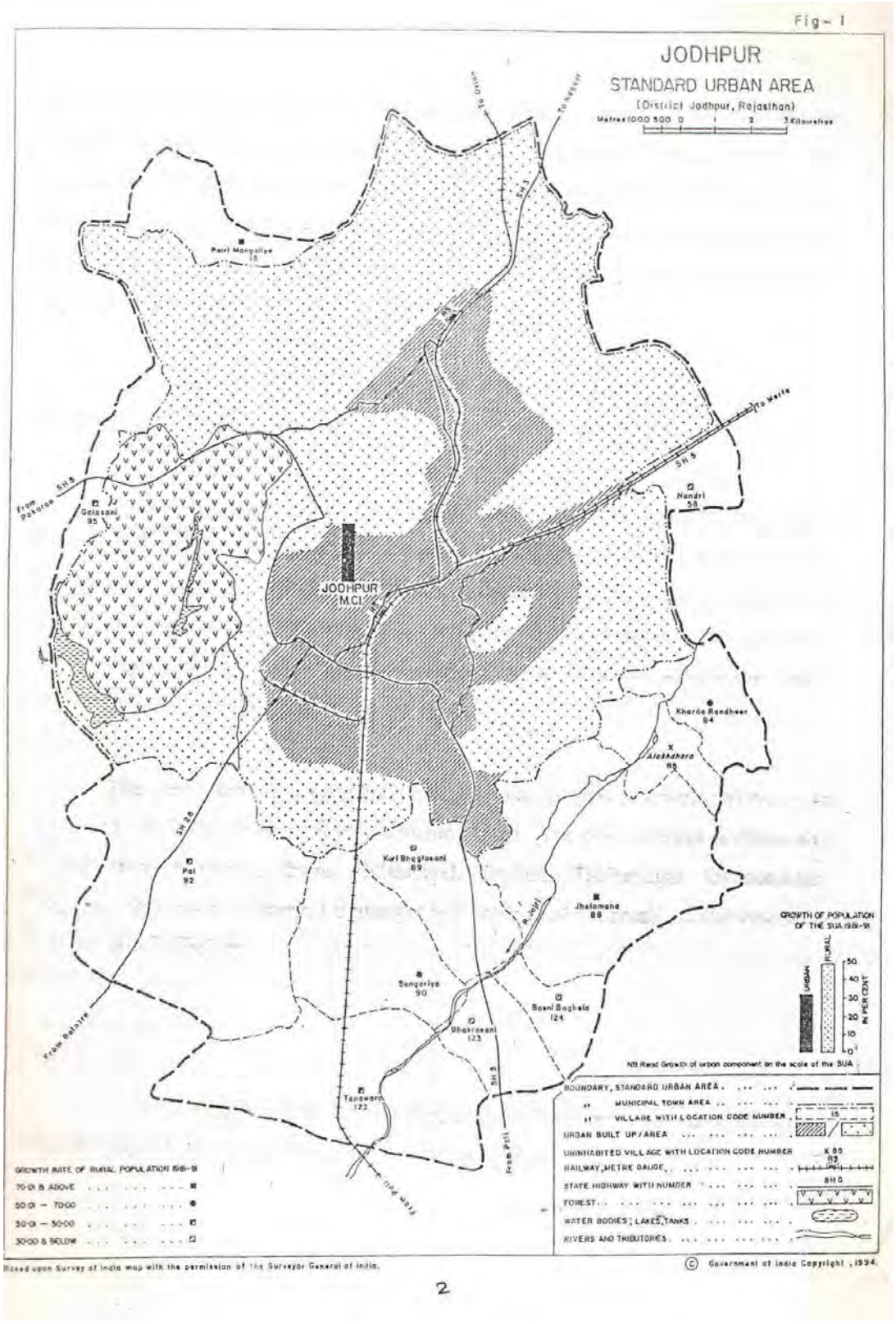

Figure 1: Jodhpur Urban Area

Physiography And Drainage

Jodhpur City is situated partly along the foot of hills and partly in the plains formed by weathering of rhyolites and sandstone . Major part of the old city lies on the piedmont zone. City is bounded by the hills in the north and west directions (Figure 2). The hills of rhyolites rising to an elevation of 395 m above mean sea level mark the prominent elevated landmark feature in the western part of the area. Topographic lowering of the plain area to the extent of 180 m above msl occurs in the south-eastern part of the area.

The area is devoid of perennial drainage. Jojari river is an ephemeral stream in the area which flow in response to monsoon rainfall. The city sewerage is directed to Jojari through various drains. Balsamand, Kaylana, Takhatsagar, Ummedsagar, Ranisar, Padamsar, Lalsagar, Gulabsagar and Fatehsagar are notable water reservoirs in and around the city.

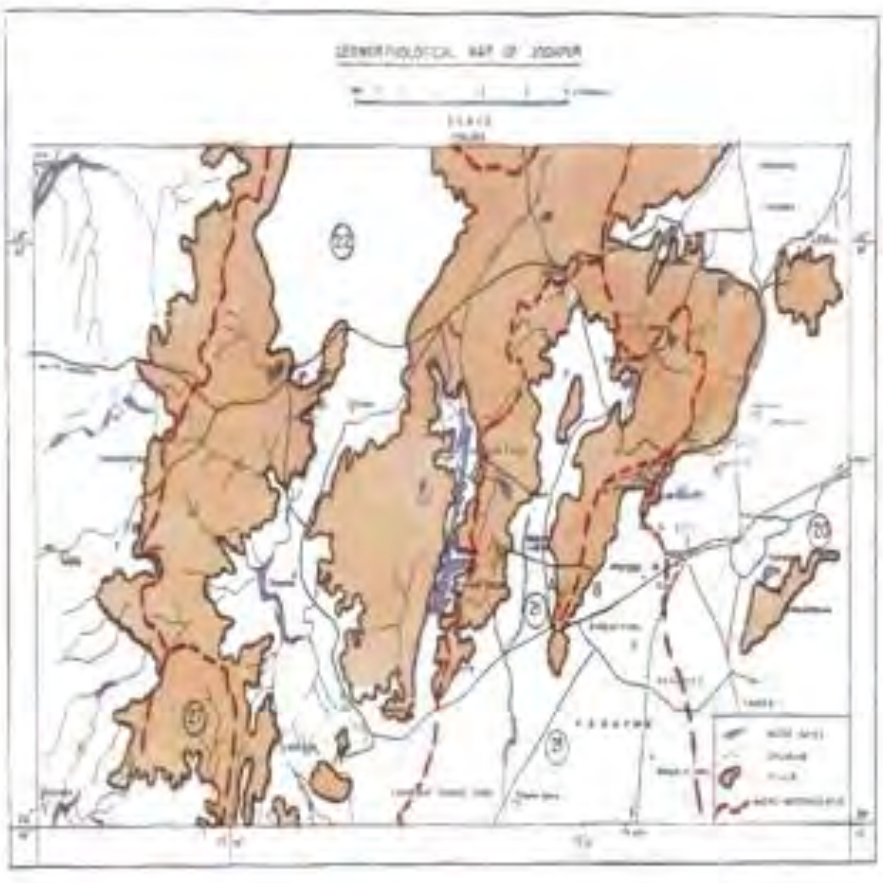

Figure 2: Geomorphology

Climate and Rainfall

The city experiences very hot climate during the summer months. Mean daily maximum temperature is highest (41.6°C) in May. However, the nights are slightly better with mean daily minimum temperature of 28.5°C being the highest in the month of June. January is the coldest month with both daily maximum and minimum temperature being lowest at 24.6°C and 9.5°C respectively. The air is generally dry during the major part of the year. However, during monsoon period the climate becomes a little humid, relative humidity is highest in the month of August (81%).

The southwest monsoon, which contributes more than 85% to the total annual rainfall, extends from July to September. August is the wettest month with normal monthly rainfall of 128.9 mm. Mean annual rainfall of the city is 377.65 mm (1969-2014) whereas, the IMD Normal Annual Rainfall is 314mm. The Rainfall data, along with the departure from average rainfall is given in figure 3. It is observed that there are periods of relatively high and low rainfall. During recent years, 1994-1999 and 2010 to 2013 have been periods of relatively high rainfall.

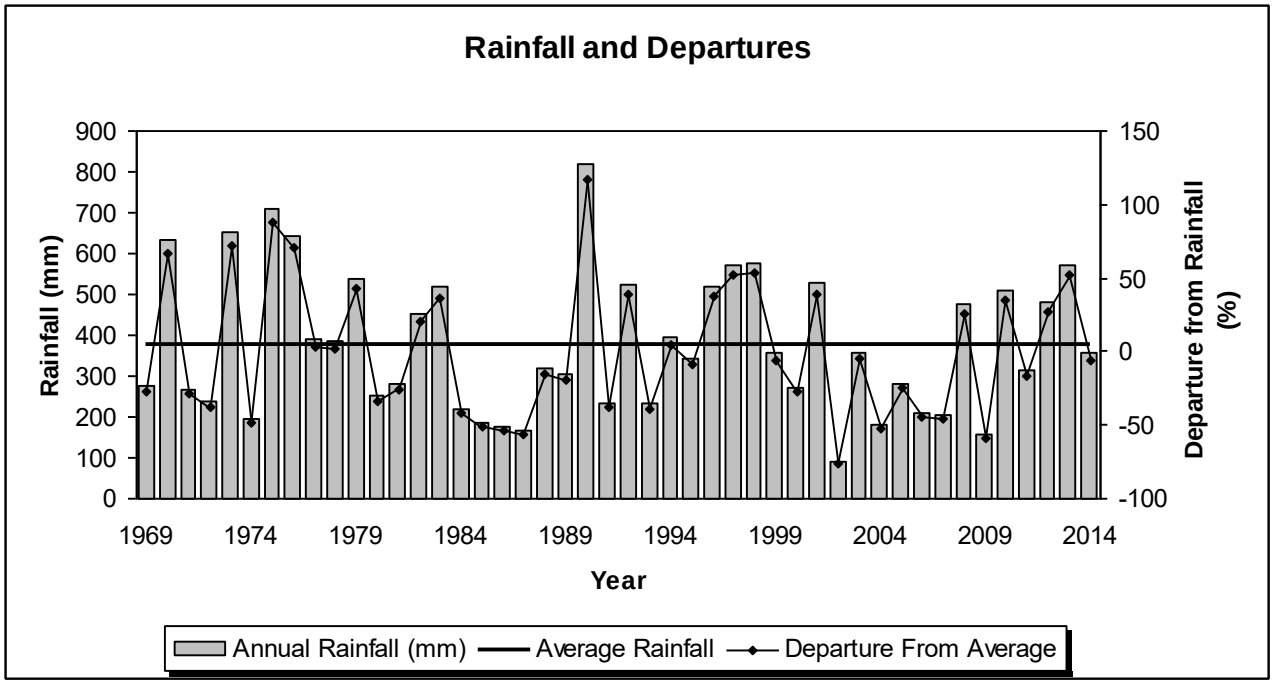

Figure 3: Rainfall and Departure of Rainfall from Average

Water Supply Scenario In Jodhpur City

Jodhpur City has scarce and inferior quality of ground water resources and the city has depended mainly on surface water sources, for various needs since past time. In the historical past, the city population used to meet their demands of water supply from “Baories” (step wells) and surface water reservoirs like Umedsagar, Lalsagar, Takhatsagar, Kaylana, Baiji Ka Talab, and Balsamand. The abundance of old baories and surface water sources indicate such type of water supply.

With time, the population of town increased and the water sources were not adequate for the increased demand of water supply. Therefore during British period Jawai reservoir located in the southern part of Pali district, was constructed to meet the water supply demands of Jodhpur town through Jawai canal. This supply was in addition to the supply from old sources of the city.

During 1966-70 Central Ground Water Board (erstwhile ETO) investigated three new areas in Jodhpur district, which could be exploited for drinking water supply to Jodhpur town. The areas were as under.

(i) Rampura – Mathania area.

(ii) Borunda – Ransigaon area.

(iii) Doli – Pal area.

To meet the increased domestic demand of drinking water for Jodhpur City, PHED authorities constructed number of tubewells in Doli-Pal area which is located about 9 km south west of Jodhpur town. Due to excessive development of ground water resources for irrigation and drinking, Doli-Pal area became overexploited. This resulted in continuous decline of water levels in the area. Western Rajasthan experienced severe drought conditions during 1986-89.Due to this the supply from Jawai reservoir reduced considerably and became insufficient. Government implemented two new schemes to meet out the demand for city water supply (I) Rampura-manai, Teori-Balarwa scheme (ii) Ransigaon scheme. PHED constructed battery of tubewells in these two areas and supplied water to Jodhpur city through pipeline. Heavy pumping from these areas for the increased demand of water for Jodhpur city together with the enhanced use of ground water by the agricultural

sector led to overexploitation conditions, this resulted in considerable decline in ground water levels in these areas and reduction in well yields. In Jodhpur city area about 1800 bored wells with hand pumps and pumps in some cases were constructed for various domestic purposes. The quality of ground water in these was inferior in general. In major parts of walled city and Ratanada area salinity in ground water is also associated with high nitrate concentration thereby making the ground water unfit for drinking purpose. Despite all above efforts the water supply to the city was far less than the requirement.

In view of the above there was an imperative need for long term planning of water supply to Jodhpur town keeping in view the increasing population. Accordingly the state authorities implemented IGNP lift canal scheme for the town. The water received through the lift canal is stored in Kaylana Takhatsagar reservoir from where it is supplied to the city. Supply from this scheme was started in 1997.The canal water stored in Kaylana lake has caused the reservoir water level to rise to a new high which is maintained almost throughout the year due to inflow of water from the lift canal. Water supply from Ransigaon area and Jawai canal has been stopped for Jodhpur city since 1998.Presently water supply to Jodhpur city is met mainly through IGNP lift canal and partly from ground water sources from the area around Jodhpur city namely Rampura-Teori-Manai-Manklao and Doli-Pal area.

Water supply to the city was 259 lac gallons/day in 1997.Present level of water supply to the city is 377.54 lac gallons/day, which is adequate considering the requirement.

Geology

General geological succession of the area is given below and geological map is given in figure 4.

Era	Formation	Group	Lithology
Quaternary	Recent to Sub recent		Wind blown sand and alluvium
Unconformity			
Paleozoic	Marwar Super Group	Jodhpur Group	Sandstone and Shale
Unconformity			
Pre-Cambrian	Malani igneous suite		Rhyolite with tuffs and Granite

Malani suite of igneous rocks comprising gray buff and brown colored volcanic flows of rhyolites mainly of porphyritic texture constitute the basement rocks in the area. Sandstone and shale of Jodhpur group lie unconformably over these volcanics. The volcanics constitute bold ridges with respect to regional ground level. These volcanic ridges separate the sandstone lithofacies of the area into two distinct outcrops. Sandstone with shale intercalations of varying thickness was deposited over the moderately uneven basement.

Jodhpur Sandstone is fine to medium grained, hard and compact with occasional intercalations of shales. It is pinkish white to reddish and purple to gray in colour. Slabs of sandstone of delicate pinkish white colour, occurring around the top of the scarps, north of Jodhpur town are extracted in great quantity at Sursagar quarries. It is being used as a principal building material and decorative stone which beautifies the township of the Jodhpur and the major part of Western Rajasthan.

Quarternary alluvium comprising sand, clay, silt, and kankars, covers southern part of the area. This is underlained by Jodhpur sandstone and/or by Rhyolite. Thickness of the quaternary sediments varies from few centimetres to 75 m in the area. It is maximum in the Pal area.

The Rhyolites in upper parts exhibit columnar joints which subsides within shallow depth. Bedding joints are quite common in sandstone besides other sets of joints. Few lineaments running in N-S and NE-SW direction have been interpreted based on remote sensing.

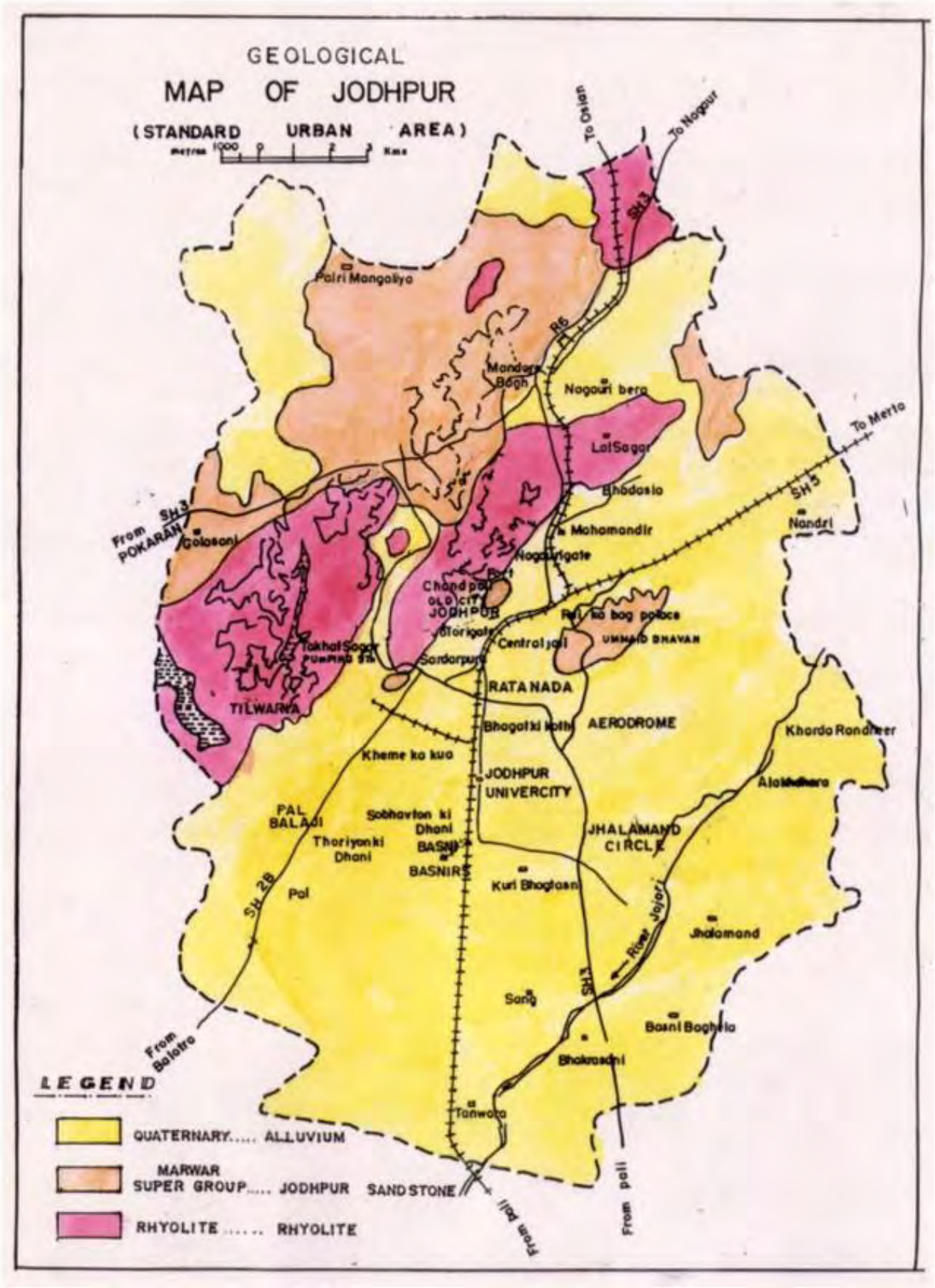

Figure 4: Geology

Hydrogeology

Hydrogeological formations occurring in the area are Malani Rhyolite, Jodhpur Sandstone and Quaternary Alluvium (Figure 5). Ground water in the area occurs under water table condition.

Malani Rhyolites form aquifer in the central part of the area covering area from Tilwaria, Chopasani nath through Chandpol, Lal Sagar to Punjla. These are hard, compact, impervious, poorly jointed and form poor aquifer yielding meager quantity of fresh to saline ground water. Ground water is restricted to joints, fractured and weathered zone.

Sandstone forms aquifer in the central and northern part of the area. It is fine to medium grained hard compact; at places shale intercalations are quite common in this formation which reduces the water potentiality. The yield of wells in this formation generally varies from 10 to 50 m^3/day.

Quaternary formation forms aquifer in the southern and eastern parts of the area. It comprises sand, silt, clay with kankars, pebbles, gravel and rock fragments. It is semiconsolidated at places due to presence of calcarious material. The saturated thickness of the alluvium varies from 3 to 10 m in the area. Yield of the wells within this aquifer varies from 50 m^3/day to 120 m^3/day. In Pal area due to excess development of ground water for irrigation and drinking, the area has become over exploited.

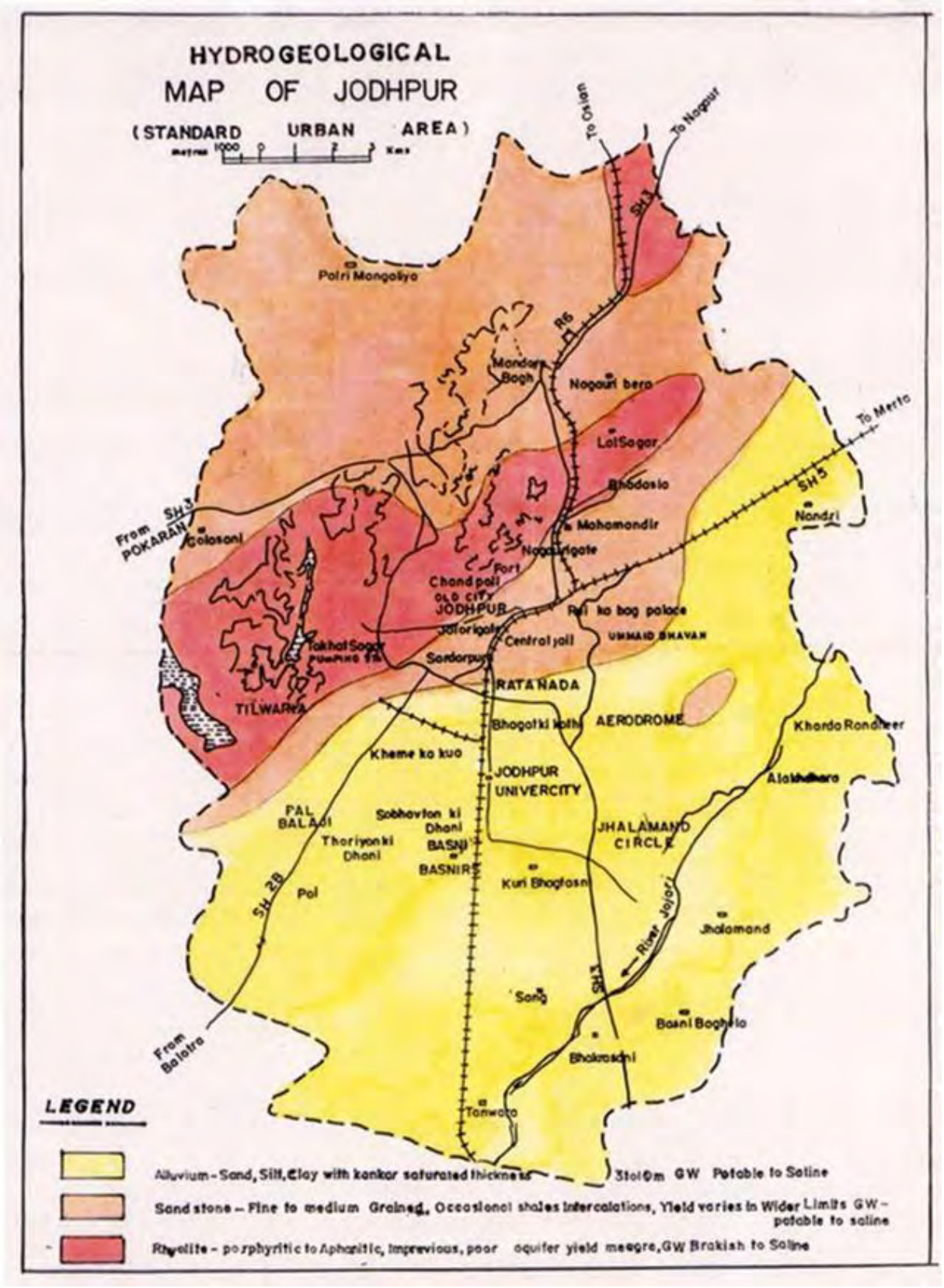

Figure 5: Hydrogology

Water Level Behaviour

Central Ground Water Board (CGWB) monitors ground water levels and quality through its network of hydrograph stations. Besides, specific studies were taken up to address the ground water scenario of Jodhpur Urban area during 1977-1978. Subsequently the studies were taken up in 2010-11 to address the issue of ground water pollution in industrial cluster. In 2012-13, the parts of Jodhpur Urban area were studied under NAQIM.

Depth to Water Level

The studies carried out during 1977-78 indicated the the depth to water level varied from 4.59 to 40.48m. bgl. Shallow water levels were observed in some parts of the old city and in Jojri river area. Year 1977 was a normal monsoon year. Further study carried out by CGWB in 2001 and as per this report the depth to water level map for the period 2001 is given in Figure 6.

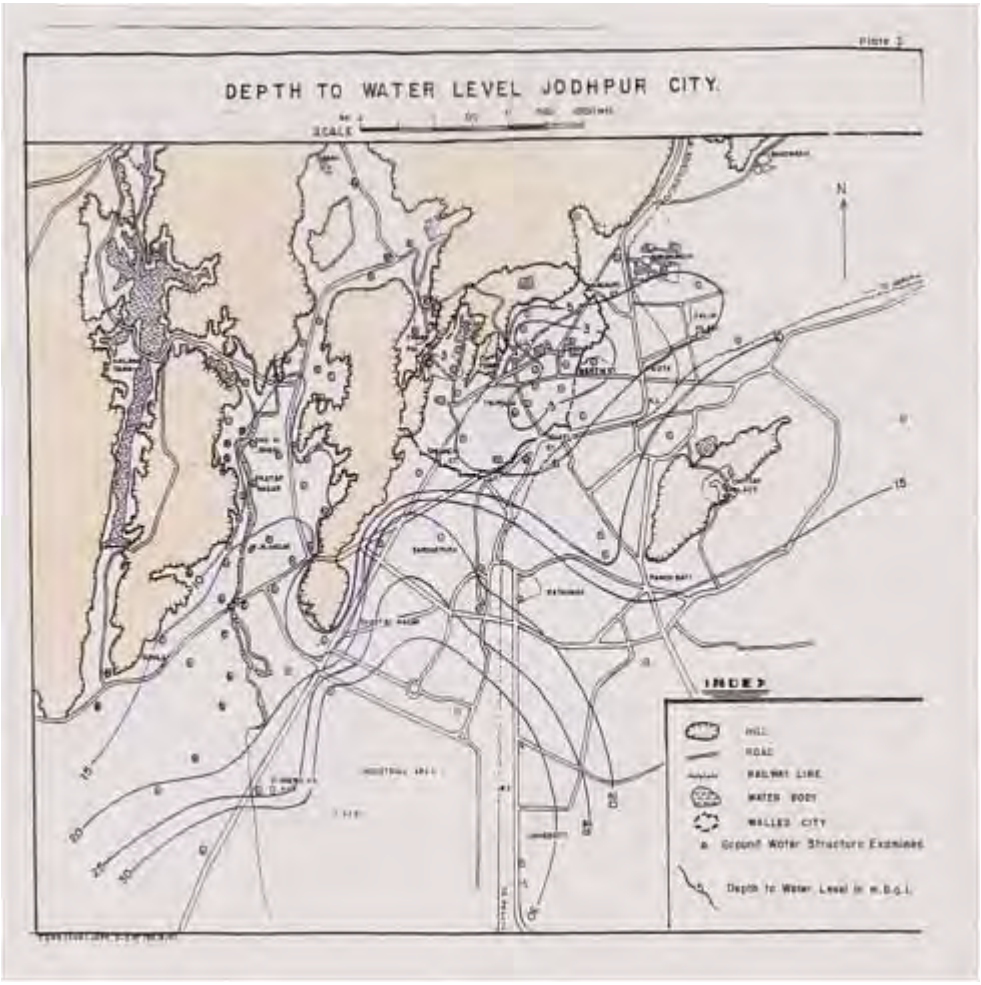

Figure 6: Depth to Water Level (2001)

The depth to water level for the period 2010 is given in figure 7. The map shows that the depth to water level varies from less than 3 mbgl to more than 60 mbgl. It is shallower in the old city area showing water logging conditions and becomes deeper towards south, southwest and southeast.

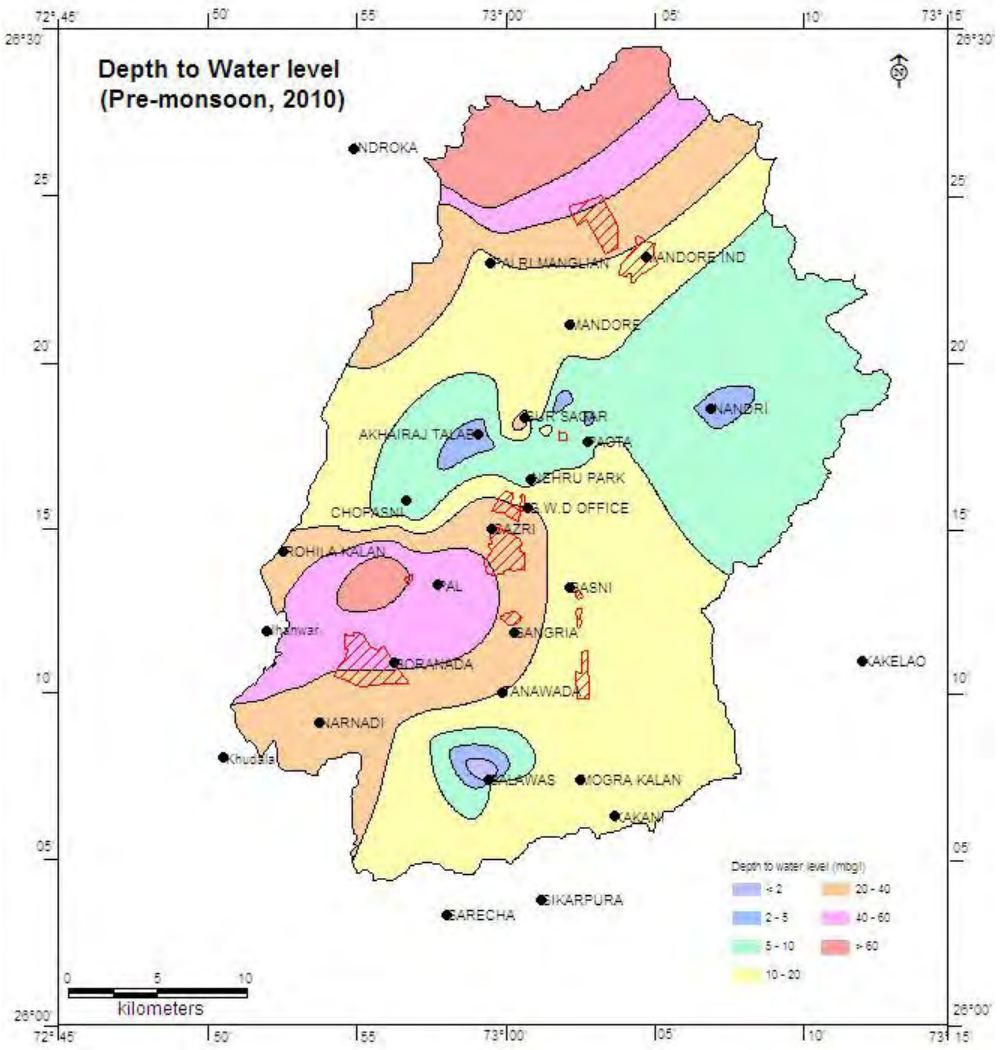

Figure 7: Depth to water level (Pre-monsoon 2010)

Election of Water Table

The water table contour map for Premonsoon 2010 (Figure 8) shows that ground water flows southwards. Slope of water table is steep in hard rock aquifers as compared to alluvium where the slope is gentle. Kaylana Takhatsagar lake area is separated from the old Jodhpur city area by two water divides comprising massive Rhyolite hills roughly trending north - south. Dan Ki Dhani – Pratapnagar - Kamla Nehru Nagar area lies in intervening valley area. The ground water flow in this valley area is also southwards. It is clearly seen from that map that ground water mound

has formed in the city area. Though, the slope of ground water table is towards north and south, i.e. away from the mound, adequate water is not being drained out due to hydrogeological conditions in the area.

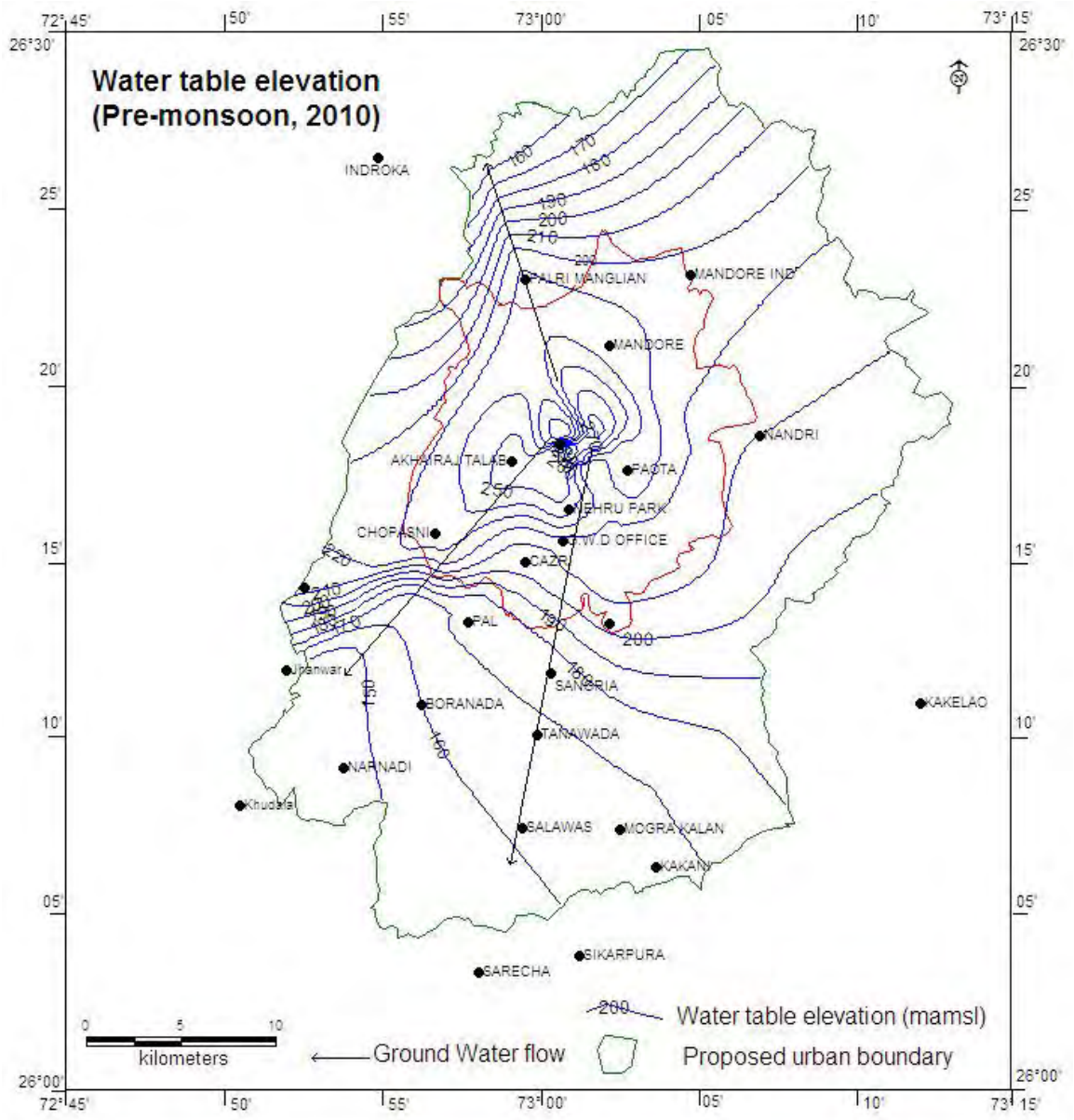

Figure 8: Elevation of Water Table

Long Term Water Level Behaviour

The CGWB monitors about 8 wells in and around Jodhpur Urban Area as part of its monitoring programme (NHS). The water level data for last 20 years (1994 to 2014) for 6 wells is shown in figure 9 a-f. The trend of water levels at these 6 monotoring wells is shown in table below. It is seen that the water level has been rising consistently in 4 wells situated with the urban area. These are: Jodhpur - Sumer

School (0.87 m/year), CAZRI Pz (1.06 m/year), Chopasani Nath (0.21 m/year), and Thorion Ki Dhani (2.25 m/year). The two monitoring stations, Mandore and Bujawar are located beyond the core urban area, here marginal rise (Mandore -0.07 m/year) or decline in water level (Bujawar - 0.12 m/year) is noticed. This indicates that the rise in water level is there mostly in the core city area.

S.No	Monitoring Station	Type of Well	Trend (m/year)	Remarks
1	Jodhpur (Sumer School)	Dug Well	-0.87	Rise
2	CAZRI	Pz	-1.06	Rise
3	Chopasni Nath	Dug Well	-0.21	Rise
4	Thorion Ki Dhani	Pz	-2.25	Rise
5	Mandore	Dug Well	-0.07	Rise
6	Bujawar	Dug Well	0.12	Decline

* Negative value indicates decline.

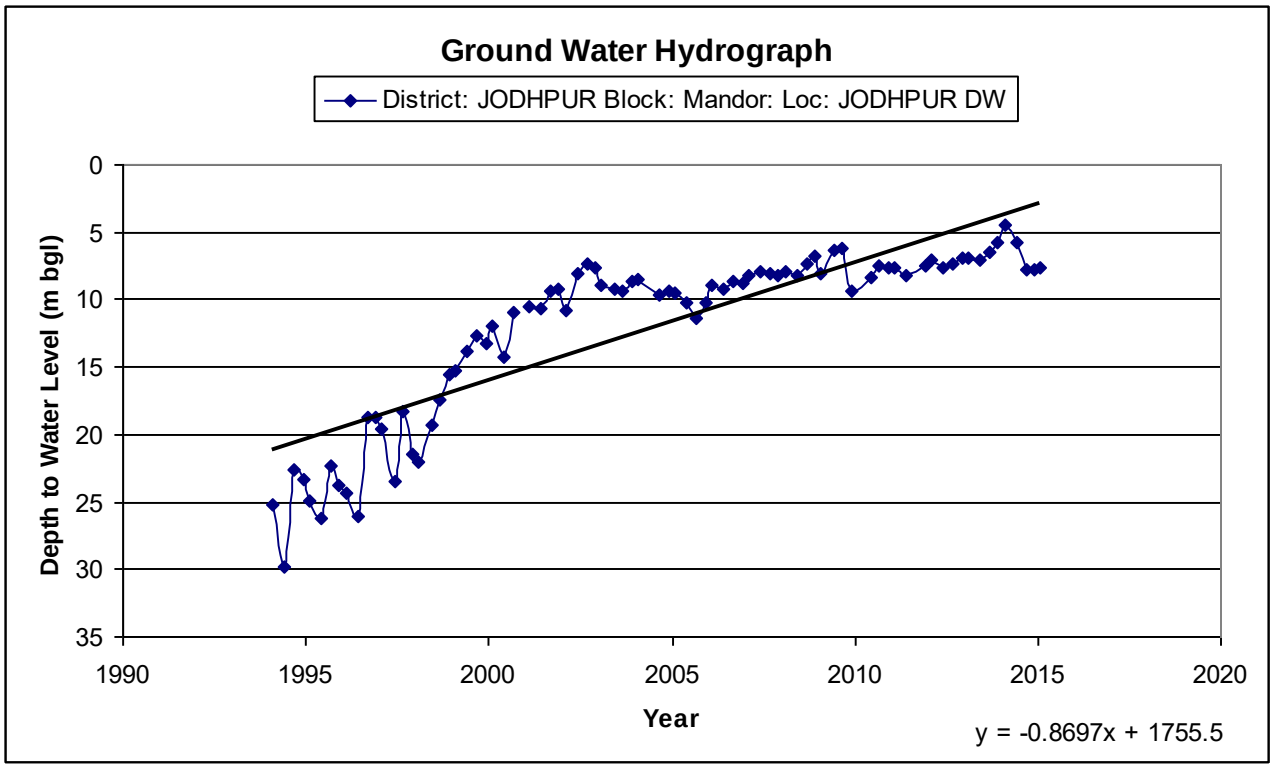

Figure 9a: Long Term Behaviour of Water Level - Jodhpur

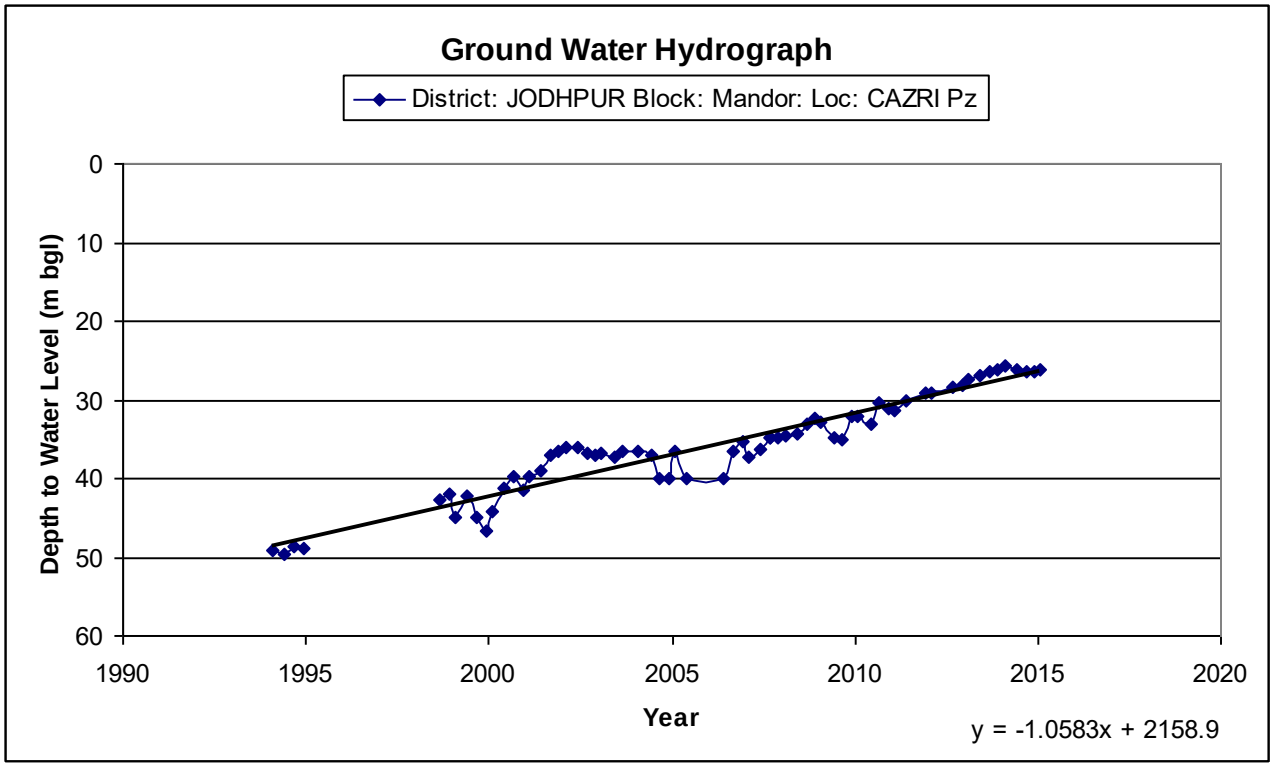

Figure 9b: Long Term Behaviour of Water Level - CAZRI Pz

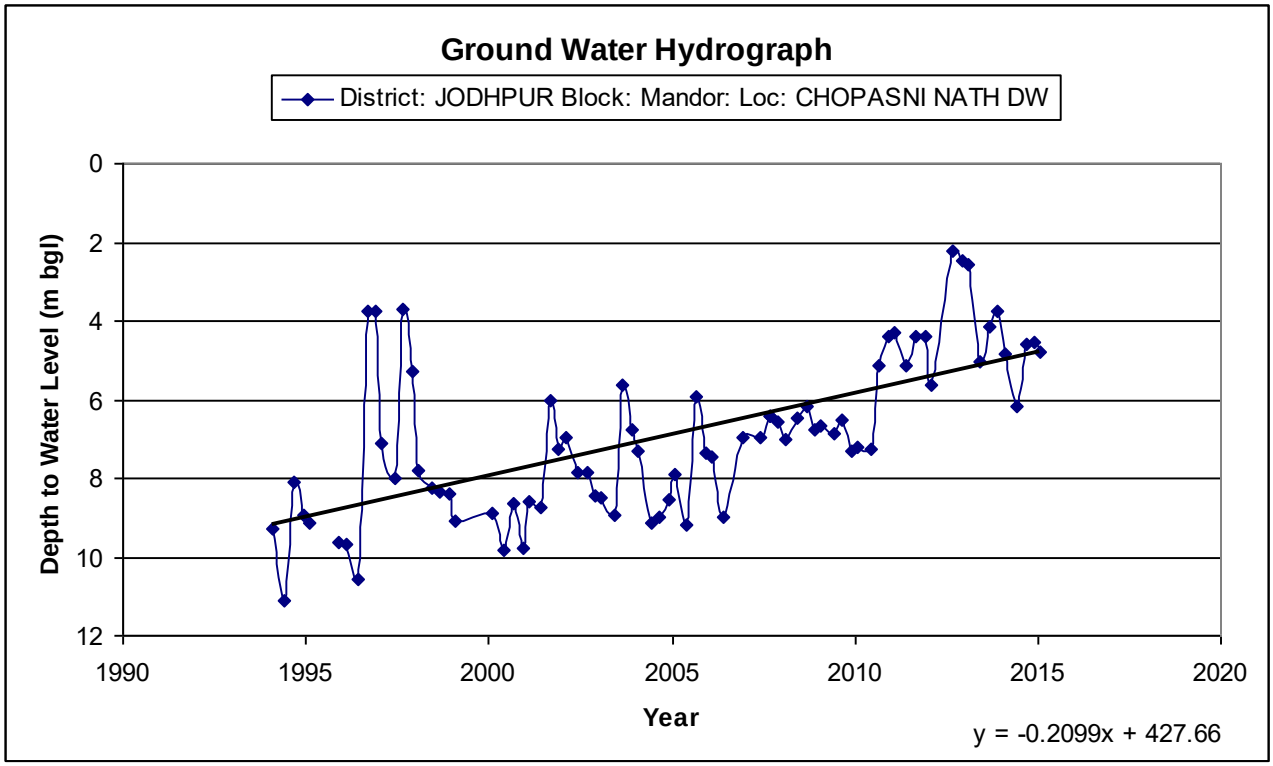

Figure 9c: Long Term Behaviour of Water Level - Chopasani Nath

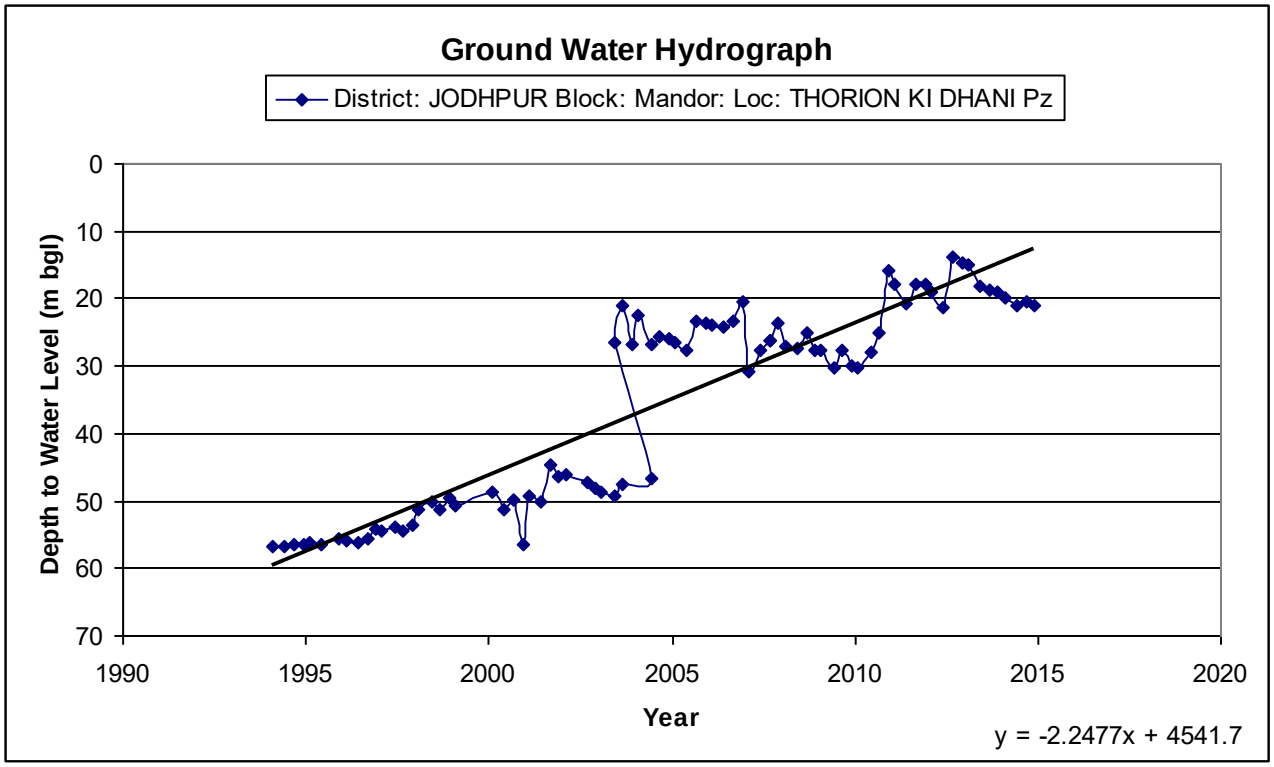

Figure 9d : Long Term Behaviour of Water Level - Thorion Ki Dhani Pz

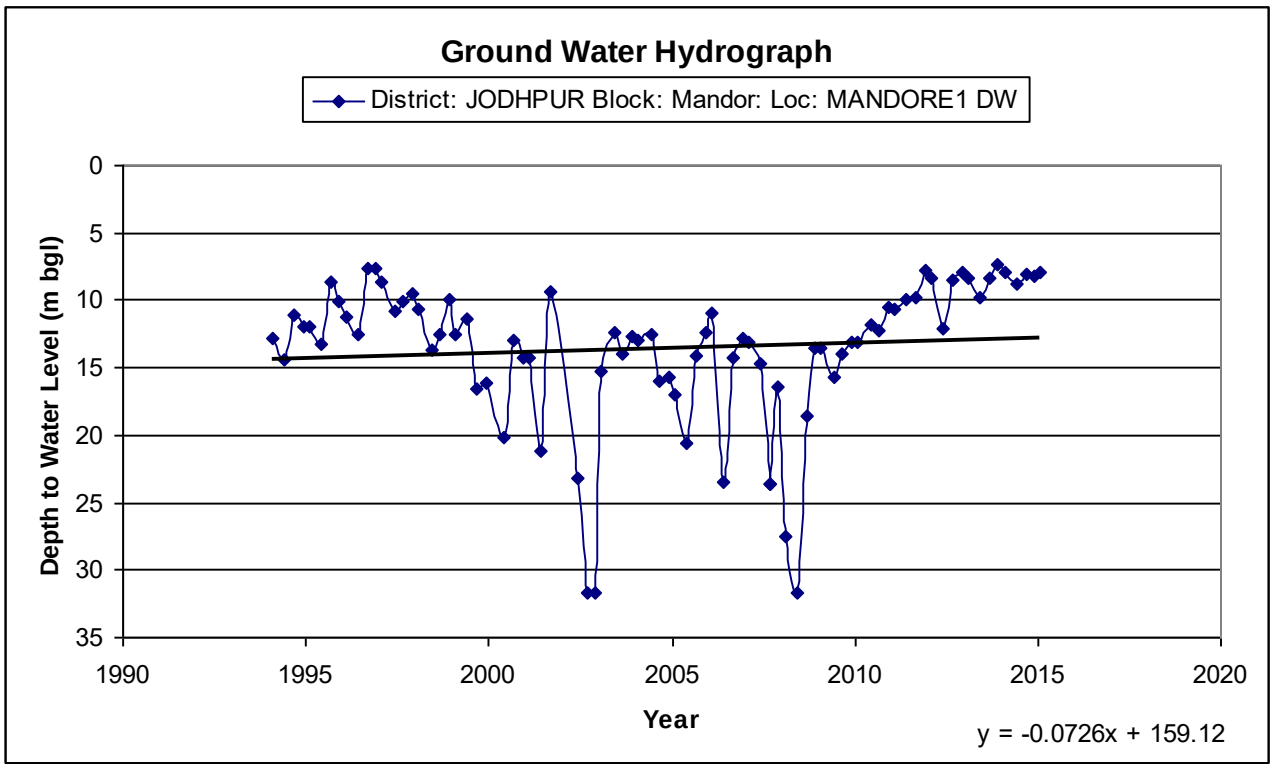

Figure 9e: Long Term Behaviour of Water Level Mandore

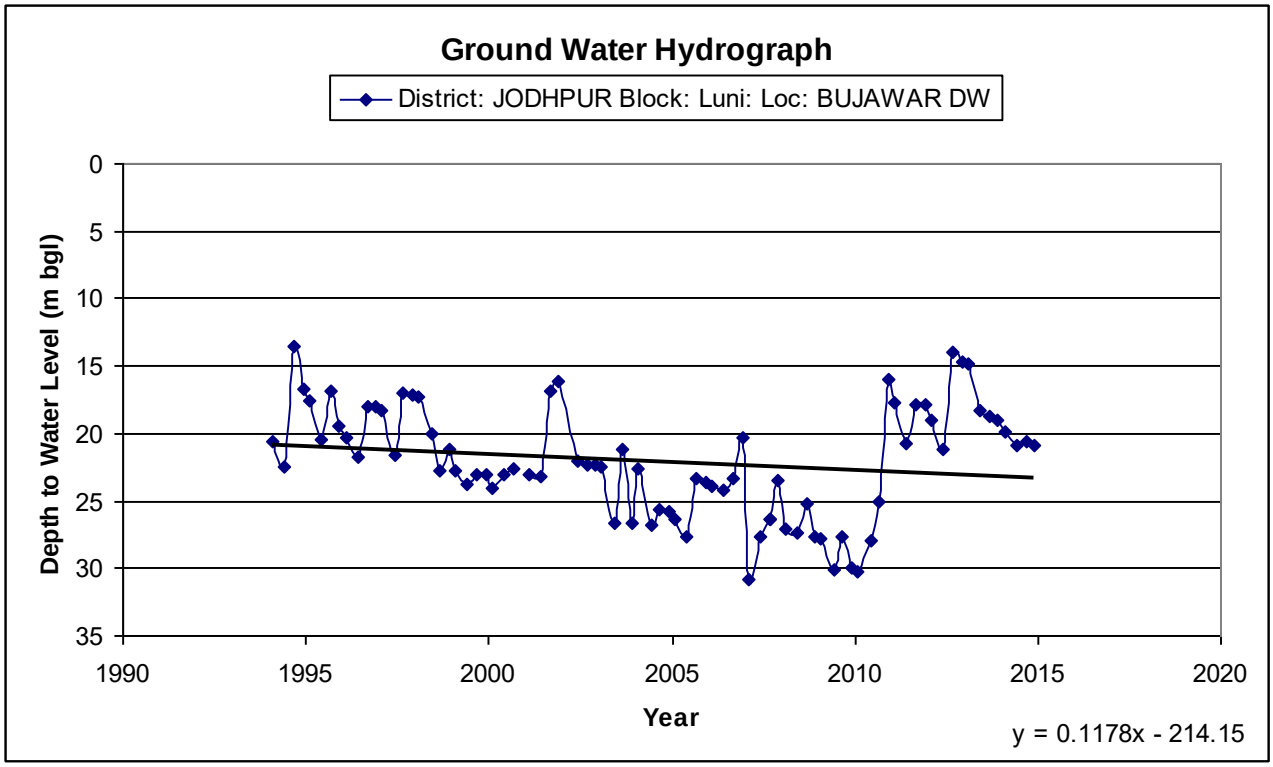

Figure 9f : Long Term Behaviour of Water Level - Bujawar

Hydrochemistry

Ground water samples were collected in January 2010 and analysed for different parameters for studying the extent of ground water pollution. In addition, 14 ground water samples were collected during AAP 2011-12 from the industrial cluster. The summarised results are tabulated below:

S. No.	Constituent	Min. Value	Max. Value	Number of samples		
				Below Desirable Limit	Between Desirable & Permissible Limits	Beyond Maximum Permissible Limit
1.	Electrical Conductivity (µS/cm)	370	15320	-	-	-
2.	Total Dissolved Solids	182	5506	-	-	-
3.	Chloride (mg/l)	21	4857	42	40	20
4.	Sulphate (mg/l)	2	1112	34	52	13
5.	Nitrate (mg/l)	0	1105	22		80
6.	Total Hardness (mg/l)	80	3445	33	39	27
7.	Calcium (mg/l)	28	215	49	36	14
8.	Magnesium	4	302	33	54	12

	(mg/l)					
9.	Fluoride (mg/l)	0.02	5.85	74	8	20

It is seen that water quality is not suitable for drinking in large number of samples. The map showing Electrical Conductivity of ground water, which is primary indicator of salinity, is shown in figure 10.

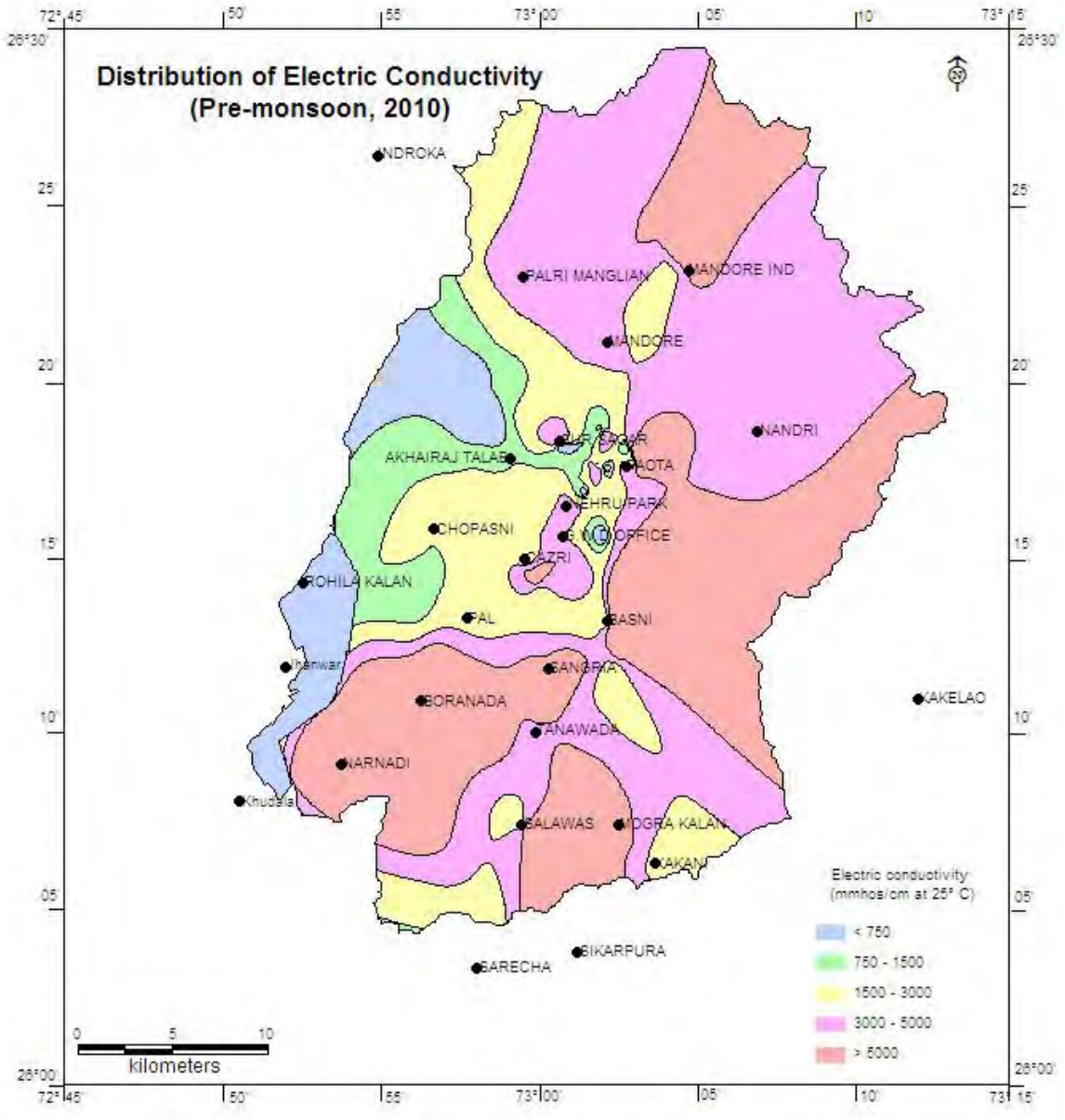

Figure 10: Electrical Conductivity of ground water (Premonsoon 2010)

The EC value ranges from 370 to 15320 µS/cm at 25°C in the study area. A perusal of EC distribution map (Fig. 6) shows that only small pockets at fringe area in the

west show value less than 750 µS/cm at 25°C. The western extreme part shows values between 750 and 1500 µS/cm at 25°C. Most of the southern and eastern parts of the area show value between 300 - 500 µS/cm at 25°C. The areas around Narnadi, Boranada, Salawas, Basni industrial pockets have EC value of more than 5000 µS/cm at 25°C.

In urban area, 13.73 % of water samples have EC value less than 750 µS/cm at 25°C, 27.45% samples have EC between 750 and 2000 µS/cm at 25°C, 21.57% samples have EC ranging from 2000 -3000 µS/cm at 25°C, 18.63% have EC value from 3000- 5000 µS/cm at 25°C and 18.63% have EC more than 5000 µS/cm at 25°C.

Causes Of Rising Water Levels

Jodhpur town has peculiar geomorphologic setting. Old walled city part is located on hill slope area and in the base of the fort hill ridge. The sloping land gradually turns to plain alluvial terrain towards east, south and southwest. Figures 11 (a & b) show a typical cross section wherein it becomes evident that a bowl like situation is formed.

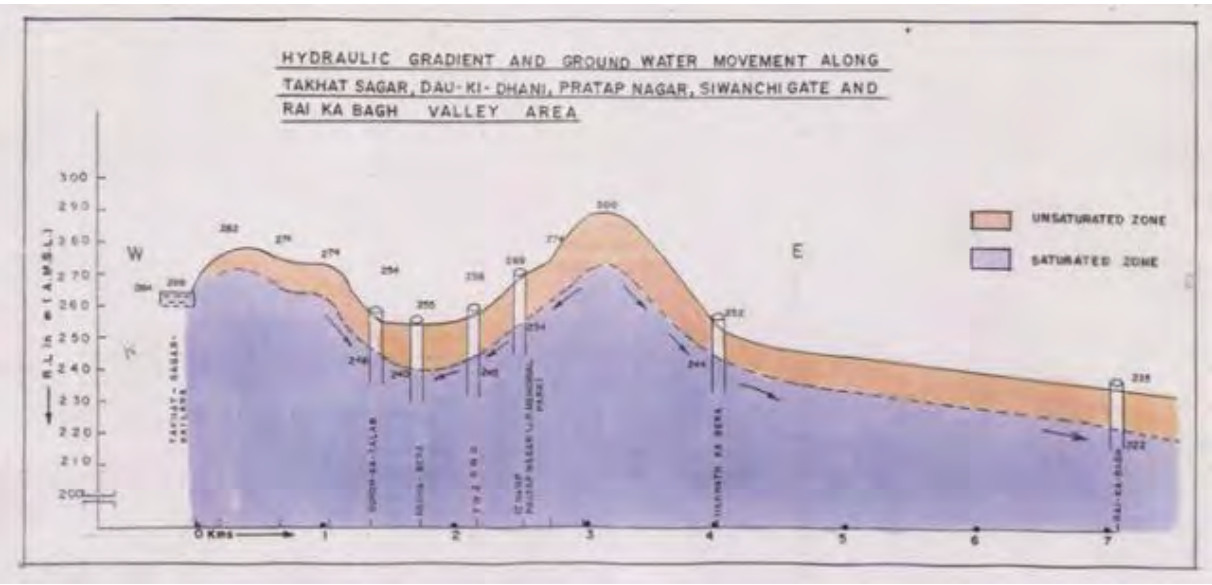

Figure 11a: Typical cross section across the urban area.

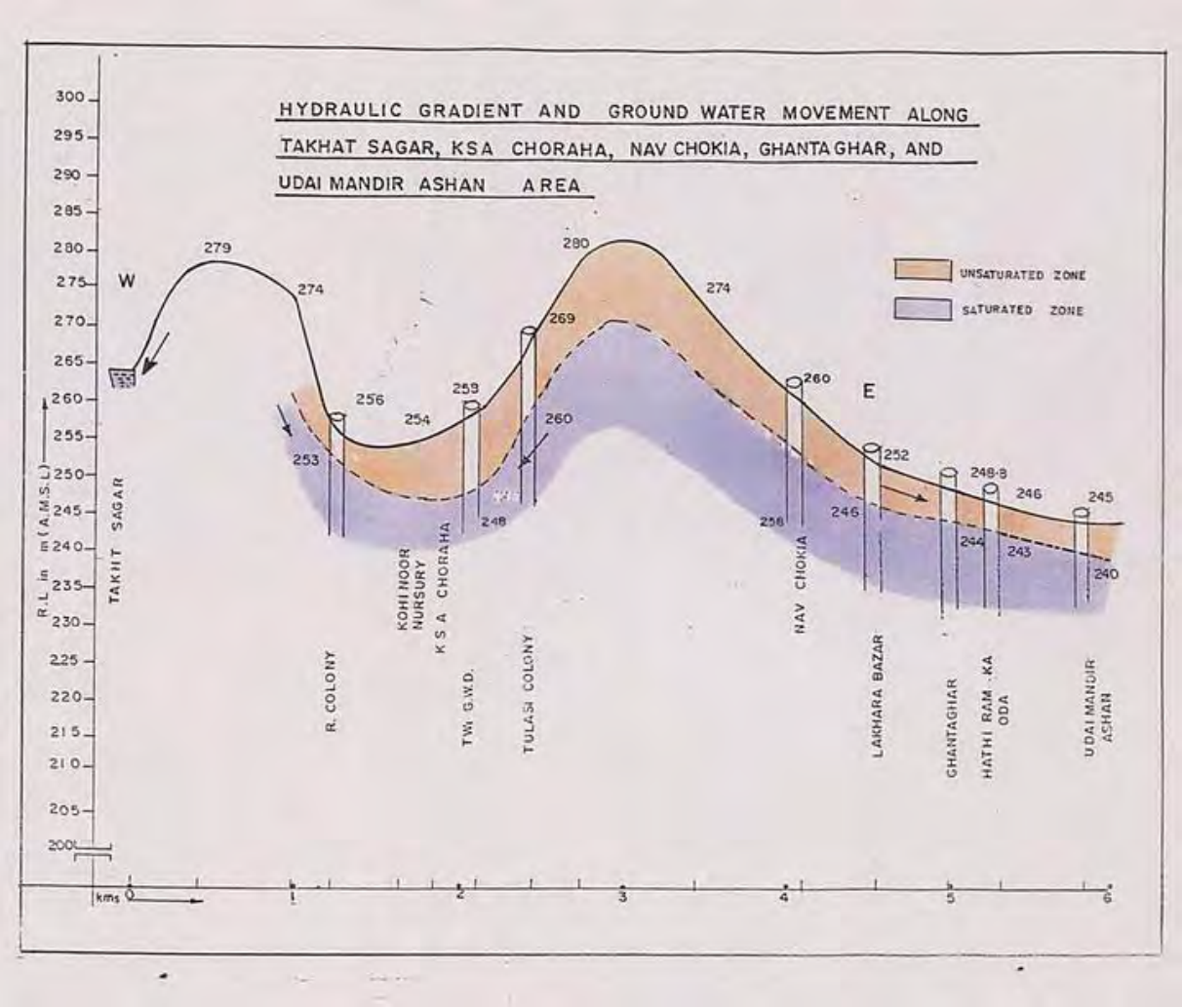

Figure 11b: Typical cross section across the urban area.

The formations have in general poor yields and inferior quality of ground water over the major area. Except in the upper weathered part both the rhyolites and sandstones are quite compact from shallow depth. Thus these formations do not allow the seepage water to percolate to deeper levels as such the transmissivity of the water bearing formations is very low. Early studies conducted during 1977-78 indicated that the draft from the area is less compared to the recharge, as a result of which water table in and around the city area was found to be rising gradually. This was the scenario much before the IGNP water was brought to Kaylana Lake.

The inflow to the aquifer system and outflow from it is in general from the following sources:

- Rainfall in the area and in upper catchment.
- Water brought from outside area for water supply to the city.
- Seepage from the water bodies located on upper levels.
- Output from the area is in the form of following:
- Ground water draft
- Subsurface outflow
- Outflow through Sewerage and drains.
- Evaporation and human consumption.

Based on the studies carried out, the main causes of water level rise in the Jodhpur city area are as below.

- Drainage and Sewerage system in the walled city area is quite old. The seepage from these open drains and sewerage lines is a process, which continues throughout the year. The flow becomes sluggish due to frequent chocking of drains due to polythene etc. Also there is frequent leakage of water from waste water pipes. This seepage directly joins the ground water in shallow water table area and causes rise.

- Increased water supply causes increase in this seepage and consequently the rise. The water supply level to the city was 183.46 lac gallons per day in 1994.This has been almost doubled and increased to 377.54 lac gallons per day presently.

- Many open water bodies lies in and around the city unutilized. These were utilized earlier for water supply. Presently these remain filled up with water throughout the year. The water bodies located on higher elevation causes continuous seepage. However the water bodies located in the lower levels are being fed by the Ground water.

- Due to plentiful availability of fresh surface water, utilization of existing ground water structures in the city area has been stopped both by the Government and private users. The ground water sources here have inferior quality of ground water and as such due to adequate supply of water met from IGNP lift canal the existing hand pumps, dug and bore wells are not been utilized causing rise in water levels.

The city area forms contact zone of rhyolite and sandstone, the rhyolite forms floor of the geological basin where sandstone deposition took place in geological past.

Presence of rhyolite (poor conduit of underground water due to massive nature from shallow depth) does not allow the seepage water to percolate to deep levels. The stagnation of this seepage water causes rise in water level.In Ghantaghar,Sojti gate and Laxminagar area sandstone of poor permeability with thick intercalation of shales form the hydrogeological formation which also hinders deep percolation of water.

Seepage to the city area directly from Kaylana Takhat sagar reservoir through inferred lineaments has been given as major reason for the water level rise in Jodhpur city by some agencies. No supportive evidence to this was observed during the studies. Direct seepage from this source to the problematic city area is unlikely. Water table contours indicate ground water movement towards southward direction. Two massive water divides comprising rhyolite hills occur between Kaylana Takhat sagar reservoir and the affected old city area.The affected old city area lies to the east of this reservoir. Dau Ki dhani-Pratapnagar-Kamla Nehru Nagar area lies in intervening valley area.The ground water flow in this valley area is southward. From both the slopes of the valley (eastern as well western) the flow of ground water is towards the center. By these observations it is inferred that there is no direct seepage from the reservoir to the old city area through long conduit fractures. This is also supported by the study of chemical quality data which indicates large difference in chemical quality regarding all the chemical parameters between the lake water and ground water/seepage water of the affected area which is having higher conductivity. There is also large difference in the chemical parameters between Kaylana-Takhat sagar water and ground water of the intervening valley area.

From the above it is evident that the water balance of the city area is greatly disturbed due to heavy input of water from outside sources and low output of water from the area resulting in the rise of water levels.

Recommended Remedial Measures

Base on the studies carried out earlier, the following measures have been recommended by CGWB to counter the problem of water table rise in problematic area of the city.

- Drainage from the city area must be improved so as to minimize the seepage losses to ground water. For efficient water management of any area there is utmost requirement of efficient drainage system.

- Scheme must be formulated to pump out the water from unutilized surface water bodies. Heavy pimping must be done from Fatehsagar, Gulabsagar, Gorinda Baori, Ranisar and Padamsar etc.This water togather with pumpage from shallow ground water potential areas may be taken away from the city area to nearby rural areas along Jojari river for irrigation purpose. Sufficient gradient exists for supply through gravity. This will lead to increase in agriculture production and lowering of water table in the area.

- Pumping from the ground water structures must be restored on a large scale. Dual water supply system based on available ground water and surface water may be introduced in the city area.

There is an urgent need to implement the suggested remedial measures to avoid damage to the civil structures and environment.

As per studies undertaken by NGRI, Hyderabad, the problems of rising ground water level has been mainly attributed to over supply of water, leakage in pipe lines and Sewerage networks etc. They have also ruled out the possibility of rising ground water levels on account of leakages from Kailana- Taktsagar reservoir. The National Institute of Hydrology, Roorkee also ruled out possibility of rising ground water levels on account of leakages from Kailana- Taktsagar reservoir.They haso also cited the reasons such as over supply of water, leakage from pipe and sewerage and drainages, NIH have recommended construction of vertical drainage systems, strengthening of pipeline & draining out water from pond. They have further recommended reduction of water supply upto 110 lpd, so the total water supply will also reduced by 30%.They have further suggested to maintain the ground water level to 4m by regular pumping as well as reducing seepage from pond by lining them with bentonitic clay.

Remedial Measures Adopted

In order to address the problems of rising ground water level in Jodhpur, concerted efforts have been made by the Government of Rajasthan. The State level and district level Task forces was constituted under the Chairmanship of Chief Secretary, Government of Rajasthan and Divisional Commissioner, Jodhpur respectively. Regular meetings of the State Level Task force are being convened. The district level task force is regularly monitoring the progress of the works programme through meetings organized from time to time. The Chief Engineer(Planning) is the Member Secretary of the of the task force.

As per decision of the task force, the Ground Water Department (GWD) has been assigned to assess the effect of withdrawal of ground water from time to time. For this purpose, the Ground Water Department the GWD, since April, 2009 have been continuously monitoring the ground water scenario through 37 piezometers and 20 underground structures. Bi monthly survey report are also submitted to Chief Engineer(Projects), PHED, Jodhpur. Presently in all these 37 piezoemeters, automatic water level recorders have been installed by the PHED.

Presently in Jodhpur city, a total number of 89 ground water sources are being pumped by PHED. The details of these pumping wells and their status as on 13.01.2015 is given in Annexure I. About 28.13 MLD (Mega Listers /day) is being pumped from these wells. Some of the ground water being pumped out is being gainfully utilised about 11.96 MLD of water being pumped from 46 tubewells is being supplied to various agencies like Water Supply to BSF, Army, Railways, etc, & and for requirement. About 5.34 MLD being pumped from 14 tubewells is being utilised for gardening etc. However, 10.84 MLD of water being pumped from 29 sources is being diverted to drainage system, probably because of lack of infrastructure and poor quality of water. .

For the purpose of assessment, the city has been divided into four zones and zone wise assessment of ground water level is done by GWD. The findings of the assessment reveals that while in three zones, significant fall in ground water levels has been observed, in the fourth zone, fall in ground water level has been found to be suboptimal. In order to solve this problem, the PHED has constructed seven tubewells in the fourth zone, which may improve the ground water situation in the

zone. Even though the ground water levels during monsoon period shows temporal rise in all these four zones, during post monsoon period gradual decline in ground water level have been observed. A zone wise status report for May 2105, prepared by GWD, Rajasthan is given in table below:

Additional Recommendations

In view to address the problems of rising ground water level in Jodhpur city, the Ground water department and Public Health Engineering Department(PHED) have initiated various actions. While Ground Water Department is engaged in zone wise micro level monitoring of ground water level in and around the affected area, the PHED is involved in abstraction of ground water through of 89 water abstraction structures, which includes tubewells, wells, water bodies etc. However, it has been observed that, in spite of the present efforts by the State Government, the problems have not yet been solved to the desired level.

The report on ‘ Rising water problems in Jodhpur City area’ as prepared by CGWB. WR was earlier forwarded to GWD for further needful action.

In the following paragraphs, some additional recommendations have been discussed which mainly deals with quantitative aspects of de-saturation of aquifers, the details of ground water structures and the utilization of pumped out water.

A. The volume of ground water to be extracted:

Based on the preliminary field surveys, water logging problems have been observed in about 20 Sqkm buffer area(city area), albeit acute problems are prevalent in the core area of about 10 Sq.km area. Accordingly, the estimates as worked are as follows:

The total volume of ground water available in saturated zone for abstraction is worked with the following equation:

$Vs = A * H * S_y$ where, *Vs* is the volume of groundwater existing in the saturated thickness; *A* is the surface area of the zone for which estimation is being made (m^2); *H* is the height of saturated water column within the depth from ground surface (m); *Sy* is the specific yield (dimensionless).

Assuming S_y as 0.02 (2% for shaly formation) in the Buffer area, the total storage would be about 1.2 MCM for a water column of 3m.

Besides, there would be incremental storages of 0.7 MCM, 0.205 MCM and 1.07 MCM due to rainfall recharge, leakages from pipelines and return from pumping wells respectively. Thus the total volume of water to be pumped (Vs) will be about 2.99 MCM, say 3.0 MCM.

B. No. of structures and their capacity required for the purpose:

As estimated, in order to pump out these accumulated storages of 3 MCM, about 50 wells, each with 8 hrs of daily pumpage for 200 days in a year should be sufficient.

C. Utilization of ground water resources proposed to be extracted:

About 15 to 20 lakhs gallons per day raw water is required by Railways, Army and Air Force establishments of the Jodhpur City which is increasing day by day. Water being extracted from the abstraction structures can be provided to the above mentioned establishments. At present 28.13 MLD water is being extracted by the PHED through 89 No. of abstraction structures. Out of this, 11.96MLD is being utilized for conjunctive use by supplying to the Army and BSF, 5.34 MLD for Gardening and other uses and remaining 10.83MLD water is being flown out from the city through sewerage. This 10.834MLD water can be utilized by the railway, air force, AFRI, CAZRI, and industries etc.

As per information of the State Government, presently, a total volume of 7.16 MCM is being pumped out by PHED through about 89 wells of located in the affected area of Jodhpur city. However, it has been observed that despite this initiatives of the State Government, sufficient lowering of ground water level have not occurred.

In view of the complexities involved in finding solutions to the problems, a detailed study is required, which may be supplemented by ground water modeling exercise. The proposed study may be of at least 3-6 month duration.

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Status of water level in different zones of Jodhpur CIty - 147th Report fortnight , May 2015

S. No.	Activity	Agency	Target		Initial Average Water Level Apr. 09	Achievement during		Average W.L. Depl./Rise		Expenditure incurred
			Physical	Financial		Current 146th F.N.30.04.15	Current 147th F.N.15.05.15	During F.N.	Cumulative	
								(Col. 7-8)	(Col. 6-8)	
13	Decline in water table	GWD	Upto 10 MTS BGL	-	mts. bgl	mts. Bgl	mts. Bgl	mts. bgl	mts. bgl	
1	2	3	4	5	6	7	8	9	10	11
	Zone-I (Kharbooja Baori)		Upto 10 MTS BGL	-	1.38	2.76	3.31	-0.55	-1.93	
	Zone-2 (Baiji ka Talab)		Upto 10 MTS BGL	-	3.60	6.53	6.61	-0.08	-3.01	
	Zone-3 (Fateh Sagar)		Upto 10 MTS BGL	-	2.61	3.91	3.95	-0.04	-1.34	
	Zone-4 (Laxmi Nagar, Mahamandir)		Upto 10 MTS BGL	-	3.62	3.08	3.28	-0.20	0.34	

Source: Ground Water Department (GWD), Rajasthan.

Annexure I

DETAILS OF SOURCES IN OPERATION FOR CONTROL OF RISING WATER LEVEL IN JODHPUR CITY DT.13.01.15

S. No	Name of Zone	Location	Date of commissioning	Type of well	Chlorinator installed	Meterd /UnMetered	Total Depth	Pump Stage Depth	Pumping (Hrs)	Discharge KLH	Approx Av. Daily Prod. (KLD)	Use	Remarks
1	BKT	Vyas park	Old	pond	C	M	4.5	3.5	12	19.8		C	Yield restriction
2	BKT	Tapi Baori	Old	Baori	C	M	45.15	20	12	36		C	Supply restriction
3	BKT	Achalnath Mandir Baori	Old	Baori	C	M	23.3	20	15	18		C	-- do --
4	BKT	Naleshwar well	Old	O/W	C	M	18	15	0	21		C	Yield restriction
5	BKT	Jalap Baori	Old	O/W	C	M	23.7	20	12	36		C	Supply restriction
6	BKT	Boron Ka Kua	Old	O/W	C	M	31.9	20	22	19.8		C	-- do --
7	BKT	Narsinghdara	Old	O/W	C	M	43.8	19	15	18		C	-
8	BKT	Dabgaron ka kua	Old	O/W	C	M	26.2	20	12	21		C	Yield restriction
9	BKT	Vimal Rajji ka Kua	Old	O/W	C	M	23	20	12	18		C	Supply
10	BKT	Braham Bagh	30.03.09	O/W	C	M	46.1	20	15	18		C	-- do --
11	BKT	Najarji ki boari	28.07.09	O/W		M	21.8	14	12	36		C	-- do AN29
12	BKT	Nehru Park	31.08.09	O/W	C	M	33.6	18	20	13.5		C	-
13	BKT	Ladji Ka Kua	31.08.09	O/W	C	M	31.9	20	22	21.6		C	Supply restriction
14	BKT	Harnath Ka Bera	31.08.09	O/W	C	M	48.5	19	0	13.5		C	-- do --
15	BKT	Kotwali well navchakia	07.09.09	O/W	C	NS	19	16	20	13.5		C	-
16	BKT	Sanshijarji Ka Than	11.09.09	O/W	C	M	59.4	20	12	13.5		C	Supply restriction
17	BKT	Baiji ka talab	17.09.09	Pond	NR	NR	7.5	5	0	24		S	Chlorinator not sanctioned
18	BKT	Gorinda Baori	22.07.09	Baori	C	NS	13.8	13	0	36		C	Supply/Double pump average.
19	BKT	Kumaron Ka Bas	09.03.10	T/W	C	NS	60	45	9	13.5		C	Supply restriction

S. No	Name of Zone	Location	Date of commissioning	Type of well	Chlorinator installed	Meterd /UnMetered	Total Depth	Pump Stage Depth	Pumping (Hrs)	Discharge KLH	Approx Av. Daily Prod. (KLD)	Use	Remarks
20	FS	Mirchi Bazar	Old	O/W	C	M	32.5	27.1	16	18		C	Draw Dawn & Supply Restriction
21	FS	Satya Narayan Baori	Old	Baori	C	M	30.8	26	10	36		C	Yield-Restriction
22	FS	Mahila Bagh Ka Jhalara	Old	Jhalara	C	M	25.2	25.5	8	18.5		C	Sewer line, Yeild
23	FS	Krishna Mandir	31.07.09	O/W	NR	M	52	37	22	13.5		S	Sewer/Supply(Chlorinator installed at Ratanada CWR) MECH FAULT
24	FS	Police Line	31.07.09	Baori	C	M	27.5	23.8	23	32		S	Supply & Yield restriction
25	FS	Police Line	01.09.09	O/W	C	M	24.8	24	21	28		S	-- do --
26	FS	Vishnoi Dhramshala	16.08.09	O/W	C	M	39	24	7	24		S	Sewer
27	FS	Golnadi	16.08.09	Baori	C	M	27.1	25	12	36		G	gardening and sewer
28	FS	Turji Ka Jhalara	30.08.09	Baori	NR	M	41.2	30	0	13.5		G	-- do --
29	FS	Loharon Ki Gali	31.08.09	O/W	C	M	29		10	18		C	Supply Restriction
30	FS	Subhash Chowk	02.09.09	O/W	C	M	23.4	23	23	13.5		S	Yield restriction
31	FS	West Patel Nagar	02.09.09	T/W	C	M	74	57	21	18		C	Sewer line/Supply
32	FS	Navlakha Boari	08.09.09	Baori	C	M	26.1	22.9	8	13.5		G	Gardening, Yield restriction
33	FS	Asan Well	11.09.09	O/W	C	M	47	30	9	13.5		C	Supply Restriction
34	FS	Gulab Sagar	17.09.09	Pond	NR	M	30	5	11	36		G	-- do -- (Water level = 4.83 mtr)
35	FS	Maheshwariyon Ki Bagechi	22.09.09	Baori	C	M	41.5	29	22	21		S	Sewer line
36	FS	Fateh Sagar	25.09.09	Pond	NR	M	32	6	15	96		G	gardening
37	FS	Umaid Garden	26.09.09	Baori	C	M	45	28.2	7	25		G	-- do --
38	FS	Naya Talab	05.09.09	Pond	NA	M	4.8	3.1	12	12		S	Water level upto 4.15 mtr,Sludge problem

S. No	Name of Zone	Location	Date of commissioning	Type of well	Chlorinator installed	Meterd /UnMetered	Total Depth	Pump Stage Depth	Pumping (Hrs)	Discharge KLH	Approx Av. Daily Prod. (KLD)	Use	Remarks
39	FS	MES Hospital	09.10.09	Baori	C	M	30.9	28.1	18	18		C	miltary
40	FS	Gaushala Maidan	26.10.09	O/W	C	M	42	25	9	13.5		G	Restricted Due
41	FS	Ghantaghar	26.10.09	T/W	C	M	30	28	6	19		C	Pumping Sewer line over flow & line discharge
42	FS	High Court T/W	07.11.09	T/W	C	M	30	28	21	13.5		G	Rly Washing line
43	FS	Panchwati Colony	5.12.09	T/W	C	M	66	30	22	9		C	Supply restriction
44	FS	HQ Chowki	17.02.09	T/W	NR	M	100	0	23	13.5		C	Rly Washing line
45	FS	JDA Complex	04.03.10	T/W	NR	M	72	60	21	13.5		C	-- do -
46	FS	Nani Bai Ka Mandir	07.02.09	O/W	C	M	35	25	18	13.5		G	New pump low,
47	FS	Mazdoor Maidan	19.01.11	T/W	NR	M	66	38	19	24		S	Sewer line
48	FS	Ajit Colony	08.12.09	T/W	C	M	60	50	22	12		C	Supply restriction
49	FS	Nai Sarak(Nr Bank)	09.04.11	T/W	C	M	82	45	6	24		C	-- do --
50	FS	Karni Bagh TW	03.12.09	T/W	C	M	92	60	16	13.5		C	-- do --
51	FS	PWD Colony Ist	19.01.11	T/W	NR	NS	70	42	21	14		S	Collaspsed T/W
52	FS	PWD Colony IInd	07.02.11	T/W	NR	M	78	38	20	24		S	Collaspsed T/W, Sewer line
53	LN	Laxmi Nagar-II	30.07.09	T/W	NR	M	120	40	22	24		C	Military Line
54	LN	Paota B Road	30.07.09	T/W	NR	M	90	40	5	24		C	Motor burn, Military Line
55	LN	Laxmi Nagar-III	08.09.09	T/W	NR	M	90	40	22	18		C	Motor burn, Military Line
56	LN	Shakti Nagar-II	08.09.09	T/W	NR	M	76	40	18	18		S	Sewer line
57	LN	Rajeev Nagar - A	11.09.09	T/W	C	M	87	40	20	18		C	Sewer line
58	LN	Soil conservation Dept	11.09.09	T/W	NR	M	74.5	40	21	12		S	Pump motor fault, Sewer line
59	LN	ZSA- 5	11.09.09	T/W	NR	M	81.5	40	20	12		S	Sewer line
60	LN	Mahamandir Jhalara	14.09.09	Jhalara	NR	M	34.1	36	21	24		S	Moter Burn Sewer line

S. No	Name of Zone	Location	Date of commissioning	Type of well	Chlorinator installed	Meterd /UnMetered	Total Depth	Pump Stage Depth	Pumping (Hrs)	Discharge KLH	Approx Av. Daily Prod. (KLD)	Use	Remarks
61	LN	Hathi Baori	09.10.09	Baori	NR	M	14.7	6.35	7	12		S	Sewer line
62	LN	Hathi Baori	09.10.09	Baori	NR	M	14.7	6.35	20	23		C	Military Line
63	LN	Natho Ka Bera	09.10.09	O/W	C	M	39	32	22	22		C	
64	LN	Vishnu Bhawan Udai Man	04.03.10	T/W	NR	M	89	40	22	13.5		S	Collaspsed T/W
65	LN	Syama Park	04.02.11	T/W	NR	M	80	55	0	24		S	Sewer line
66	LN	Lal Maidan	03.02.11	T/W	C	M	56	45	21	18		G	Pipe line leakage
67	LN	Laxmi Ngr Park 1	03.02.11	T/W	C	M	100	55	23	24		C	Military
68	LN	Laxmi Ngr (Devi S Haweli	06.02.11	T/W	NR	M	100	45	22	24		S	Sewer line
69	LN	Shakti Nagar-4	27.02.11	T/W	NR	M	30	0	20	24		S	Nagar nigam nallah construc Sewer line
70	LN	Shakti Nagar-6	24.02.11	T/W	NR	M	32	26	23	18		S	Sewer line
71	LN	Income Tax Colony	10.02.11	T/W	NR	M	42	28	21	24		S	-- do --
72	LN	Senapati Bhawan	24.02.11	T/W	NR	M	88	50	21	12		S	-- do --
73	LN	Opp.All India Radio Cly	26.07.11	T/W	C	M	88	35	22	36		S	-- do --
74	LN	Shakti Nagar Gali No. (1)	28.07.11	T/W	C	M	36	25	22	18		S	-- do --
75	LN	Paota Near Kabra School	27.07.11	T/W	C	M	80	32	22	36		S	-- do --
76	LN	Raipur Ka Hattha	14.08.11	T/W	C	M	100	35	22	18		C	Military line
77	LN	Jain Colony (Laxmi Ngr)	12.08.11	T/W	C	M	90	34	22	13.8		C	-- do --
78	LN	J.S. Ka Hattha(Nr school)	10.08.11	T/W	C	M	80	30	21	36		S	Sewer line
79	LN	Mangu Singh Rajvi Park	14.08.11	T/W	C	M	101	34	0	36		S	-- do --

S. No	Name of Zone	Location	Date of commissioning	Type of well	Chlorinator installed	Meterd /UnMetered	Total Depth	Pump Stage Depth	Pumping (Hrs)	Discharge KLH	Approx Av. Daily Prod. (KLD)	Use	Remarks
80	LN	Dharm Narayan ka Hatha	21.08.11	T/W	C	M	72	32	21	13.5		S	-- do --
81	LN	Ram Garhi Kaga Kagri	01.08.11	T/W	C	M	34	28	2	18		C	-
82	KB	Mata Ka Kund	Old	O/W	C	M	30	22	6	18		C	Draw Dawn
83	KB	Suraj Kund	02.09.09	Baori	C	M	40	27	3	18		C	Water table drawn to lower level
84	KB	Vidhyashala DIET	31.05.09	O/W	C	M	25	18	16	18		C	-- do --
85	KB	Raghunath Boari	02.07.09	Baori	C	M	35	22	0	10		C	Draw Dawn
86	KB	Kharbuja Baori	19.12.08	Baori	NR	M	35	18	22	80		G	Gardening purps Mandore Garden & BSF
87	KB	Kriya Ka Jhalara	31.05.09	Jhalara	NR	M	30	20	8	12		G	Connected to Kharbuja Baori water table down to lower water level. Yield is less
88	KB	Jalechi Jhalara	31.05.09	Jhalara	NR	M	30	22	8	18		G	
89	KB	Ram Baori	20.06.09	Baori		M	35	25	16	12		G	
		Total							30.032				

Summary

Type of Use	Source (Nos)	Qty (MLD)	Remarks
C: Conjunctive Use	46	11.961	Water Supply to BSF, Army, Railways, etc, & Local Supply
G: Gardening & Other	14	5.337	Locally used for gardening
S: Sewerage	29	10.834	Un-utilised; being discharged into sewer
Total	89	28.132	