GROUND WATER YEAR BOOK
2011-12
National Capital Territory, Delhi

GOVERNMENT OF INDIA

CENTRAL GROUND WATER BOARD

MINISTRY OF WATER RESOURCES

STATE UNIT OFFICE

NEW DELHI

OCTOBER-2012

FOREWORD

Ground Water Year Book is based on the information generated by monitoring of ground water observation wells of NCT-Delhi during the field Season of 2011-12.All the hydrograph data have been analyzed by a team of Officers of State Unit Office-Delhi. The ground water quality analysis has been done by CGWB, NWR, Chandigarh. The reports, annexures and maps have been generated using GEMS Software, Version-2.1 developed indigenously by Central Ground Water Board.

Depiction of ground water hydrograph of Delhi state along with ground water quality provides information on availability of ground water in terms of quantityandquality, development prospects and management options. I am happy to note that the scientific information in this report is presented in a simplified form. I sincerely hope this report will be of immense help not only to planners, administrators, and policy makers but also to the common man in need of such information to make himself aware of the situation and help in formulating development and management strategy.

The untiring efforts made by**ShriSanjay Kumar Naik,** Asstt. Hydrogeologistfor bringing out this report are highly appreciated. Apart from this the contribution made by Sh. MuninKonwar, Scientist-B and the Chemists from NWR-Chandigarh is duly acknowledged.

(A.D. RAO)
Officer In-charge
State Unit Office, Delhi
Central Ground Water Board,
Ministry of Water Resource

New Delhi,
OCTOBER-2012

EXECUTIVE SUMMARY

GROUND WATER YEAR BOOK 2011-12
NCT DELHI

National Capital Territory of Delhi occupies an area of 1483 Sq. Km. and lies between 28^0 24' 15'' and 28^0 53' 00'' N latitudes and 76^0 50'24" and 77^0 20' 30" E longitudes. The total population of NCT Delhi, as per the census 20011 is 167.53 lakhs with a density of 11297 persons/Sq. km area.

The normal annual rainfall of NCT Delhi is 611.8mm. The rainfall increases from the South-West to the North-West. About 81% of the annual rainfall is received during the monsoon months July, August and September. The rest of the annual rainfall is received in the form of winter rain.

The ground water availability in the territory is controlled by the hydrogeological conditions characterized by occurrence of different geological formations namely Delhi (Quartzite) Ridge, Older & Younger Alluvium. Central Ground Water Board (CGWB) has established 162 hydrograph monitoring stations, out of which 25 are dug wells and 137 are Piezometers. The ground water monitoring stations are spread over both Alluvial as well as Delhi ridge area. Nearly 60 stations fall in Delhi ridge area whereas 109 stations fall in alluvial area including Yamuna Flood Plain.

District wise distribution of hydrograph network stations is highly uneven and varies from one monitoring station per 1.4 Sq. Km in New Delhi district to one monitoring station per 30 Sq. Km in North East district. Considering this un-evenness, Central Ground Water Board is striving to increase the number of monitoring stations for better monitoring of the ground water regime in the diverse hydrogeological terrain.

The depth to water level recorded in NCT Delhi during **May-2011** ranges from 0.96 to 66.45 m.bgl (below ground level). 44% wells of South district show more than 40 m.bgl water level and 26% wells have 20 to 40 m.bgl water level. In New Delhi and South-West districts 10 to 20 m.bgl water level is shown by 47% and 59% wells respectively. The depth to water level in Central, East and North-West districts have 50%, 44% and 40% wells in the range of 5-10 m.bgl whereas East, North, North-East, North-West, and West district of 44%, 56%, 33%, 34% and 22% of wells show water level in the range of 2 to 5m water level respectively; the entire Yamuna flood plain is also falling in the 2 to 5m category.

The fluctuation of water level between **May-2010**and **May-2011** of Delhi state shows rise in water level in the range of 0.01 m to 39.35 m in the district of New Delhi, South, North-West, South-West, East and West. Whereas rest of the districts like North-East, Central, South and South-West shows fall in the range of 0.02 to 5.70 m. *The overall data indicates that South and South-West districts are showing falling trend.*

When the data of **May-2011** was compared with **10 year mean of May** water level, it shows that 40% of wells show a fall in the range of 0.02 to 14.07 m. 59% wells of the New Delhi, East, North, North-West, South and South-West show a rise in water level varying from 0.05 to 31.32m. *The maximum fall has taken place in North-West, South and South-West districts (i.e. 9.76 to 14.07 m).*

The Depth to water level recorded in NCT Delhi during **Aug-2011** ranges from 0.58 to 66.80 m. bgl. In which 48% wells of south district show more than 40 m.bgl water level and 22% wells have 20 to 40 m.bgl water level. In New Delhi and South-West district 47% and 53% wells have shown 10 to 20 m.bgl water level, respectively.

The fluctuation of water level between **Pre-monsoon (May-2011)** and **August-2011**for Delhi indicates that 69% wells show rise in the range of 0 to 2 m and 25% depict a fall ranging from 0.02 m to 28.30 m.

The hydrograph analyses of **August-2010**and **August-2011** water level reveals that most of the districts (only in pockets) show rise in the range of 0 to 2 m while in few districts like New Delhi and South show fall in ground water level in the range of 4 to 6 m. In totality 28% wells show fall in the range of 0 to more than 4m whereas 69% wells show a slight rise in water level. The fall of more than 4 m is recorded in only two districts i.e. New Delhi and South.

The overall analyses of the hydrographs show an improvement situation in the state during monsoon period.

The depth to water level recorded in NCT Delhi during **November-2011** ranges from 0.91 to 66.73 m.bgl. 50% wells of South district have shown more than 40 m.bgl water level and 18 % wells have water level of 20 to 40 m.bgl. The South-West district has 57% and 20% wells in the Category of 10 to 20 and 20 to 40 m.bgl respectively. The depth to water level of East, North-East, North West and West district show 33%, 60%, 38% and 22% in the range of 5-10 m.bgl whereas Central, North, N-E, N-W and West districts are marked by wells of 50%, 57%, 20%, 28% and 44% in the range of 2 to 5m water level respectively. The entire Yamuna flood plain is also falling in 2 to 5 m. bgl category.

The fluctuation of water level between **Pre-monsoon (May-2011)** and **Post Monsoon (Nov-2011)** of Delhi state shows 0.01 to 10.30 m rise in 62% of the wells. Few wells of South and South-West district shows fall in the range of 0 to 4m. Analysis of data reveals that the declining trend is very less in the South and South-West districts.

When the data of **Nov-2011**was compared with **10 year mean of Nov.** it shows that 53% of wells show a fall of water level in the range of 0.01 to 12.28.

The depth to water level recorded during **January-2012** ranges from 0.89 to 66.84 m. bgl in which South district alone shows 50% wells in the category of more than 40 m depth to water level and 18% in the range of 20 to 40m depth to water level. 51% wells of district like South-West and New Delhi have water levels in the range of 10 to 20 m. A few patches of 20 to 40 m water level are also seen in these districts. Rest of the districts comes under the category of 2 to 10 m. Some of *the monitoring stations viz. MadanGir, Saket and PushpVihar show depth to water level in the range of 51 to 67m, which is maximum in Delhi state.*

The fluctuation of water level between **Pre-monsoon (May-2011)** and **January-2012**of Delhi state reveals that 41% wells of South, S-W and West District fall in the range of 0.87 to 28.10 m and 62% wells show rise in the range of 0.31 to 40.70 m in Central, East, North, North-East & New Delhi district.

When the data of **January-2012** was compared with **10 year mean of January,** It has been observed that49% of monitoring stations of New Delhi and North West districts show a fall in water levels, the maximum fall is 2.80m

and 3.49 m respectively. The same conditions prevail in South and South West Districts where 54% of the wells show fall in water level where the maximum fall is 8.34 m and 11.49 m respectively. East and North East districts have also suffered depletion of water table in the range of 1.22 to 2.22 m only. *The overall observation of the state shows that the southern districts of Delhi state are showing declining condition.*

Ground Water Quality:

In almost 30 percent ground water samples of NCT Delhi mostly from the district of South-West, West, and North-West contain high concentration of fluoride beyond prescribed maximum permissible limit 1.5mg/l. Some more sites are also affected by Fluoride content in ground water of Delhi which are sporadically located. On perusal of data and affected locations, it is observed that wherever existence of Saline/Brackish water is at shallow depth fluoride concentration are more.

The Nitrate concentration in ground water of NCT Delhi shows a wide range (i.e. less than 1mg/l to 1500mg/l). The Nitrate concentration in ground water is generally spread out over the entire state but is more significant in parts of West, South-West and some pockets of New Delhi districts. The Nitrate pollution in the ground water is mostly anthropogenic and may be due to improper disposal of sewage and unhygienic conditions around the well.

GROUND WATER YEAR BOOK
NCT DELHI
2011-12
CONTENTS

CHAPTERS

PAGE NO.

TABLE:

ANNEXURE:

PLATES / FIGURES:

1. Location of Hydrograph Network Stations
2. Isohyetal Map of NCT Delhi
3. Ground Water User Map, NCT Delhi
4. Depth to Water Level Map May - 2011
5. Depth to Water Level Map Aug - 2011
6. Depth to Water Level Map Nov - 2011
7. Depth to Water Level Map Jan - 2012
8. Fluctuation in Water Level, May-10 to May-11
9. Fluctuation in Water Level, Aug-10 to Aug-11
10. Fluctuation in Water Level, Nov-10 to Nov-11
11. Fluctuation in Water Level, Jan-11 to Jan-12
12. Fluctuation in Water Level, Pre and Post Monsoon
13. Decadal Fluctuation in Ground Water Level Mean May (2001-2010)-May 2011
14. Decadal Fluctuation in Ground Water Level Mean Aug (2001-2010)-Aug 2011
15. Decadal Fluctuation in Ground Water Level Mean Nov (2001-2010)-Nov 2011
16. Decadal Fluctuation in Ground Water Level Mean Jan (2002-2011)-Jan 2012
17. Electrical Conductivity Map, NCT Delhi
18. Fluoride Concentration Map, NCT Delhi
19. Nitrate Concentration Map, NCT Delhi
20. Piper Diagram
21. US Salinity Plot

Chapter - 1

INTRODUCTION

1.1 - GENERAL INTRODUCTION

National Capital Territory of Delhi occupies an area of 1483 Sq.km. and lies between 28° 24' 15'' & 28° 53' 00''N latitudes and 76° 50'24" & 77° 20' 30" E longitudes. Area is covered under Survey of India Toposheet Nos. 53D and 53H.For administrative purposes, NCT Delhi is divided into 9 districts and 27 Tehsils/Sub-divisions. NCT Delhi has three Statutory Towns, viz., the MCD, the NDMC and the DCB, 110 Census Towns and 112 Villages as per the census of 2011. Population of Delhi has increased at a rate of 2.1% per annum during the decade 2001-2011. Considering the same growth rate for the present decade, it is estimated that the population of Delhi in 2019 is about 184 lakhs and it would be about 188 lakhs in 2021, 208 lakhs by 2031. In order to evaluate the changes in ground water regime effect due to ever growing demand for ground water and the increasing numbers of abstraction structures in the city, CGWB has been continuously monitoring the water level variation with its own network stations spread over the entire area of NCT Delhi.

1.2 - GROUND WATER REGIME MONITORING

Monitoring of ground water regime is an effort to obtain information on variation in ground water levels and chemical quality through representative sampling both in time and space. The important attributes of ground water regime monitoring are:

a) Ground Water Level

b) Ground Water Quality and

c) Temperature.

The primary objective of establishing the ground water monitoring network stations is to record the response of ground water regime to the natural and artificial conditions of recharge and discharge with reference to geology, climate, physiography, land-use pattern and hydrologic characteristics. The natural conditions affecting the regime involve climatic parameters like rainfall; evapo-transpiration etc. and the artificial conditions include pumpage from the aquifer, recharge due to irrigation system and other

man made causes like waste disposal etc. The database generated can form the basis for ground water development and management programme. The objectives of the Ground Water Observation Network may be broadly summarized as below:

Collection of basic data on ground water conditions for:

- Study of inter-relationship between ground water and climatic parameters,
- Study the influence of geology, topography, land-use on ground water regime,
- Understanding the role of ground water in the hydrologic cycle and influence of the recharge on ground water storage changes, chemistry and temperature.

Application of ground water monitoring data for:

a. Reference purposes

b. Prediction measures

c. Environmental evaluation

d. Estimation of resources

Monitoring may come under two categories:

i) Background monitoring to characterizing the initial stage of a system,

(*Background monitoring commences with inventory of existing information like land-use, topography, extent, thickness, structure of the geological units and their hydraulic properties. Based on the analysis of the data, different ground water systems can be identified.)*

ii) Specific monitoring to deal with systems, where significant changes have taken place. This functions as an early warning system and provides information for remedial actions.

GROUND WATER LEVELS:

The configuration of the water table depends upon topography, geology, climate, water yielding and water bearing properties of rocks in the zones of aeration and saturation which controls the ground water recharge. The upper surface of the zone of saturation is the **Water Table**. In case of wells penetrating confined aquifers, the water level represents the pressure or

Piezometric Head at that point.

Hydrograph network planning is basic to ground water assessment and development programme. The ground water, being subterranean resource can only be assessed through indirect reflection in the form of water level changes. The systematic and regular monitoring of ground water levels can bring out the changes taking place in the regime. The data so generated is of immense help for regional ground water flow modeling to serve as a ground water management tool and to provide the necessary advance information to the user agencies to frame contingency plans in case of un-favorable ground water recharge situation. The data also has immense utility in settling the legal issues arising out of conflicting interests of ground water users.

BASIC ACTIVITY

The NCT Delhi covers an area of 1483 Sq. Km. Delhi state is divided into 9 districts and 27 sub-divisions. Geologically, Delhi state is occupied by Quartzite interbedded with Mica-Schist belonging to Delhi Super Group, un-conformably overlain by unconsolidated Quaternary to Recent sediments. The ground water availability in the territory is controlled by the hydrogeological situation characterized by occurrence of alluvial formation and quartzite hard rocks. The hydrogeological set up and the following distinct physiographic units influence the ground water occurrence: -

1. Alluvial plain on eastern and western sides of the ridge.
2. Yamuna flood plain deposits.
3. Isolated and nearly closed Chattarpur alluvial basin.
4. NNE-SSW trending Quartzitic Ridge.

The basic activities pertaining to monitoring well design and construction are as follows:

a. Suitable locations for installation of piezometer, working out optimal depth and diameter of piezometer.

b. Appropriate drilling technique and suitable drilling rig for piezometer construction.

c. Installation of suitable well assembly to tap the aquifer proposed to be monitored, i.e. casing, screen etc.

d. Maintenance of well.

It is essential to have a complete understanding of aquifer disposition and geometry in the area before the piezometers are designed and installed. The hydrogeological mapping in the area may indicate the disposition and inter-relationship of the aquifers spatially and depth wise. The information generated from ground water surveys and exploration would enable one to decide grouping of interrelated aquifers into one aquifer system for the purpose of monitoring. The decision to install piezometers monitoring phreatic and deeper confined aquifers would be dependent on the nature of aquifer systemviz., alluvial aquifers or hard rock aquifers.

Alluvial aquifers:

In Delhi state alluvial areas, characterized by occurrence of number of sand zones constituting the aquifers, it may not be essential to install piezometers for each sand zone. Based on inter-relationship and behavior, these aquifers are grouped into major aquifer systems and piezometers have been installed accordingly.

In National Capital Territory of Delhi and adjoining, the hydrogeological mapping and ground water exploration indicates the presence of three distinct potential aquifer groups within the depth of 450 m below ground level. Each of these aquifer groups comprises of number of individual sandy horizons. The grouping of aquifers was done as follows:

Aquifer Group I - **Down to 65 m. below ground level (Un-confined)**

Aquifer Group II- **Between 65 to 200 m. below ground level (Confined/ Semi-Confined)**

Aquifer Group III- **Between 200 to >300 m. below ground Level (Confined)**

Separate piezometers were installed, tapping the two aquifer groups, the first one in the phreatic zone, deep enough to accommodate long term fluctuation (i.e. up to 65 m deep) and the other one tapping the middle parts of the aquifer groups II lying between 65 to 200 m. The Aquifer group III is not being monitored at present.

Hard rock aquifers*:*

The hard rock area of NCT Delhi is being monitored through piezometric nests, which are installed in a single borehole tapping the weathered and fractured aquifers composedly. Generally, the depth of the well goes up to 80 m, but in some cases it goes up to 140 m.

1.3 - DISTRIBUTION OF HYDROGRAPH NET WORK STATIONS

Central Ground Water Board has established 162 hydrograph monitoring stations, out of which 25 are dug wells and 137 are piezometers till March, 2012. District wise details of National Hydrograph Network Monitoring Stations for the last four years are given in following Table 1.1.

Table-1.1

Status National Hydrograph Monitoring Stations in NCT, Delhi

Name of the district	Total No. of NHNS as on 31-3-2009	Total No. of NHNS as on 31-3-2010	Total No. of NHNS as on 31-3-2011	Total No. of NHNS as on 31-3-2012
North-West	39	39	33	33
North	13	13	10	10
North-East	6	6	07	07
East	18	18	14	14
New Delhi	29	29	18	18
Central	2	2	02	02
West	11	13	13	13
South-West	45	47	39	39
South	37	39	26	26
Total	**200**	**206**	**162**	**162**

Central Ground Water Board is striving to increase the number of monitoring stations in NCT, Delhi to monitor and have close observation in the diverse hydrogeological domain. In the recent years Delhi is facing rapid decline in ground water levels, which calls for attention and close watch through monitoring. The establishment of Peizometer in metropolitan city of Delhi is very hard due to non-availability of space. However, the establishment of monitoring station is in progress gradually for the precise observations of ground water conditions.

District wise distribution of hydrograph network station is highly uneven and varies from one monitoring station per 1.4 Sq. Km in the

New Delhi district to one monitoring station per 30 Sq. Km in the North-East district. Table-1.2 shows the density distribution of hydrograph stations in NCT Delhi.

Table-1.2
Density distribution of NHNS in NCT Delhi

Name of the district	Area in Sq. Km	No. of NHNS	Density Sq. Km per well
North-West	440	33	13.33
North	60	10	6
North-East	60	7	8.57
East	64	14	4.57
New Delhi	35	18	1.94
Central	25	2	12.5
West	129	13	9.92
South-West	420	39	10.76
South	250	26	9.61
Total	**1483**	**162**	**9.15**

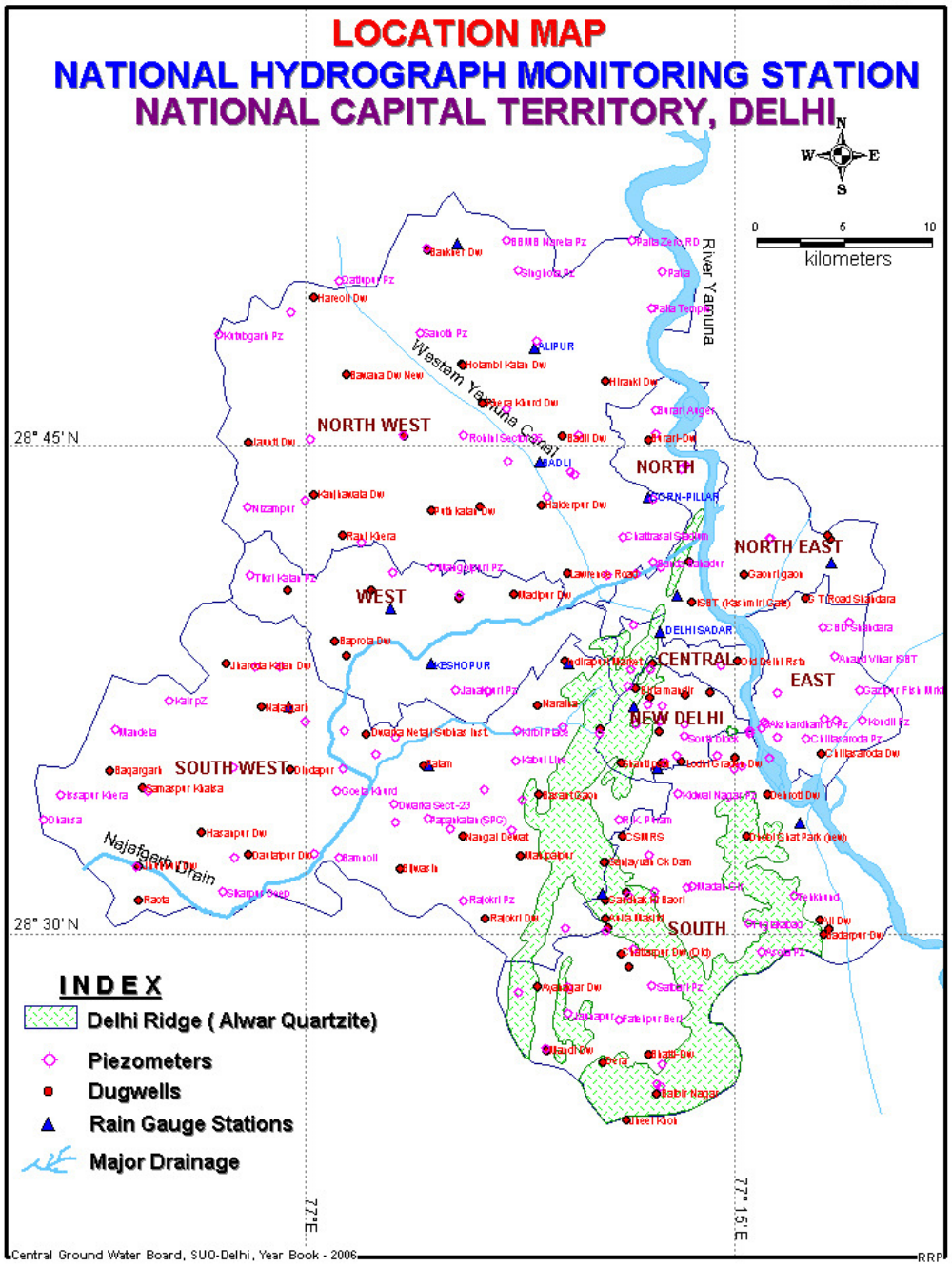
1.4 - PERIODIC ANALYSIS:

Analysis is normally done immediately after each phase of ground water monitoring; viz. May, August, November and January. The water level data generated are utilized to prepare the depth to water level maps and also fluctuation maps, to bring out the prevailing status of ground water regime. The depiction of the data through maps on district wise basis can be made as follows:

1. DEPTH TO WATER TABLE MAP:

Depth to water table maps usually presented for Delhi State on appropriate scale bringing out suitable depth ranges say; 0-2 m, 2-5 m, 5-10 m, 10-20 m, 20-40 m, 40-60 m &>60 m. The depth ranges are categorized considering prevailing water levels, depth zone of water logging, depth zone of prone to water logging centrifugal pumping depths etc.

Plate No. -


LOCATION MAP
NATIONAL HYDROGRAPH MONITORING STATION
NATIONAL CAPITAL TERRITORY, DELHI
N
W
E
S
0
5
10
kilometers
River Yamuna
Western Yamuna Canal
Najafgarh Drain
NORTH WEST
NORTH
NORTH EAST
WEST
CENTRAL
EAST
NEW DELHI
SOUTH WEST
SOUTH
DELHI SADAR
KESHOPUR
BADLI
ALIPUR
GOPAL PILLAR
28° 45' N
28° 30' N
77° E
77° 15' E
INDEX
Delhi Ridge (Alwar Quartzite)
Piezometers
Dugwells
Rain Gauge Stations
Major Drainage
Central Ground Water Board, SUO-Delhi, Year Book - 2006
RRP

2. ***WATER LEVEL FLUCTUATION MAPS:***

The ground water level fluctuation usually depicted through a set of maps showing the status of the water levels under observation as compared to the levels of the same period of the previous *year* and to the decadal mean water levels etc. These maps can be drawn as:

a. Fluctuation map comparing the water levels monitored with the corresponding water levels in the preceding *year.*

b. Fluctuation maps comparing the Post-monsoon water level monitored with Pre-monsoon water level of the same water *year.*

c. Fluctuation maps comparing the water level monitored with the mean water levels of the period *for* at least a decade. This map would bring out departures *from* normal ground water storage situations during the period under consideration.

*3.****GROUND WATER QUALITY MAPS:***

The ground water quality maps usually prepared are based on the frequency of ground water sample collection. As the ground water quality regime does not show marked variations sample collection is done once in a *year.* Only major constituents analyzed are used in preparation of the maps. The maps to be prepared are:

I. Map showing EC variation in the ground water

2. Map showing Nitrate distribution in the ground water

3. Map showing high point values of Fluoride, Nitrate and other pollutants.

*4.****STATUS*** **OF** ***GROUND WATER REGIME:***

After each measurement, a comprehensive report is prepared, which include the following:

a. Brief write-up supported by water level data, maps of depth to water, and rise and fall of ground water levels and ground water quality maps etc.

b. Effects of various factors on ground water regime like rainfall, ground water pumpage, irrigation practices etc.

c. Departure in the normal behavior of water levels bringing out the factors responsible.

The report and maps are of immense help to the planners and ground water users to chalk out the development strategy.

Chapter - 2

CLIMATE AND RAINFALL

CLIMATE:

The climate of NCT Delhi is mainly influenced by its inland position and the prevalence of air of the continental type during the major part of the year. Extreme dryness with the intensely hot summer and cold winter are the characteristics of the climate. Only during the three-monsoon months July, August, and September does air of oceanic origin penetrate to this state and causes increased humidity, cloudiness and precipitation. The year can broadly be divided into four seasons. The cold season starts in late November and extends up to the beginning of March. This is followed by the hot season, which lasts till about the end of June when the monsoon arrives over the state. The monsoon continues to the last week of September. The two post monsoon months October and November constitute a transition period from the monsoon to winter condition.

Table-2.1
Seasons in NCT, Delhi

Season	Begin	End
Cold/Winter	End of November	Middle of March
Summer	Middle/End of March	End of June
Rainy season	Early July	September

RAINFALL:

Rainfall data of six of the stations located in NCT, Delhi has been collected from IMD and presented in Table-2.3. For calculation of normal rainfall of NCT Delhi, rainfall records from 1930-1980 for 13 stations were considered. The normal annual rainfall in NCT Delhi is 611.8 mm. The rainfall in NCT Delhi increases from the southwest to the northwest. About 81% of the annual rainfall is received during the monsoon months July, August and September. The rest of the annual rainfall is received as winter rains and as thunderstorm rain in the pre and post monsoon months. The variation of rainfall from year to year is large.

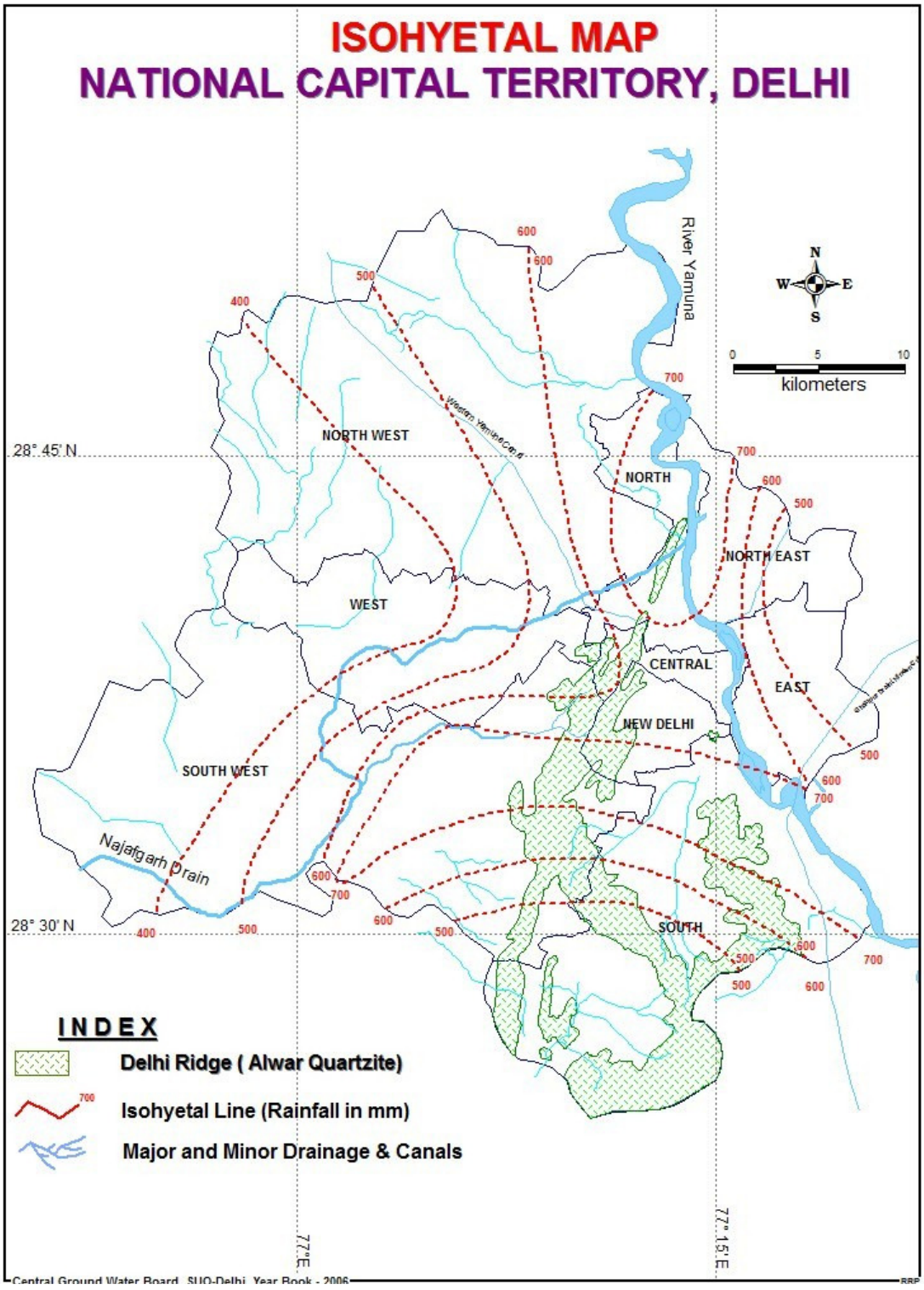

ISOHYETAL MAP
NATIONAL CAPITAL TERRITORY, DELHI
River Yamuna
Western Yamuna Canal
N
W
E
S
0
5
10
kilometers
28° 45' N
28° 30' N
77° E
77° 15' E
NORTH WEST
NORTH
NORTH EAST
WEST
CENTRAL
EAST
NEW DELHI
SOUTH WEST
SOUTH
Najafgarh Drain
400
500
600
700
INDEX
Delhi Ridge (Alwar Quartzite)
Isohyetal Line (Rainfall in mm)
Major and Minor Drainage & Canals
Central Ground Water Board, SUO-Delhi, Year Book - 2006

Table-2.2:Annual rainfall and deviations from Normal Rainfall i.e. 611.8 mm

District	Station	2001		2002		2003	
		Annual rainfall in mm	Deviation from Normal rainfall	Annual rainfall in mm	Deviation from Normal rainfall	Annual rainfall in mm	Deviation from Normal rainfall
New Delhi	Safdarjung	693.8	+ 13%	561.2	- 8.3%	1161.3	+ 90%
	RashtrapatiBhawan	585.0	- 4.4%	--	--	--	--
North	Delhi University	669.9	+ 9.5%	664.1	+ 8.55%	703.5	+ 15%
	Delhi ridge	657.4	+ 7.4%	611.5	- 0.05%	558.3	- 8.64%
South west	Palam	529.0	- 13.5%	456.0	- 25.5%	881.4	+ 44%
South	Ayanagar	656.9	+ 7.4%	596	- 2.58%	1119.1	+ 83%
NCT, Delhi Mean		**632.0**	**+ 3.3%**	**572.47**	**- 6.43%**	**884.7**	**+ 44.6%**

A perusal of rainfall data from 2001 to 2003 shows that NCT Delhi received surplus rainfall of 3.3% in 2001 and 44.6% during 2003 and year 2002 has deficient rainfall of -6.43%. Comparison of annual rainfalls of 2001, 2002 and 2003 has been done with that of Normal rainfall of NCT Delhi and presented in Table-2.2. The details of the Normal and the Extreme Rainfall are tabulated in Table-2.3. A perusal of the table shows that all the stations in NCT Delhi have received deficit rainfall during the year 2002 with maximum deviation of 25.5% at Palam station. During the year 2001 out of six stations four of the stations received surplus rainfall and two stations were received deficit rainfall. During 2003 surplus rainfall was recorded in five stations and one rainfall station located at Delhi ridge received deficit rainfall. Maximum deviation of surplus rainfall is observed at Safdarjung meteorological station which is 90% of normal rainfall.

Rainfall in Delhi is thus highly variable with deviations from –25.5% to +90% from normal rainfall which in urn affects the natural recharge to ground water from year to year.

Month-wise Normal Rainfall with Rainy days and Evaporation losses are given in Table-2.4. The average annual evaporation losses are 2224 mm.

Table 2.3 - Normal and Extremes of Rainfall

Stations	No. of Years of DATA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	HIGHEST ANNUAL AS % OF (YEARS)**	LOWEST RAINFALL NORMAL &	HEAVIEST RAINFALL In 24 HOURS * Amount (mm)	Date
Chandrawal (obsy)	20 a	8.5	15.3	16.7	5.5	18.2	47.6	329.8	308.4	102.3	14.4	8.2	11.6	886.5	163	64	171.0	1976 Aug 08
	b	0.6	1.2	1.2	0.5	1.5	2.2	10.5	10.4	3.9	0.9	0.2	0.8	33.9	(1977)	(1969)		
New Delhi (Safd)	79 a	20.5	20.1	13.3	7.8	12.5	62.2	203.2	202.2	137.6	21.7	3.1	8.0	712.2	215	43	495.3	1875 Sep 09
	b	1.8	1.5	1.2	0.8	1.4	3.6	9.2	9.5	5.1	1.0	0.2	0.7	36.0	(1933)	(1905)		
Delhi (University obsy)	29 a	20.7	18.3	19.1	5.1	16.4	62.2	281.6	263.5	147.4	41.6	4.1	7.6	887.6	209	52	250.0	1963 Sep 16
	b	1.6	1.4	1.5	0.7	1.5	2.8	10.3	10.5	5.2	1.6	0.2	0.8	38.1	(1957)	(1974)		
New Delhi Palam	22 a	14.7	14.1	9.3	6.1	18.9	54.2	241.1	284.3	119.4	16.8	6.4	8.6	793.9	164	51	265.8	1972 Jul 09
	b	1.3	1.5	1.0	0.6	1.5	3.5	10.9	10.7	4.9	1.4	0.2	0.6	38.3	(1967)	(1965)		
Okhala (obsy)	21 a	9.6	11.9	14.7	2.6	17.1	66.9	212.5	296.3	124.6	23.2	5.7	7.3	792.4	159	66	190.0	1967 Aug 26
	b	0.9	1.3	0.9	0.3	1.4	3.4	9.3	10.7	5.1	0.9	0.3	0.6	35.1	(1964)	(1974)		
Mahruali	33 a	13.9	10.1	7.3	9.4	3.6	28.3	159.9	152.5	98.7	11.5	1.5	2.3	499.0	197	42	177.8	1911 Sep 28
	b	1.1	0.7	0.6	0.6	0.3	1.5	5.8	5.9	3.0	0.3	0.2	0.3	20.3	(1944)	(1954)		
Delhi Sadaer	38 a	22.6	17.5	13.0	8.8	9.6	44.8	184.3	180.0	132.3	26.1	3.5	5.1	647.6	194	42	224.8	1942 Sep 05
	b	1.9	1.4	1.4	0.6	0.9	2.4	7.6	8.9	4.7	1.0	0.3	0.6	31.7	(1964)	(1903)		
Nangloi	25 a	8.5	4.6	1.1	4.0	2.4	19.8	100.3	121.6	69.0	5.0	0.4	0.5	337.2	246	21	120.0	1964 Aug 14
	b	0.8	0.3	0.2	0.2	0.3	1.1	4.6	5.4	3.1	0.4	0.0	0.0	16.4	(1964)	(1950)		
Sahadra	12 a	15.5	17.9	5.6	5.3	2.8	24.8	170.7	125.8	74.9	7.9	0.0	0.6	451.9	206	42	129.5	1944 Sep 04
	b	0.7	0.8	0.7	0.3	0.5	1.4	6.1	5.0	2.8	0.3	0.0	0.1	18.7	(1944)	(1948)		
Najafgarh	23 a	8.9	8.2	4.7	4.2	3.0	25.1	122.0	122.8	75.9	21.7	0.5	1.8	398.9	171	10	139.7	1954 Oct 01
	b	0.8	0.7	0.2	0.4	0.4	1.3	5.5	5.6	3.2	0.8	0.0	0.2	19.1	(1942)	(1959)		
Badli	23 a	13.7	8.6	9.6	3.6	1.4	21.8	154.2	181.3	88.2	32.9	0.8	0.0	516.1	257	37	205.7	1962 Jul 17
	b	1.0	0.7	0.6	0.4	0.2	1.1	5.8	6.4	3.7	0.8	0.0	0.0	20.7	(1961)	(1951)		
Alipur	21 a	11.7	10.6	3.3	3.6	6.0	26.7	146.1	137.1	87.7	13.7	1.3	1.1	448.9	202	12	162.1	1961 Jul 17
	b	1.3	0.7	0.4	0.4	0.4	1.5	4.7	6.0	2.9	0.7	0.1	0.1	19.3	(1961)	(1959)		
Narela	19 a	19.9	14.5	10.6	4.9	7.2	20.6	184.7	190.4	111.2	14.8	1.1	1.4	581.3	196	29	184.1	1947 Sep 15
	b	1.5	0.9	1.1	0.6	0.4	1.6	6.4	8.2	4.0	0.5	0.1	0.2	25.3	(1961)	(1965)		
Delhi (District)	a	14.5	13.2	9.9	5.5	9.2	38.8	191.6	197.4	105.3	19.3	2.8	4.3	611.8	251	44		
	b	1.2	1.0	0.8	0.5	0.8	2.1	7.4	7.9	4.0	0.8	0.1	0.4	27.0	(1933)	(1951)		

(a) Normal rainfall in mm.

(b) Average number of rainy days (i.e. days with rainfall of 2.5 mm or more)

* Based on all available data up to 1980.

** Years given in brackets.

Table 2.4 Rainfall and Evaporation Losses

Month	Jan	Feb	Mar	Apr.	May	Jun	July	Aug	Sep	Oct	Nov.	Dec.	Annual
Rainfall (in mm)	14.5	13.2	9.9	5.5	9.2	38.8	191.6	197.4	105.3	19.3	2.8	4.3	611.3
Rainy days	1.2	1.0	0.8	0.5	0.8	2.1	7.4	7.9	4.0	0.8	0.1	0.4	27.0
Evaporation (in mm)	71	101	177	300	400	333	233	133	147	149	102	78	2224
Source: Indian Meteorological Department													

Temperature:

The cold season starts towards the latter half of November when both day and night temperature drop rapidly with the advance of the season. January is the coldest month with the mean daily maximum temperature at 21.3ºC and the mean daily minimum at 7.3ºC. In the winter months during cold waves which affect the district in the wake of western disturbances passing across north India, minimum temperatures may sometimes go down to the freezing point of water. From about the middle of March, temperature begins to rise fairly rapidly. May and June are the hottest months. While day temperature is higher in May the nights are warmer in June. From April the hot wind known locally as 'loo' blows and the weather is unpleasant. In May and June maximum temperature may sometimes reach 46 or 47ºC. With the advance of the monsoon into the area towards the end of June or the beginning of July day temperatures drop appreciably while the night temperatures remain high. In October the day temperatures are as in the monsoon months but the nights are cooler.

Humidity:

The air over Delhi is dry during the greater part of the year. Humidity is high in the monsoon months. April and May are the driest months with relative humidity of about 30% in the morning and less than 20% in the afternoons.

Cloudiness:

During the monsoon especially in July and August skies are heavily clouded and often overcast. In the rest of the year skies are clear or lightly

clouded. But in the months January, February and early March skies become cloudy and overcast when the district is affected by western disturbances.

Winds:

Winds are generally light during the post monsoon and winter months. They strengthen during the summer and monsoon months. Except during the monsoon months, winds are predominantly from a westerly or northwesterly direction and tend to be more northerly in the afternoon. Easterly and southeasterly winds are more common in the monsoon months.

Chapter - 3

Hydrogeological Framework of Delhi

3.1 - PHYSIOGRAPHY

The union territory of Delhi has four distinct physiographic units; these are as follows:

1- **Delhi (Quartzitic) Ridge**

2- **Older alluvium on both side of the Delhi Ridge**

3- **Younger Alluvium –All along Yamuna Flood Plain**

4- **Alluvium Deposits of Chattarpur Enclosed basin**

The quartzitic ridge enters the area from the South-Eastern part and passes through the Eastern part extending up to the western bank of river Yamuna near Wazirabad. The rocky ridge has a length of about 35km and trends in a NNE-SSW direction. Isolated exposures of the quartzite are also found in the Western part of the area. The elevation of the crest of the ridge varies from 213 to 314 m above mean sea level with an average elevation of 40 m from the surrounding plain. The land surface on the Eastern side of ridge slopes towards the river Yamuna with a general gradient of 3.3 m/km. On the West side of the ridge the ground slopes towards the Najafgarh*Jheel* in the South-West.

The alluvial plain in the area is almost flat and is interrupted by cluster of sand dunes and quartzite ridges. The sand dunes which are more prominent in the western part of the area are of varying dimensions and have North-East to South-West trend. The crests of these dunes generally lie between 3 to10 meters above the surrounding plains. The dunes in the area are more area less fixed with vegetation on them. The dunes are mostly longitudinal in nature.

The nearly closed alluvial basin of Chattarpur (28^0 25' 30 " to 28^0 32' 30" N and 77^0 07 ' 30" to 77^0 13' 00" E) in South Delhi occupies an area of about 78 km^2. This is a closed inland basin, the boundary of which is marked by the quartzite ridges. The general slope of the land is towards the center of the basin from the surrounding ridges. The slope in the southern part of the basin is towards south. The maximum land altitude in the basin is about 259 m MSL whereas the land at the ridges is about 274 m MSL.

Younger alluvium (Flood Plain) deposits are confined all along the river Yamuna, which are presently demarcated by embankment on both sides of the river. Virtually, this is an active flood plain domain covering an area of nearly 97 sq. km, characterized by granular deposits with shallow depth to water level. Presently, the entire flood plain area is protected by constructing embankment running all through Dahia Border to Badarpur border on Western bank and Loni border to MayurVihar border on the Eastern bank of Yamuna River within National Capital Territory. The depth to water level varies from 3 to 6 m.bgl in active flood plain.

The river Yamuna is the only perennial river flowing in the Southerly direction. Either side of the river Yamuna is marked by the extensive alluvial flood plain. The aerial extent of the active flood plain in NCT Delhi is 97 sq. km. The flood plains towards the North falls in Narela and Civil-lines tehsils of North District, the Central parts fall in North-East district and Daryaganj tehsil of Central district and the Southern most part falls in Saidabad and Kalkaji tehsil of South district. In general, the alluvial flood plain slope is towards South. The average slope of the Yamuna River bed from North to South is 0.4 m/km. Eastern and Western Yamuna Canal and Agra Canal are the three major canals originating from the river with Bawana, Rajpur and Lampur distributaries. A dense network of lined canals system exists in the North-Western part of the state.

A number of micro watersheds originate from the quartzite ridge. The drainage on the East of the ridge enters river Yamuna, whereas on the West, it enters natural depressions located in Najafgarh Tehsil of South-West district. The geographical area of NCT Delhi, is broadly divided into seven drainage basins, ultimately discharging into the Yamuna – (I) The Najafgarh Drain is about 39 Km long, flows North-Easterly and joins Yamuna River at Wazirabad in North Delhi. (ii) Supplementary drain, (iii) Barapullah drain. (iv) Wild life sanctuary area, (v) Drainage of Shahadra area, (vi) Bawana drain basin, (vii) Otherdrains directly out falling into river Yamuna on right bank. Swamp areas are common along the flood plains of Yamuna.

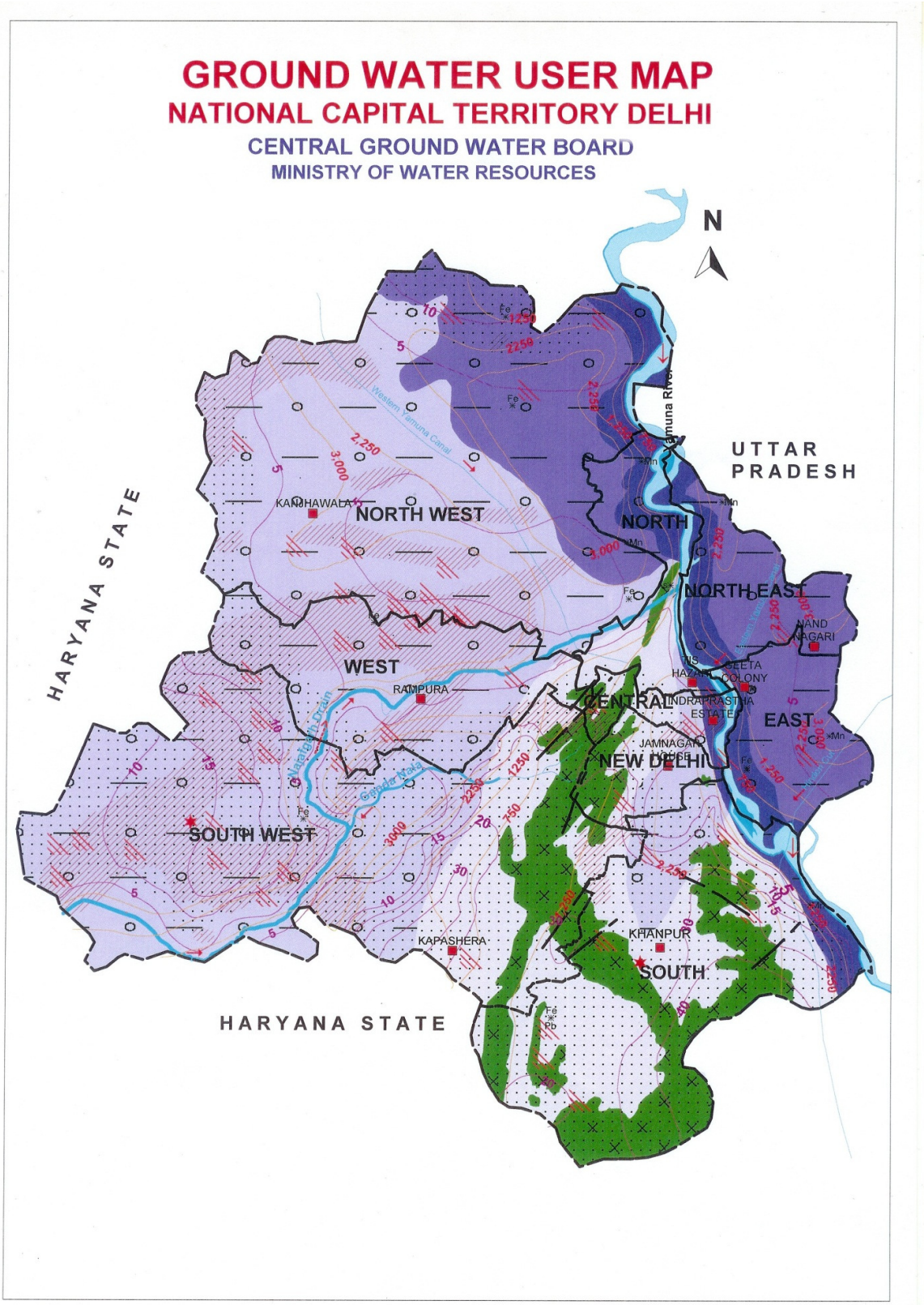
3.2 - GEOLOGY:

NCT Delhi is occupied by Quartzite inter-bedded with Mica-Schist belonging to Delhi Super Group. Unconsolidated sediments of Quaternary to Recent age unconformably overlie these. The quartzite is grey to brownish grey, massive to thinly bedded and structurally form a coaxially refolded regional Antiform plunging towards South-West. The major planar structure strikes NE-SW with steep South-Easterly dips. Quartzite occurs in the Central and Southern part of the area while the Quaternary sediments comprising older and newer alluvium cover the rest of the area. The older Alluvium comprises silt and clay mixed with kankar in varying proportions. The Newer Alluvium mainly consists of un-oxidized sands, silt and clay occurring in the Yamuna flood plain. The thickness of alluvium on eastern and western side of the ridge is variable but west of the ridge it is generally thicker (>300 m). The area is dissected by number of faults, fractures and shears; the trend of these varies from NNE-SSW to ENE-WSW. The important faults west of the ridge area are Rajendra Nagar fault, MES Depot, East Patel Nagar fault, Anand Parbat, West Patel Nagar fault and Inderpuri fault. The notable faults east of the ridge are Kishangarh fault, a WNW-ESE trending fault between QutabMinar and Mehrauli and LadoSarai fault. The general stratigraphic sequence of the rock formations in the territory is given in Table-3.1.

The geological succession in the area around National Capital Territory (NCT), as worked out by Heron (1917), is given in table -3.1 and 3.2

Table –3.1
Geological succession around National Capital Territory

Post Tertiary	Recent and Sub-recent Alluvium	Blown sand and nodular limestone (Kankars)
----------Unconformity----------		
Delhi System (Proterozoic)	Intrusive pegmatite, and quartz veins , granite , amphibolites	Hornstone BrecciasKushalgarh Limestone
Alwar Series		Quartzite, Arkoses Grits, conglomerate, Limestone, Schist, mica
and contemporaneous volcanic- Railo Series, Lime Stone and quartzite -		
----------Unconformity----------		
Aravali System (Archaean)	Intrusive quartz veins, granite amphibolites.	Mica Schist , crystalline Limestone, quartzite Schistose conglomerate.


GROUND WATER USER MAP
NATIONAL CAPITAL TERRITORY DELHI
CENTRAL GROUND WATER BOARD
MINISTRY OF WATER RESOURCES
N
HARYANA STATE
UTTAR PRADESH
HARYANA STATE
NORTH WEST
NORTH
NORTH EAST
WEST
CENTRAL
EAST
SOUTH WEST
SOUTH
NEW DELHI
KANJHAWALA
RAMPURA
KAPASHERA
KHANPUR
NAND NAGARI
SEELTA HAZARI
COLONY
INDRAPRASTHA ESTATE
JAMNAGAR HOUSE
Yamuna River
Western Yamuna Canal
Najafgarh Drain
Grand Trunk

NATIONAL CAPITAL TERRITORY DELHI

LEGEND

Rock Types	Wells feasible & Formation	Rigs suitable	Depth of Well (m)	Discharge (lpm)	Suitable Artificial Recharge Structures **
Soft Rock	Tube Wells Yamuna Flood Plain	Reverse / Direct Rotary	25-65*	300-2400	Not Feasible
Soft Rock	Tube wells Younger Alluvium	Reverse /Direct Rotary	25-45*	300-1500	Shaft/Trench with recharge well, Recharge Pit with/without bore
Soft Rock	Tube Wells Older Alluvium	Reverse / Direct Rotary	25-90*	120-600	Shaft/Trench with recharge well, Recharge Pit with/without bore
Hard Rock	Tube Wells Quartzites	DTH / Rotary cum DTH	60-120*	90-240	Shaft/Trench with recharge well
Depth to Water level in m (Pre-monsoon decadal mean, 1993-2002) 5		Electrical Conductivity (Micro mhos/cm at 25° C) 3000		Major river / Drain	Faults/Lineaments
Fluoride > Permissible limit (1.5 ppm)		Nitrate > Permissible limit (100 ppm)		Iron > Permissible Limit (1.0 ppm) / * Fe	
State boundary		District boundary		Tehsil boundary	
District head quarter		Over exploited block		Area feasible for Artificial recharge structures	

* Depth of the well is restricted to the availability of fresh water. ** Feasible in areas where depth to water level is more than 8 m below ground level.

OTHER INFORMATION

Name of State	Delhi
Number of Districts	9
Geographical Area	1485 Sq.Km.
Major Geological Formation	Soft Rock - Younger/Older Alluvium Hard Rock - Quartzites
Major Drainage System	Yamuna
Population (as on 2001)	138.57 lakhs
No of Tehsils	27
Existing Major / Medium Irrigation Projects	-
Replenishable Ground Water Resources	28156.32 Hac. m. or 0.28 BCM
Total Ground Water Draft	47945 Hac. m. or 0.47 BCM
Stage of Ground Water Development	170.28 %
Average Annual Rainfall	Safdarjang – 712 mm Palam – 794 mm
Range of Mean Daily Temperature	18-32 ^{O}C
Districts Showing Intensive Ground Water Development	All 7 Dist except North and Central Dist

RRP

Table -3.2

Geological succession in Delhi

Recent and Sub-Recent	Younger Alluvium	Yamuna River Sand and deposits in stream bed
	Older Alluvium	Yellow and reddish soil comprising Silt/clay with local Kankar beds Sand lances and small Ferruginous concretions
Post Delhi Intrusive	----------	Quartz Veins, Pegmatite
Delhi Group	Alwar Series	Quartzite, crystallized bluish, greyish and pinkish in colour, Arkoses grits, thin inter beds of micaceous schist's Quartzite containing pyrite specks, stringers and Occasionally graphitic stringers.

3.3 - BASEMENT TOPOGRAPHY

The basement topography of NCT, Delhi is highly uneven depicting the presence of sub-surface ridges and valleys because of folding of the geological formations during the Pre-Cambrian and subsequent periods. The thickness of unconsolidated sediments towards east of the ridge gradually increases away from the ridges, with the maximum reported thickness being 170 m. In the South-Western, Western and Northern parts of the area, the thickness of sediments is more than 300 m except at Dhansa where the bedrock has been encountered at 297m below land surface. In Chattarpur basin, the maximum thickness of sediments is 116 m.The nature of bedrock topography in different parts of NCT, Delhi is rendered uneven due to existence of sub surface ridges. Thickness of alluvium overlying the quartzites increases away from the outcrops. The thickness of alluvium is 300 m or more in most parts of South West, West and North West districts. The depth to bed rock is within 30 m on the east side of the ridge with a gradual downward slope towards river Yamuna. On the west of ridge near Mall road and VikramadityaMarg, the depth to bed rock varies from 1 to 30 m.bgl. Further west of it and East of Najafgarh drain, there is a sudden increase in depth to 100 m. Near Sabjimandi, Rani Jhansi Road, Aram bagh, PaharganjChandaniChowk and Sadar Bazaar areas, thickness of alluvium is of the order of 10 to 20 m whereas near Roshanara Garden the thickness is about 200 m.

In the Central part of the city area near Dayabasti railway station, Karanpura, Patel Nagar Railway Station, the bedrock occurs within 30 m depth. But a little east of Karanpura, in DCM Chemical works, the bedrock has not been touched down to a drilling depth of 182.88 m. Such sharp and sudden change in thickness of alluvium may be due to faulting. In the Irwin Hospital, Delhi Gate, Daryaganj, Vijay Chowk and Pusa road areas the depth to bedrock varies from 5 to 10 m.bgl. In LalQuila and

Rajghat areas the depth to bedrock varies between 40 to 60 m.bgl. In Shantivan area bedrock is encountered at a depth of 23 m.bgl. In NanglaMachi and Zoo complex, bedrock exposures are present on surface. In Okhla village bedrock is exposed on surface within the JamiaMiliaIslamia campus. The thickness of alluvium is about 30 m at rail Bhawan and is about 100 to 150 m around India Gate. In Trans Yamuna area the thickness of alluvium varies from less than 20 (near Kailash colony) to more than 150 m away from Yamuna. In Usmanpur area bedrock is encountered at a depth of about 60 m. In Sonia Vihar area bedrock is encountered at a depth of 50 m.bgl. In Chattarpur basin of Mehrauli block, the alluvial thickness varies from a few meters near periphery to 115m around Satbari bund.

3.4 - SUBSURFACE CONFIGURATION AND AQUIFER DISPOSITION

Central District:

Central district of NCT Delhi is located in hard rock terrain of Delhi quartzite at one end while alluvium is underlain by Delhi quartzite at another end. Nearly 25 Sq. Km area covered in the district which is extending east to west, where eastern part is just terminating along Yamuna Flood Plain. Depth to bedrock in the eastern part is ranging from 10 to 60 m.bgl. In the western part some of the rock exposures of Delhi ridge are also seen, sporadically covering 1.91 Sq.km area. Quaternary alluvium is comprised of fine sand, silt, clay along with the occurrence of kankars. The sub surface geology comprise of top soil which is silty clay and sand, sand which is medium grained, sub-angular to sub rounded, grey in colour, composed of quartz grains and mica flakes which occurs as massive as well as fractured, admixed with calcareous matters and mica schist, alternate bands of light greyish to whitish in colour. The aquifer system consists of sand which is fine to medium grained, yellowish in colour, kankars medium to high grade. The depth to water level varies from 2 m to 7 m. The quality of water down to 31 m.bgl is found to be fresh.

North District:

North District of NCT Delhi just lying all along Yamuna River covering 60 Sq.Km areas. Its 40% area is under Yamuna Flood Plain. The Southern part of the District have a thin veneer of alluvium cover over quartzitic rock which is an extention of Delhi Ridge (Strike-SSW to NNE), near Wazirabad Barrage. The slope of the surface in the district is towards south by 0.40 m/km, but at the place of concealed Delhi Ridge it gets elevated. Due to this reason it forms a depression at the northern part of the upland area of the ridge leading to water logging conditions. Some of the exploratory wells Drilled by CGWB falling in this area are Delhi University, Dhirpur and Jagatpur encountered with bed rock at the depth of 32 m, 28 m and 167 m

respectively. The alluvium covers are dominant with the clayey-silt followed by buff coloured semi plastic clay and on the margin of bedrock angular gravels with fine to coarse sand occur. The bedrock encountered have suffered moderate to high weathering in this area. The borehole logs of the Yamuna Flood Plain are characterized by the granular zones consisting of fine to medium Yamuna sand. The Percentage of Silt and Clay in flood plain are in lower side than sand.

East District:

East district of Delhi is located in the East of Yamuna River and extends up to the borders of Gaziabad and Noida ares of Uttar Pradesh. Covering a total area of 64 Sq. Km. Virtually, East district of NCT Delhi is a domain lying in between two rivers i.e. Yamuna in the West to Hindon in the East (6 Km eastward from the Delhi border).

The sub-surface material along yamuna flood plain and along eastern border (proximity of Hindon River) shows thick fine sand and sandy-silt strata at shallower depth i.e. up to 60 m.bgl. The finer sediments like clayey-silt, silty-clay and buff coloured clay along with Kankars also do exists, as parting between granular zones. The deeper zones beyond 60 m depth are characterized by fine material and lacking in granular zone. The basement rock condition in East district area is moderately uneven with gentle slopping towards East. It is unlike from western flank of NCT Delhi. At Ghazipur, Kalyanpuri and MayurVihar a mound like basement rock prevails in the depth range of 54 to 79 m.bgl. The basement rock situation around Yamuna flood plain in East Delhi District is ranging from 28 to 204 m.bgl. Especially around Akhsardham temple it ranges from 88 to 120 m.

The depth to water level in this district varies from 5 to 8 m.bgl and the discharge of tube well in Flood Plain is in the range of 600 to 1800 LPM and in the rest of the area it is 300 to 900 LPM with a draw-down of 6 to 13 m.

The Fresh–Saline water interface in Yamuna Flood Plain is ranging from 32 to 50 m whereas in rest of the area it is ranging from 25 to 38 m.

New Delhi District:

New Delhi district is located centrally in the state occupying an area of 35 Sq. Km. with varied surface altitude due to Delhi Ridge. Nearly 10 sq. Km. area falls within ridge area having a height of 225 to 255 m Above Mean Sea Level (AMSL). The surface is sloping gradually towards east up to the Yamuna river course where altitude is 210 m AMSL. The sub-surface configuration of New Delhi is different at various places, the western part which is adjoining to Delhi ridge is characterized by

marginal alluvium of 0 to 30 m thickness overlain on weathered and fractured quartzite rocks (Delhi Ridge). The alluvium consists with clay, silt and fine to medium sand. A substantial amount of *Kankar*is also admixed with the clayey-silt below 20 m depth. This is the main aquifer material found in these areas. The top soil zone is predominantly consists of silty-clay material followed by thin partings of clayey-silt, sandy-silt and clay layers alternatively. Sandy-silt strata behave as favorable aquifer zone with a substantial discharge. In the western part of New Delhi district covering area of RashtrapatiBhavan, Chanakyapuri, Shantipath, South and North Avenue and Connaught Place, tubewells are tapping both prevailing formation i.e. alluvium as well as hard rock, whereas in the eastern part only alluvial aquifers are tapped with yield ranging from 200 to 500 LPM. The extreme eastern part of New Delhi District bounded by river Yamuna where a domain of Yamuna Flood Plain exists in a linear fashion along river Yamuna .The potentiality of Ground water in this formation is relatively high i.e. ranging from 500 to 1600 LPM.

Ground water in the area occurs both under water table as well as under semi-confined conditions in the alluvium. The depth to water level in the district ranges from 5 to 25 m below ground level. The depth to water level varies widely depending upon the topographic elevation; it varies from 5 to 8 m in Yamuna flood plain and increases to 10 to 25 m towards the Delhi ridge. The tubewells usually tap *kankar* zone admixed with clayey-silt and sandy-silt aquifer zone. These aquifer zones are generally encountered alternatively below the depth of 20 m.bgl and onward up to the basement rock.

North-East District:

North-East district is located east of Yamuna River and bordering to Gaziabad district in the east and Merrut district in the north of Uttar Pradesh. It covers 60 Sq.Km of area. Virtually, North-East district of NCT Delhi is a domain lying in between two rivers i.e. Yamuna in the west to Hindon in the east (6 Km eastward from the Delhi border).

The sub-surface material along Yamuna flood plain and along eastern border (proximity of Hindon River) shows thick fine sand and sandy silt strata at shallower depth i.e. up to 60 m.bgl. The finer sediments like clayey–silt, silty-clay and buff coloured clay along with Kankars also do exists, as parting between granular zones. The deeper zones beyond 60 m depth are characterized by fine material and lacking in granular zone. Basement rock condition along the Yamuna Flood Plain in this district is shallower because Delhi central ridge which is running NNE to SSW diminishes at Wazirabad Barrage and protruding further in the same direction resulting to shallower depth of basement condition in sub-surface–horizon. In this

district the depth is ranging from 54 m.bgl (Mandoli) to 67 m.bgl (Ushmanpur). Further east the depth of basement rock increases.

The depth to water level in this district is 5 to 8 m.bgl and the discharge of tube well in Flood Plain is in the range of 600 to 1800 LPM and in the rest of the area it is 300 to 900 LPM with a draw-down of 6 to 13 m.

The Fresh –Saline water interface in Yamuna Flood Plain is ranging from 32 to 50 m whereas in rest of the area it is ranging from 25 to 38 m.

North-West District:

The North-West district of NCT Delhi covers 440 Sq. km. area characterized by unconsolidated quaternary alluvium deposits. So for 250 m depth has been explored without encountering bed rock. The expected depth of bed rock is about 300 m or beyond. Thick pile of alluvium over the basement rock possesses varied sediment strata in an alternate fashion of geological setting. Nearly fine to medium and silt grade of sediment are frequent up to the depth of 50 m along with buff coloured clayey bed admixed with Coarse kankars. On the other hand after the depth of 50 m, silty–clay and clay (Light yellow) beds with Kankars increases with depth. The semi-plastic and plastic clay beds are also common at deeper depth i.e. 80 m.bgl to 250 m.bgl. The granular zone (Fine sand and silty–sand) at deeper depth are not so frequent as in the shallower depth.

In large part of the district the water levels are shallow ranging from 2 to 8 m.bgl, whereas in a limited area towards the northern border (Narela) the water levels are somewhat deeper ranging from 6 to 12 m.bgl.

The line of fresh-saline water interface also varies greatly in entire area. All along the western Yamuna Canal and along Yamuna Flood Plain it shows deeper existence that is between 40 to 70 m, whereas in rest of the area it is at 22 to 40 m deep. It was also observed from the exploratory well data that salinity of water increases with depth and there are no fresh water aquifers in between the saline zone.

South District:

The South district of NCT Delhi covers 250 Sq. Km. of area of which 45.2 Sq. Km area shows mountainous undulating terrain exposed with Delhi quartzite. The district is also characterized by a saucer shaped vast alluvium field in the central part of the district popularly known as Chattarpur Basin. Virtually this is valley fill deposit,

the alluvium thickness varies from 0.0 m to 140.00 m.bgl (Satbari village), below which quartzitic basement rock prevails. Some of the villages like Chattarpur, Gadaipur, Mandi, Ghitorni, Ayanagar, FatehpurBeri and Satbari fall within this area. The overburden composed of unconsolidated clay, silt, sand and varying proportions of Kankars. In the deep basin area, depth zone of 38 m to 55 m is characterized as prominent gravel zone admixed with silt and fine sand followed by clayey-silt and fine sand with occasional kankar nodules. Near to basement somewhat medium sands and angular gravels (ferruginous and gritty types quartzites) are also encountered. At some places viz.Aya Nagar &FarehpurBeri at depth near to the basement rock, lenses of sticky yellowish clay also are encountered. The area across southern Delhi Ridge which falls in South District namely Hauj-khas, Saket, Khanpur, Pushpvihar, Lal-kunwa and Saritavihar are underlain by marginal alluvium deposits with a thickness ranging from 60 m to 94 m below which Quartzitic basement rock prevails.

The bore hole constructed in Quartzites (Jaunapur, Asola, MandiTughlakabad) reveals that moderately fractured zones are prevalent in the depth of 30 m to 90 m and their fractured density gradually decreasing as depth increases. The weathered zone is found at every place above hard rock but their thickness varies from place to place.

The depth to water level varies widely in this district and is ranging from 8 m to 65 m. In the eastern tract of the district where Yamuna Flood Plain occur, depth to water level varies from 8 m to 22 m.bgl but in rest of the area it ranges from 30 to 65 m.bgl. The fresh/Saline water interface depth varies from 75 m to 100 m. The thickness of the fresh water zone varies from 30 m to 85 m.

South-West District:

The South-West district of NCT Delhi covers 420 Sq. km. Majority of the area characterized by unconsolidated quaternary alluvium deposits and about 18 Sq. Km area is covered by denudation hills especially in the eastern part of the district. Exploration upto a depth of 302 m was done to study the hydrogeological condition. The bed rock was encountered at different depth i.e. in Dhansa (297 m), Pindwalakala (300 m), Toghanpur (298 m) and Jhul-jhuli(251 m) Thick pile of alluvium over the basement rock possesses varied nature of sediment strata in an alternate fashion of geological setting. Nearly fine to medium and silt grade of sediment are frequent up to the depth of 50 m along with buff coloured clayey bed admixed with coarse kankars. On the other hand after the depth of 50m, silty–clay and clay (Light yellow) beds with Kankars increases with depth. The semi-plastic and plastic clay beds are also common at deeper depth i.e. 80 m .bgl to 250 m.bgl. The granular zone

(Fine sand and silty–sand) at deeper depth are not so frequent as in the shallower depth.

In major part of the district the depth to water level ranges from 5 to 28 m.bgl where as in rocky area which are lying in the eastern part of the district (Central Delhi Ridge) the depth to water level is in the range of 22 m to 50 m.

The line of Fresh-Saline water interface also varies greatly in entire area. All along the Najafgarh Drain and Two Depression (GumanheraVill. &PindwalanKalan) possesses somewhat deep fresh water layer i.e. up to 35 m.bgl but on the other hand rest of the area is having thin layer of fresh water i.e. up to the depth 25 to 28 m.bgl only. In the Eastern rocky area the fresh–saline Interface lies at greater depths i.e. around 80 to 90 m.bgl.

West District:

West district is occupied by unconsolidated Quaternary alluvium underlain by Precambrian meta-sediments of Delhi System. Quaternary alluvium comprises of sand, clay, silt, gravels/pebbles, kankars. The aquifer system include sand fine to coarse grained admixed with kankars with little amount of clay and silt. Clay is sticky and plastic in nature, light grayish in colour, admixed with a little sand and kankars, fine to medium grained. The depth of water level varies in the district, 2 m to 15 m. The depth of fresh saline interface also varies from 25 m to 50 m at different places. The depth of fresh water zone varies from 10 m to 45 m.

Chapter-4

WATER LEVEL BEHAVIOR OF HYDROGRAPH STATIONS DURING 2011-12

4.1. MAY- 2011:

Depth to water level:

The Depth to water level recorded in NCT Delhi during **May-2011** ranges from 0.96 to 66.45 m. bgl. The total 142 station of Delhi state have been analyzed district wise where 43% wells of South district shown more than 40 m.bgl water level and 26% wells have 20 to 40 m.bgl water level. In New Delhi and South-West district 47% and 59% of the wells show water levels ranging from 10 to 20 m.bgl, (Plate-4, Annexure-I, Table- 4.1). In 50%, 44% and 40% of the wells in Central, East and North West districts the water level ranges from of 5 to10 m.bgl respectively. The entire Yamuna flood plain the water levels are between 2 to 5 m.

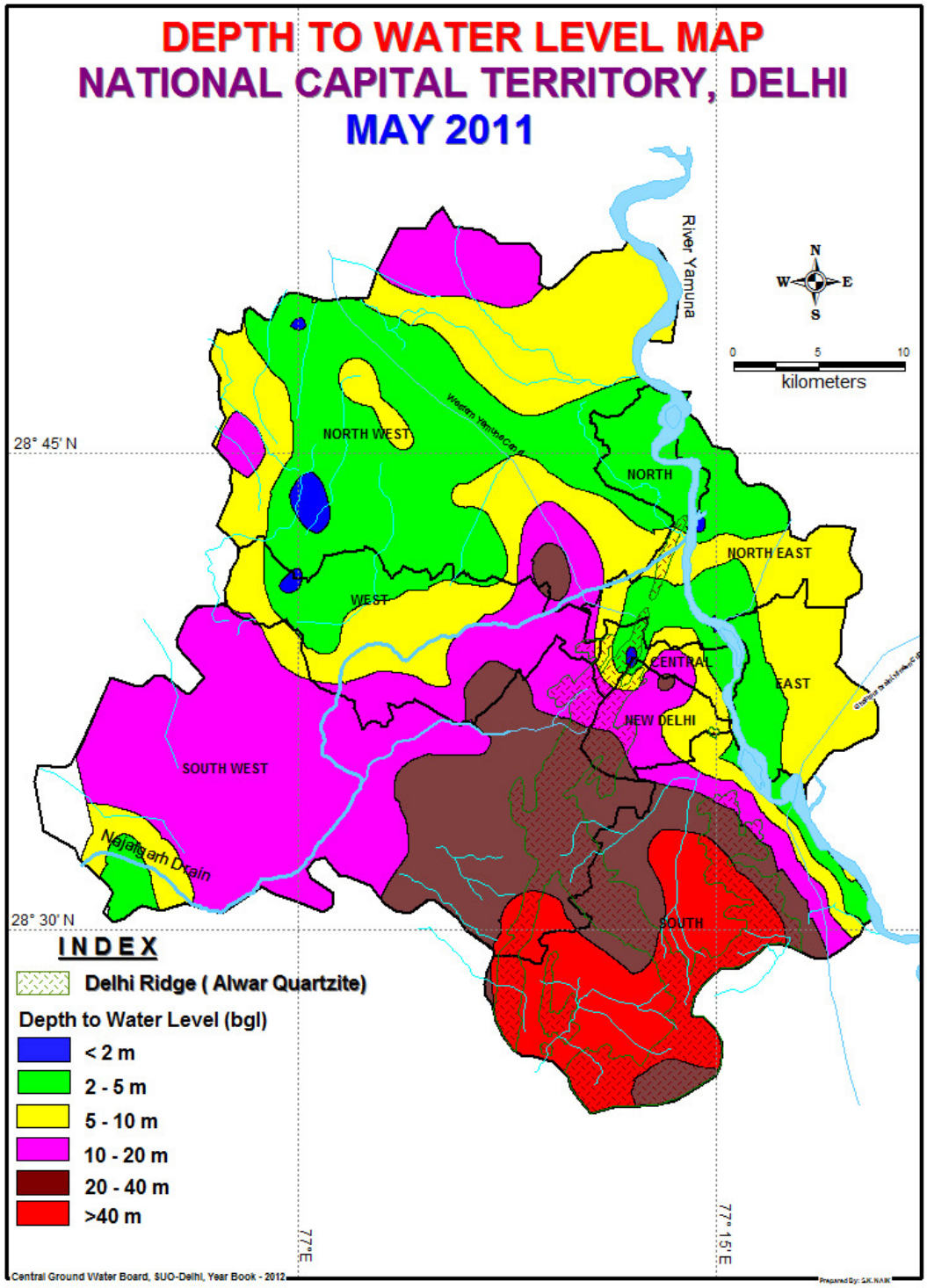
Annual Fluctuation:

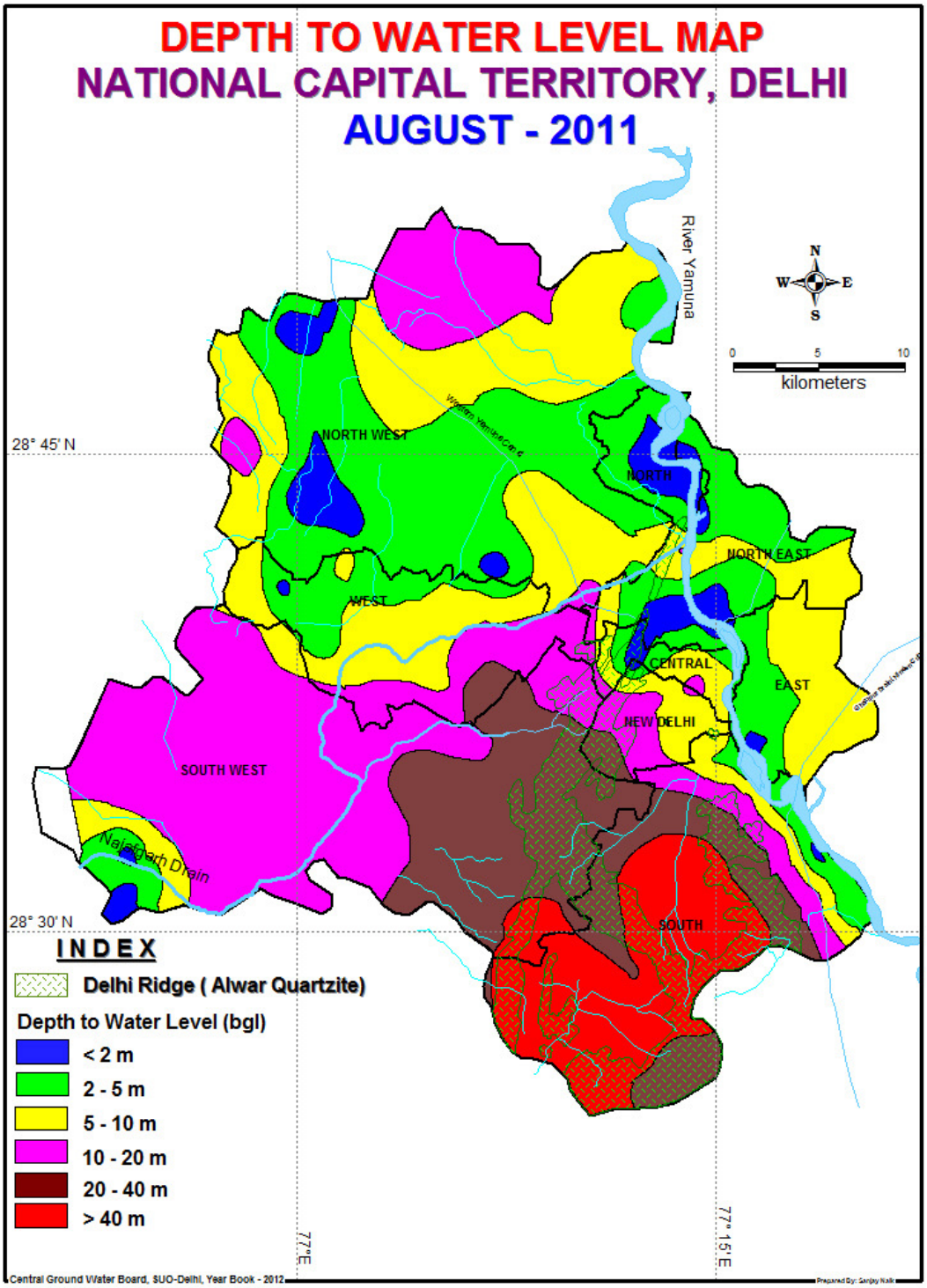
The fluctuation of water level between **May-2010** and **May-2011** of Delhi state shows rise in nearly 75% of wells with respect to the previous year water level in the districts of North, North-West, New Delhi and South. Whereas rest of the district like Central, East, North-East, South and South-West shows fall in the range of 0.26 to 5.70 m in 22% of the wells. The overall data indicates that South and South–West districts are sharing a continuous fall in comparison to other areas. (Plate-8).

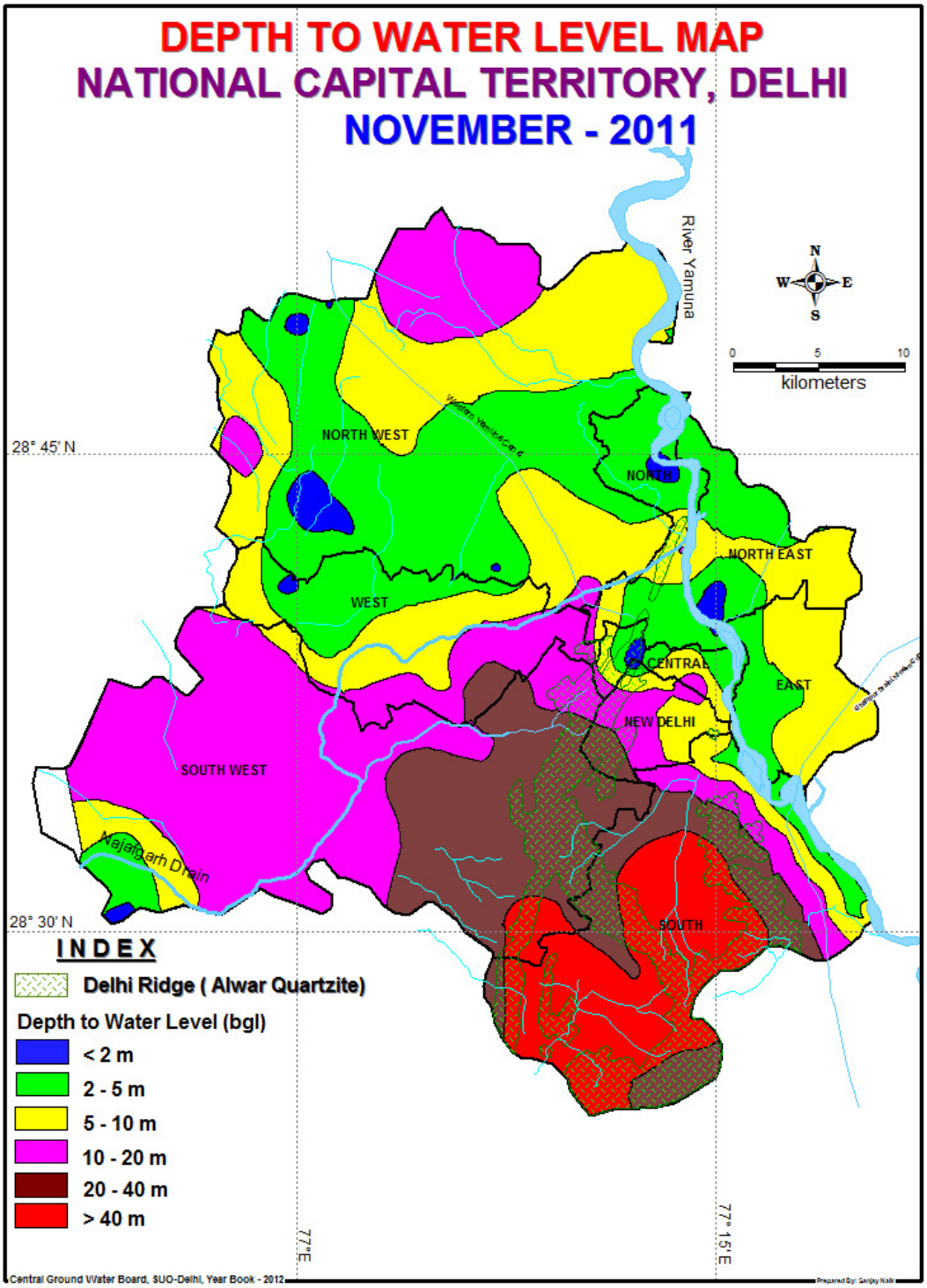
Decadal Fluctuation:

When the data of **May-2011**has compared with **10 year mean of May** water level 40% of the wells indicate fall in the range of 0.02 to more than 14.07 m. Only 57% wells of the North-West, West and New Delhi have been observed to show rising condition in the range of 0 to 2 m. The maximum fall has taken place in district of South and South-West (i.e. 9.76 to 10.96 m) (Plate-13, Table-4.2)

Area wise analysis of water level data of *May, 2011 for*142 stations is shown in the following table:-


DEPTH TO WATER LEVEL MAP
NATIONAL CAPITAL TERRITORY, DELHI
MAY 2011
River Yamuna
N
W
E
S
0
5
10
kilometers
28° 45' N
NORTH WEST
NORTH
NORTH EAST
WEST
CENTRAL
EAST
NEW DELHI
SOUTH WEST
Najafgarh Drain
28° 30' N
SOUTH
77° E
77° 15' E
INDEX
Delhi Ridge (Alwar Quartzite)
Depth to Water Level (bgl)
< 2 m
2 - 5 m
5 - 10 m
10 - 20 m
20 - 40 m
>40 m
Central Ground Water Board, SUO-Delhi, Year Book - 2012


DEPTH TO WATER LEVEL MAP
NATIONAL CAPITAL TERRITORY, DELHI
AUGUST - 2011
River Yamuna
N
W
E
S
0
5
10
kilometers
28° 45' N
28° 30' N
NORTH WEST
NORTH
NORTH EAST
WEST
CENTRAL
EAST
NEW DELHI
SOUTH WEST
SOUTH
Najafgarh Drain
INDEX
Delhi Ridge (Alwar Quartzite)
Depth to Water Level (bgl)
< 2 m
2 - 5 m
5 - 10 m
10 - 20 m
20 - 40 m
> 40 m
77° E
77° 15' E
Central Ground Water Board, SUO-Delhi, Year Book - 2012


DEPTH TO WATER LEVEL MAP
NATIONAL CAPITAL TERRITORY, DELHI
NOVEMBER - 2011
River Yamuna
N
W
E
S
0
5
10
kilometers
28° 45' N
28° 30' N
77° E
77° 15' E
NORTH WEST
NORTH
NORTH EAST
WEST
CENTRAL
EAST
NEW DELHI
SOUTH WEST
SOUTH
Najafgarh Drain
INDEX
Delhi Ridge (Alwar Quartzite)
Depth to Water Level (bgl)
< 2 m
2 - 5 m
5 - 10 m
10 - 20 m
20 - 40 m
> 40 m
Central Ground Water Board, SUO-Delhi, Year Book - 2012

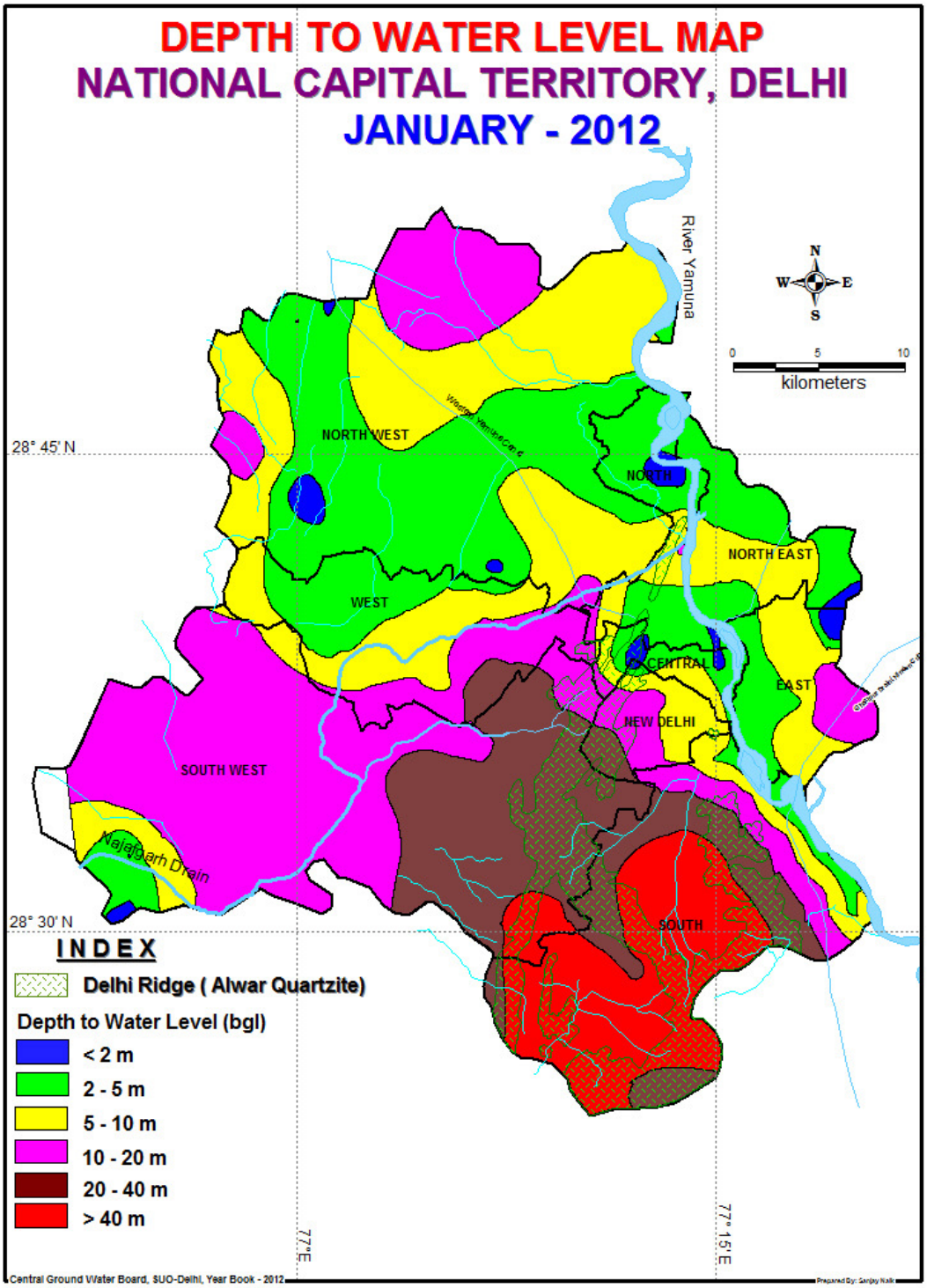

DEPTH TO WATER LEVEL MAP
NATIONAL CAPITAL TERRITORY, DELHI
JANUARY - 2012
River Yamuna
N
W
E
S
0
5
10
kilometers
28° 45' N
NORTH WEST
NORTH
NORTH EAST
WEST
CENTRAL
EAST
NEW DELHI
SOUTH WEST
Najafgarh Drain
28° 30' N
SOUTH
77° E
77° 15' E
INDEX
Delhi Ridge (Alwar Quartzite)
Depth to Water Level (bgl)
< 2 m
2 - 5 m
5 - 10 m
10 - 20 m
20 - 40 m
> 40 m
Central Ground Water Board, SUO-Delhi, Year Book - 2012

Table-4.1
Area under various Depth to Water Level in NCT Delhi

Depth to water Level in m	Area in Sq. Km.	Locations	Districts
0-2	3.8	Raj Ghat, Dhirpur, Kanjawala, JhulJhuli etc.	Central, N-W, North
2-5	465	NangliRajapur,	East
5-10	287	Indiagate, Anandvihar, Akhardham, Connaught Place etc	New Delhi, East Delhi, S-W &N-W
10-20	410	Birla Mandir, Kidwai Nagar, Kichner Road, Shram Shakti Bhavan, Dwarka, Daulatpurect.	S-W, New Delhi,
20-40	247	MahavirBanasthali, Nehrupark, JamaliKamali, Sanjayban, Satbari etc.	S-W, South, New Delhi
40-45	68	BhattiGadaipur ,Asola	South
> 45	7.15	PushpVihar, Ladosarai, Tughlakabad, Chattarpur, Bhatti, Jaunapur, Ayanagaretc	South District

4.2. AUGUST 2011:

Depth to water level:

The Depth to water level recorded in NCT Delhi during **Aug-2011**ranges from 0.58 to 66.80 m. bgl. Total 134 stations have been analyzed district wise, 48% wells of South district shown more than 40 m.bgl water level and 22% wells have 20 to 40 m. bgl water level. In South-West district water levels in 20% of the monitored wells range between 20 to 40 m.bgl. In New Delhi district 47%of the wells have 10 to 20 m.bgl water level. (Plate-5, Annexure-I). The depth to water level in East and North-West district range between 5 to 10 m. bgl in 30% and 28% of the district whereas in East, North and West district the water levels in 30%, 14%, and 22%wells range between 2 to 5 m. bgl respectively, the entire Yamuna flood plain is also falling in this category.

May – August Fluctuation:

The fluctuation of water level between **Pre-monsoon (May-2011)** and **August-2011**indicate that 69% wells shows rise in the range of 0 to 2m, 5% in the range of 2 to 4m and the rest show a fall in water level. The water level fall has been observed in the district South for this period and the maximum fall is 28.30 m. This may be the result of heavy withdrawal during the period. (Annexure-I)

Annual Fluctuation:

The variation of water level from **August-2010**and **August-2011** reveals that there is a fall in the range of 0 to 2m in nearly 21% of the wells (only in pockets). In the districts like New Delhi, South-West and South district the range of water level fluctuation in between 3.94 to 6.02 m. In totality 28% wells shows fall in the range of 0 to more than 4 m. The fall of more than 4m are recorded in only two districts i.e. South and New Delhi. The overall analysis indicates a rising situation in the state (Plate-9).

Decadal Fluctuation:

The water level data of **August-2011** when compared with **10 year mean of August** indicate that in 42% of the wells the water levels are falling in the range of 0.01 to 10.16. In the districts like East, New Delhi, North, South-West, South and West 46% of the wells show decline whereas the district like Central shows somewhat static condition in case of water level behavior (Plate-14).

4.3. NOVEMBER 2011:

Depth to water level:

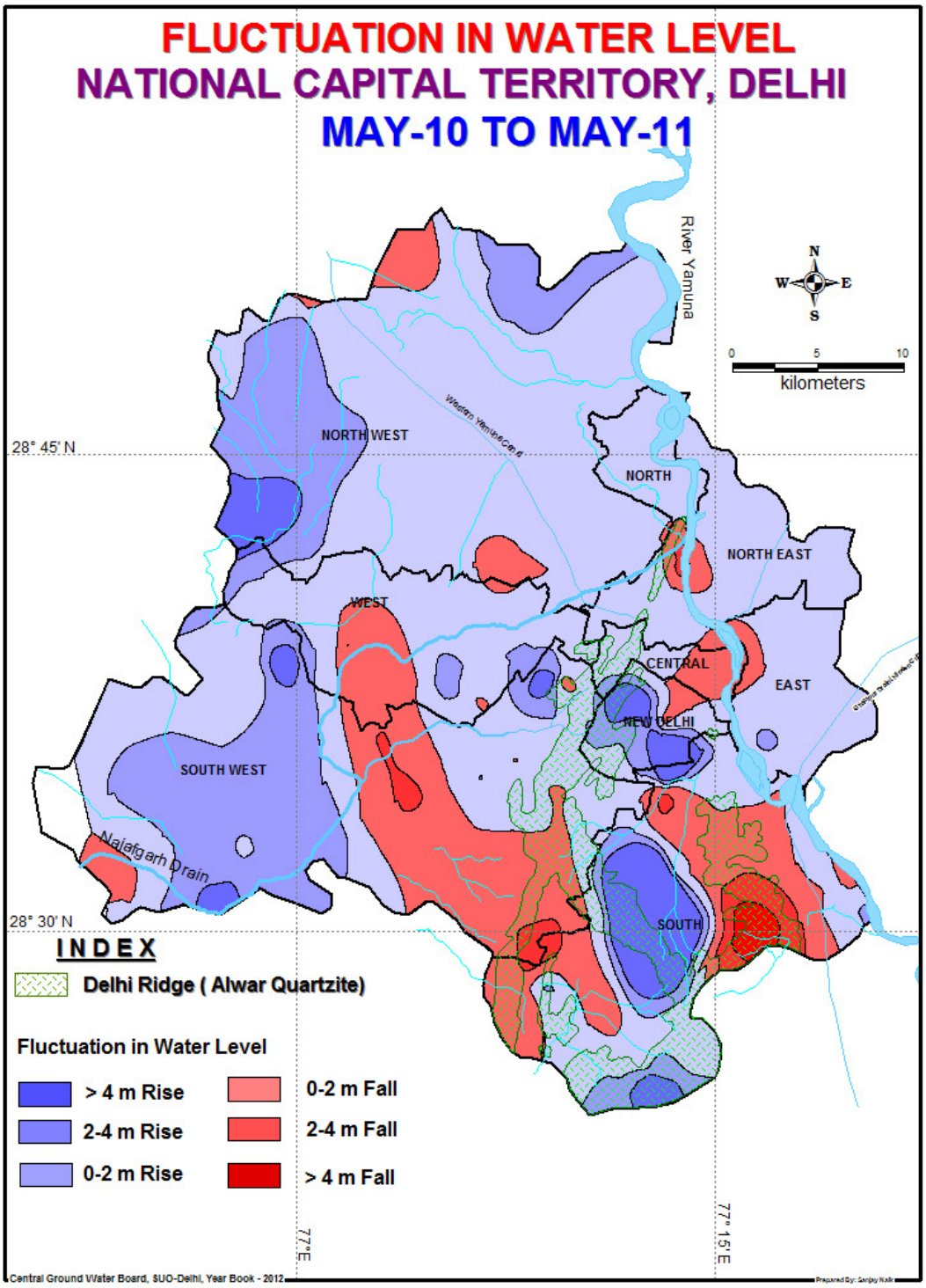
The Depth to water level recorded in NCT Delhi during **November-2011**ranges from 0.91 to 66.73 m.bgl. The data from 131 stations (Plate-6, Annexure-I) has been analyzed district wise. 50% wells of South district shown more than 40 m. bgl water level and 18% wells have 20 to 40 m.bglwater level. In South-West district 20% wells have water level between 20 to 40 m. bgl. The depth to water level of East, North-East and North-West districts are in the range of 5-10 m.bgl in 33%, 60% and 37% respectively whereas in North and South districts 57% and 18% wells are in the range of 2-5 water level respectively. The water levels of entire Yamuna flood plain are in the range of 2 to 5 m. bgl.

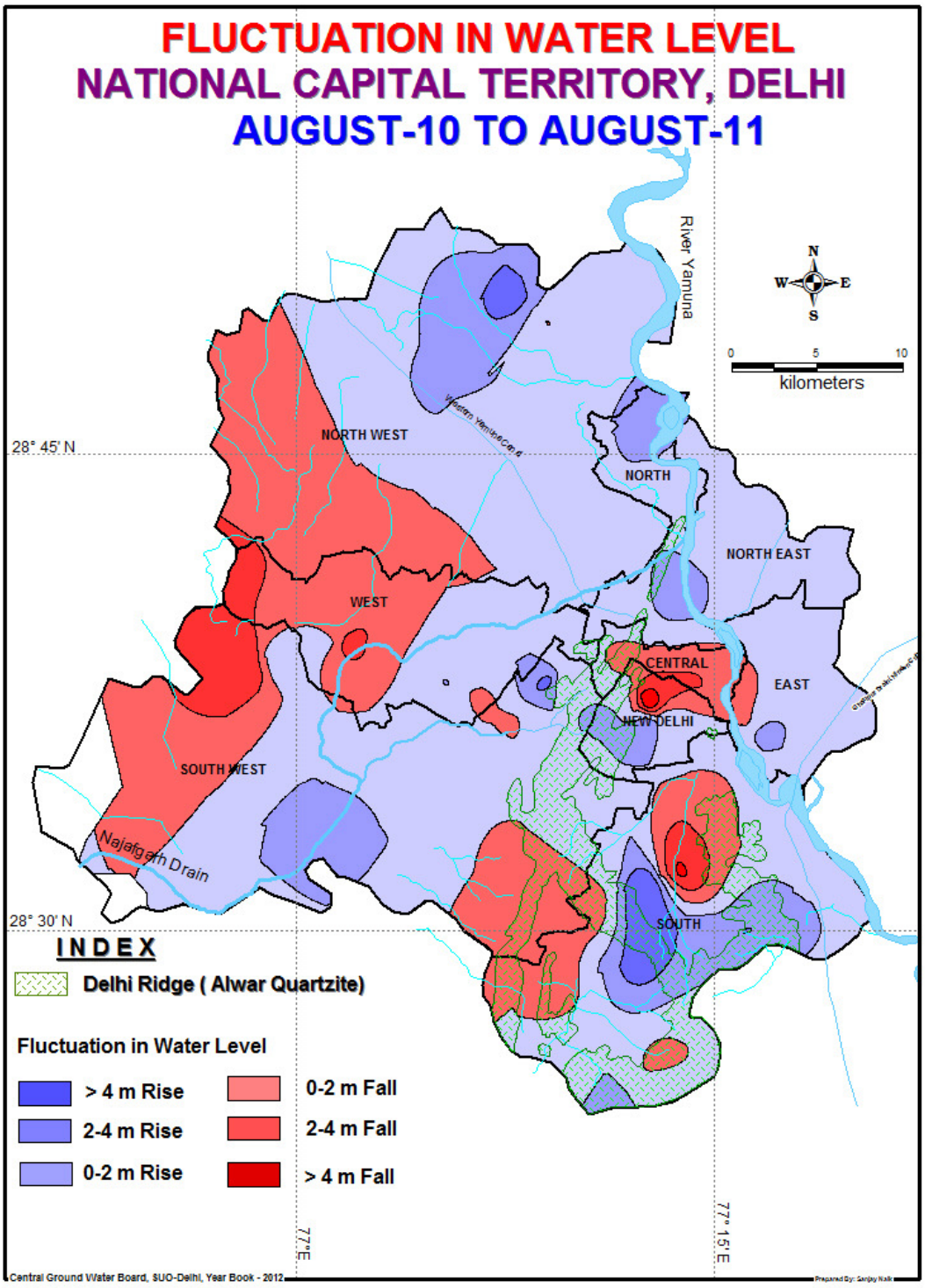
Pre-Post Monsoon Fluctuation:

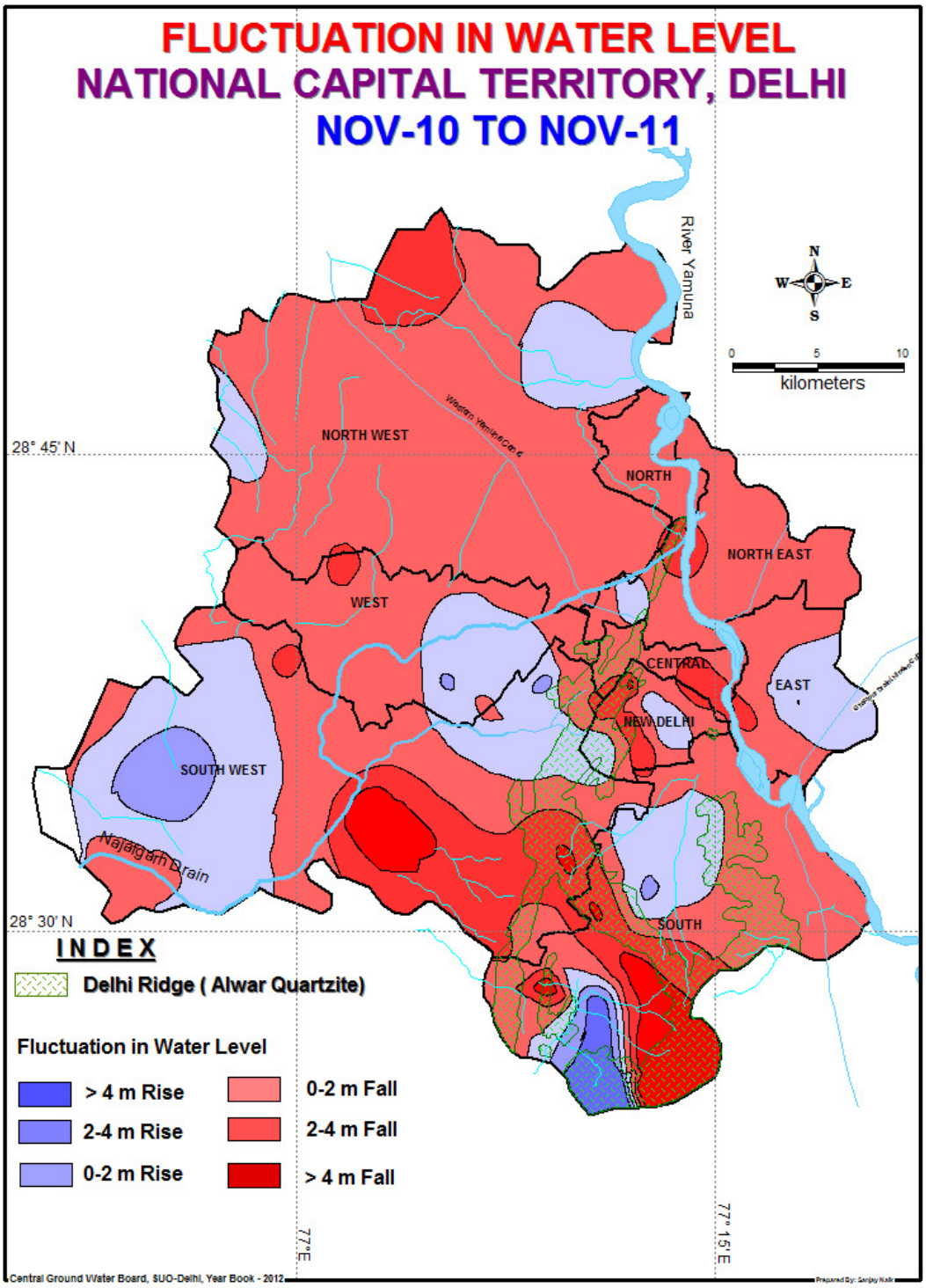
The fluctuation of water level between **Pre-monsoon (May-2011)** and **Post Monsoon (Nov-2011)** of Delhi state shows 0.01 to 10.30 m rise in 62% of the wells, but some of the districts i.e. East, North, North-East and West shows a rise in the range of 0 to 4 m in 71% of the wells. Few wells of South and East district show fall in the range of 0 to 4 m. An analysis of the data indicates that the declining trend is continuing in the South and South-West districts. (Plate-12, Annexure-I).

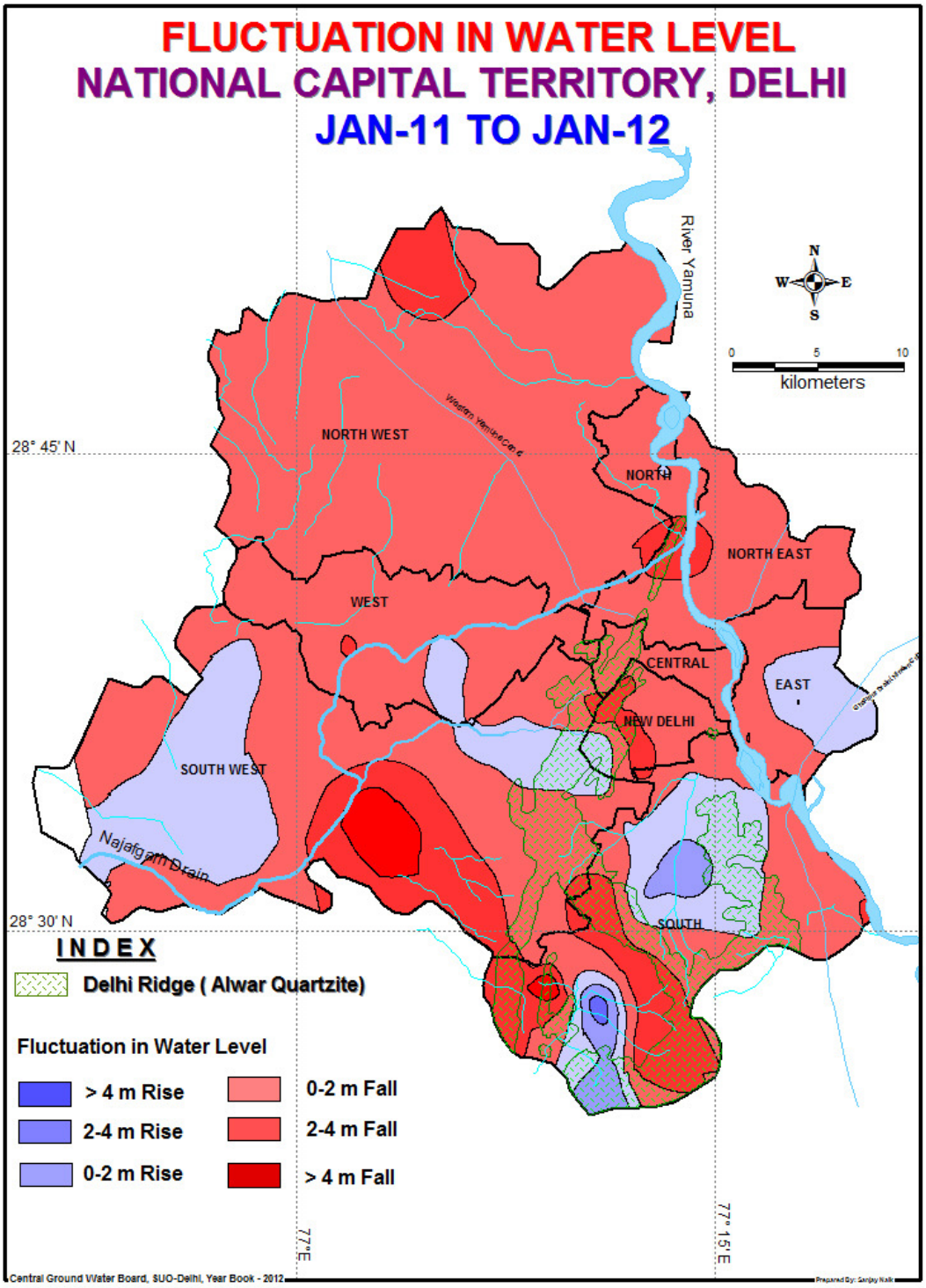
Annual Fluctuation:

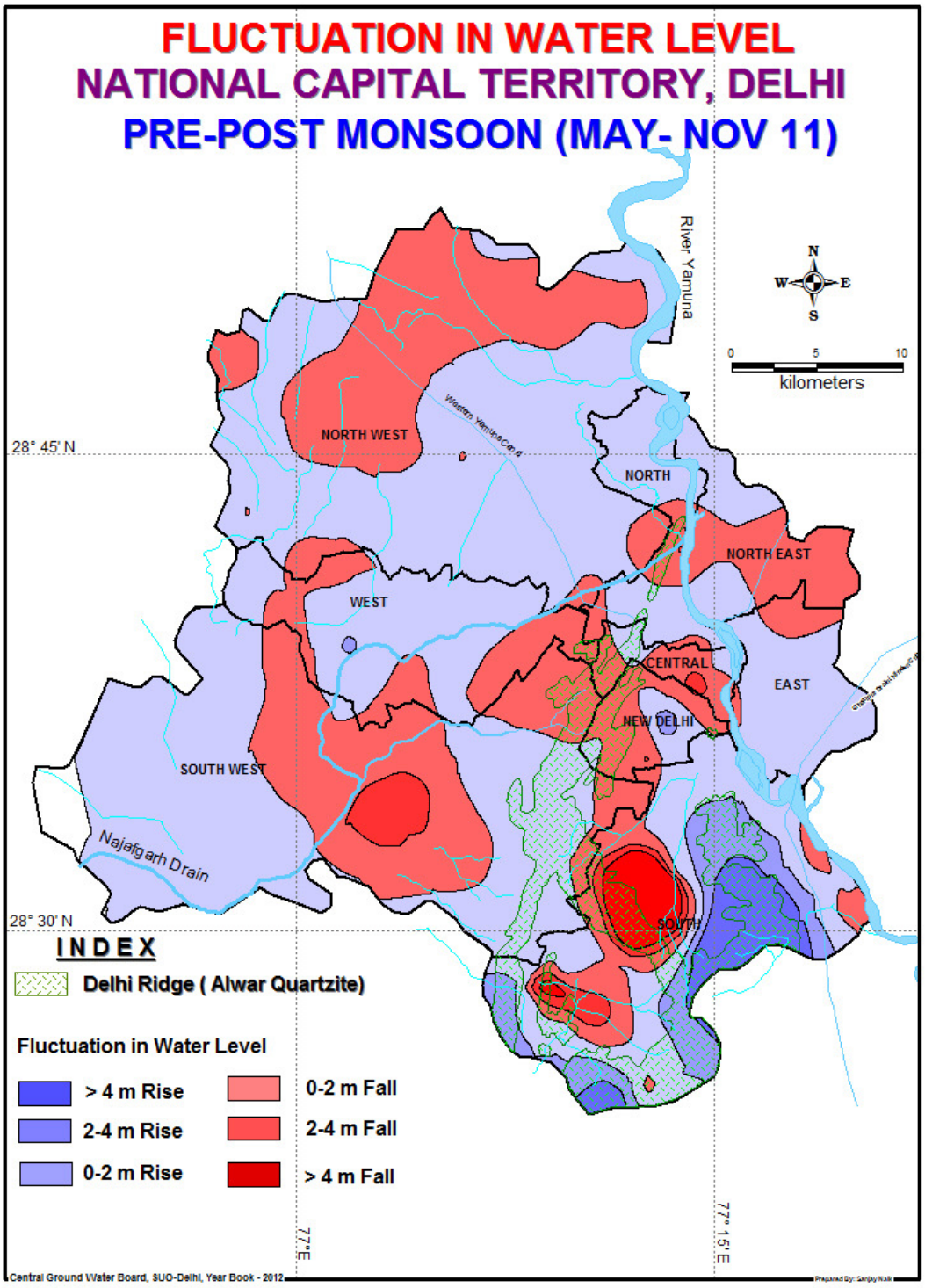
The hydrograph analyses of **Nov-2010 and Nov-2011**water levels of 130 wells reveals that 76% of the wells shows fall in the range of 0 to more than 4m whereas in 24% there is no perceptible change or just above than the previous year water level. The fall of more than 4 m are recorded only in three districts, i.e. New Delhi, South and South West. The overall analysis indicates a declining situation in the state (Plate-10).


FLUCTUATION IN WATER LEVEL
NATIONAL CAPITAL TERRITORY, DELHI
MAY-10 TO MAY-11
River Yamuna
N
W
E
S
0
5
10
kilometers
28° 45' N
NORTH WEST
NORTH
NORTH EAST
WEST
CENTRAL
EAST
NEW DELHI
SOUTH WEST
Najafgarh Drain
28° 30' N
SOUTH
INDEX
Delhi Ridge (Alwar Quartzite)
Fluctuation in Water Level
> 4 m Rise
2-4 m Rise
0-2 m Rise
0-2 m Fall
2-4 m Fall
> 4 m Fall
77° E
77° 15' E
Central Ground Water Board, SUO-Delhi, Year Book - 2012


FLUCTUATION IN WATER LEVEL
NATIONAL CAPITAL TERRITORY, DELHI
AUGUST-10 TO AUGUST-11
River Yamuna
N
W
E
S
0
5
10
kilometers
28° 45' N
NORTH WEST
NORTH
NORTH EAST
WEST
CENTRAL
EAST
NEW DELHI
SOUTH WEST
Najafgarh Drain
28° 30' N
SOUTH
INDEX
Delhi Ridge (Alwar Quartzite)
Fluctuation in Water Level
> 4 m Rise
2-4 m Rise
0-2 m Rise
0-2 m Fall
2-4 m Fall
> 4 m Fall
77° E
77° 15' E
Central Ground Water Board, SUO-Delhi, Year Book - 2012


FLUCTUATION IN WATER LEVEL
NATIONAL CAPITAL TERRITORY, DELHI
NOV-10 TO NOV-11
River Yamuna
N
W
E
S
0
5
10
kilometers
28° 45' N
28° 30' N
NORTH WEST
NORTH
NORTH EAST
WEST
CENTRAL
EAST
NEW DELHI
SOUTH WEST
SOUTH
Najafgarh Drain
INDEX
Delhi Ridge (Alwar Quartzite)
Fluctuation in Water Level
> 4 m Rise
2-4 m Rise
0-2 m Rise
0-2 m Fall
2-4 m Fall
> 4 m Fall
77° E
77° 15' E
Central Ground Water Board, SUO-Delhi, Year Book - 2012


FLUCTUATION IN WATER LEVEL
NATIONAL CAPITAL TERRITORY, DELHI
JAN-11 TO JAN-12
River Yamuna
N
W
E
S
0
5
10
kilometers
28° 45' N
NORTH WEST
NORTH
NORTH EAST
WEST
CENTRAL
EAST
NEW DELHI
SOUTH WEST
SOUTH
Najafgarh Drain
28° 30' N
INDEX
Delhi Ridge (Alwar Quartzite)
Fluctuation in Water Level
> 4 m Rise
2-4 m Rise
0-2 m Rise
0-2 m Fall
2-4 m Fall
> 4 m Fall
77° E
77° 15' E
Central Ground Water Board, SUO-Delhi, Year Book - 2012


FLUCTUATION IN WATER LEVEL
NATIONAL CAPITAL TERRITORY, DELHI
PRE-POST MONSOON (MAY- NOV 11)
River Yamuna
N
W
E
S
0
5
10
kilometers
28° 45' N
NORTH WEST
NORTH
NORTH EAST
WEST
CENTRAL
EAST
NEW DELHI
SOUTH WEST
SOUTH
Najafgarh Drain
28° 30' N
INDEX
Delhi Ridge (Alwar Quartzite)
Fluctuation in Water Level
> 4 m Rise
2-4 m Rise
0-2 m Rise
0-2 m Fall
2-4 m Fall
> 4 m Fall
77° E
77° 15' E
Central Ground Water Board, SUO-Delhi, Year Book - 2012

Decadal Fluctuation:

When the data of **Nov-2011** was compared with **10 year mean of Nov.** it shows that the water levels in 53% of the wells have a fall in the range of 0.01to 12.28 m. Only 42% wells of the North, East and New Delhi districts have a rising condition in the range of 0 to 2m (Plate-15).

4.4. JANUARY 2011:

Depth to water level:

The Depth to water level recorded in NCT Delhi during **January-2011**ranges from 0.96 to 66.79 m.bgl. A total of 203 stations have been analyzed district wise. An analysis of the data reveal that in south district 48% of the wells have water levels of more than 40 m. bgl and 25% in the range of 20 to 40 m. bgl. The water levels in the districts like South-West and New Delhi are in the range of 10 to 20 m. bgl in 50% of the area and a few patches of 20 to 40 m. bgl water levels are also observed in New Delhi, South and South-West districts. In rest of the districts the water level is between of 2 to 10 m. bgl indicating that only in 27% of the state the water levels are below 10 m. bgl (Plate-7, Annexure-I) covering entire Yamuna Flood Plain and East, N-E, N-W and North districts. Maximum water levels in the states are observed in the monitoring wells at Tughalakabad, Saket, PushpVihar and LadoSarai ranging between of 58 to 62 m. bgl.

May 10 – January 11 Fluctuation:

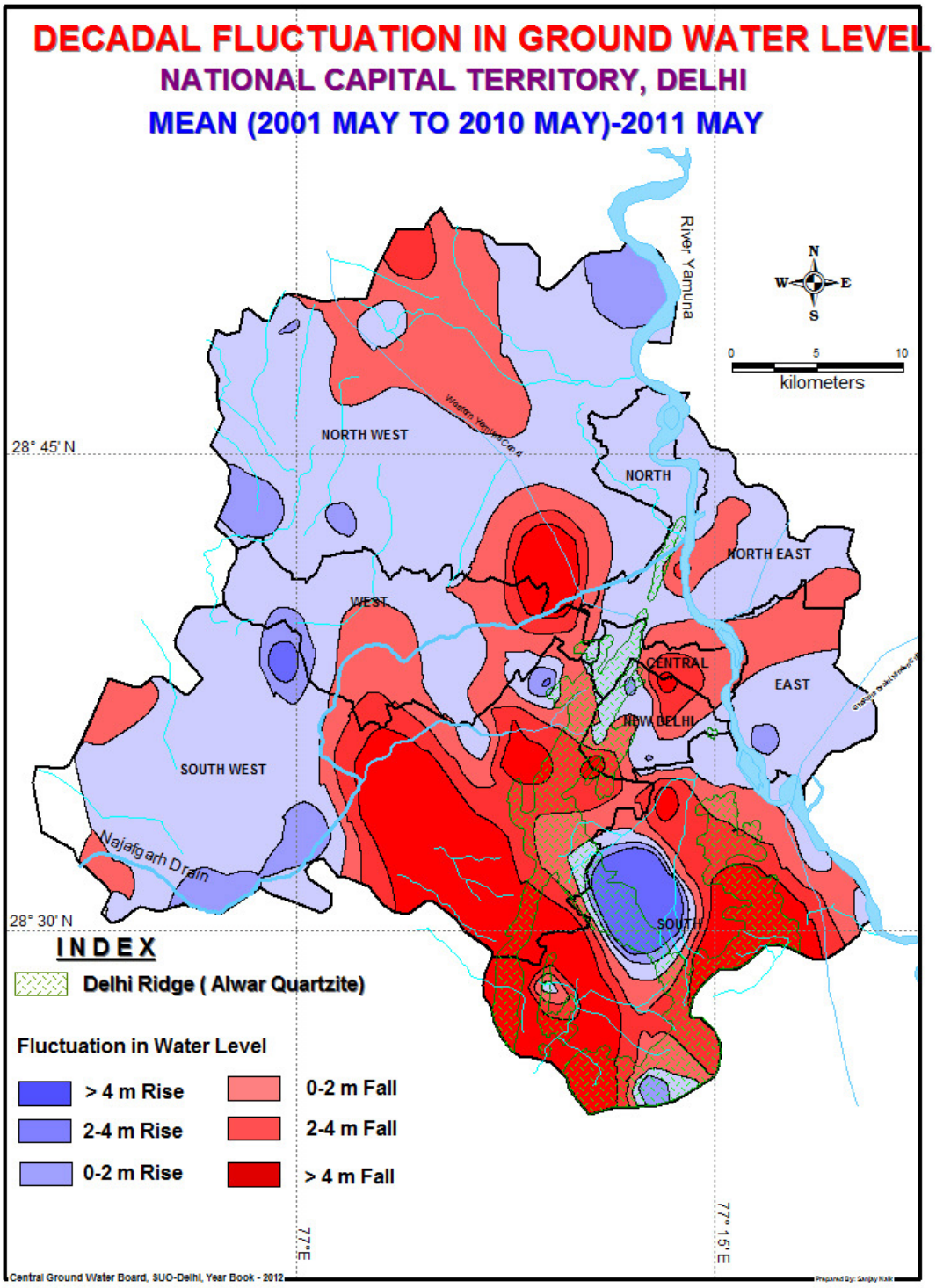
The fluctuation of water level between **Pre-monsoon (May-2010)** and **January-2011**have been analyzed for 200 wells in which it has been found that 39% wells fall in the range of 0.01 to 36.78 m mostly in South, S-W and in New Delhi District, and 59% area show rise in the range of 0.01 to 7.60 m in which the district like East, North, N-E, West are covered (Annexure-I).

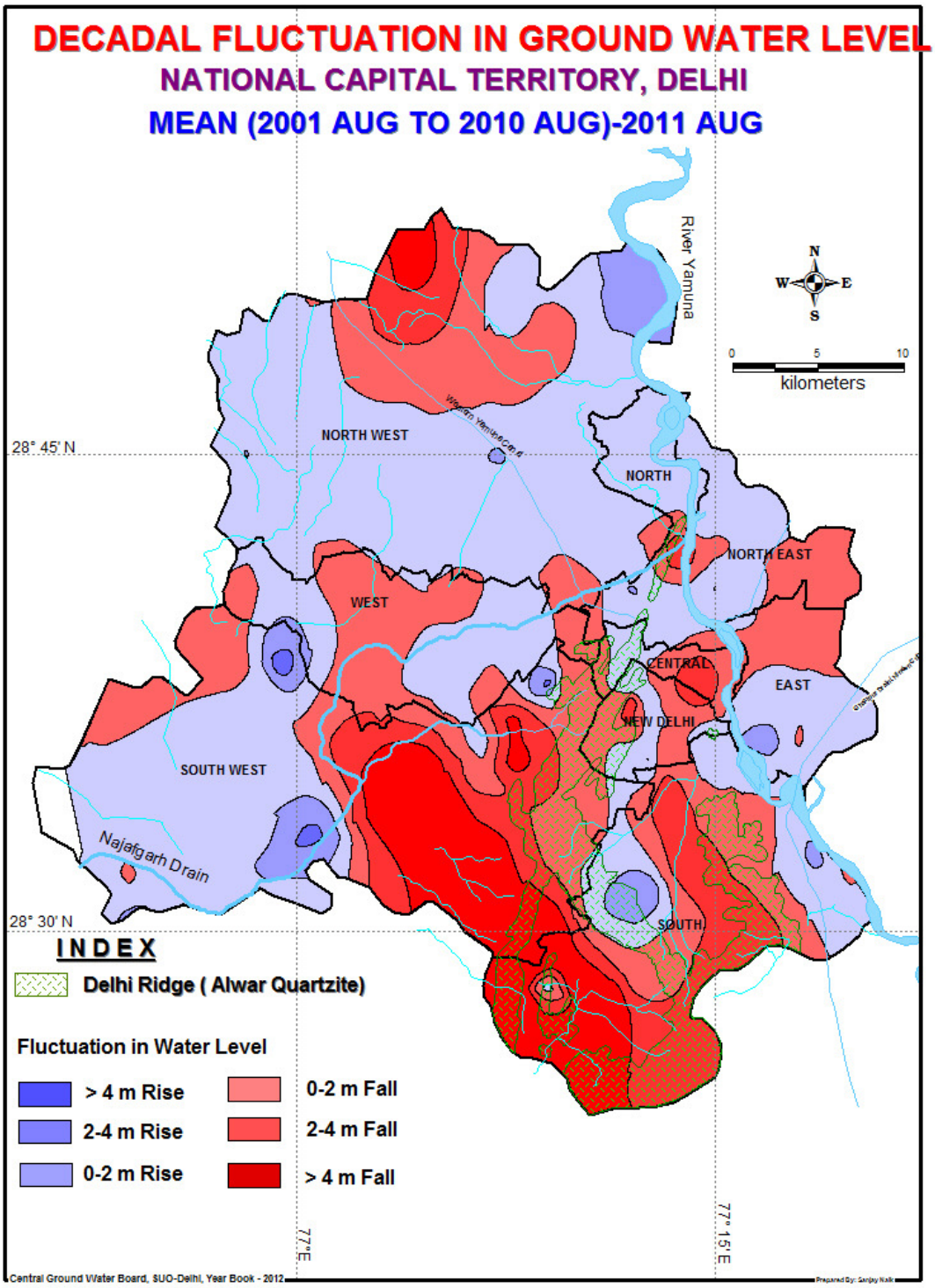
Annual Fluctuation:

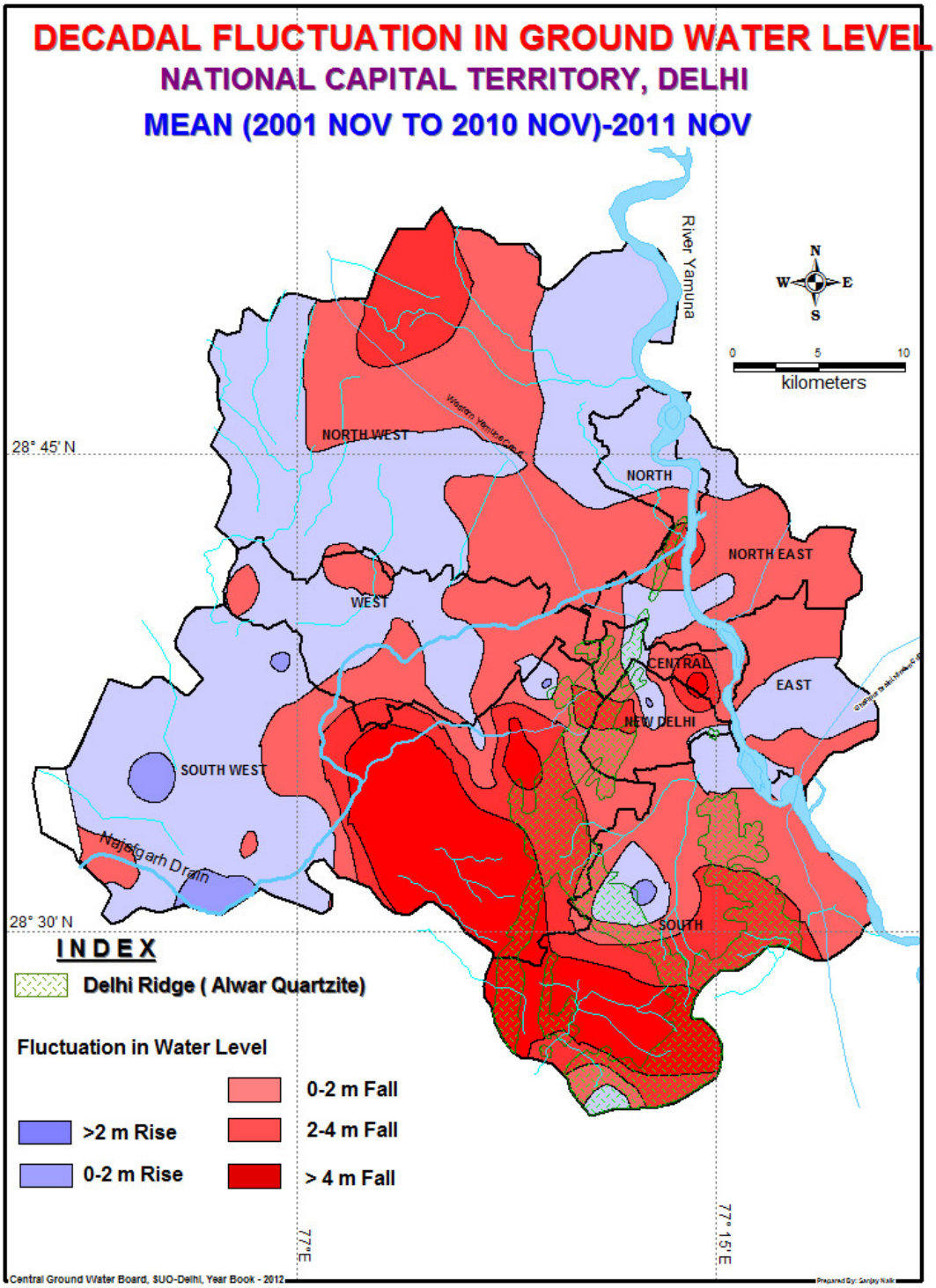
The hydrograph analyses of **January-2010 and January-2011**reveals that in 70% of the wells the water level is falling and only in 29% rising, rise is in the range of 0 to 2 m. Only eight stations (Ladosarai, Jhelkhoh, Saket etc.) of South district and six stations (Ghitorni, Kabuline, Kirbi Place etc.) of S-W district are showing fall of more than 2 m (Plate-11).

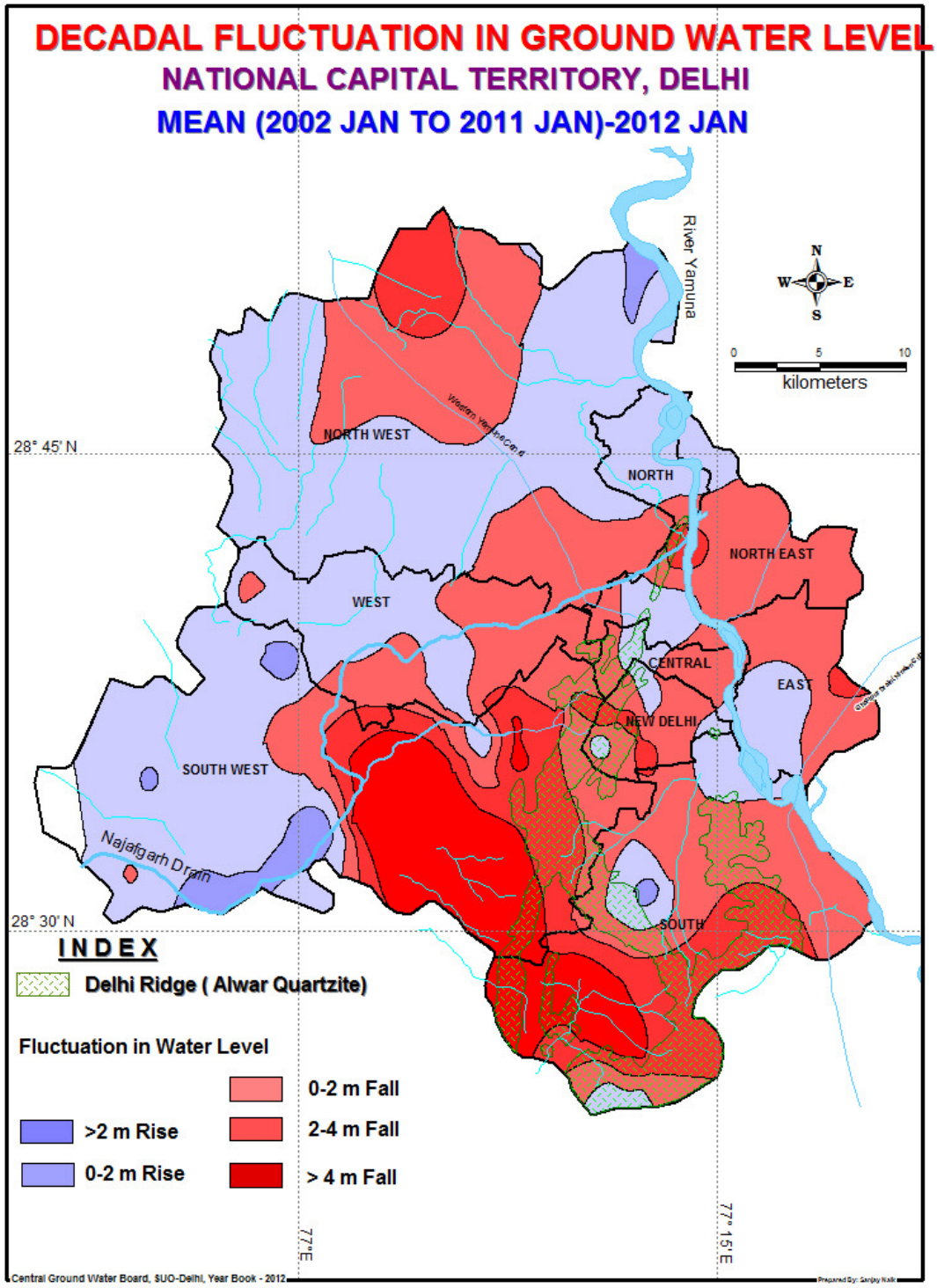
Decadal Fluctuation:

When the data of **January-2011** has compared with **10 year mean of January.** It has been observed that74% of monitoring stations of New Delhi and North West show a fall in water level where the highest fall is 36.32 and 4.86 m respectively. The same condition prevails in South and South West District in 73% of the area where the highest depletion is 7.95 m and 11.02 m respectively. North East and East have also suffered depletion of water table but this is in the range of 1.00 to 2.40 m only. The overall observation of water levels in the state indicates that the southern district facing maximum declining condition (Plate-16).


DECADAL FLUCTUATION IN GROUND WATER LEVEL
NATIONAL CAPITAL TERRITORY, DELHI
MEAN (2001 MAY TO 2010 MAY)-2011 MAY
River Yamuna
N
W
E
S
0
5
10
kilometers
28° 45' N
NORTH WEST
NORTH
NORTH EAST
WEST
CENTRAL
EAST
NEW DELHI
SOUTH WEST
SOUTH
Najafgarh Drain
28° 30' N
INDEX
Delhi Ridge (Alwar Quartzite)
Fluctuation in Water Level
> 4 m Rise
2-4 m Rise
0-2 m Rise
0-2 m Fall
2-4 m Fall
> 4 m Fall
77° E
77° 15' E
Central Ground Water Board, SUO-Delhi, Year Book - 2012


DECADAL FLUCTUATION IN GROUND WATER LEVEL
NATIONAL CAPITAL TERRITORY, DELHI
MEAN (2001 AUG TO 2010 AUG)-2011 AUG
River Yamuna
N
W
E
S
0
5
10
kilometers
28° 45' N
NORTH WEST
NORTH
NORTH EAST
WEST
CENTRAL
EAST
NEW DELHI
SOUTH WEST
SOUTH
Najafgarh Drain
28° 30' N
INDEX
Delhi Ridge (Alwar Quartzite)
Fluctuation in Water Level
> 4 m Rise
2-4 m Rise
0-2 m Rise
0-2 m Fall
2-4 m Fall
> 4 m Fall
77° E
77° 15' E
Central Ground Water Board, SUO-Delhi, Year Book - 2012


DECADAL FLUCTUATION IN GROUND WATER LEVEL
NATIONAL CAPITAL TERRITORY, DELHI
MEAN (2001 NOV TO 2010 NOV)-2011 NOV
River Yamuna
N
W
E
S
0
5
10
kilometers
28° 45' N
28° 30' N
77° E
77° 15' E
NORTH WEST
NORTH
NORTH EAST
WEST
CENTRAL
EAST
NEW DELHI
SOUTH WEST
SOUTH
Najafgarh Drain
INDEX
Delhi Ridge (Alwar Quartzite)
Fluctuation in Water Level
0-2 m Fall
2-4 m Fall
> 4 m Fall
>2 m Rise
0-2 m Rise
Central Ground Water Board, SUO-Delhi, Year Book - 2012


DECADAL FLUCTUATION IN GROUND WATER LEVEL
NATIONAL CAPITAL TERRITORY, DELHI
MEAN (2002 JAN TO 2011 JAN)-2012 JAN
River Yamuna
N
W
E
S
0
5
10
kilometers
28° 45' N
28° 30' N
77° E
77° 15' E
NORTH WEST
NORTH
NORTH EAST
WEST
CENTRAL
EAST
NEW DELHI
SOUTH WEST
SOUTH
Najafgarh Drain
INDEX
Delhi Ridge (Alwar Quartzite)
Fluctuation in Water Level
0-2 m Fall
2-4 m Fall
> 4 m Fall
>2 m Rise
0-2 m Rise
Central Ground Water Board, SUO-Delhi, Year Book - 2012

Chapter – 5

HYDROGEOCHEMISTRY

5.1 - GENERAL INTRODUCTION:

Chemical quality of ground water in NCT Delhi varies with depth and space. The fresh ground water aquifers mainly exist up to a depth of 25 to 35 m in Northwest, West and South-West districts and in minor patches in North and Central districts. In Southwest district, especially in Najafgarh*Jheel*area the fresh water occurs up to a depth of 30 to 45 m. A localized area located just north of Kamala Nehru Ridge (part of Delhi ridge falling in Central District) covering area of Dhirpur, Wazirabad and Jagatpur are characterized by shallow depth of fresh water aquifers that is in the range of 22 to 28m, regardless of proximity to River Yamuna.

In alluvial formations, the quality of ground water deteriorates with depth, which is variable in different areas. The ground water is fresh at all depths in the areas around the ridge falling in Central, New Delhi, South and eastern part (Ridge Area) of South-West districts and also Chattarpur basin. In the areas west of the ridge, in general, the thickness of fresh water aquifers decreases towards North-West, the thickness of fresh water zone is limited in most parts of west and southwest districts. In the flood plains of Yamuna, in general, fresh water aquifers exist down to depth of 30-45m and especially in Palla and zero RD area it reaches to the depth of 60 to 75m below which brackish and saline water exists.

5.2 - DISCUSSION AND RESULT:

Distribution of Electrical Conductance (Salinity) in Ground Water

Electrical conductance of water is measured to get an approximate idea about the extent of mineralization of ground water. It also gives idea of total dissolved salts in a water sample. Out of the total 124 analyzed samples (Annexure-II) of NCT Delhi 42 samples have high EC value that is in the range of 2000 to 16700 µs/cm (Kair). Most of the higher values are falling in western part of Delhi, especially West of Delhi Ridge. The area of Najafgarh and Kanjhawala Block, Bhalsawa, Burari, Dhirpur and Jagatpur are showing exceptionally high EC Values, even in shallower depth of tube wells (i.e. up to the depth of 25/30m). While carrying out exploratory programme, it has been found that deeper aquifer water have greater EC value than the shallow aquifer, value increases with increase in depth.

South district and Delhi quartzite ridge area have EC values lower than the 2000 µs/cm (Plate-15).

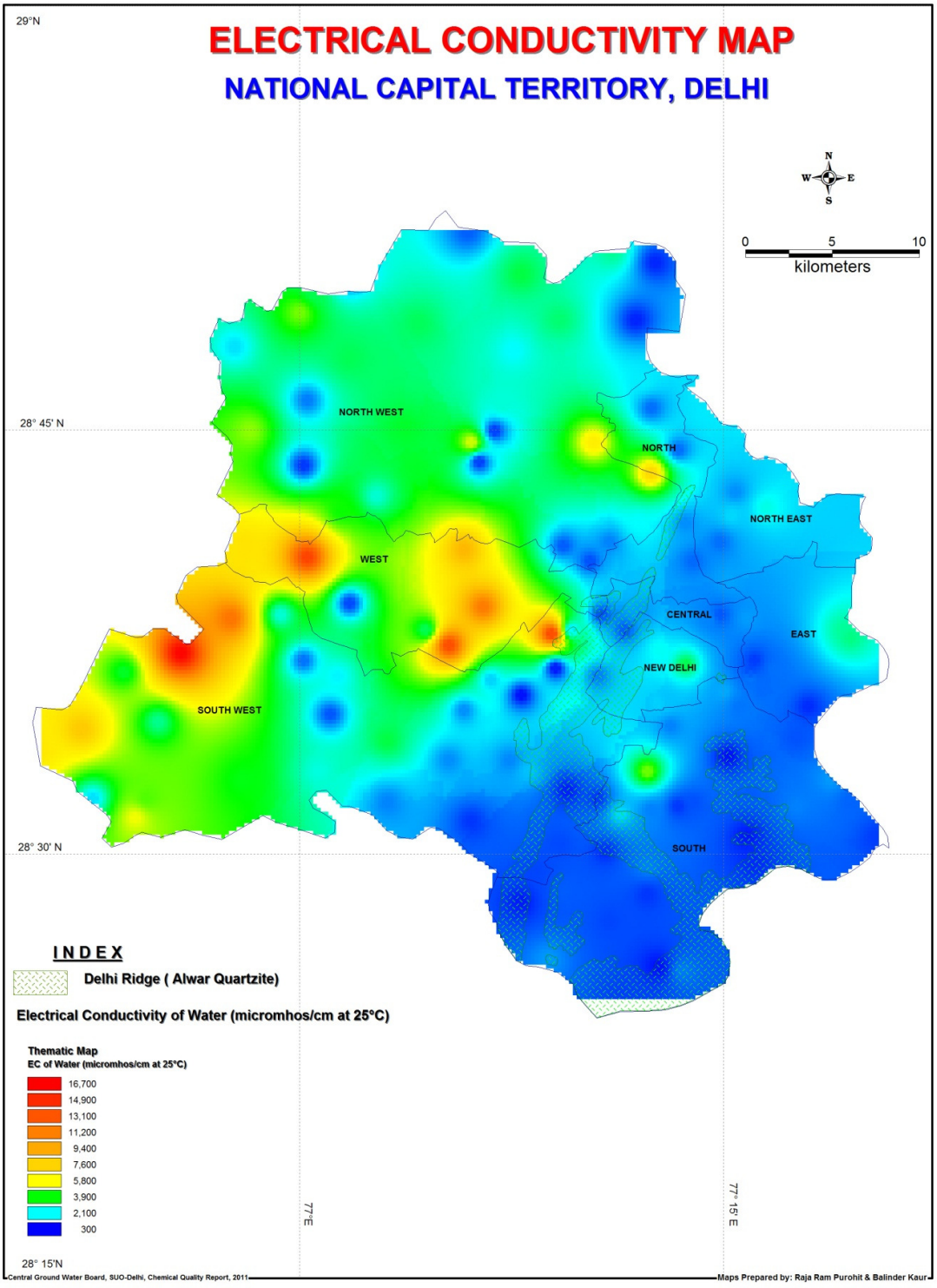
Fluoride in Ground Water:

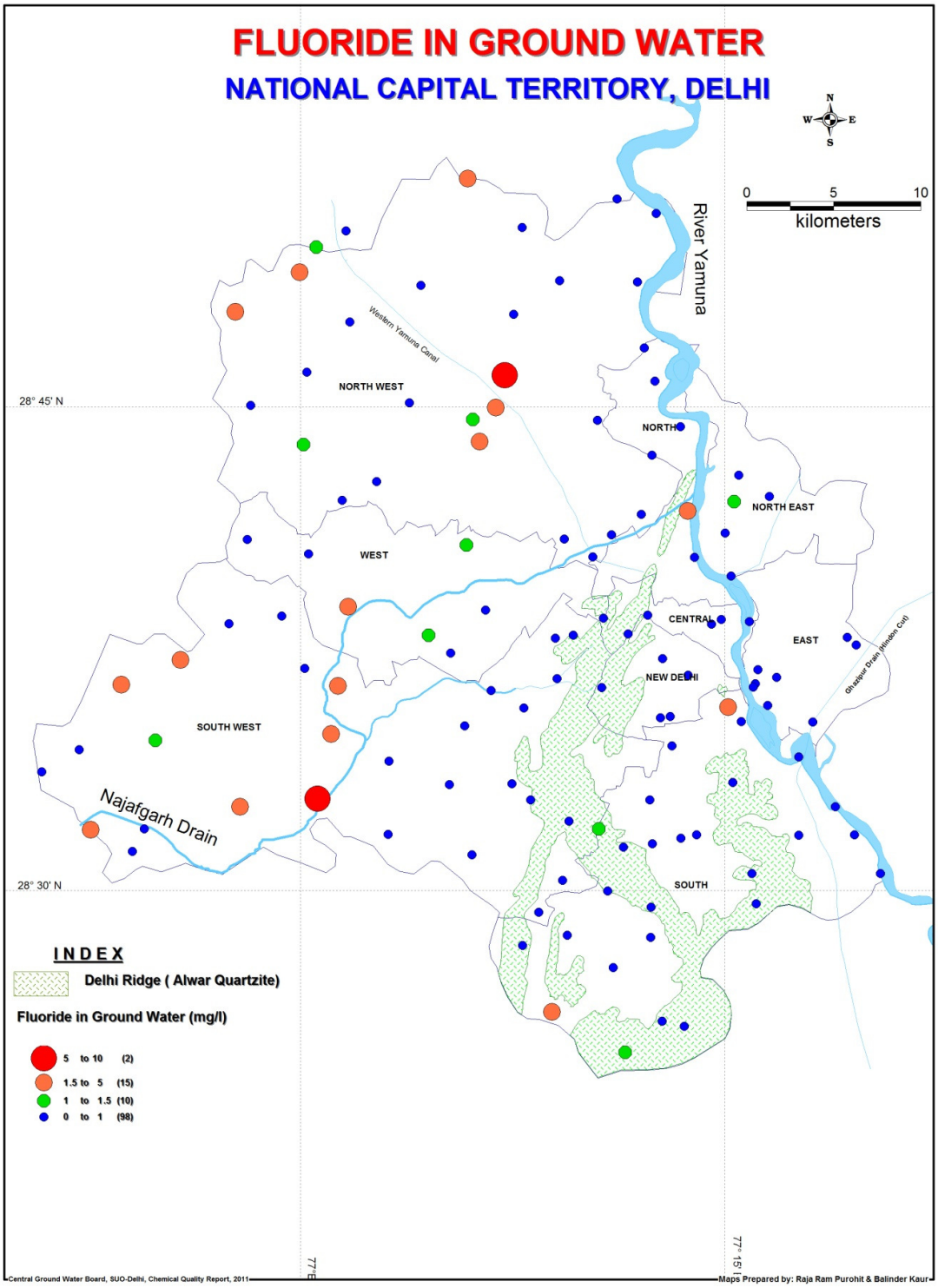
Out of 124 analyzed samples nine samples are showing higher value of Fluoride concentration i.e. more than 1.5mg/l (this is the permissible limit of fluoride). The data indicate that South–West and North-West districts are the only effected parts of NCT Delhi. Rests of the sample are well within the limit of permissible limit. The fluoride minerals present in soil strata have mostly contributed fluoride pollution (geo-genic). High fluoride levels are mostly found in the areas where ground water is brackish to saline in nature. Human activities like use of fluoride salts in steel, aluminum, bricks and tile-industries and also agricultural discharges, can also contribute for fluoride pollution in ground water (Plate-16).

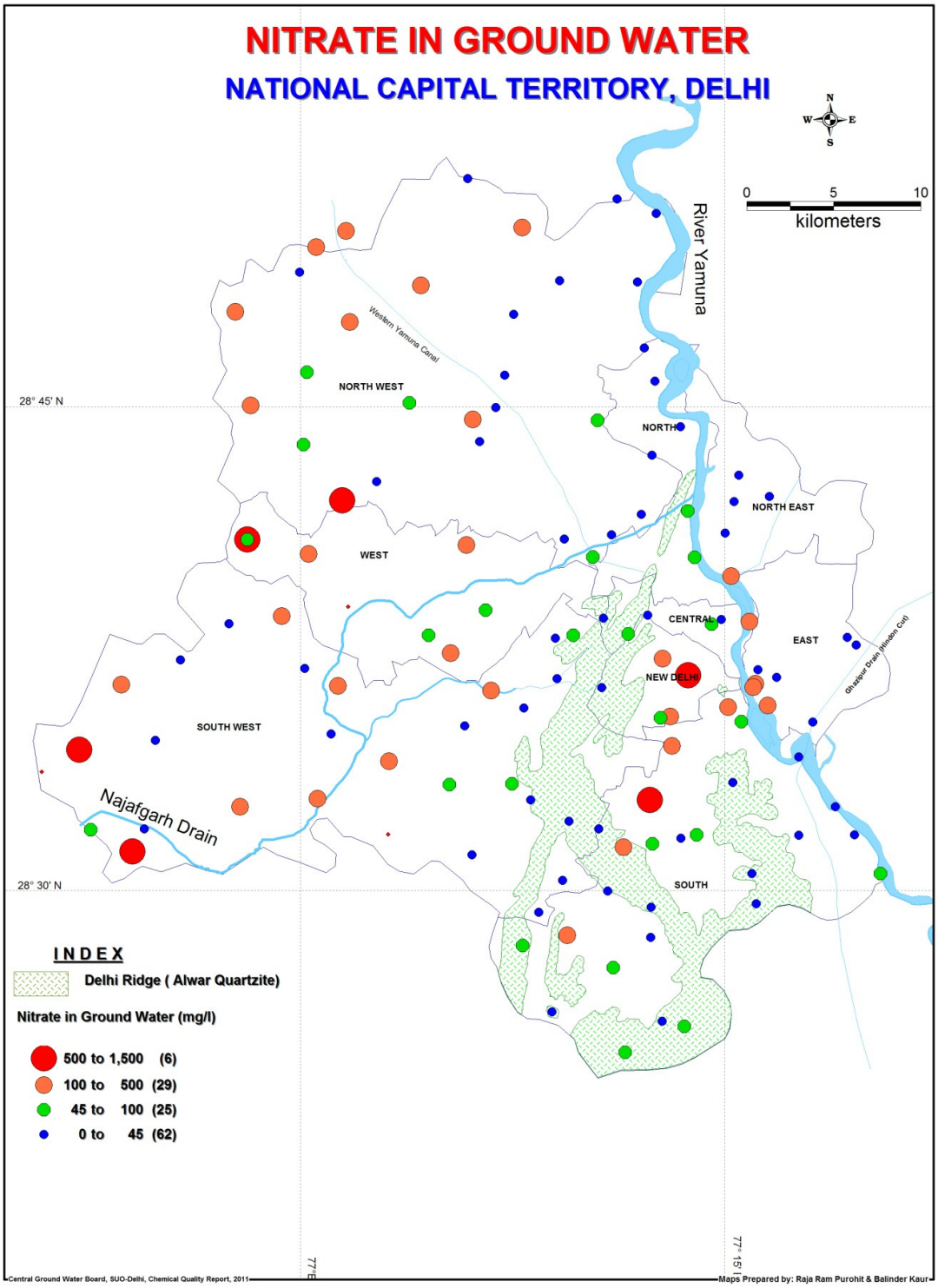
Nitrate in Ground Water:

The studies carried out by CGWB indicates that nitrate concentrations in ground water of Delhi have wide range (0.5mg/l Indirapuri Market to 1500 mg/l Tikrikalan).Out of 124 analyzed samples (Plate-17) three samples are only showing more than 100 mg/l i.e. Inderlok Temple well 116 mg/l, Chattarpur Temple 140mg/l and Chawala 136 mg/l. The higher nitrate concentration may be attributed due to combined effect of contamination from domestic sewage; livestock rearing, landfills and run off from fertilized fields, unlined drains and cattle sheds. The perusal of data indicates that higher concentration of nitrates are found at the places where domestic effluent is discharged into open unlined drains and usually this places are thickly habitated settlements. Mainly the higher concentration is due to point source of contamination.

Delhi's ground water has more nitrate contents at shallow levels but decrease with depth. Well depth was found to be a dominant factor affecting nitrate concentrations. This is mainly due to the sub-standard well construction and location factor of wells near potential source of contamination like domestic effluent.


ELECTRICAL CONDUCTIVITY MAP
NATIONAL CAPITAL TERRITORY, DELHI
29°N
28° 45' N
28° 30' N
28° 15'N
77°E
77° 15' E
N
W
E
S
0
5
10
kilometers
NORTH WEST
NORTH
NORTH EAST
WEST
CENTRAL
EAST
NEW DELHI
SOUTH WEST
SOUTH
INDEX
Delhi Ridge (Alwar Quartzite)
Electrical Conductivity of Water (micromhos/cm at 25°C)
Thematic Map
EC of Water (micromhos/cm at 25°C)
16,700
14,900
13,100
11,200
9,400
7,600
5,800
3,900
2,100
300
Central Ground Water Board, SUO-Delhi, Chemical Quality Report, 2011
Maps Prepared by: Raja Ram Purohit & Balinder Kaur


FLUORIDE IN GROUND WATER
NATIONAL CAPITAL TERRITORY, DELHI
N
W
E
S
0
5
10
kilometers
River Yamuna
Western Yamuna Canal
NORTH WEST
NORTH
NORTH EAST
WEST
CENTRAL
EAST
NEW DELHI
SOUTH WEST
SOUTH
Najafgarh Drain
Ghazipur Drain (Hindon Cut)
28° 45' N
28° 30' N
77° 15' E
INDEX
Delhi Ridge (Alwar Quartzite)
Fluoride in Ground Water (mg/l)
5 to 10 (2)
1.5 to 5 (15)
1 to 1.5 (10)
0 to 1 (98)
Central Ground Water Board, SUO-Delhi, Chemical Quality Report, 2011
Maps Prepared by: Raja Ram Purohit & Balinder Kaur


NITRATE IN GROUND WATER
NATIONAL CAPITAL TERRITORY, DELHI
N
W
E
S
0
5
10
kilometers
River Yamuna
Western Yamuna Canal
NORTH WEST
NORTH
NORTH EAST
WEST
CENTRAL
EAST
NEW DELHI
SOUTH WEST
SOUTH
Najafgarh Drain
Ghazipur Drain (Hindon Cut)
28° 45' N
28° 30' N
77° 15' E
INDEX
Delhi Ridge (Alwar Quartzite)
Nitrate in Ground Water (mg/l)
500 to 1,500 (6)
100 to 500 (29)
45 to 100 (25)
0 to 45 (62)
Central Ground Water Board, SUO-Delhi, Chemical Quality Report, 2011
Maps Prepared by: Raja Ram Purohit & Balinder Kaur

5.3 - HYDRO-CHEMICAL FACIES

The concept of hydro-chemical facies can be used to denote the diagnostic chemical characteristics of water in hydrological systems. The facies reflect the effect of chemical processes occurring between the mineral within the lithologicframe-work and the ground water. The flow pattern based on the geology of the area controls the type of facies and its distribution. The difference in hydro-chemical facies in the same group of formations may be caused by characteristics of ground water flow and the dilution effect of local recharge.

Hydro-chemical facies or hydro-chemical zonation for 124 analyzed data has been carried out by plotting percentage reacting values of major ions in trilinear diagrams. Trilinear diagram (Hill piper) which adds to the original two triangles, is a diamond shaped area in which two points plotted with triangles are projected into diamond and plotted as a single point. The analyzed data on the hydro-chemical facies of ground water in NCT Delhi has been presented in trilinear diagrams (Plate-20) which indicate distribution of hydro-chemical types present in respective area.

Formation of Various Chemical Type of Ground Water and Hydro-Chemical Zones

The plot of South-West, West and North–West District chemical data of ground water from more than 25m deep indicates that the water is predominantly of Calcium-Bicarbonate type (temporary hardness) and Sodium-Chloride Type (Saline) whereas aquifer from less than 25m shows mixed water type. Virtually, this is the end product of exchange reactions of facies like Na-Ca-HCO_3-Cl, Ca-Mg-HCO_3-SO_4, Na-Ca-Cl-HCO_3, Na-Mg-HCO_3-SO_4, Na-SO_4-HCO_3, Na-CO_3–Cl, Ca-Na-HCO_3, and Na-SO_4-Cl.

In case of South and New Delhi districts where majority of samples have been collected from deeper levels in Delhi Ridge areas are falling in the category of Calcium Chloride Type (Permanent Hardness) and calcium Bicarbonate Type. But few samples also fall in the range of mixed type.

In East Delhi most of the samples collected from the Akshardham and Ghazipur Border area comes under the zone of calcium Bicarbonate type and mixed Type.

At a few places in North District, ground water at depth of about 10/12m is of Ca-CO_3 type, which is in confirmation of general characteristic of ground water in the recharge areas. In some of the Tube wells such as Dhirpur, Jagatpur and King'sway camp ground water is of mixed facies, i.e. SO_4-Cl, HCO_3-Cl, Cl-HCO_3, type with predominance of sodium cations

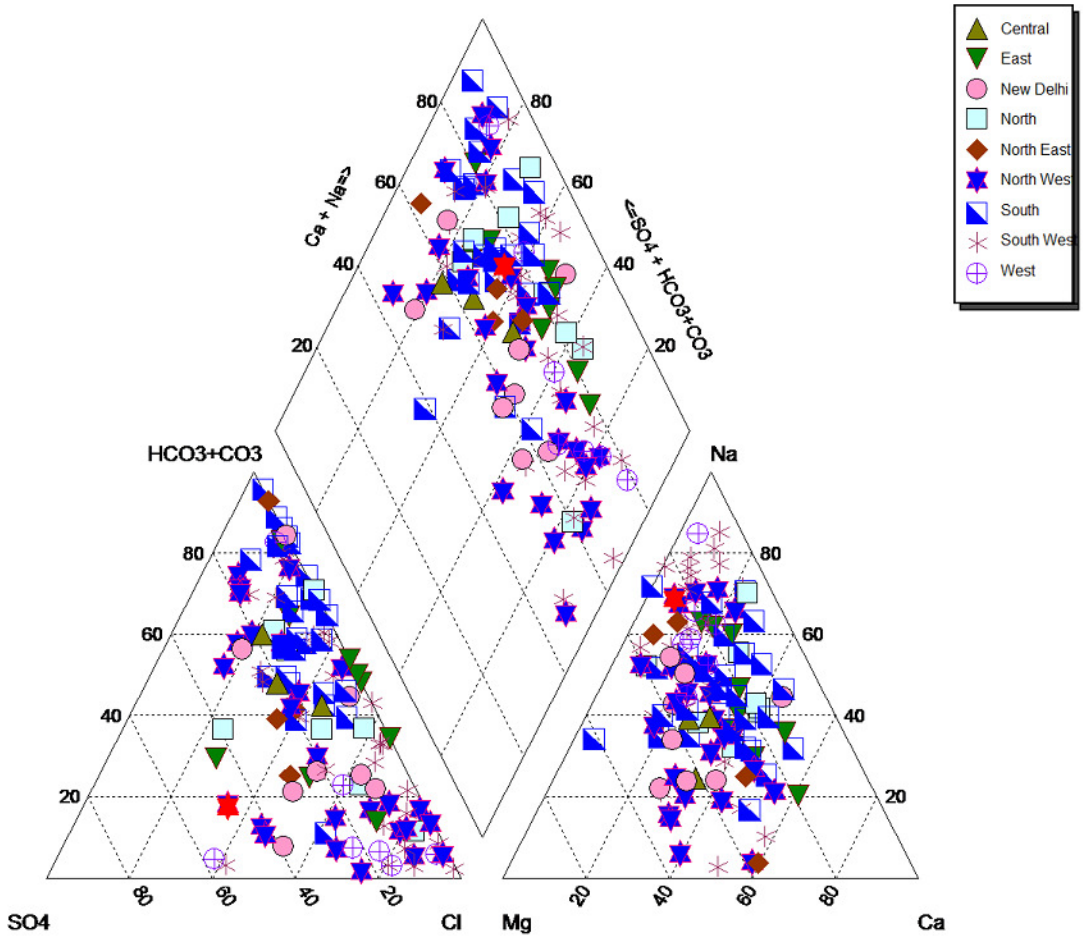
US SALINITY DIAGRAM.

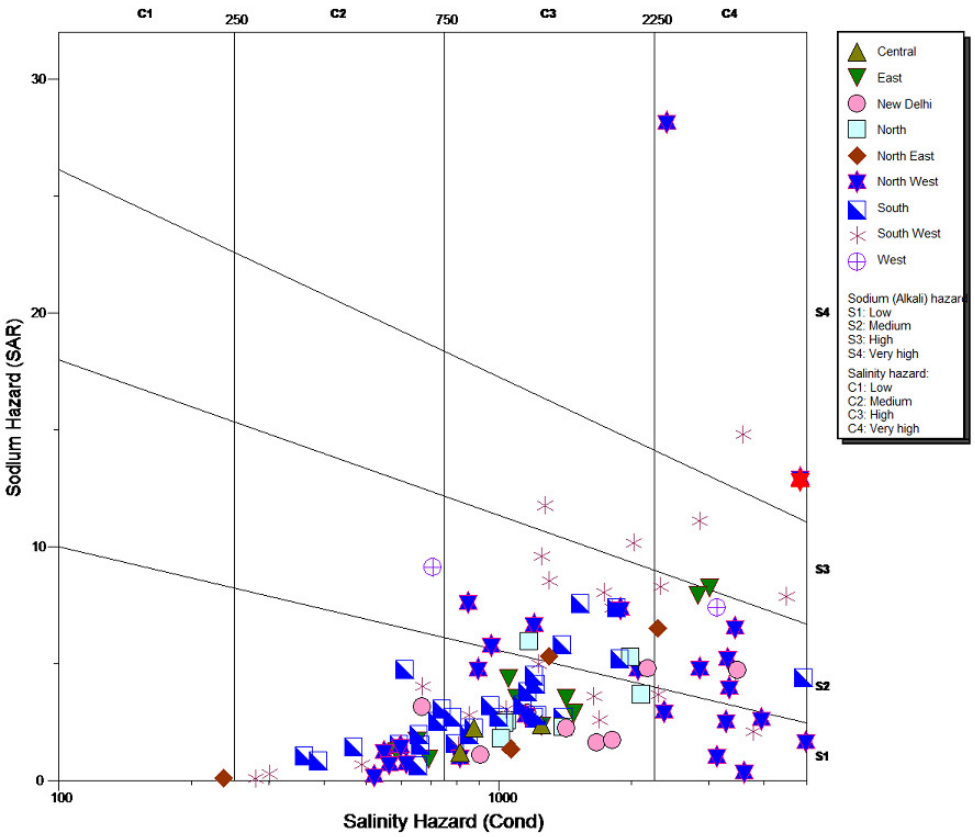
The total dissolved-solids content, measured in terms of specific electrical conductance gives the salinity hazard of irrigation waters. Beside the salinity hazard, excessive sodium content in water renders it unsuitable for soils containing exchangeable ca^{++} *and* Mg^{++}ions. If the percentage of *Na to Ca + Mg + Na* is considerably above 50 in irrigation waters, soil containing exchangeable Calcium and Magnesium takes up Sodium and in exchange for Calcium and Magnesium causing Deflocculation and impairment of filth and permeability of soils. The Sodium Hazard in irrigated waters is expressed by determining the sodium adsorption ratio (SAR) by the relation:

$$SAR = \frac{Na}{\sqrt{(Ca + Mg)/2}}$$

Out of 124 ground water samples 72% falls in the category of C2 & C3 type of salinity hazard, which is medium and high salinity (< 2250 EC). A few sites of S-W District and South district fall in very high salinity category.

In case of Sodium hazard, the ground water of NCT Delhi covers low and medium Hazard that means this kind of water contain appreciable Sodium hazard in fine-textured soils having high cat ion-exchange capacity, especially under low-leaching condition. A few samples of South and S-W Districts are placed under high sodium hazard condition.


Central
East
New Delhi
North
North East
North West
South
South West
West
Ca + Na=>
<=SO4 + HCO3+CO3
HCO3+CO3
Na
SO4
Cl
Mg
Ca
20
40
60
80


C1
250
C2
750
C3
2250
C4
30
20
10
0
100
1000
Sodium Hazard (SAR)
Salinity Hazard (Cond)
S4
S3
S2
S1
Central
East
New Delhi
North
North East
North West
South
South West
West
Sodium (Alkali) hazard:
S1: Low
S2: Medium
S3: High
S4: Very high
Salinity hazard:
C1: Low
C2: Medium
C3: High
C4: Very high