AN EVALUATION OF GROUND WATER ABSTRACTION FOR WATER SUPPLY IN DHAKA CITY

A PROJECT REPORT

By

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Submitted to the Department of Civil Engineering, Bangladesh University of Engineering and Technology, Dhaka, in partial fulfillment of the requirement for the degree

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DECLARATION

I do hereby declare that the project work reported herein, has been performed by me and this work has neither been submitted nor is being concurrently submitted in candidature for any degree at any other university.

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ABSTRACT

DWASA is responsible for supplying potable water for the city dwellers. At present total water requirement in the Dhaka city is about 1620 MLD (million liter per day) but DWASA is only supplying 828.09 MLD, 94% of this water comes form underground source and the rest 6% from two small surface water treatment plants.

Ground water which is the principal source of drinking water supply, has depleted considerably. The rate of lowering of piezometric water table was 0.5m per year in the eighties which increased to 0.75m in early nineties. In some locations such as Gopibag, Gulbag the present rate of water level lowering has been found to be more than 2 m per year. Comparing to the present situation, it is clear that Dhaka city ground water level has been depleting very rapidly. The situation should not go any long. Moreover the Government is actively considering the fourth interim project of DWASA and it will provide an additional 121 new and replacement deep tubewells to its system. Obviously then the situation would be further deteriorated.

`Dhaka Regional Ground water and subsidence study' conducted by DWASA in 1991 suggested a safe limit of maximum allowable depth of water level which was 20-25m for the central part of city. The study also predicted a maximum water level of 24 m below ground surface in Motijheel area in 2010. But some of the DTWs in DWASA indicate a static water level greater than 40m bellow ground level. As DWASA has no regular groundwater level monitoring system , the overall condition of the city groundwater level cannot be assessed exactly at this time. However BWDB piezometers provide adequate data on piezometric levels in the upper aquifer, but additional piezometers are required in the main aquifer.

No doubt the situation of groundwater abstraction is very much alarming for the city of Dhaka. It may result in the failure of some of the existing pumping wells to collect water in near future and increase in the effective pressure on underlying soil layer by about 37.7%. The incremental weight may cause a settlement of 4.9cm. which would be uniform in nature because of the presence of a thick consolidated clay layer at the surface beneath Dhaka City. The high cohesion of this clay layer is likely to prevent any differential settlement which could be detrimental to the growth of the city. Vegetation is not likely to be affected by the lowering of water table as the water table in the upper aquifer is not very much affected by abstraction of water from the deep aquifer and the intermediate vadose zone contributes water to the root zone.

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ABBREVIATIONS

BGS	British Geological Survey
BM	Bench Mark
BMRE	Balancing, Modernization, Rehabilitation and Expansion
BWDB	Bangladesh Water Development Board
CBD	Central Business Destination
DOE	Department of Environment
DTW	Deep Tube well
DWW	Dhaka Water Works
DWASA	Dhaka Water Supply and Sewerage Authority
DPHE	Department of Public Health Engineering
EQS	Environmental Quality Standard
LPCD	Liter Per Capita Per Day
MLD	Million Liter Per Day
MMI	Mott MacDonald International
MODS	Maintenance, Operation and Distribution Services
MPO	Master Plan Organization
PWL	Pumping Water Level
SWL	Static Water Level
SWTP	Surface Water Treatment Plant

NOTATIONS

T	Coefficient of Transmissibility (L^2/T)
K	Permeability (L/T)
B	Aquifer Thickness (L)
V	Volume of soil Mass (L^3)
ρ	Density of Water (M/L^3)
g	Gravitational Acceleration (L/T^2)
γ_{sat}	Saturated unit Weight of Soil (M/L^3)
W_1	Apparent Weight of the Soil Mass (M)
W	Real Weight of Soil Mass ρ (M)
N	Newton (ML/T^2)
KN.	Kilo Newton (ML/T^2)
σ_T	Total Stress (M/LT^2)
P	Pore Water Pressure(M/LT^2)
σ_e	Effective Stress(M/LT^2)
$d\sigma_T$	Change in Total Stress (M/LT^2)
$d\sigma_e$	Change in Effective Stress (M/LT^2)
dp	Change in Fluid Pressure (M/LT^2)
dh	Change in Hydrostatic Head (L)
α	Comprssivility of Sand (LT^2/M)

CHAPTER 1

INTRODUCTION

1.1 Background

Dhaka city is growing very rapidly with population, housing, industrial installations, shopping centers etc. (since it became the capital of erstwhile east Pakistan after partition of India in 1947). To keep pace with such rapid expansion the existing utility services of the city is facing an acute stress as a whole. Water supply is one of the most important utility services in this regard.

Drinking water supply to the city of Dhaka dates back to the year 1874 when the then Nowab Abdul Gani laid the foundation stone of Dhaka water works (DWW) at Chandnighat water works consisted of narrow water distribution mains, street hydrants and house connection to elites and well- to- do of the then Dhaka city. The city started growing mainly towards the east and northern direction and Department of Public Health Engineering (DPHE) was responsible for the development of water supply system in the developing areas.

The city of Dhaka assumed importance and started to grow at a faster rate after partition of India in 1947, but water supply continued to develop in piecemeal basis in pockets of developed areas. The Dhaka Water Supply and Sewerage Authority (DWASA) came into being in 1962 to take over the responsibility of adequate quantity of water to the city people. To meet the over growing demand of water for drinking and other purposes, the WASA started to sink further deep tubewells in various parts of the city but the situation has not improved because of rapid increase of population. Presently about 94% of water of the city water production comes form underground sources and the rest 6% from two small surface water treatment plants. Obviously the exploitation of the ground water has its own limit. But how far this ground water could provide adequate supply for city dwellers is the burning question for the city planners. The extensive withdrawal of groundwater and a permanent lowering of water table could greatly reduce the subsurface ground water pressure and increase vertical pressure compounded with an increasing overburden pressure. These might include vertical compacting of subsoil and ground water withdrawal may cause land subsidence. Moreover from the structural point of view Dhaka city is situated in a earthquake prone area. If any major earthquake takes place that may significantly contribute to land subsidence due to variability of ground condition. Excess abstraction of groundwater will also responsible for the lowering of yield from existing well, failure of plant lives to collect water through roots and thus an ecological imbalance.

1.2 Objectives

The main objectives of this research work are as follows:

- Assessment of present and expected rate of ground water abstraction in Dhaka City for water supply.

- Analysis of the situation of ground water table decline in different areas of the city.

- Assessment of the possible effect of increased ground water abstraction on output of tubewells, land subsidence, vegetation etc.

1.3 Scope and Methodology:

The scope of the study program is confined to Dhaka Metropolitan city area. Both DWASA deep tubewells' static water level (SWL) data and BWDB peizometric level data of ground water are considered for analysis. Information and relevant features have been gathered form DWASA and BWDB.

The methodologies adopted to carryout the study program are as follows:

a) For observing the overall water table condition of the main aquifer, contour maps on Dhaka Metropolitan city map (used by DWASA) were plotted.

b) Seasonal Variations of Water Level: To observe seasonal variations (i.e. Jan-Dec.) and comparative declination of ground water level of different areas seasonally, "Depth of water level (m) below land surface vs. months" for the period of ten years (1988-97) were plotted.

c) Gradual Declination of Ground Water Level: To observe the decline of ground water level of different areas for the period of ten years (1988-98) "Depth of water level(m) below land surface vs. year" were plotted.

d) To evaluate the possible effects of increased ground water abstraction on yields of tubewells, increase in overburden pressure on soil strata and possible redistribution of soil-water zones, qualitative approach were considered. Because many other parameters are related to these topics. However to evaluate the ground subsidence and well performance a quantitative analysis was performed.

1.4 Limitations: DWASA does not have regular water table data monitoring cell, so the contour maps were plotted with few data. Actually water level of main aquifer can be only evaluated by the SWL of deep tubewell. Although BWDB ground water circle maintains monthly water level data, but many data are missing and many aberrant data were found. These created problems during analysis. It is to be noted that BWDB piezometers are installed at a depth of less than 45 m. The data recorded by these piezometers gives the water level of upper aquifer.

1.5 Organization of the Study

In chapter two a brief description of Dhaka City (the study area) has been presented which are related to the study program. The available literature on hydraulic properties of aquifer, recharge to the aquifer system, role of ground water in water resource system and their management characteristics of ground water, function of aquifers, river-aquifer interrelationships etc. have been presented in Chapter three. In chapter four data analysis and discussions are presented. In chapter five possible effects of increased ground water abstraction are presented. Conclusions of the study program with recommendations are presented in Chapter six.

CHAPTER 2

STUDY AREA

2.1 Location

The study area is defined as an area of about 310 km^2. The project area is bounded by the Buriganga river to the south and west and Lakhya river to the east. The convergence of Turag and Balu river limits the northern boundary. It is situated at 23° 45' N and 90° 24' E on the north bank of Buriganga river. The study area is shown in Fig. 2.1.

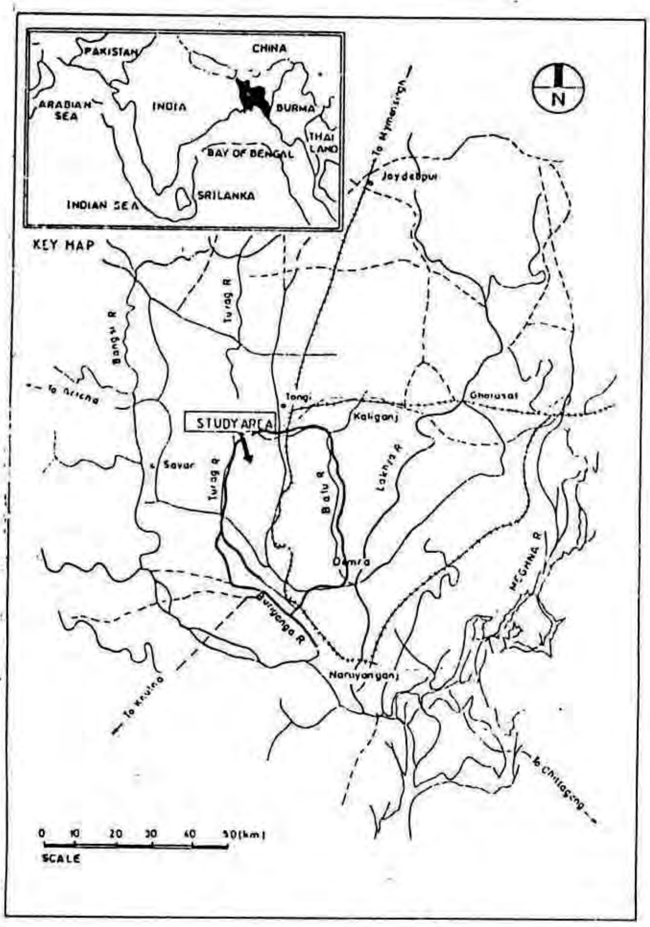
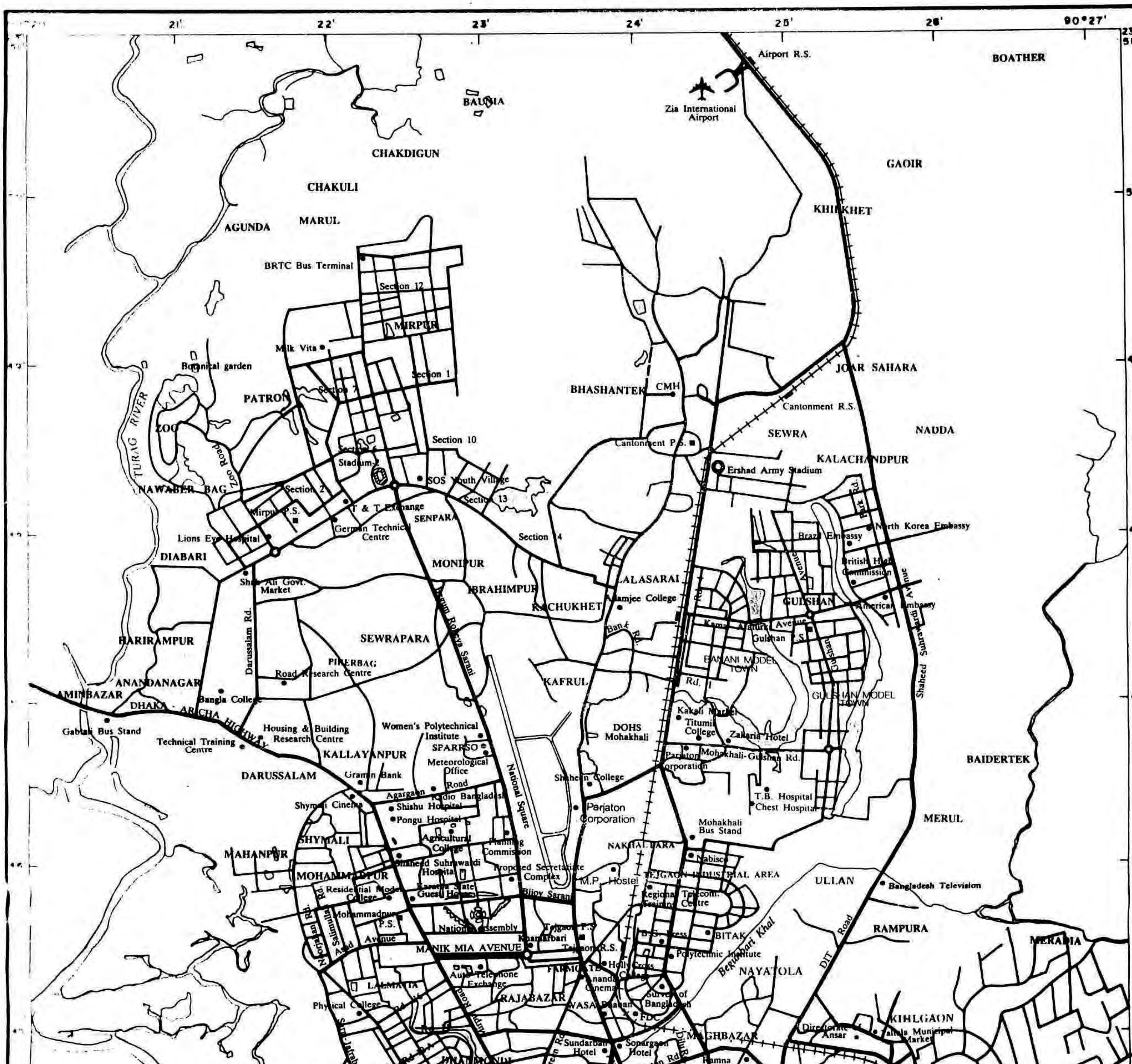


Fig. 2.1: Location of the Study Area



GRAPHOSMAN, 3/3-C, Purana Paltan, (Karim Mansion, 1st Floor),
Dhaka-1000, Tel : 232394

2.2 Geology and Topography

All water bearing strata in the Dhaka region are alluvial deposits of Quaternary age. Two formations form major aquifers under Dhaka city and in areas east of the Bangshi River in the main aquifer is the late Pleistocene lower Alluvial sequence. Both formations are typically in the order of 40-80 meters thick.

The aquifers are covered by silt and clay deposits to the Madhupur clay Residuum and/or the Lowland Alluvium. These fine grained surface deposits are generally less than 10 meters thick at Dhaka but may exceed 40 meters north of Tongi and in the Narayanganj area. The Madhupur clay, which forms an elevated area known as the Madhupur Tract, has been dissected by the Pleistocene to Holocene channels that have been infilled by softer deposit belonging to the Highland Alluvium.

Quaternary sedimentation has been controlled by a network of deep seated faults that divide the region into a series of tectonic blocks. The Turag, Tongi, Pagla and Balu faults define a block around Dhaka city which have been uplifted relative to the surrounding area.

Most rivers, which generally follow fault lines, have previously cut channels much deeper than their present level, and often penetrated the main aquifer. The sediment that infilled these channels are of variable composition and may either enhance or retard the recharge of river water to the underlying aquifers.

The base of the Dupi Tila aquifer in Dhaka city is at about 120-150 meters below ground. There is no evidence of any other major aquifer within the upper 45 meters of the geological sequence.

The geomorphology around Dhaka city is shown in Fig. 2.2. The deposited sediments of this area has two distinct entities.

Madhupur clay formation of Pleistocene age which is well dissected with clay and very fine sand particles.

Dupi Tila formation of Pliocene age, overlain by the Madhupur clay formation is characterized by medium to coarse sand with occasional conglomerates.

Structurally, the metropolitan area is monoclinical in nature and there is no evidence of folding. Along the Buriganga river, a NW-SE trending fault is identified. Other identifiable faults are N-S trending Baunia fault in the west, Demra fault in the Eastern outskirts of the city and E-W Tongi fault followed by Tongi canal.

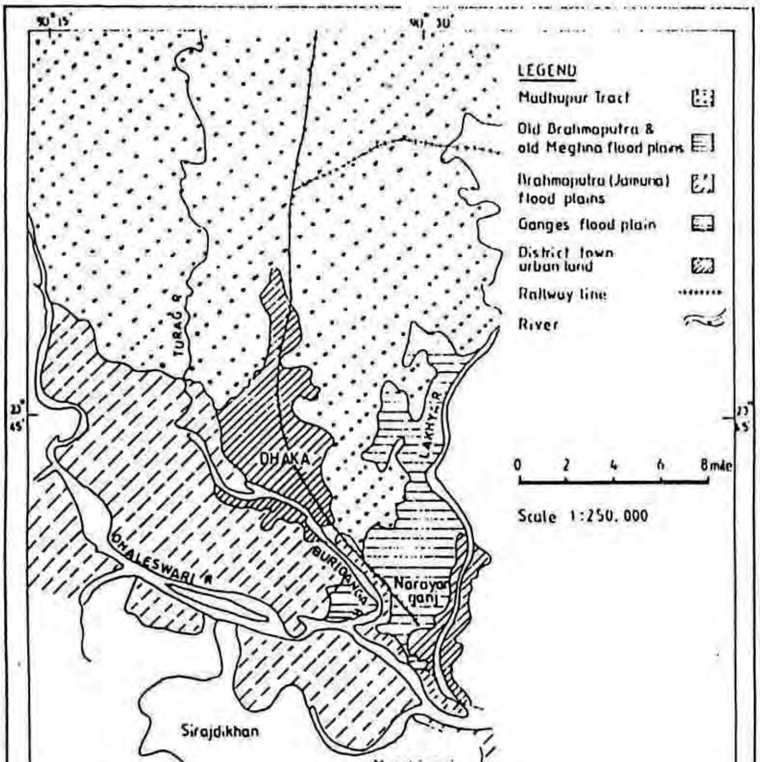


Fig. 2.2 : Geomorphology Around Dhaka City

Source: Shahabuddin (1996)

The city is situated on flat plain with an average elevation of 5 m. The surrounding part of the city is low-lying in comparison to the central part of the city. The topography is shown in fig. 2.3.

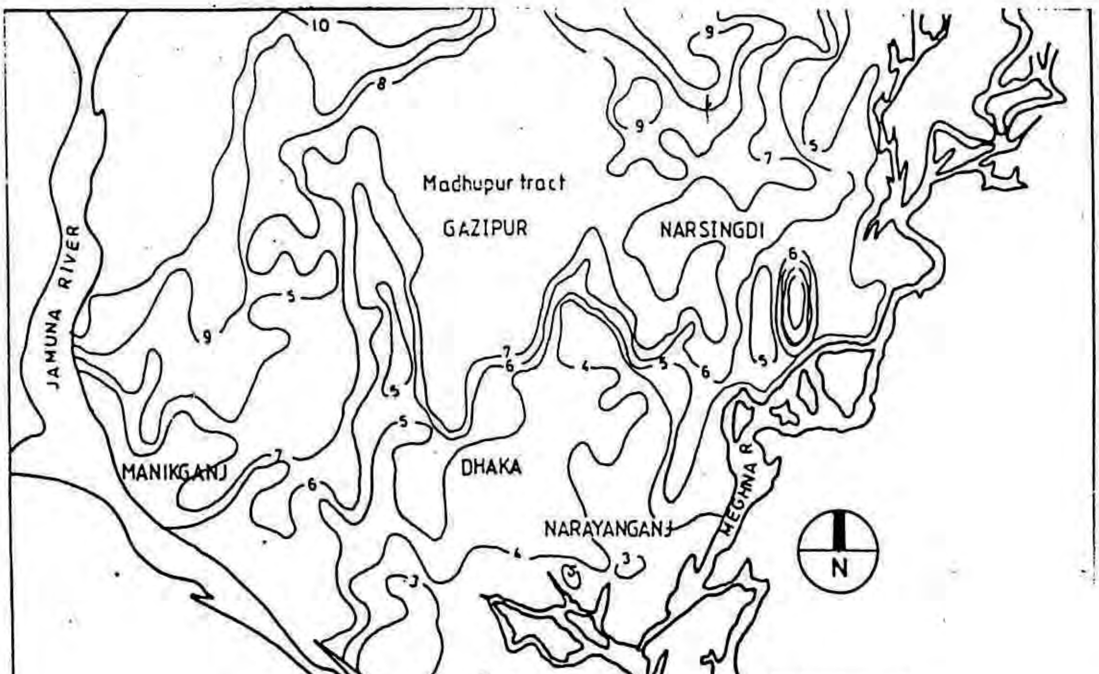


Fig. 2.3: Topographic Map of Dhaka Region
Source: Shahabuddin (1996)

2.3 Land Use Pattern of Dhaka City

Land use pattern plays an important role on the recharge of the aquifer system. Dhaka city expands through its land use for urban and industrial development. The pucca area, increased day by day, affects the recharge considerably through the change of runoff length, evapotranspiration, etc. In density built up areas, the natural recharge will significantly reduce. However urbanization may produce other form of recharge such as - leakage from water distribution and sewerage system.

2.4 Subsurface Geology and Aquifer System

Detailed information about the subsurface geology are available from the BWDB and DWASA borelog data. The aquifer system beneath Dhaka is complex in nature and functioning as a leaky, semi-confined aquifer. The thickness of different formation layers as well as the aquifer properties are found to vary between places. A simplified configuration of this aquifer system (which is a closer approximation of the actual lithology) have been visualized and developed as below for analytical purposes .

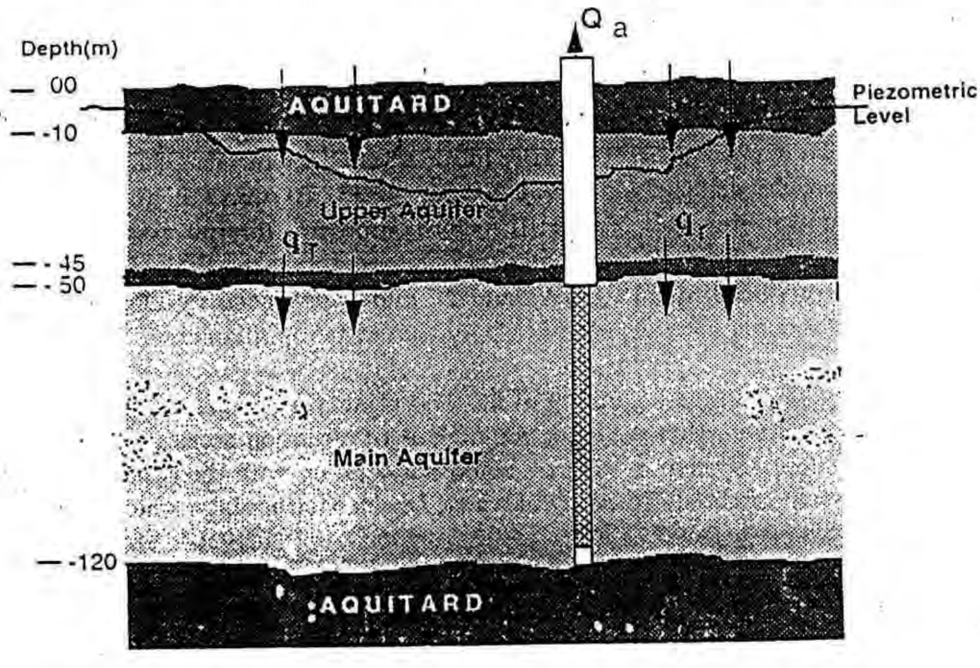


Fig. 2.4: The Typical Aquifer Condition Beneath Dhaka City
Source: Ahmed (1998)

2.4.1 Upper Aquitard: The top most layer composed of top soil, finer plastic concretion, impervious clay and low permeable silt. It ranges from 6 to 10 meters up to 15 m thick at different places.

2.4.2 Upper Aquifer: Below the upper aquitard, the formation layers are mainly composed of fine to medium fine sand to a depth of 30 to 45 m. Aquifer tests data indicate that the whole of the upper aquifer sequence behaves as a single aquifer system in which all the units are hydraulically connected. Shallow and hand-pumped tube wells extract water from this aquifer.

2.4.3 Lower Aquitard: This can be considered as the bottom of the upper aquifer. It is composed of silt and clay with varied thickness and even not present throughout the whole region.

2.4.4 Lower Aquifer: Bellow the lower aquitard, the lower of the main aquifer is composed of medium to coarse sand with a thickness ranging from 90 to 120 m at a 140 to 150 m deep. This water bearing formation is the main soruce of municipal and irrigation water supply for Dhaka region. It is found that in majority of the places the main aquifer can be classified as semi-confined in nature.

2.5 Water Quality

2.5.1 Ground Water Quality: The Dhaka water supply is primarily based on ground water source as good quality ground water is available in an aquifer extending between 50m and 120m below ground level. The water can very conveniently be abstracted by deep tubewells and supplied to adjacent population without any major treatment. Table 2.1 conforms the generally excellent quality of the water from WASA tubewells. But the water reaching the consumers has been found to be contaminated in many places. Water contamination in distribution mains may be attributed to leaks in old pipes and the nature of water supply. The water supply in Dhaka City is intermittent and absence of pressure or negative pressure during non-supply hours permits of contaminants in the distribution system.

Table 2.1: Chemical Analyses of Selected WASA Tubewells

Item	Unit	Bangladesh Standard	Hazaribagh	Armanitola	Baridhara
P^H	-	6.00	6.80	6.80	6.80
Conductivity	uS/cm	--	362.00	430.00	194.00
PO_4-P	mg/l	6.00	<0.1000	<0.1000	0.20
Hg	mg/l	0.0005	<0.0004	<0.0004	<0.0004
Cd	mg/l	0.0050	0.0007	0.0006	0.0005
As	mg/l	0.01	<0.01	<0.01	<0.01
Pb	mg/l	0.050	0.003	0.004	0.003
Cr	mg/l	0.0500	0.0017	0.0013	0.0043
Mn	mg/l	0.10	0.23	0.13	0.00
Mg	mg/l	30-50	11.0	15.0	5.0
Ni	mg/l	0.10	0.01	0.01	0.01
Zn	mg/l	5.00	0.051	0.017	0.005
Cu	mg/l	1.00	0.004	0.005	0.010
Fe	mg/l	0.3-1.0	0.905	0.187	0.067
Al	mg/l	0.20	0.012	0.014	0.014
NH_4-N	mg/l	0.50	<0.0100	<0.0100	<0.0100
F	mg/l	1.00	0.20	0.30	0.50
K	mg/l	12	1.80	2.30	1.30
Cl	mg/l	250-600	35.0	35.0	4.0
Ca	mg/l	75	26.9	31.6	14.1
Na	mg/l	150-200	25.2	20.1	29.9
SO_4	mg/l	300	22.0	15.0	7.0

Source: Dhaka Region Ground Water and Subsidence Study (1991)

2.5.2 Surface Water Quality: At present there are two small surface water treatment plant (SWTP) Chandnighat water treatment plant and BMRE project of treatment plant which are serving a part of the water demand to the city dewellers. Both of the surface water treatment plants abstract water from the Buriganga. The amount of supply water by SWTP is insignificant in comparison with the total demand in the Dhaka Metropolitan City . Presently another surface water treatment plant is under construction at Saidabad, for which water will be abstracted from the Lakhya river at Sarulia near Demra. Another SWTP with a production capacity of 225 MLD of water to be constructed at Postogola near the friendship bridge.

Dhaka City is surrounded by five rivers - Tongi, Balu, Lakhya, Buriganga & Turag. The rivers are polluted by industrial and domestic discharges. Table 2.2 summarizes the findings of data analyses by DOE. Environmental quality standards (EQS) of relevant parameters set out by (DOE, 1991) for drinking, fishing , recreational and irrigation are shown in Table 2.3.

Table 2.2 Summary of Water Quality Data Analyses for the Turag, Buriganga, Dhaleswari and Lakhya (Testing done at the DOE lab)

Water Quality Parameter	Turag (d/s of Gabtoli)		Buriganga		Dhaleswari		Lakhya(up to Demra)	
	Min. value	Max. Value	Min. value	Max. Value	Min. value	Max. Value	Min. value	Max. Value
DO	0.1	8.2	0.1	17.2	2.8	22.7	1.9	10.5
BOD_5	1	150	2.5	430	1	200	2	110
COD	4	382	8	540	4	530	6	240
NH_3-N_2	0	14.53	0	15.2	0	0.11	0	0.12
NH_4-N_2	0	109	0	114	0	0.76	0	0.96
E.Coli	75	7500	10	55000	4	4000	25	1800
T.Coli	25	20000	125	80000	50	6500	120	6000
TSS	9	80	10	42	10	35	10	42
NO_3-N_2	0	6.7	0	8.9	0	4.58	0.08	6.76
Ort-PO_4-P	0.06	5.36	0.43	15.22	0.78	11.54	0.47	7.14
Cr	0	0.016	0	0.014	0	0.01	0	

Note: All values are in mg/l, except E. Coli and T.Coli which are in Nos./100ml
Source: Kamal and Rabbi (1997)

Table 2.3 EQS of Some Relevant Water Quality Parameters (DOE, 1991)

Parameter	Drinking	Recreational	Fishing	Irrigation
Ammoniacal Nitrogen (as N), mg/l	NYS	2	0.025	3
BOD, mg/l	0.2	3	6	10
COD, mg/l	4	4	NYS	NYS
Chromium, mg/l	0.05	NYS	0.05	NYS
Coliform (total), Nos./100 ml	2	200	5000	1000
Coliform(faecal), Nos./100	0	NYS	NYS	10
DO, mg/l	6	4 - 5	4 - 6	5
Nitrate (as N), mg/l	10	NYS	NYS	NYS
SS, mg/l	10	20	25	NYS

Note: NYS - Standard not yet set

2.6 Water Demand

A variety of population of different profession and income are available in Dhaka city. Among this a large percentage has no access to DWASA water distribution network. These include

- Slum population with no water supply facilities
- Squatters and floating people
- People using street hand pump facilities

It is assumed that about 35% of the population has no direct connection to the distribution system. They are formally served through municipal standpipes or informally through neighboring connection.

However, the total population of Dhaka can be divided into four categories based on the kind of dwelling houses which reflect the level of income and consequently the water consumption per inhabitant.

- Poor: Slum, villages settlements, squatters floating people
- Low income: Semi-puce, unplanned puce housing
- Medium income: Planned pucca housing
- High income: Residential areas

For these categories, the water consumption is assessed as follows:

Poor:	30 lpcd
Low income :	110 lpcd
Middle income :	170 lpcd
High income :	240 lpcd

Table 2.4: Water Demand and Water Production

DWASA Zones	Area (km^2) (Approx.)	Population (lac) (Approx.)	No. of DTWs(1)	Present water production(1) (MLD)	Estimated water Demand(2) (MLD)	Shortage (-) surplus(+) (MLD)
I	90	20	39 DWW	149.12 18.64	360	- 192.24 (53.40%)
II	30	11	26	102.39	198	- 95.61 (48.28%)
III	35	14	36	130.03	252	- 121.97 (48.40%)
IV	50	15	36	127.68	270	- 142.32 (52.71%)
V	65	14	43	155.64	252	- 96.36 (38.26%)
VI	40	16	49	144.59	288	- 143.41 (49.79%)
Sub-Total	310	90	229	828.09	1620	- 791.91 (48.88%)

(1) DWASA Management Information Report, May 1998.

(2) Assuming a water consumption rate of 180 lpcd for the population within the zone.

2.7 Annual Abstraction of Ground Water by DWASA

The annual abstraction of ground water has been continuously increasing. Fig. 2.4 shows that in the year 1988 the abstraction was 158 Mm^3 (Million cubic meter) on the other hand the abstraction increases nearly 330 Mm^3 which is more than double than the abstraction of the year 1988. Besides these WASA wells, nearly 400 private owned shallow and deep tubewells inside the city withdraw about 90 Mm^3 of water annually. The abstraction by DWASA will be about 560 Mm^3 annually by the year 2002 when the fourth interim project of DWASA will be implemented.

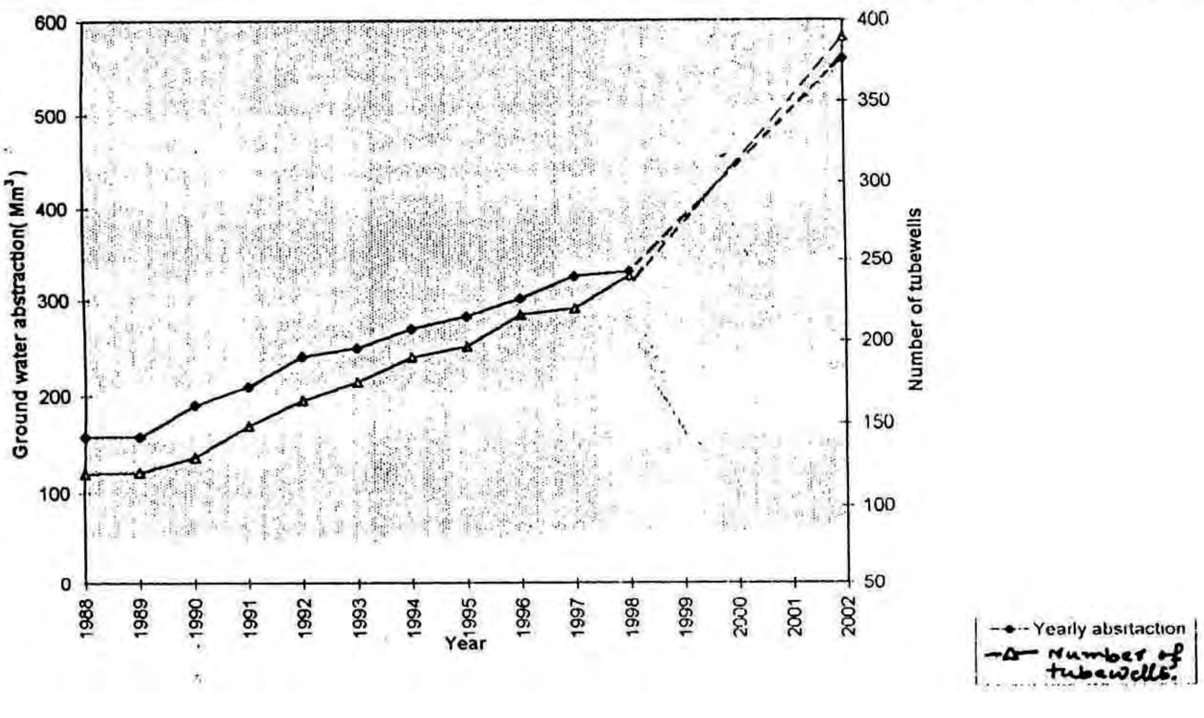


Fig. 2.5: Annual Ground Water Abstraction and Tubewells Development by DWASA

CHAPTER 3
LITERATURE REVIEW

3.1 Hydraulic Properties of the Aquifer

Various hydraulic properties of aquifer in Dhaka city are available from various published aquifer tests, commissioning tests, laboratory tests, correlation with grain size and in some areas form the relationships between river stages and adjacent ground water level.

Aquifer test data are reported by parson (1980), BWDB (1984), the British Geological Survey (BGS) as reported by Barket et al. (1989) and MMI (1990). Parsons (1980) supervised various aquifer tests on DWASA tubwells to estimate the various aquifer parameters.

3.1.1 Thickness

Since most of the well drilled by BWDB in the study area did not penetrate the entire thickness of the aquifer, the thickness of it could not found properly. So the thickness of the aquifer is interpreted on the basis of the sections penetrated by test wells of up to 107 m depth generally. 'BWDB water supply paper- 446' states that in the eastern and western zone of the Dhaka district the thickness of the aquifer generally varies from 60 m to 76 m where as in the central zone, the limit of thickness is 46m.

3.1.2 Permeability

Permeability is the ability of a formation to transmit water through its pores when subjected to a difference in head. It can be defined as the flow per unit cross-sectional area of the formation when subjected to a unit hydraulic head per unit length of flow (i.e. per unit hydraulic gradient) and has the dimension of velocity, i.e. L/T.

Dhaka Region groundwater and subsidence study performed aquifer tests. The tests provide an estimate of the vertical permeabilities. Based on these tests their results of analysis are given in Table 3.1.

Table 3.1 Vertical Permeability from Aquifer Test

Location	Aquitard	Permeability
Azimpur, Dhaka	Madhupur clay/sand	6.5×10^{-4} m/d
Mirpur, Dhaka	Madhupur clay/sand	1.6×10^{-3} m/d
Uttara, Dhaka	Madhupur clay/sand	2.2×10^{-4} m/d
Gymkhana, Dhaka	Madhupur clay/sand	1.6×10^{-2} m/d
Tongi, Tongi	Madhupur clay	1.6×10^{-2} m/d

Source: Dhaka Region Groundwater and Subsidence Study (1991)

3.1.3 Transmissibility Coefficient

The coefficient of transmissibility (T) is the discharge through unit width of aquifer for the fully saturated depth under a unit hydraulic gradient and is usually expressed as m^2/day. It is the product of field permeability (K) and saturated thickness of the aquifer(b); T = Kb and has the dimension L^2/T.

Welsh (1977) determined transmissivity close to Dhaka by analyzing the attenuation of river state fluctuations in adjacent piezometers, Wesh (1977) concluded that the magnitude of the ground water fluctuations proves that there is a good hydraulic conductivity between the river and the aquifer. His results are given in Table 3.2.

Table 3.2 Tansmissivities Estimated from River Stage Fluctuations

Balu Khal at Demra	435 m2/day
Buriganga at Mill Barak	683 m^2/day
Tongi Khal at Tongi	807 m^2/day
Turag at Mirpur	497 m^2/day

Source: Dhaka Region Groundwater and Subsidence Study (1991)

Dhaka Region Groundwater and Subsidence Study (1991) suggests that the transmissivity derived form the aquifer test in Dhaka city is approximately double the value of that indicated above table. Except at Tongi where the clay is 40-50 m in thickness, the rivers cut through the upper clay but do not penetrate the main aquifer. Unfortunately, Welsh (1977) did not report the storage values used; however, these results still provide a very useful indication of the conductivity between the aquifer and the rivers, although not an accurate measure of transmissivity.

'BWDB Water Supply Paper -466' has prepared a transmissivity map of Dhaka district (Fig. 3.1) which shows that the values decrease from north-west to south-east of the mapped area. The highest value is Kaliakair thana 293.3 gpd/ft (in thousand) and the lowest value in the Mirpur thana which is 70.4 gpd/ft (in thousand).

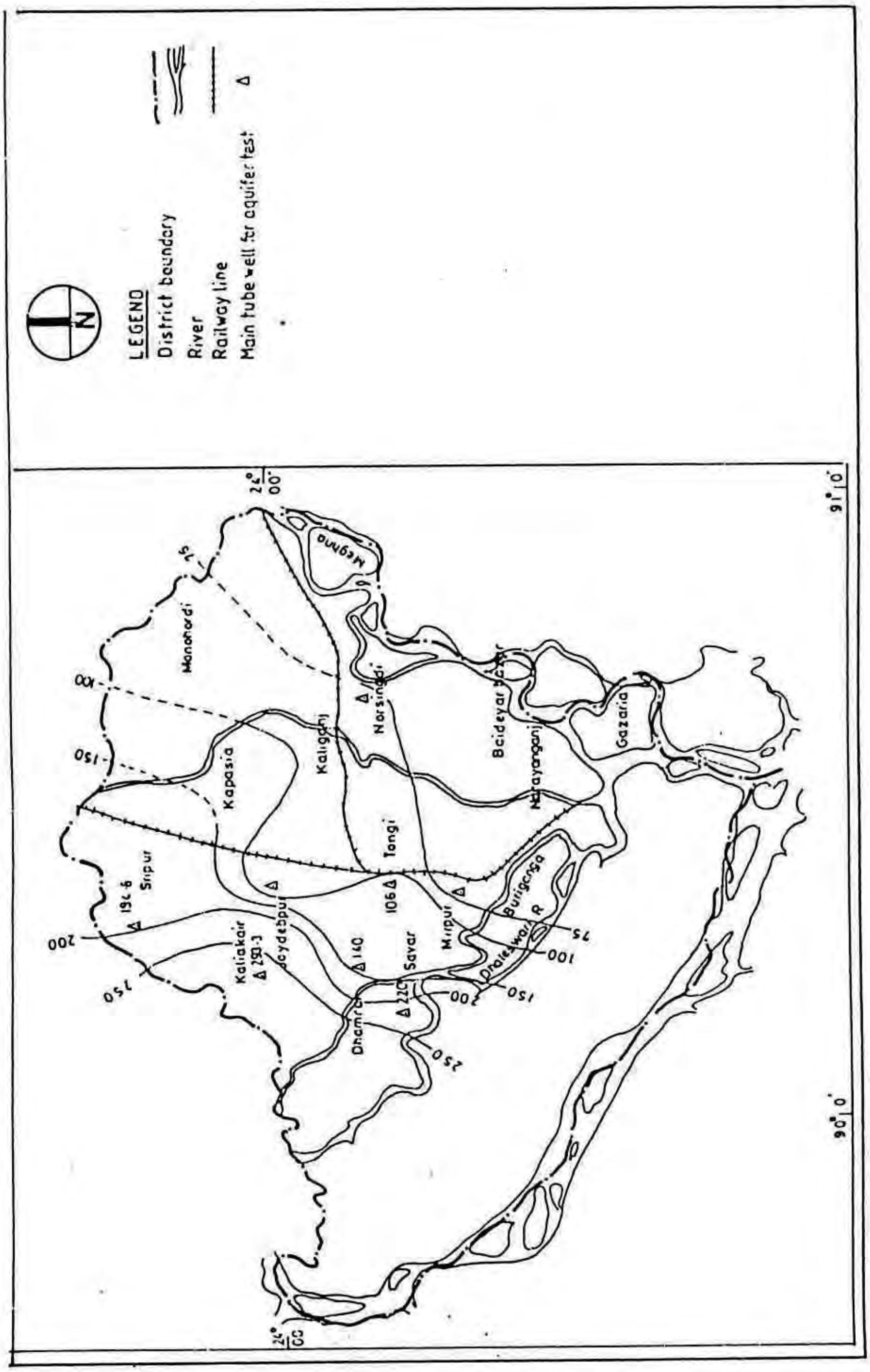


Fig. 3.1 Transmissivity Map of Dhaka City
Source: Shahabuddin (1996)

3.1.4 Storage Coefficient

Storage Coefficient of an aquifer is the volume of water discharged from a unit prism, i.e. a vertical column of aquifer standing on a unit area (1 m^2) as water level (piezometric level in confined aquifer artesian conditions) falls by a unit depth.

Confined storage co-efficient for the aquifer were taken from published test analysis. BWDB water supply paper - 466 has prepared a general map of storativity (Fig. 3.2). The lowest value has been observed in southern part and the highest value found in north-west part of the map. The value ranged from $2.9x10^{-5}$ to $7.14x10^{-4}$.

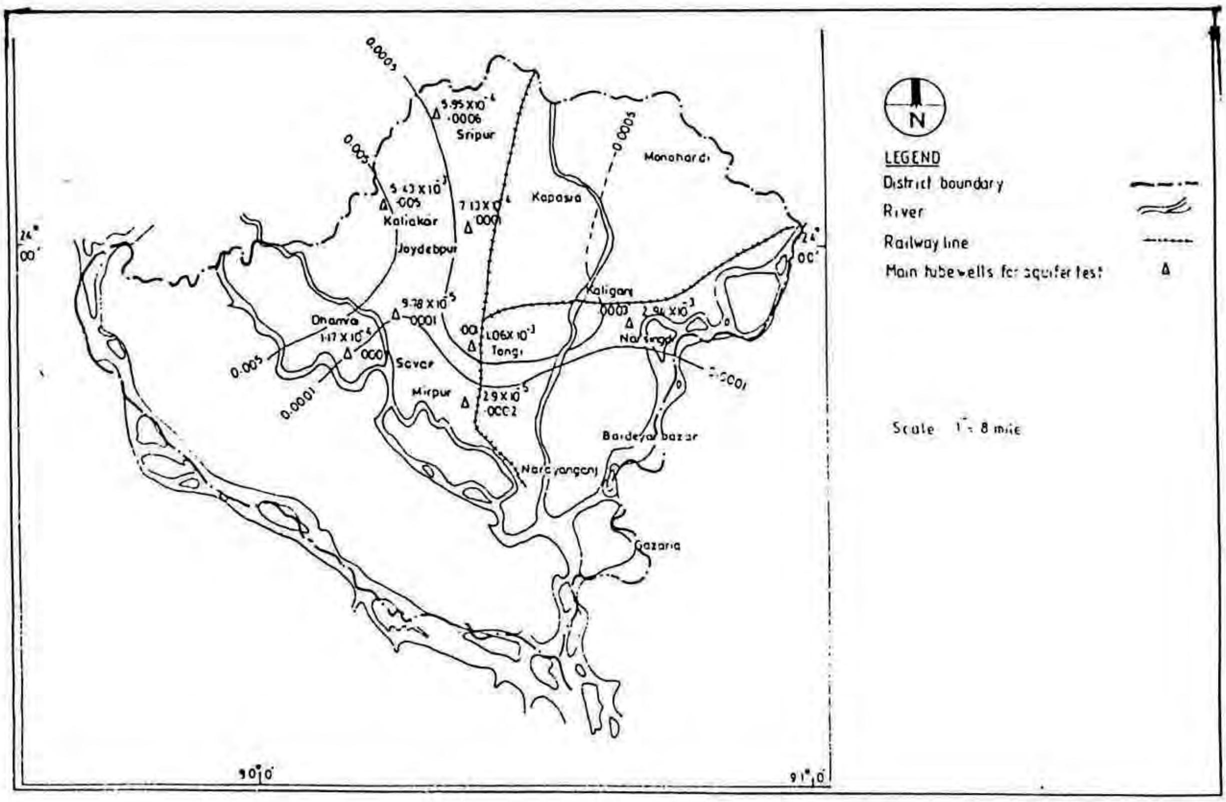


Fig. 3.2 Storage Coefficient Map of Dhaka City
Source: Shahabuddin (1996)

3.2 Recharge to the Aquifer System

Natural recharge to the aquifer system by infiltration from land surface (i.e. recharge from rainfall and flooding) is controlled by a large number of parameters, which according to the MPO may be categorized into major groups as follows:

- Physical parameters:
  - Land type distribution
  - Soil characteristics within land type areas
  - Local relief characteristics
- Hydrological parameters:
  - Rainfall (totals, distribution, frequency);
  - Relationship between effective and gross rainfall
  - Surface water retention capacity for different land types
- Surface run-off characteristics;
- Extend, duration and depth of deep flooding
- Reference crop evapotranspiration
- Soil Characteristics:
  - Infiltration and deep percolation rates
  - Soil moisture characteristics of different soil types
- Parameters related to agricultural practices:
  - Crop coefficient
  - Cropping calendar
  - Relationship between cropping patterns and soil and land types
  - Rooting depth of crops or depth of plough pan
  - Ratio of cultivable to gross area
  - Crop statistics

The MPO have calculated potential recharge on Thana basis for a large number of thanas in Bangladesh. Potential recharge is defined as the maximum possible recharge should be clearly distinguished from actual recharge, which is in effect potential recharge minus recharge rejected form the system due to partial or complete aquifer full conditions.

For areas in Dhaka city the potential recharge is reduced to a varying extent for the following reasons:

- The change in infiltration capacity of the ground surface due to paved and built up area.

- The existence of storm water drainage systems reduces the built up of surface flooding for extended periods of time.

- Flood protection schemes reduce the flood depth.

3.3 Role of Groundwater in Water Resource Systems and their Management

In order to discuss the role that ground water may play in the management of regional water resources, it may be assumed that both kinds of water - surface water and groundwater - are present in relatively significant quantities in a region.

3.3.1 Surface Water Versus Groundwater

Actually surface water (in lakes and streams) and groundwater (in aquifers) are not necessarily separate and independent water resources. Consider, for example, the interrelations between passing through a region under which a phreatic aquifer exists. If the river or lake bed is not completely clogged, water levels in the former are higher than in the latter, and vice versa. Base flow in streams is provided by ground water. In this way, rivers and lakes in direct continuous hydraulic contact with adjacent, or underlying aquifers serve as boundaries to the flow domain in the latter.

By controlling water levels in them, it can be controlled the flow of water through them into or out of an aquifer.

Spring discharge is another example of ground water emerging under certain conditions at the ground surface and becoming surface runoff. By controlling groundwater levels in the vicinity of a spring its discharge is controlled, or even stopped completely.

The above considerations apply not only to water quantity, but also to water quality, defined, for example, by some chemical species or bacteria carried with the water. Polluted surface water may easily reach and pollute groundwater.

It is thus obvious that the management of regional water resources should always include both resources simultaneously, incorporating each of them in the overall system according to its individual features. In one way or another, any control of one resource will eventually, if not immediately, affect the other. The possible time lag may be due to storage and /or the relatively slow movement of groundwater and of pollutants carried by it. It should be noted, however, that the water divide delineating a ground water basin and that delineating a surface one are not necessarily geographically identical and that depending on the geographical boundaries of any considered region, management may include transfer of water from one basin to another within the framework of regional conjunctive use.

Although it seems obvious that ground water, when present in a region, should be used conjunctively with surface water within the framework of any development and management scheme, one finds in many parts of the world a certain degree of reluctance to include ground water in the development and management of water resources.

Perhaps in part, this attitude stems from the fact that unlike water in streams and lakes, one cannot actually see ground water in aquifers. However, in trying to rationalize this attitude, the following reasons are often given:

- Exploitation of groundwater is energy consuming and expensive, especially when the water table or the piezometric surface is deep.

- Planning the development of ground water resources requires long-term data, which usually are not available.

- Evaluation and planning groundwater resources require highly trained personnel which are not available.

- It is difficult to predict the response of an aquifer (in terms of both water quantity and quality) to proposed activities.

- Groundwater projects are usually single purpose ones, namely, to supply water (whereas most surface water projects have multiple purposes).

Obviously in order to examine these arguments and to compare surface water with groundwater, one must know the local conditions. In general, however, it seems that at least in part, these arguments are based on lack of knowledge, for example;

- It is true that when pumping heads are large, energy costs may be significant (whereas energy may be produced from surface water). However, if one includes in the annual expenditures also the relatively high investments required for hydraulic structures, such as storage dams diversions, canals, and pipes, the overall economic picture may show a clear advantage of ground water.

Because of the large storage and slow motion involved, ground water levels at any instant reflect the accumulated effect of a rather long period of time; changes are relatively small and slow, in comparison with those of surface water. Hence, in general, shorter ground water records give sufficient information for planning purposes, whereas much longer records are required in order to obtain a complete picture of the more frequent and rapid fluctuating behavior of surface water.

- It is true that a certain amount of knowledge is required which often is not part of the usual training of engineers. Most of this knowledge has been developed in the last two or three decades. Nowadays, however, this information is included more and more in the ordinary training of hydrologists and civil and agricultural engineers, or in special courses of continuing education. Most of the necessary theory is also included in the present text, as a contribution to the dissemination of information on ground water. Consequently, the lack of skilled personnel can easily be overcome, even in regions where this subject has been neglected in the past.

- With modern hydrological tools, there is no difficult in modeling the behavior of a groundwater system and forecasting its response (both quantity and quality wise). In general, the forecasts are reliable. Digital computers are often used when the complexity of the system warrants it.

- One can certainly not use ground water for recreation, as one does in a large storage reservoir. Nevertheless, and perhaps to a more limited extent, ground water projects may also serve multiple purposes. For example, in addition to water supply, drainage and reclamation of land may be achieved. It has been already mentioned above the control of base flow in streams which may be achieved by controlling ground water levels in adjacent aquifers. Artificial recharge can be used for disposal of reclaimed sewage water using the purifying and mixing properties of the aquifer for augmenting the exploitable groundwater quantity.

3.4 Characteristics of Groundwater

The man purpose in bringing these arguments is not to show that groundwater utilization is always superior and more advantageous, but to emphasize again that whenever the two resources are present, they should be used conjucntively according to their individual features. Following are some of the main characteristics of ground water.

i) Location: Springs occur at points, surface water flows along fixed curved paths. Their utilization usually requires the construction of regulative facilities which will make the water available only along certain portions of their path. Ground water, on the other hand, underlies (when at all present) extended areas. If these coincide also with demand areas, there is no need for a surface distribution system, as the aquifer acts also as a conduit and each consumer can pump his share directly from the aquifer. The feature is of special interest in regions where development is gradual. More wells are sunk when an increase in pumpage is required. Often control structures for surface water (e.g., dams or diversions) cannot be built in stages.

ii) Flow and availability: Fluctuations in surface flow may be significant. Minimum flows, including zero flow, occur often during the season of highest demand. On the other hand, climatic fluctuations in ground water levels are usually small relative to the thickness of an aquifer, so that the large volume of water stored in the aquifer may serve as buffer and also supply water in periods of drought. Whereas the regulation of surface flow requires hydraulic structures which are often rather costly, the regulation of ground water flow is incorporated in the implementation of management schemes, namely through an appropriate aerial and temporal distribution of pumpage and artificial recharge.

The regulation of ground water flow is, therefore, in general, much less expensive. Base flow in streams and spring flow (including the drying up of streams, which means transforming surface flow into groundwater flow) can be regulated by controlling ground water levels in their vicinity.

iii) Annual and Seasonal Variability: Annual and seasonal fluctuations are much more pronounced in surface than in ground water flow. In surface flow, this means large losses of water by spillage in period of excess water or the need for expensive regulatory structures (e.g., dams). In groundwater flow, storage is provided by the aquifer itself; spillage due to very high water levels near an outlet is relatively small and can easily be avoided by manipulating water levels through pumping. In Fig.3.3 a dry season peizometric map in Dhaka City is shown chronologically. From these figures it is clear that each year significant subsidence of ground water is occurring.

iv) Energy: Energy must always be expended in order to lift ground water to the ground surface. In general capital investments in wells are low, but operating costs are relatively high.

v) Quality of Water: In many regions ground water does not pose major biological or physical quality problems. Surface flow is much more susceptible to man made pollution, which usually requires costly treatment for its removal. This does not mean that ground water cannot be affected by pollutants. For example faulty sewage pipes or oil spillage may cause severe pollution of ground water. In certain formations, pollutants may travel large distances in an aquifer without being modified. As for mineral quality, although the range of concentrations encountered is very large, in general one may observe that ground water is more liable to pick up minerals in solution. The removal of such minerals is usually very expensive.

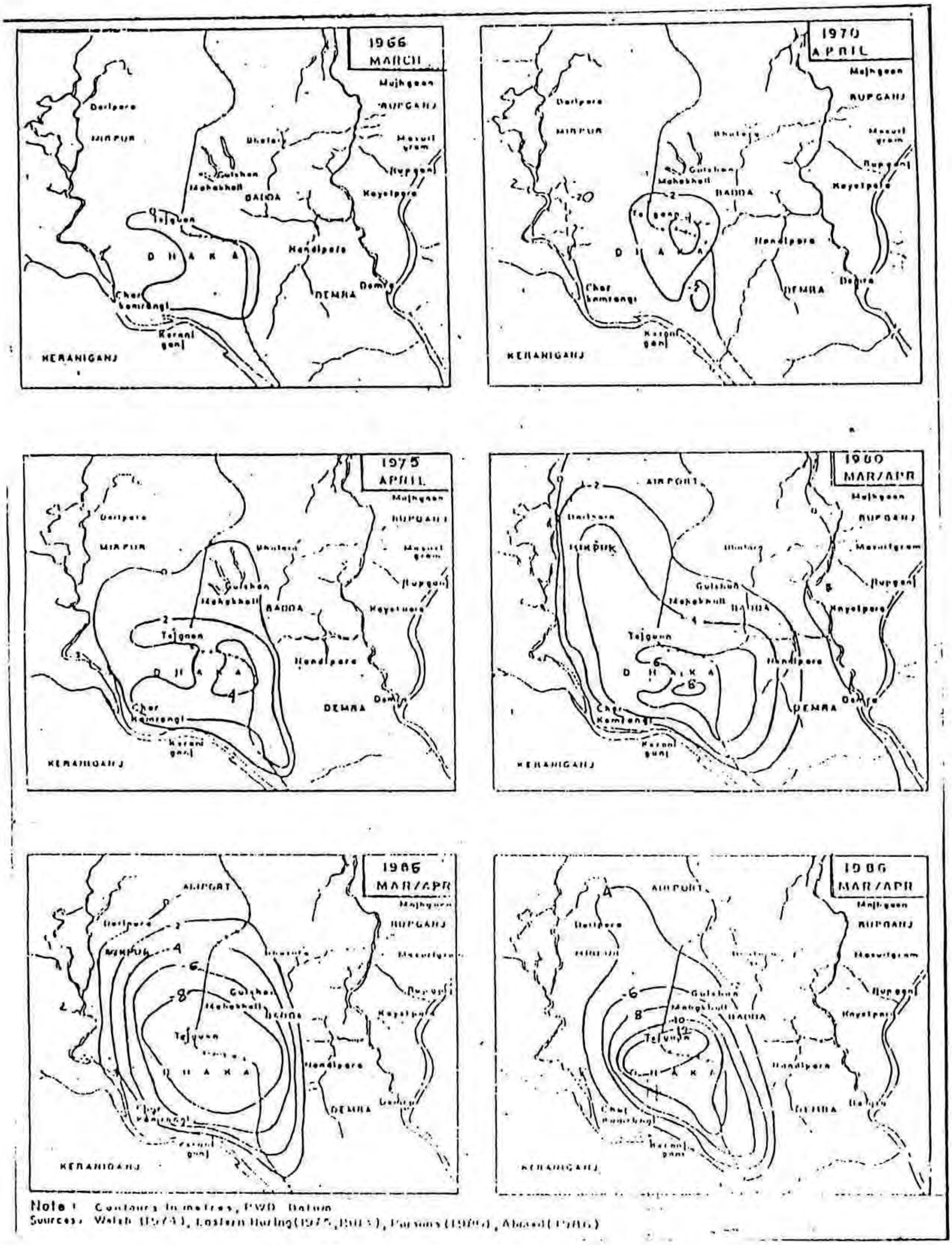


Fig. 3.3: Dry Season Piezometric Maps in Dhaka City
Source: Dhaka Region Ground Water and Subsidence Study (1991)

When ground water does get polluted (e.g., by polluting solutes such as leachate from land fills carried down with the water form the ground surface, or by intrusion of ground water of inferior quality into an aquifer), the restoration of quality and the removal of pollutants by mixing with and leaching by clean ground water is a very slow hence lengthy, sometimes practically impossible process (i.e., the process is practically irreversible). This is due to the very slow movement of ground water especially in layers of very fine material, imbedded in formations of higher permeability, and to adsorption and ion-exchange phenomena on the surface of the solid matrix. These phenomena are especially significant when fine grained materials, such as clay are present in an aquifer. Adsorbed species continue to be fed into the ground water flow for prolonged periods.

On the other hand, for certain polluting elements carried with the water, the above processes of adsorption and ion exchange are an advantage as they remove them from the water. The aquifer then plays the role of a filter and a purifier, taking advantage of the adsorptive capacity of the solid matrix.

In general, there is always the trend of salinization of ground water by solutes brought down from the surface. Under natural conditions, an equilibrium is reached by the fact that water leaving the formation carries solutes with it.

vi) Impact on Drainage Problems: The lowering of the phreatic surface by pumping may solve drainage problems in areas where the latter are produced by a high water table. The application of surface water in such cases may require a drainage system to maintain the water table at the desired depth.

In the case of marshes or of a water table which is close to the ground surface, the lowering of water table will also reduce evapotranspiration, thus making more water available for beneficial use. When artificial recharge is implemented, one should make sure that the rising water table of a phreatic aquifer will not create drainage problems.

vii) Land Subsidence: When water is pumped out of a confined aquifer the inter granular stress in the solid matrix is increased even without changing the load at the ground surface. When relatively soft layers (e.g., clay or silt) are present within the aquifer, they are compressed and it is observe land subsidence. In certain areas this subsidence is very significant and limits, or even forces the stoppage of pumping. Land subsidence is not an unlikely case for Dhaka City because some of the cities such as Bangkok , London , The Texas Gulf Coast , California , Mexico City have experienced land subsidence due to excess pumping of ground water

viii) Data: The main source for information about the movement and accumulation in an aquifer of water and solutes (or other pollutants) carried with the water, are measurements of water levels and solute concentrations in observation wells. Spring discharge and base flow are also sources of data. As already emphasized above, even with a relatively small amount of information, preliminary conclusions as to the feasibility of development can be drawn, with more information gathered as development proceeds. The construction of more refined modes of aquifer behavior requires more data, well distributed over space and time.

ix) Staged and Gradual Development: The fact that ground water is withdrawn through wells, with each well adding an increment of annual withdrawal, often located at the actual area of consumption, makes it easy to develop ground water stage by stage as needs arise, or according to a development plan. Each facility is added when actually required. The economy of scale, so important in surface flow regulative structures, does not exist in this case. A large storage dam may not be fully utilized before a long period after its construction has elapsed, depending on the rate of growth of consumption.

3.5 Functions of Aquifers

It should be obvious from the discussion presented above that an aquifer is a system which is managed and operated as a unit to achieve various objectives, beyond serving as just a source for water, some of the functions of aquifers are reviewed below.

I) Source for Water: This is the more obvious function. When an aquifer contains water stored if in the far past, usually under different climatic conditions, its water should be considered a non-renewable resource. However, in general, an aquifer is replenished annually from precipitation over the region overlying it or over its intake region (if it is a confined one). Thus in general, ground water is a renewable resource. Obviously only a certain part of the precipitation, depending on the distribution of storms, land topography and cover, permeability of soil, etc., infiltrates through the ground surface and replenishes the underlying phreatic aquifer. Aquifer can also be replenished from stream flow (with permeable beds) and floods. In many arid regions, aquifers in the low lands are replenished during a very short period once in several years, from flash floods originating in the mountains.

Under natural conditions, a quasi-equilibrium situation is maintained with inflow equal to outflow. Part of the replenishment can be intercepted by pumping thus reducing the outflow and establishing a new quasi-equilibrium. In this way the aquifer serves as a source for water.

ii) Storage Reservoir: Every water resource system requires storage, especially when replenishment is intermittent and is subject to random fluctuations. A large volume of storage is available in the void space of phreatic aquifers. Just to give a rough idea, $15x10^{6}$ m^3 of water can be stored in a portion of an aquifer of 10 km x 10 km, with a storativity of 15 percent, raising the water table by 1 m using the technique of artificial recharge, large quantities of water can thus be stored in a phreatic aquifer. By doing so, water levels rise and outward (from the recharge area) gradients are established. These cause the stored water to spread over ever increasing areas and/or to leave the aquifer through its boundaries. Thus the stored water is gradually lost if not used. Nevertheless, due to the slow movement of ground water, and with appropriate management schemes, these losses can be minimized. A possible management procedure is first to lower the water table by pumping in excess of natural replenishment, withdrawing the volume of water as a one time reserve stored in the aquifer between the initial and final water levels, and then use the denatured zone for storage. In this way, storage is provided without raising the water table to too high elevations. Sometimes even it may be started by producing a crater in the groundwater table and then filling it up for storage. Again losses form storage are minimized (recalling always that losses exist also from surface storage by evaporation and seepage).

An aquifer can be used for long term storage, e.g., from a wet sequence of years to a dry one, for seasonal storage, from the rainy season to the dry one, or even for shorter periods. The selection of the type of storage, the right combination of surface and underground storage, etc., depends on local conditions, economies, etc.

iii) The Aquifer as a Conduit: Using the techniques of artificial recharge, water can be introduced into an aquifer at one point and be withdrawn by pumping at another point (or several other points). The injected water will flow through the aquifer from the high water levels of the region of recharge to the region of pumping, where water levels are lower, the rate of flow depending also on the aquifer's transmissivity. Large distribution systems, say to individual consumers spread out over large areas, may be avoided in this way. Obviously, there is a limit to the permissible rise in water levels, as well as to permissible drawdowns; these impose a limit to the use of an aquifer as a conduit.

iv) The Aquifer as a Filter Plant: Using the techniques of artificial recharge, an aquifer may serve as a filter and purifier for water if inferior quality injected into it. This may take several forms:

- By recharging an aquifer (through infiltration ponds) with surface water containing fine suspended load, the latter is removed by the time the water reaches the water table. The bottom of the pond and the soil column act as a filter.

Various chemicals may be removed by chemical reactions, by adsorption and by ion exchange phenomena on the solid surface of the porous matrix, especially when clay colloids are present of special interest is the reduction in organic matter content as well as the removal of taste, or bacteria and viruses, especially if the flow is of sufficient length and duration. Sometimes, minerals are added to the water by solution.

Mixing of injected water with indigenous water of an aquifer is achieved by their simultaneous movement in the aquifer due to both the mechanism of hydrodynamic dispersion and the geometry of the flow pattern.

- Pumping near a river induces recharge from the latter into the aquifer. Filtering of the river water and purification are achieved by the flow through the aquifer material from the river to the wells.

In each case, the ability of an aquifer to upgrade the quality of water depends on the chemical and physical properties of the aquifer material and on the type of mineral and organic impurities contained in the water, taking into account that a significant part of the removal of impurities takes place at the phase of entry into the soil material (that is, bottom of an infiltration pond or vicinity of a recharge well).

v) Control of Base Flow: This can be achieved in springs and streams by controlling water levels in the aquifer supplying water to them.

vi) Aquifer as a Water Mine: It has been already mentioned above the possibility of mining a one time reserve stored in an aquifer between some initial phreatic surface and a planned ultimate one. The same is true (using some coefficient of efficiency of mining, due to hydrodynamic dispersion) in the case of the advancement of the interface in a coastal aquifer toward its planned position.

In general, the yield of an aquifer is a long term average of part of its replenishment (renewable resource). However, under certain conditions albeit very rarely, it may be planned to completely mine an aquifer (like any other non-renewable resource), not worrying about what will happen once this source has been depleted. In this case mining is usually based only on economic considerations.

3.6 River-Aquifer Interrelationships

River passing through a region underlain by a phreatic aquifer (and in special cases even by a confined aquifer) may either contribute water to the aquifer or serve as its drain. Much of the low water flow in streams (base flow) is derived form groundwater whose water table elevations in the vicinity of a stream are higher than the stream. Such streams are called effluent streams (Fig. 3.4a). On the other hand, when the water level in a stream is higher than the water level in an adjacent (or underlying) aquifer, water will flow from the river to the aquifer. The river is then called an influent river (Figs. 3.4b and c). When a stream cuts through an underlying confined aquifer, the stream may be either an influent one or an effluent one, depending on whether the piezometric heads in the aquifer are above or below the water level in the stream (Fig. 3.4d). The same stream can be an influent one along one stretch and an effluent one along another, or, it can be both influent and effluent at the same point, as shown in Fig.3.4e.

Obviously the entire discussion presented above is based on the assumption that the river bed is not completely clogged and that water can flow freely through the river bed. Otherwise there is no hydraulic contact between the water in the river and in the aquifer and no relationship exists between the two. It is possible that the profile of a stream is such that its deeper part, accommodating for low flows, is completely clogged, while above a certain level, the river bed is pervious (Fig. 3.4f).

When the water table under an influent stream is sufficiently deep, a mound is formed in the forms by the percolating water (Fig. 3.4c).

The volume of water contributed to an aquifer by stream flow (or drained into a stream from an aquifer), is part of the regional water balance. The rate of flow in either direction, also when the stream bed is partly clogged, can be calculated.
In view of the different possible situations shown in Fig.3.4, the river can play several roles when solving a ground water forecasting problem.

- The river may act as a boundary of specified head to the flow domain in the adjacent aquifer. This situation is shown in Figs 3.3a, b, d and e. It should have in mind an aquifer-type flow, which is based on the assumption of essentially horizontal flow in the aquifer, so that the shape of this boundary is a curve in the xy plane. This is a good approximation, overlooking the details of the flow net under the stream. A somewhat different boundary condition should be employed when the river bed is semipervious.

- The river serves as a source, contributing water to the aquifer. The rate of leakage depends on the depth of water in the river and on the permeability of the river bed. This can be a line (actually curve) source, or a strip of some width, when the river is sufficiently wide. The main point is that the rate of seepage is independent of the water levels in the aquifer (Figs. 3.4 c and f).

Thus, depending on the elevation of the water table, both situations (a) and (b) above are possible at different periods of time for the same stretch of river (and certainly for different stretches of the same river).

Finally, it can be noted that when a river is sufficiently large in terms of the rate of flow, the exchange of water between it and an aquifer practically does not affect the flow, and hence the depth of flow, in it. However, in small streams, the leakage itself may lower the water level in the stream and even completely dry up the stream. A passage have been encountered from condition (a) to (b) as defined above.

Often, the type of situation to be realized is not known a priori, when solving a forecasting problem and some trial and error, or iteration is required.

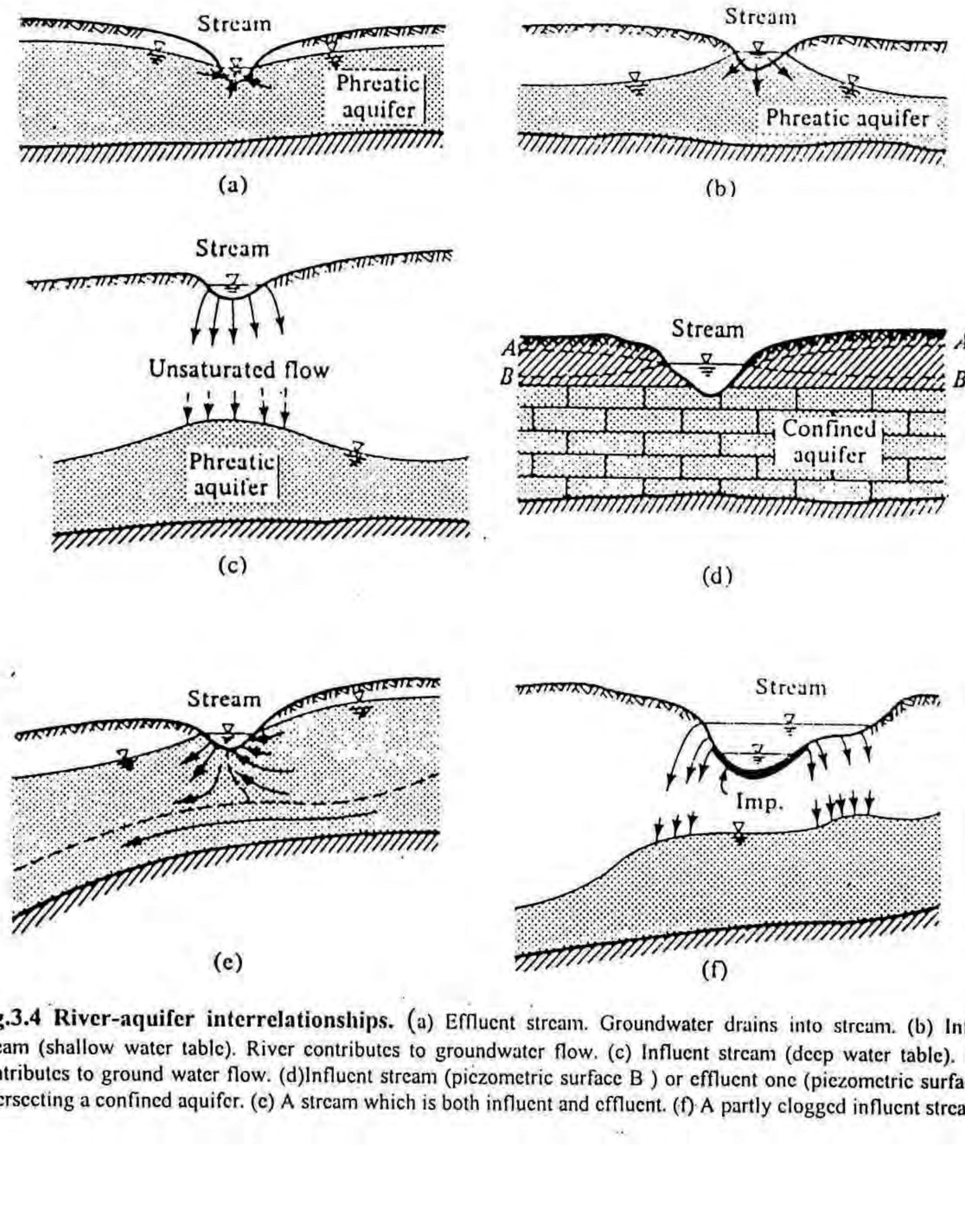


Fig.3.4 River-aquifer interrelationships. (a) Effluent stream. Groundwater drains into stream. (b) Influent stream (shallow water table). River contributes to groundwater flow. (c) Influent stream (deep water table). River contributes to ground water flow. (d)Influent stream (piezometric surface B) or effluent one (piezometric surface A) intersecting a confined aquifer. (e) A stream which is both influent and effluent. (f) A partly clogged influent stream.

CHAPTER 4

DATA ANALYSIS AND DISCUSSIONS

4.1 Introduction

Fluctuation of ground water is different at different places depending on ground water abstraction and recharge. Short term water level variation may be due to rainfall and river flow condition. Although rainfall contributes very little to the main aquifer (50 m - 120 m). Long term water level variation occurs due to over abstraction of ground water. To evaluate the abstraction of ground water different types of water level variations were analyzed.

4.2 Data collection

Static ground water level data are collected from BWDB and DWASA. BWDB has regular data monitoring cell, but DWASA does not have. Ten years data of nine BWDB piezometers were considered for the analysis of 'seasonal water level variation' and 'gradual declination of ground water level'. To plot the contour maps two years (1991&1998) static water level (SWL) were considered from DWASA deep tubewells inventory. The data of BWDB and DWASA are not quite identical because BWDB piezometers are installed at a depth of less than 50m whereas DWASA deep-tubewells are located more than 50m. Actually BWDB data gives the water level of upper aquifer (i.e. 0-50m) and DWASA data gives the water level of lower aquifer which is semi-confined in nature.

4.3 Seasonal Water Level Variation

The seasonal variation of ground water of the study area can be clearly understood from the piezometric water level of BWDB observation wells. Figs. (4.1 - 4.9) show the seasonal variation from (1988-1997) for a particular well location and Figs (4.10-4.19) show the comparative seasonal variation of a particular year for different well locations.

A marked response to seasonal variation of ground water level is not observed for most of the well locations. But it should likely be happened a rise of water level in the rainy season (June - October). However a distinct variation is observed in old Dhaka [i.e. Lalbag, Sutrapur, Sultangonj (Mohammadpur)] than in central part of the city. This indicates that a substantial part of recharge originates from the Buriganga river in the rainy season when river stage is relatively high.

There might have some reasons for which central part of city did not show distinct seasonal variation.

- Gradual reduction of recharge areas due to construction of buildings, roads and concrete pavements.
- The top most finer material of Dhaka City soil consists of plastic clay (about 7m - 15m in thick)
- Lowering of ground water level increases the length of flow paths which in turn develops the time constraint of recharge.
- Contribution of recharge to this main aquifer may be negligible.

A number of observation wells (Fig. 4.1-DA124, Fig..4.2-DA108, Fig.4.6-DA111and Fig.4.8-DA103) have shown sharp rise of water level. In this regard the possible cause for this sharp rise of water level was the disturbance of deep tubewells adjacent to the respective observation wells. Due to disturbance of deep tubewells, it might not run properly or it was totally abandoned. Thereby recovery of drawdown contributed to water level rise.

But sharp fall of water level which was found at the observation well no (Fig.4.3-DA110, Fig.4.5-DA13, Fig.4.6-DA111) might be happened due to install a new abstraction well adjacent to the respective observation well. But the case is different for the year of 1988 when most of the part of the city flooded.

However disturbance of piezometer may also create the above mentioned two problems

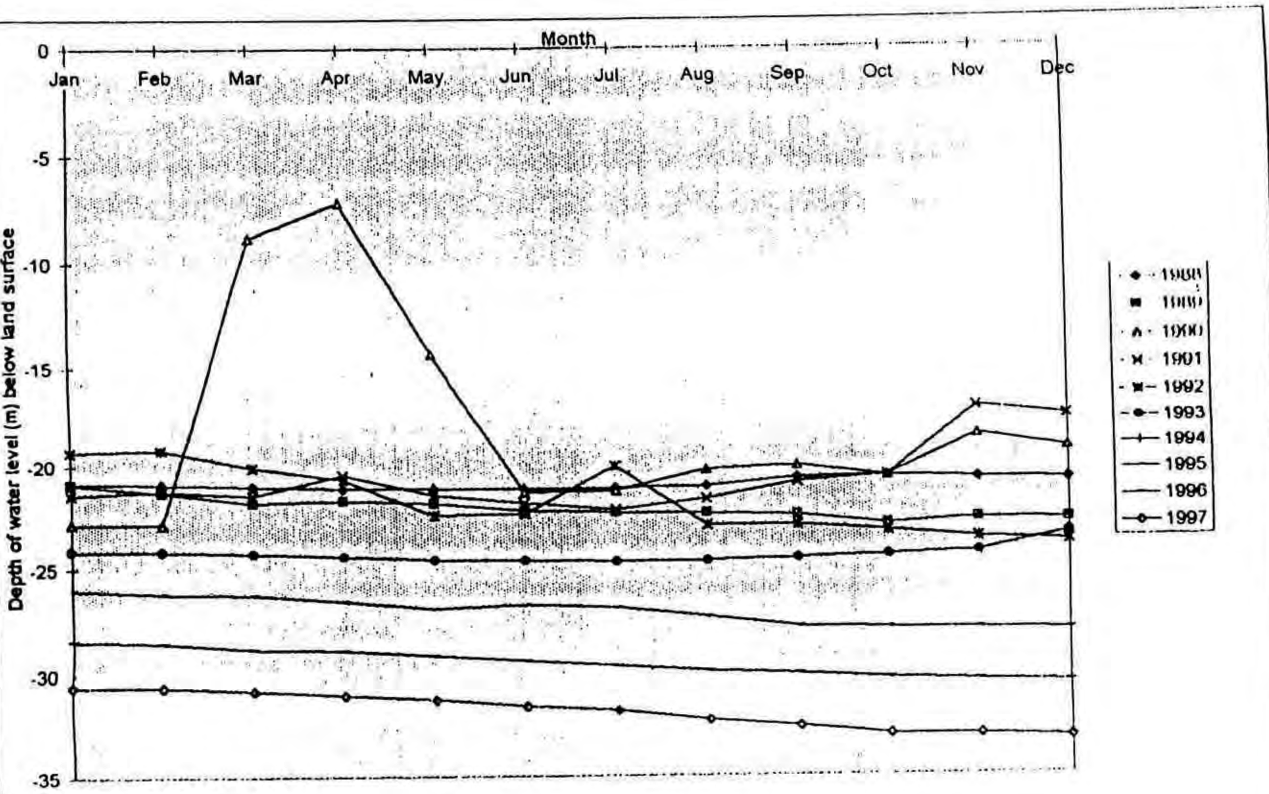


Fig. 4.1: Seasonal Water Level Variations at the Observation Well no. DA124(Motijheel)

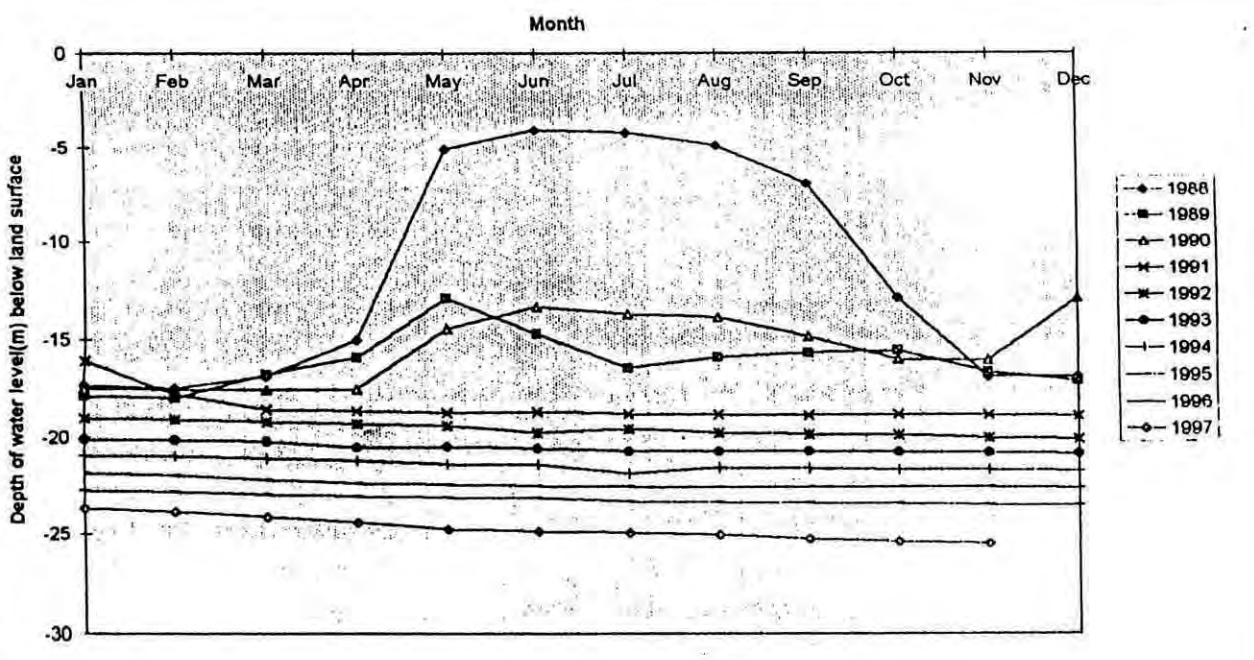


Fig. 4.2: Seasonal Water level Variations at the Observation Well no.DA108(Mohammadpur)

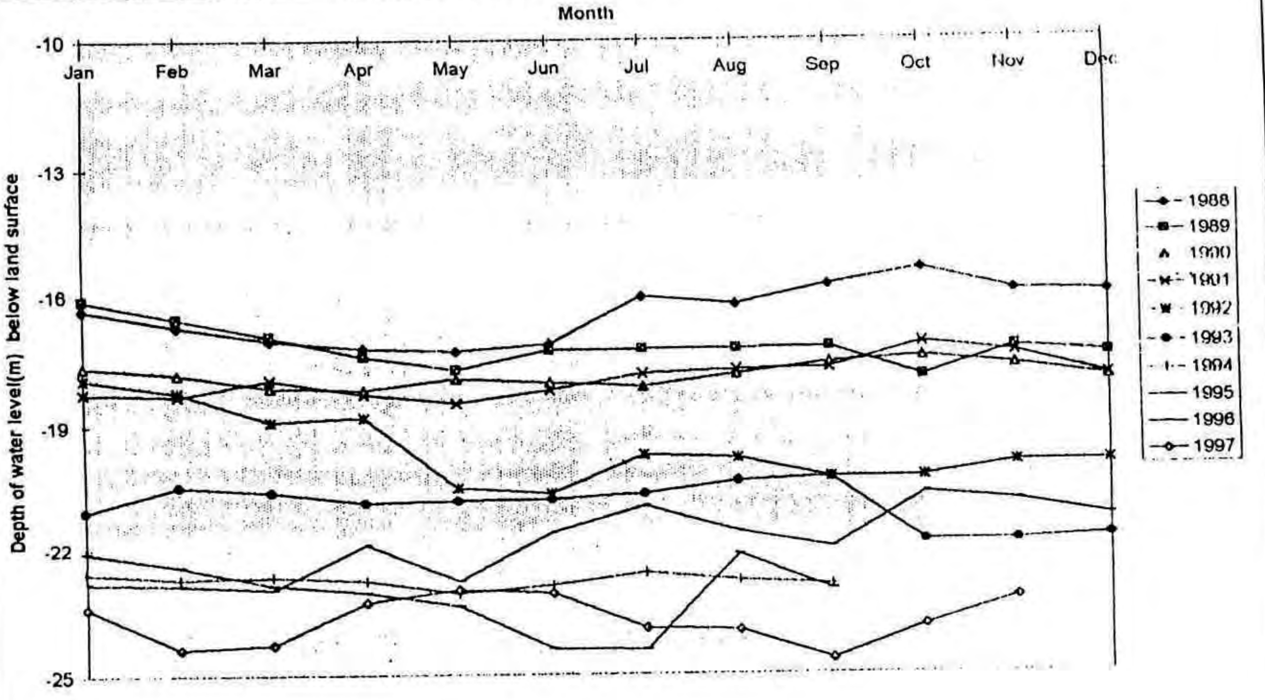


Fig. 4.3: Seasonal Water Level Variations at the Observation Well no. DA110(Lalbagh)

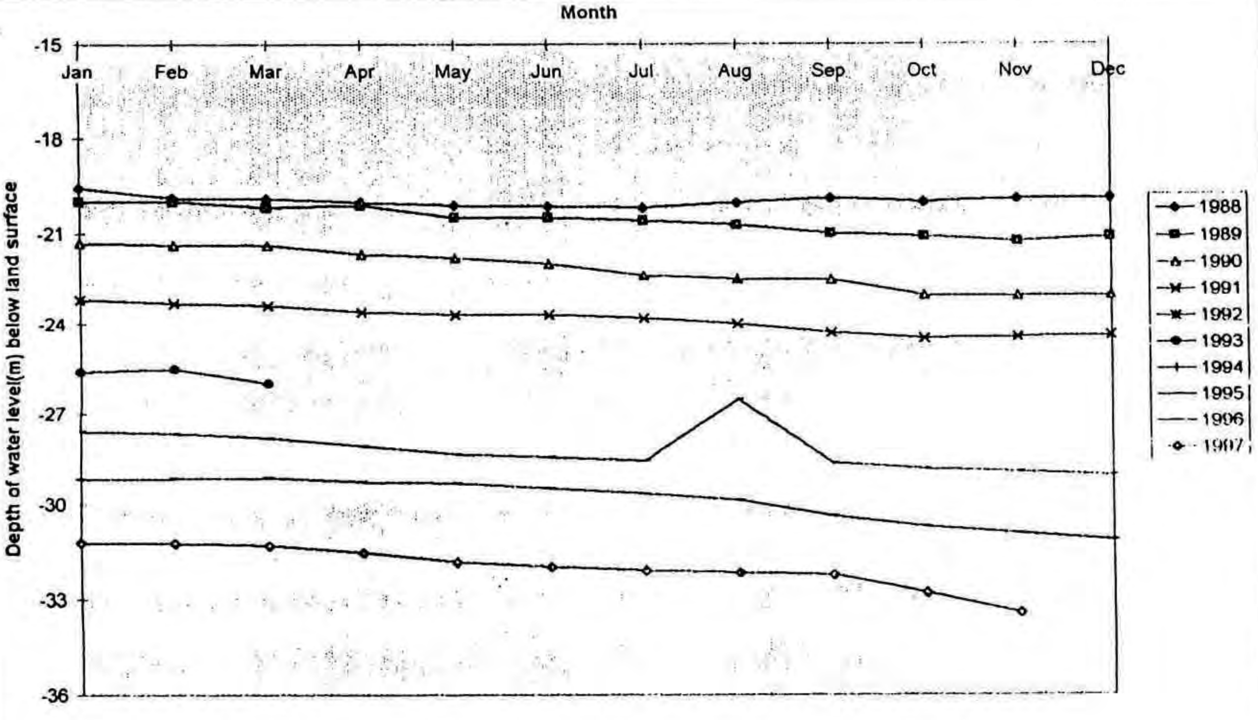


Fig. 4.4: Seasonal Water Level Variations at the Observation Well no. DA112 (Malibagh)

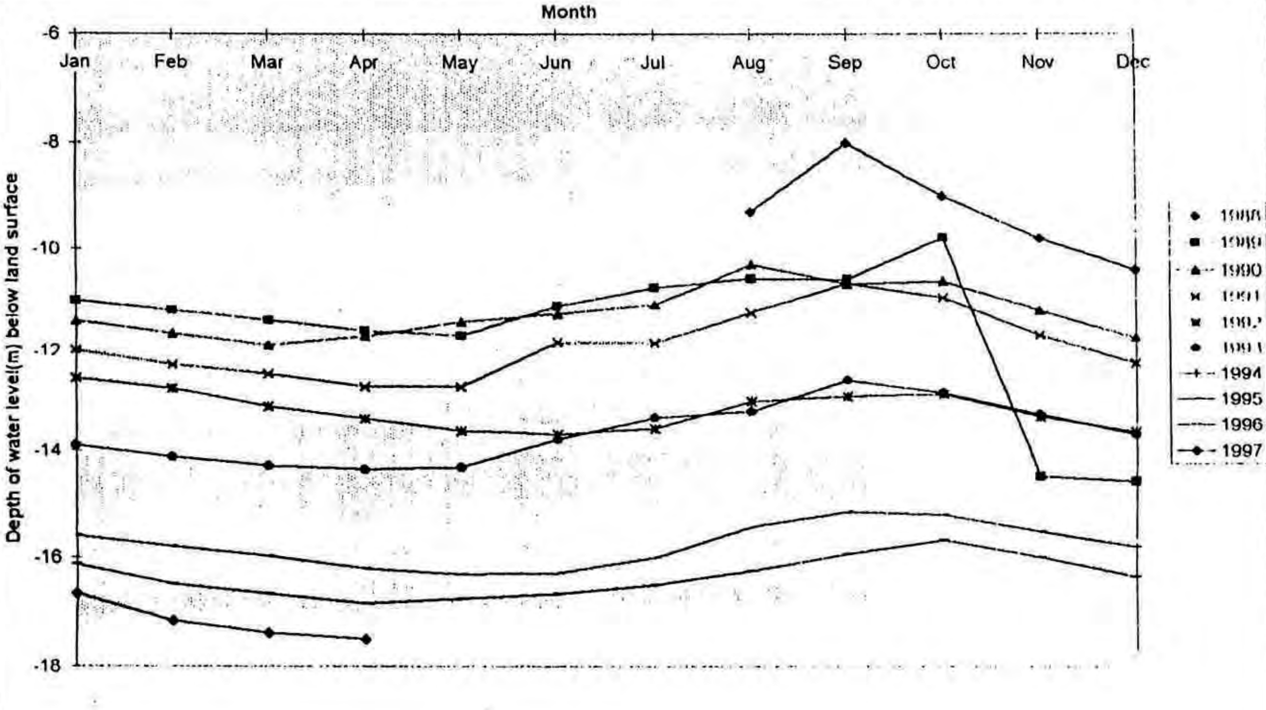


Fig. 4.5: Seasonal Water Level Variations at the Observation Well no. DA13(Sutrapur)

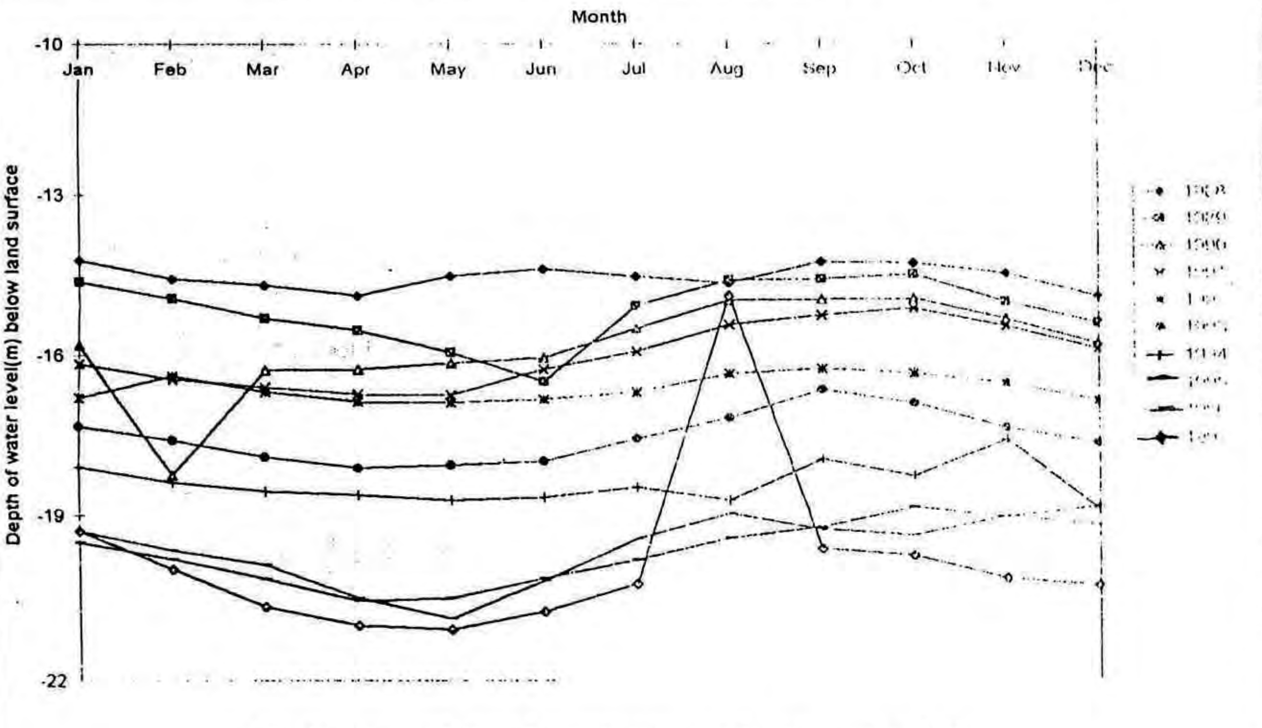


Fig. 4.6: Seasonal Water Level Variations at the Observation Well no DA111(Sultangonj,Mohammadpur)

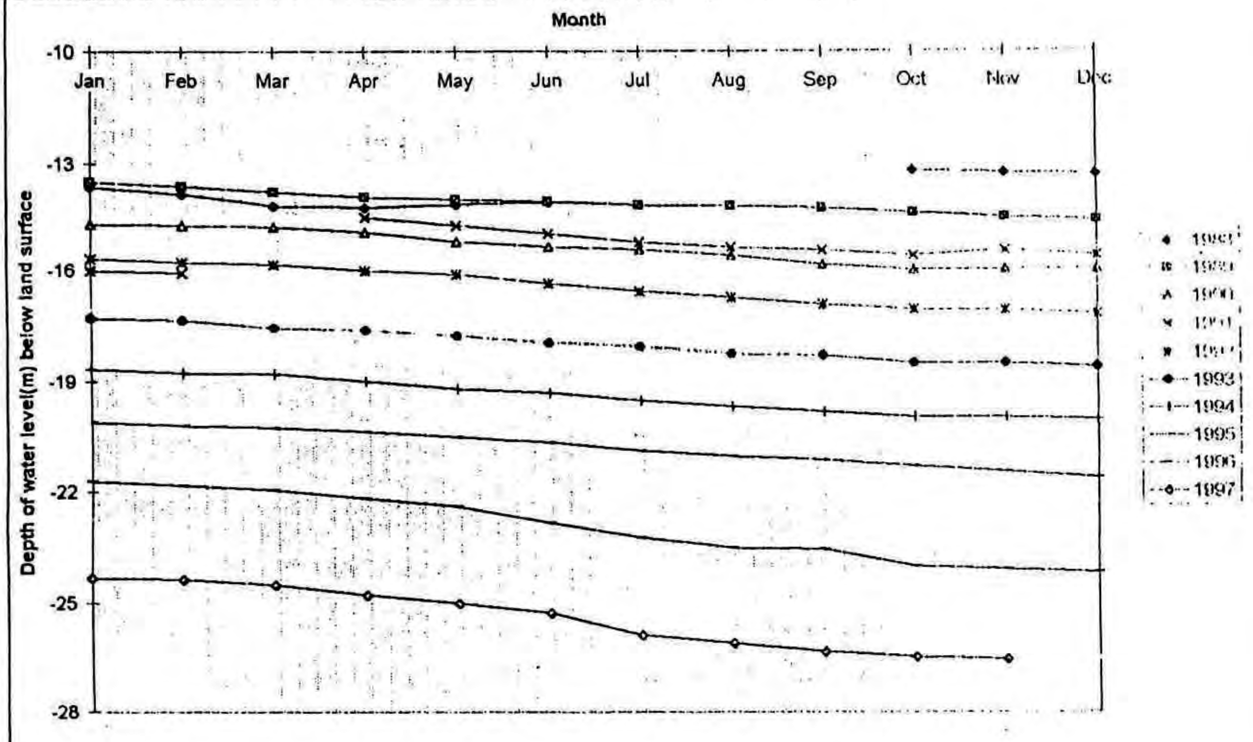


Fig.4.7: Seasonal Water Level Variations at the Observation Well no. DA15(Mirpur)

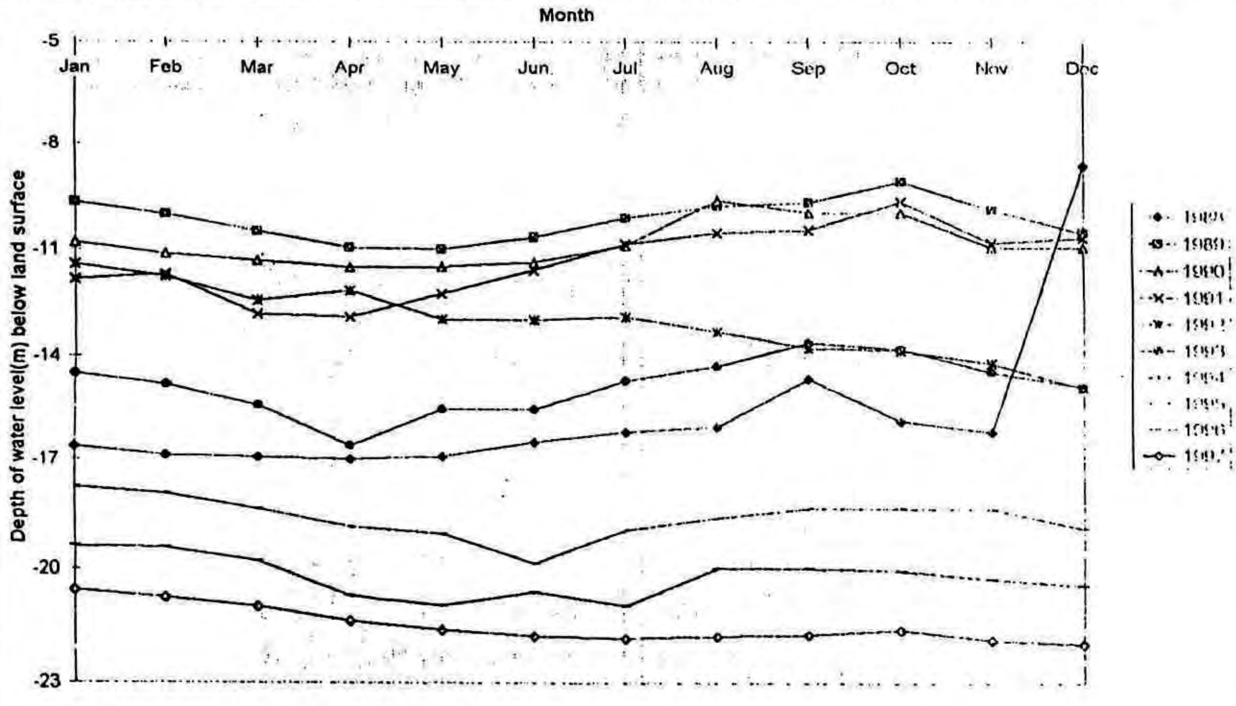


Fig. 4.8: Seasonal Water Level Variations at the Observation Well no. DA[illegible]

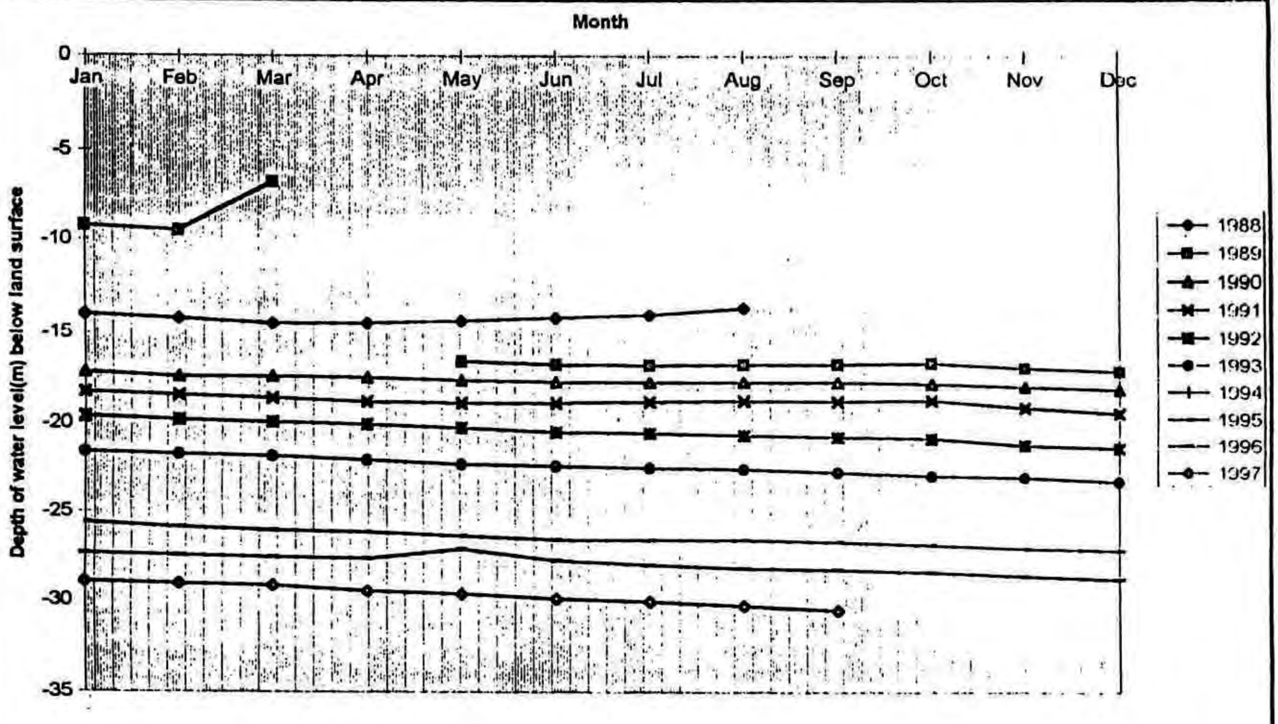


Fig. 4.9: Seasonal Water Level Variations at the Observation Well no. DA123(South [illegible])

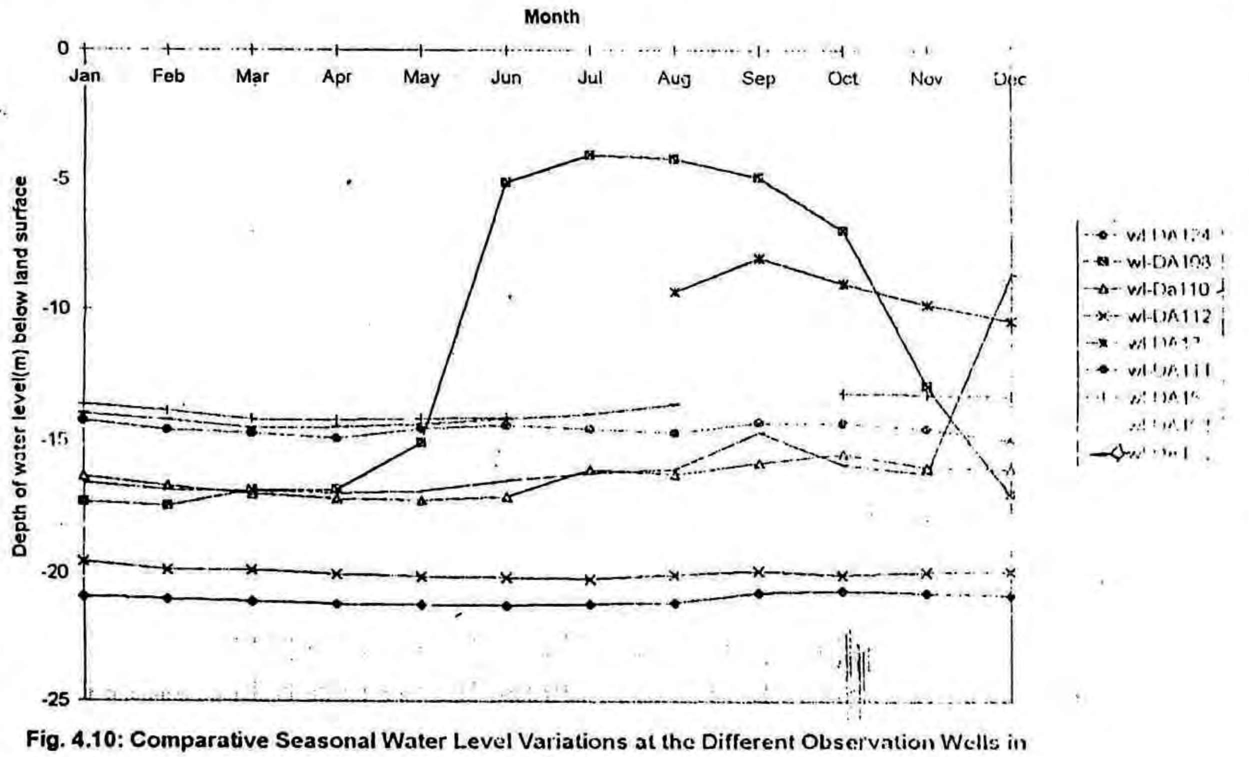


Fig. 4.10: Comparative Seasonal Water Level Variations at the Different Observation Wells in [illegible]

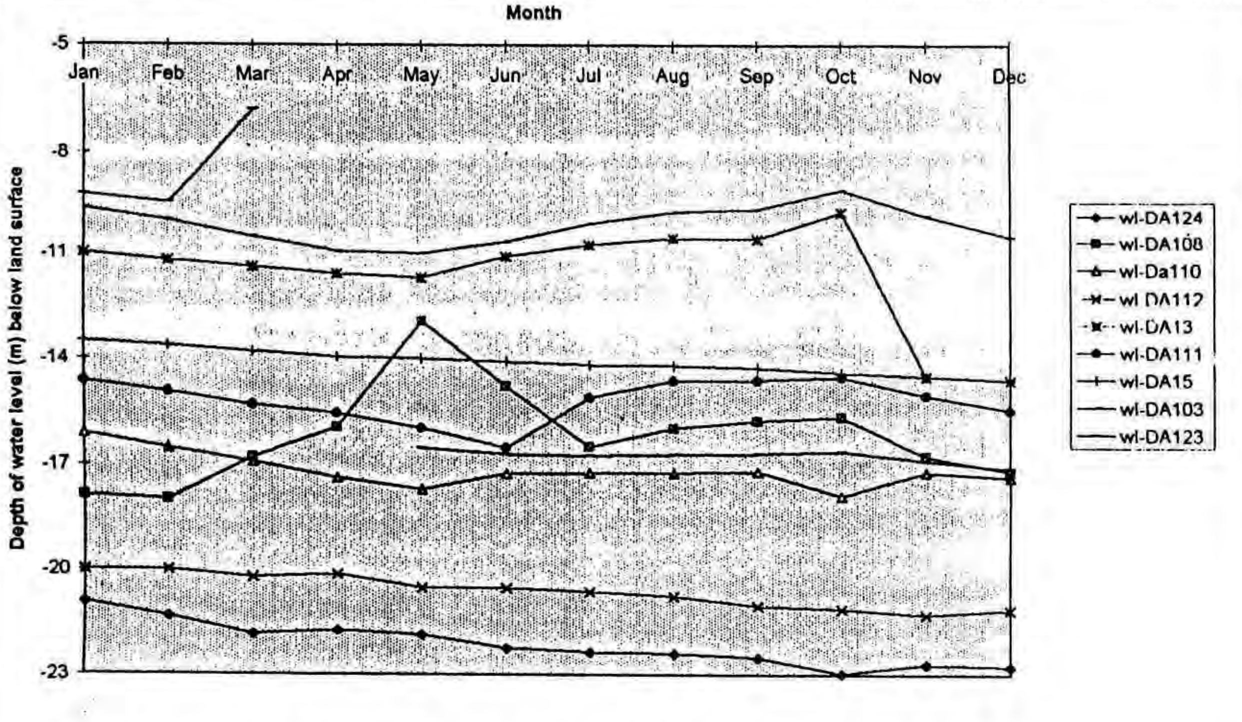


Fig. 4.11: Comparative Seasonal Water Level Variations at the Different Observation Wells in 1989

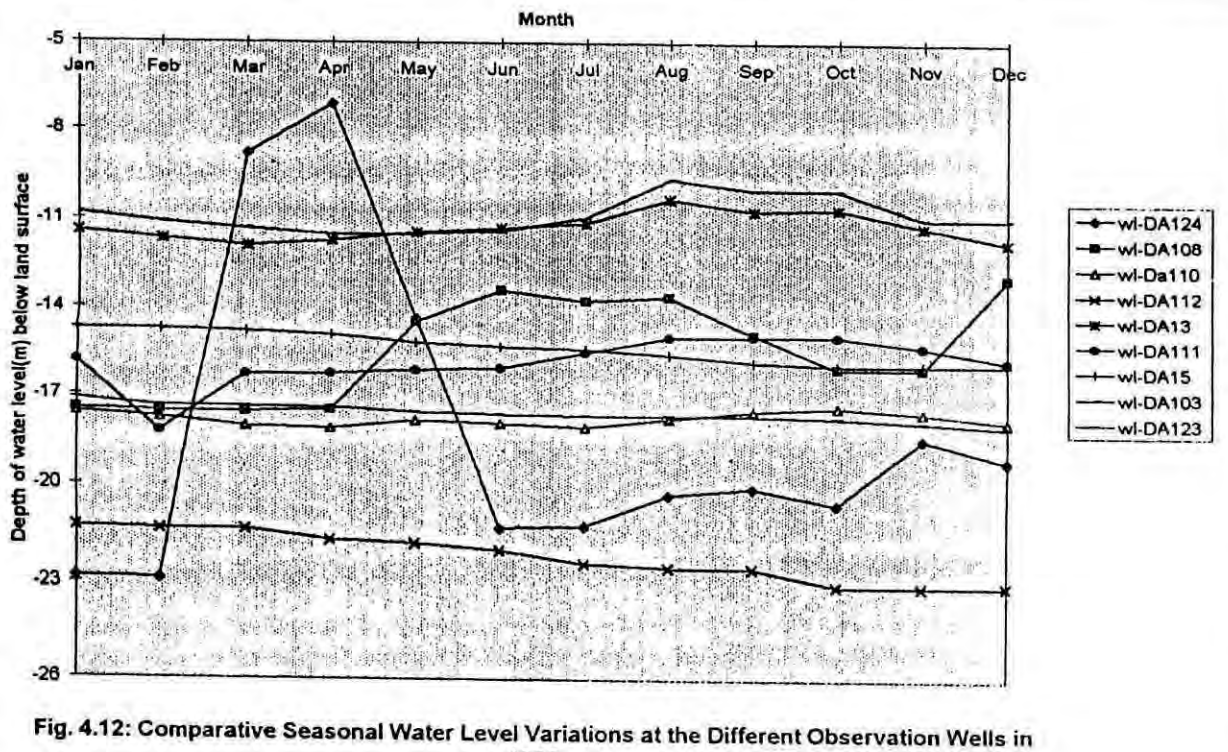


Fig. 4.12: Comparative Seasonal Water Level Variations at the Different Observation Wells in 1990

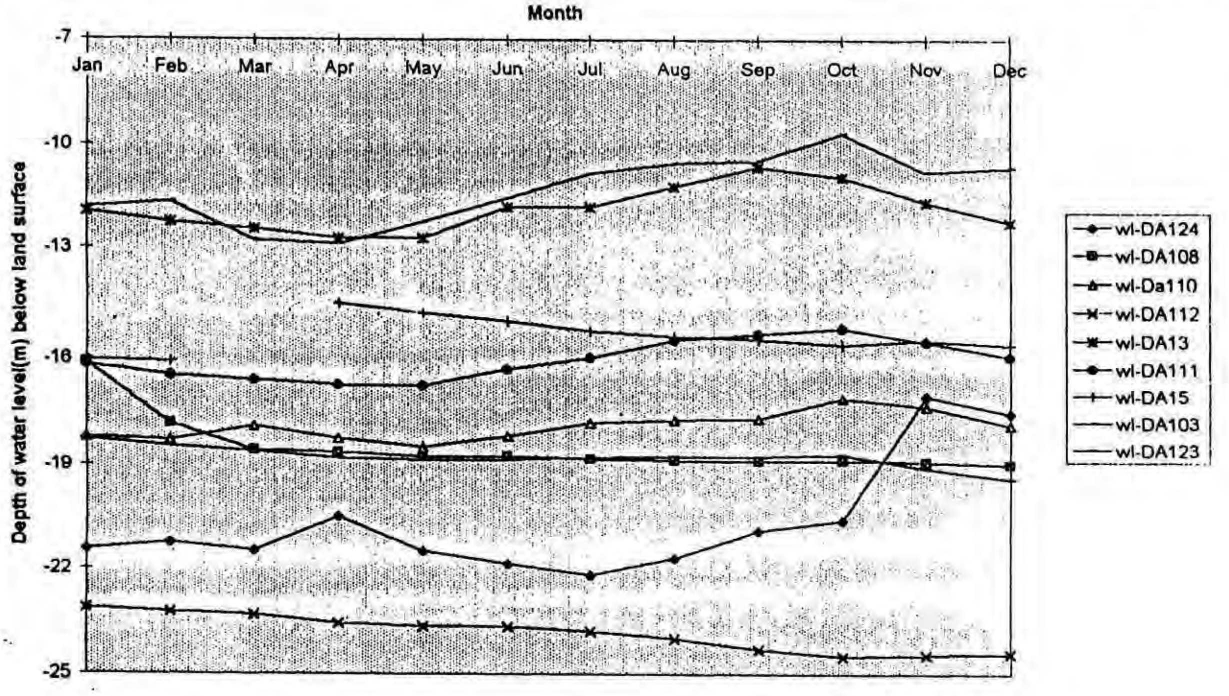


Fig. 4.13: Comparative Seasonal Water Level Variations at the Different Observation Wells in 1991

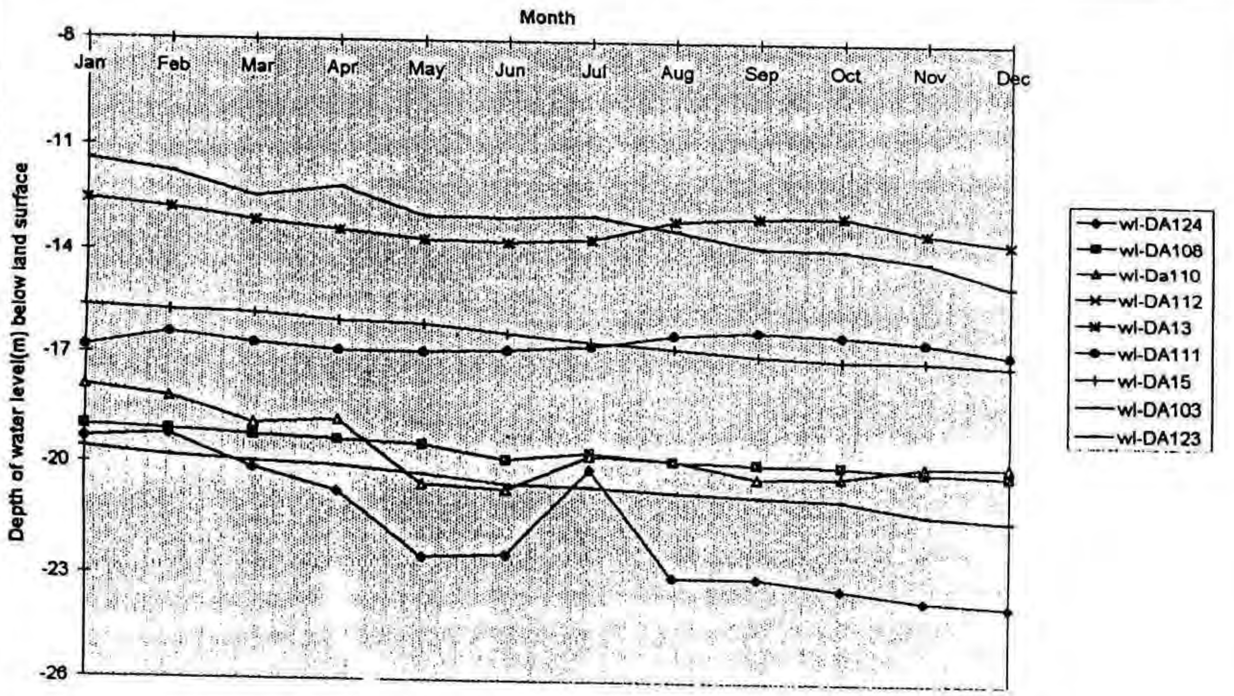


Fig. 4.14: Comparative Seasonal Water Level Variations at the Different Observation Wells in 1992

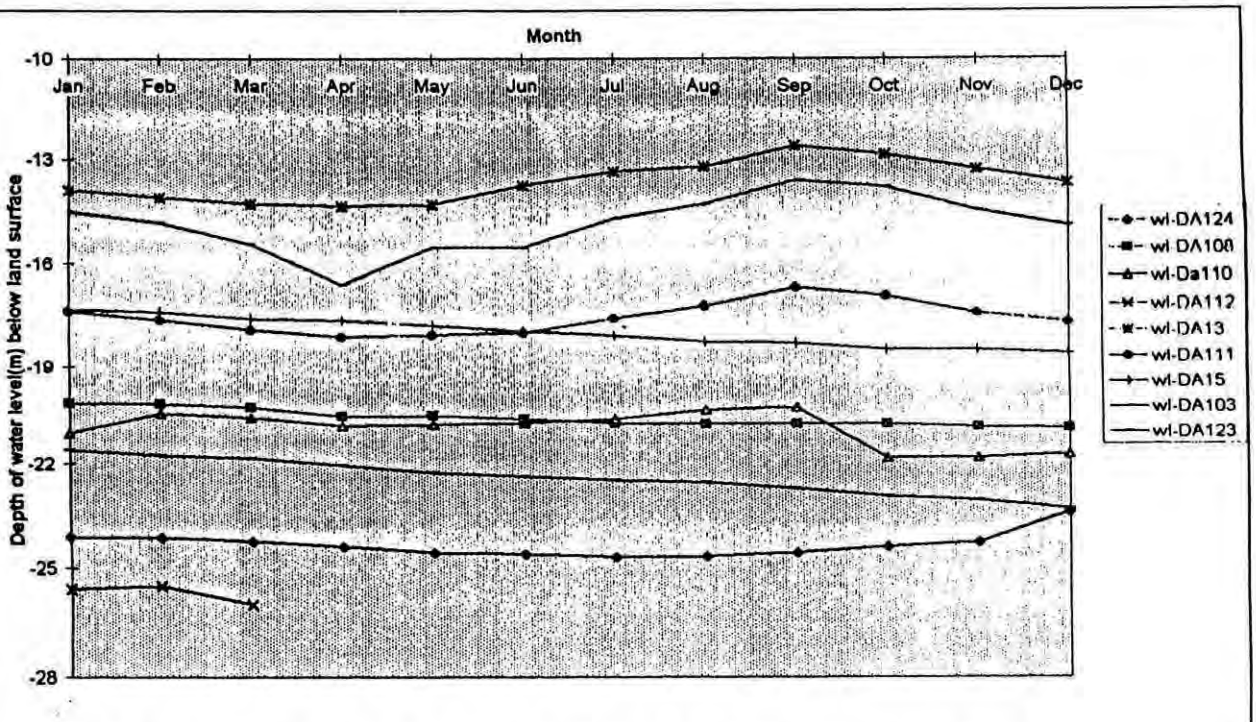


Fig. 4.15: Comparative Seasonal Water Level Variations at the Different Observation Wells in 1993

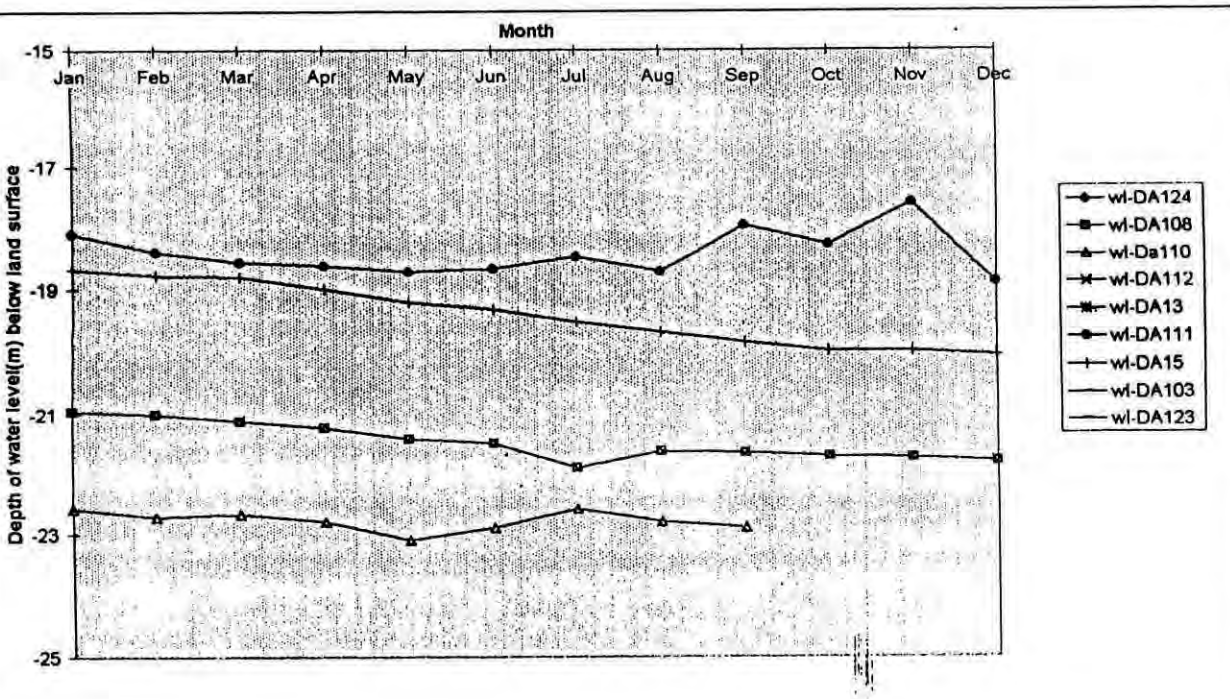


Fig. 4.16: Comparative Seasonal Water Level Variations at the Different Observation Wells in1994

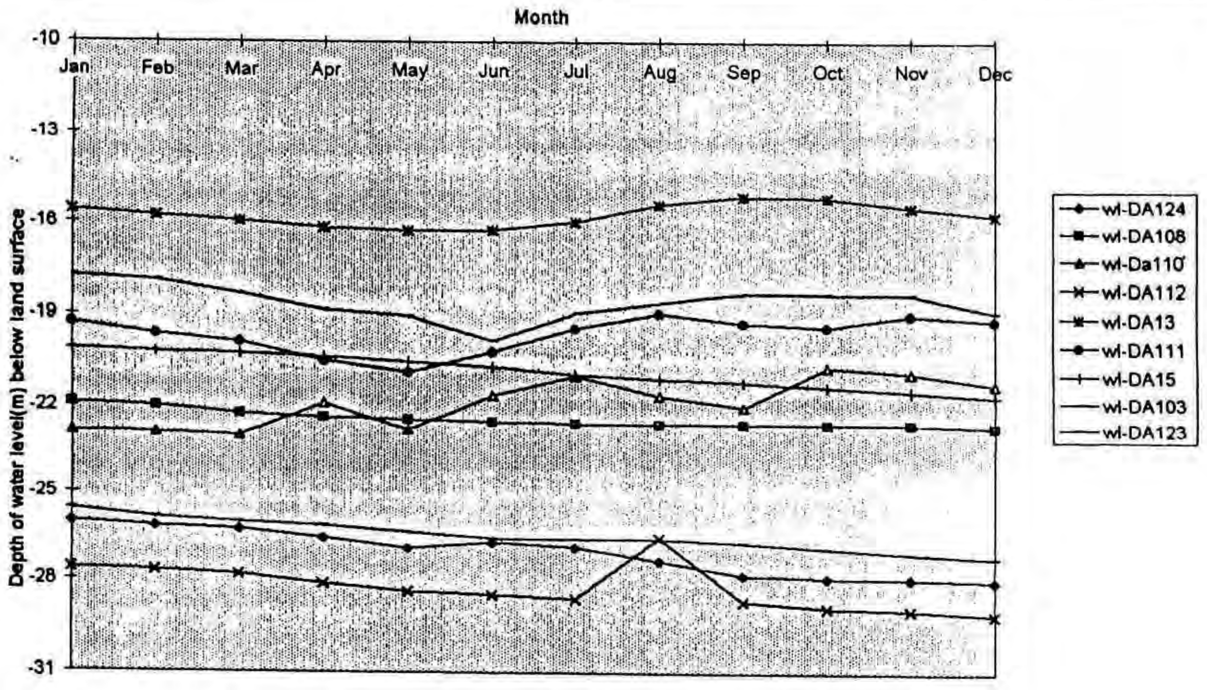


Fig. 4.17: Comparative Seasonal Water Level Variations at the Different Observation Wells in 1995

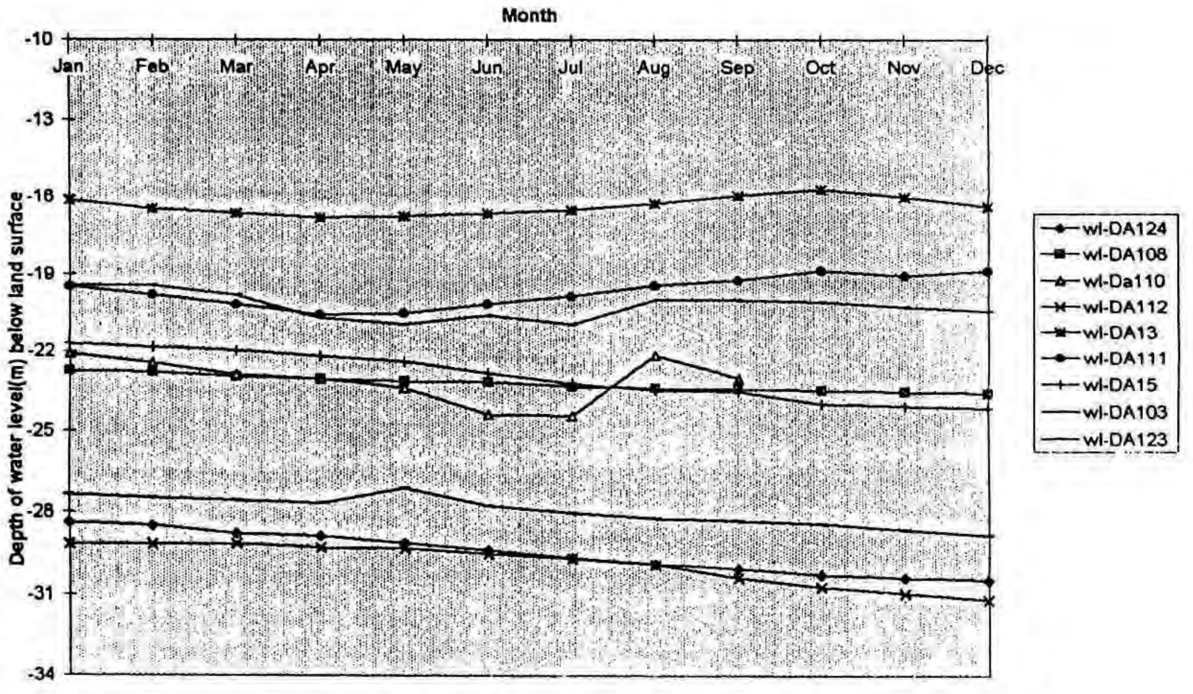


Fig. 4.18: Comparative Seasonal Water Level Variations at the Different Observation Wells in 1996

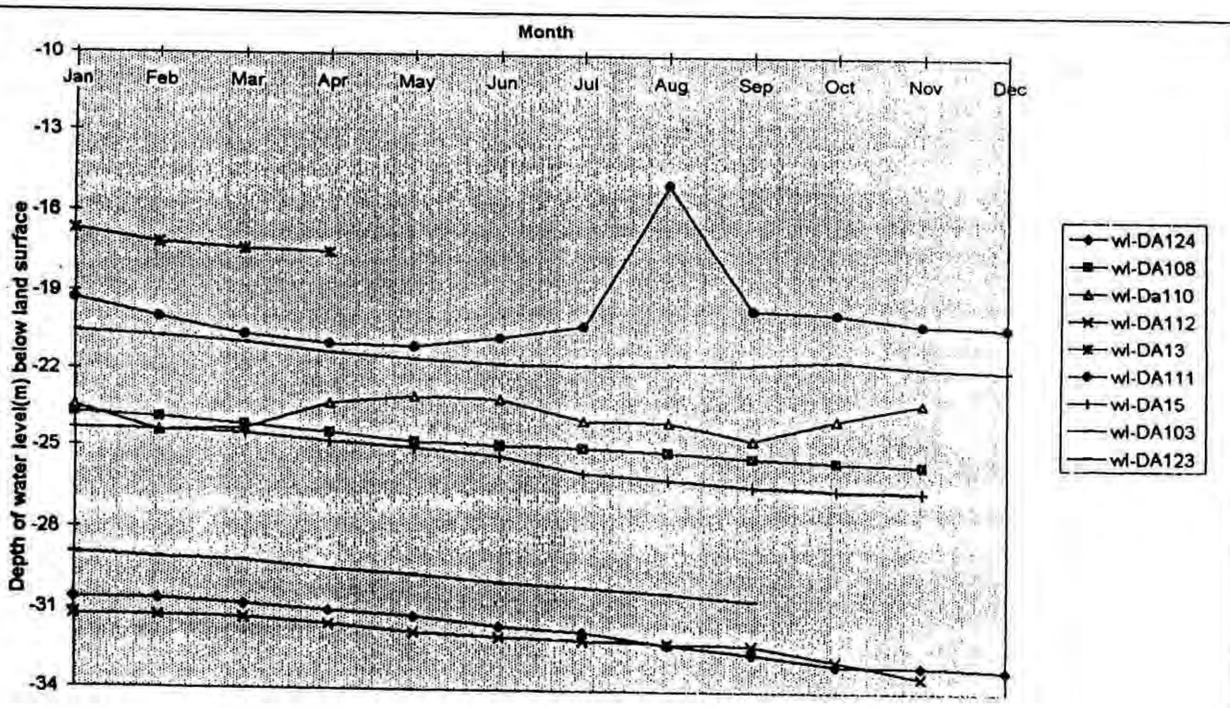


Fig. 4.19: Comparative Seasonal Water Level Variations at the Different Observation Wells in 1997

4.4 Gradual Declination of Ground Water Level

Figs. (4.20-4.29) show the fall of static water level from (1988-1992) and (1992-1997). It has been found from these figures that maximum depth of water level varies form -10.40 m (at Sutrapur Thana in 1988) to -33.16 m (at Motijheel Thana in 1997). Most of the figures have shown a gradual declination of water level. The rates of declination which are tabulated in table 4.2 are significantly greater for the year of (1992-1997) than that of (1988-1992). This implies that the ground water abstraction is being increased with an alarming rate day by day. The rates of declination for the year (1988-1992) at the well no. DA123(South Basabo), DA112(Malibagh), DA15(Mirpur), DA124 (Motijheel) and DA103(Cantonment) were respectively 1.612 m/yr., 1.471 m/yr., 0.738 m/yr., 0.443 m/yr. and 0.227 m/yr.,whereas these values increased to 1.8398m/yr., 1.8386m/yr., 1.862m/yr., 1.8698m/yr. and 1.4301m/yr. respectively for the year (1992-1998). But for the well locations DA13(Sutrapur), DA110(Lalbagh), DA111(South Basabo) and DA108 (Mohammadpur) the rates of declination were 0.469 m/yr., 0.762 m/yr., 0.413 m/yr. and 0.435 m/yr. respectively for the year (1988-1992), whereas these values increased to 0.7838m/yr., 0.8006m/yr., 0.8923m/yr., and 1.1674m/yr. respectively for the year (1992-1997). So it is very clear that the rate of declination is gradually increasing. The declination is more in the inner part of the city than in the peripheral area. The possible causes of this situation may be the result of -

- the excessive abstraction of groundwater in the central city.
- lack of significant recharge.

Hossain(1985) also performed a study on the rate of declination of water table for some observation wells. From his study it was found that the average rate of declination for the central part of the city was 0.27 m/yr. in the early seventies whereas the values increased to 0.45m/yr. in the early eighties.

A sharp change is observed for some observation well such as (Fig. 4.24 & Fig. 4.27). For the case of Fig. 4.24 new deep tubewell installation adjacent to the observation well might have lowered the water table. For the case in fig. 4.29 deep tubewell adjacent to the observation well might have abandoned in that period.

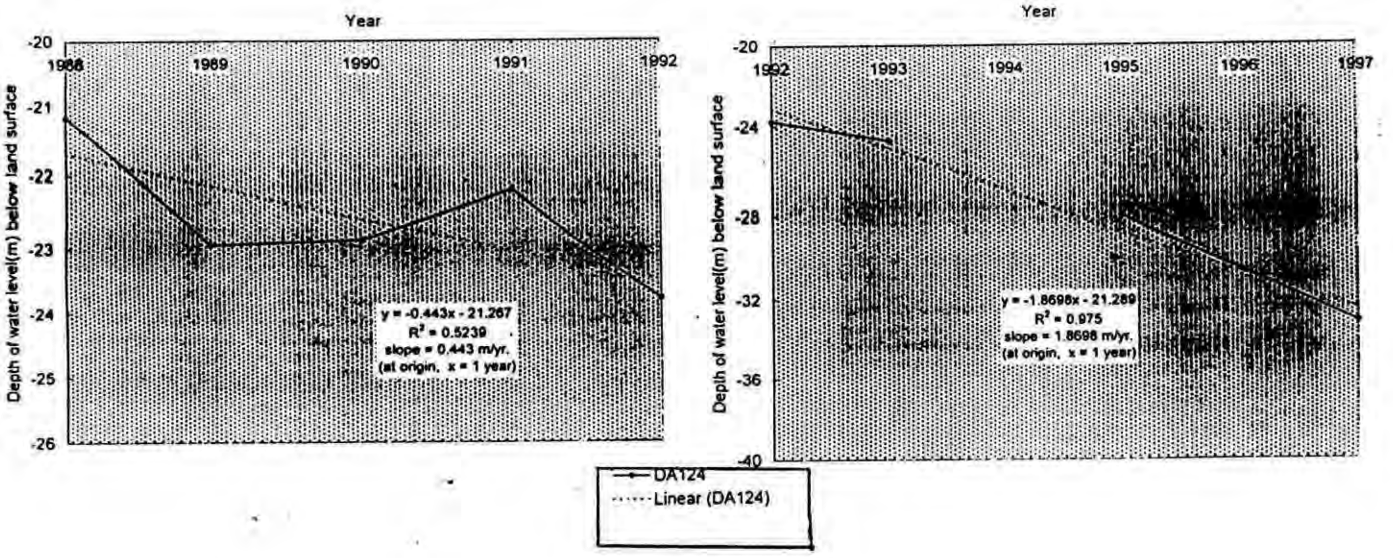


Fig. 4.20: Yearly Water Level Variations at the Observation Well no. DA124(Motijheel)

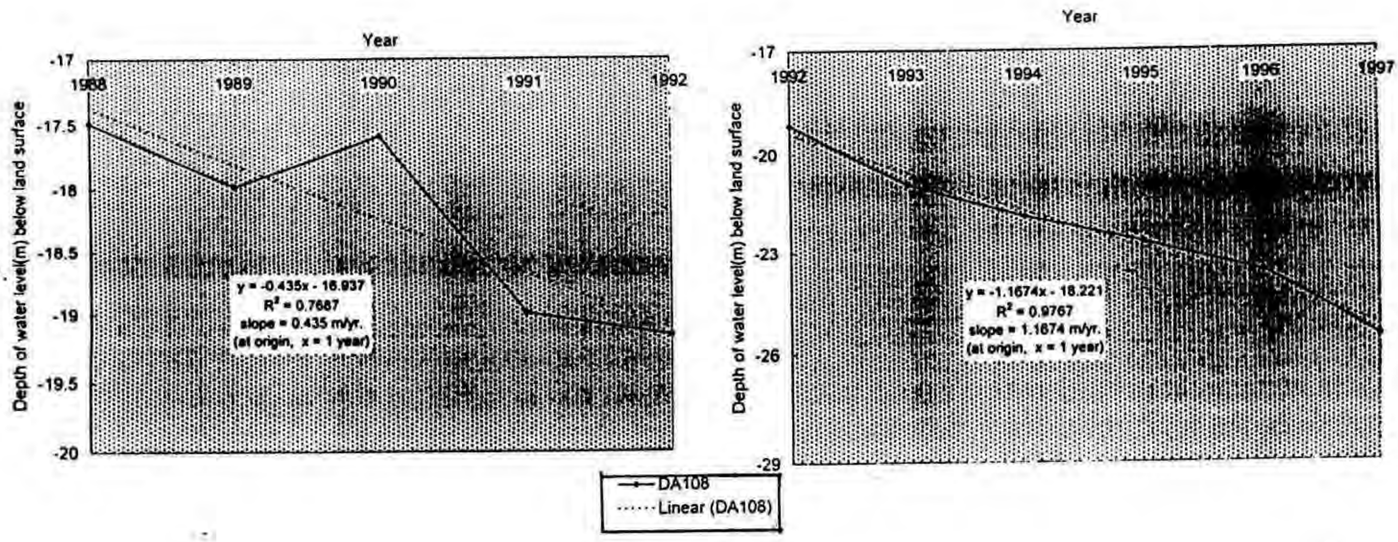


Fig. 4.21: Yearly Water level Variations at the Observation Well no. DA108(Mohammadpur)

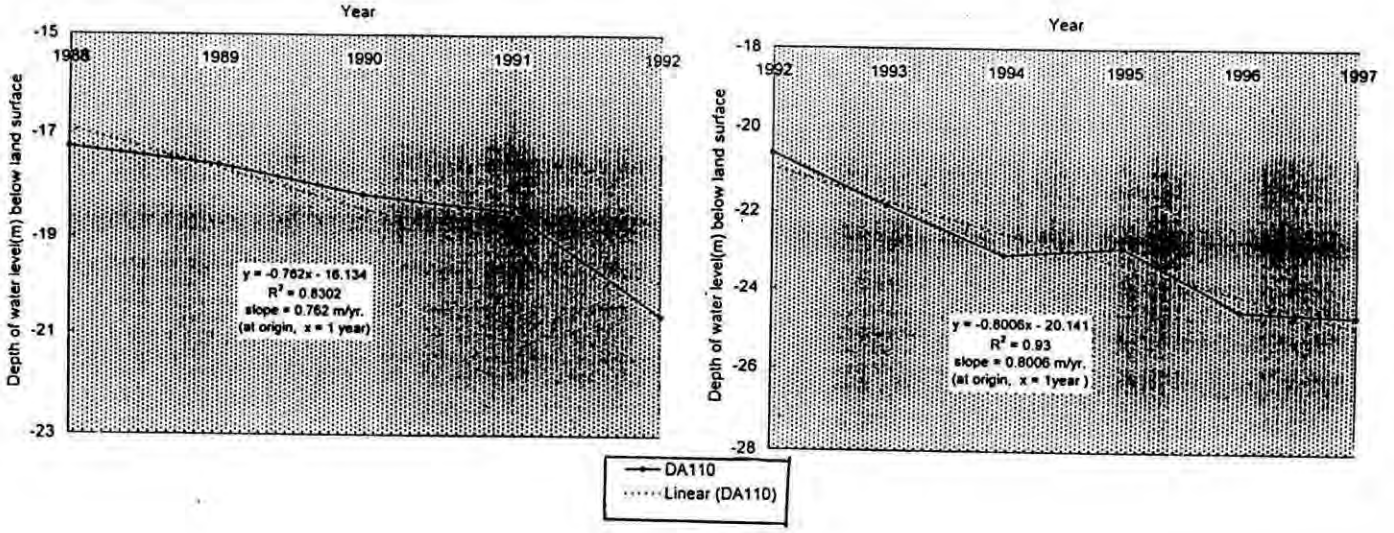
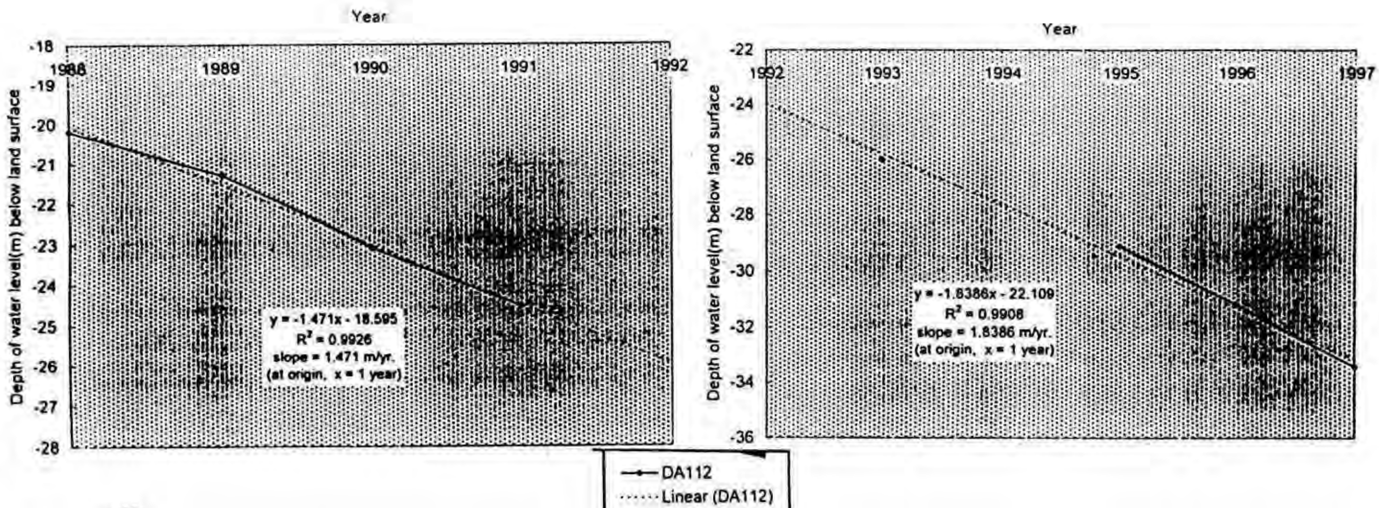


Fig. 4.22: Yearly Water Level Variations at the Observation Well no. DA110(Lalbagh)



4.23

Fig. 4.23: Yearly Water Level Variations at the Observation Well no. DA112(Malibagh)

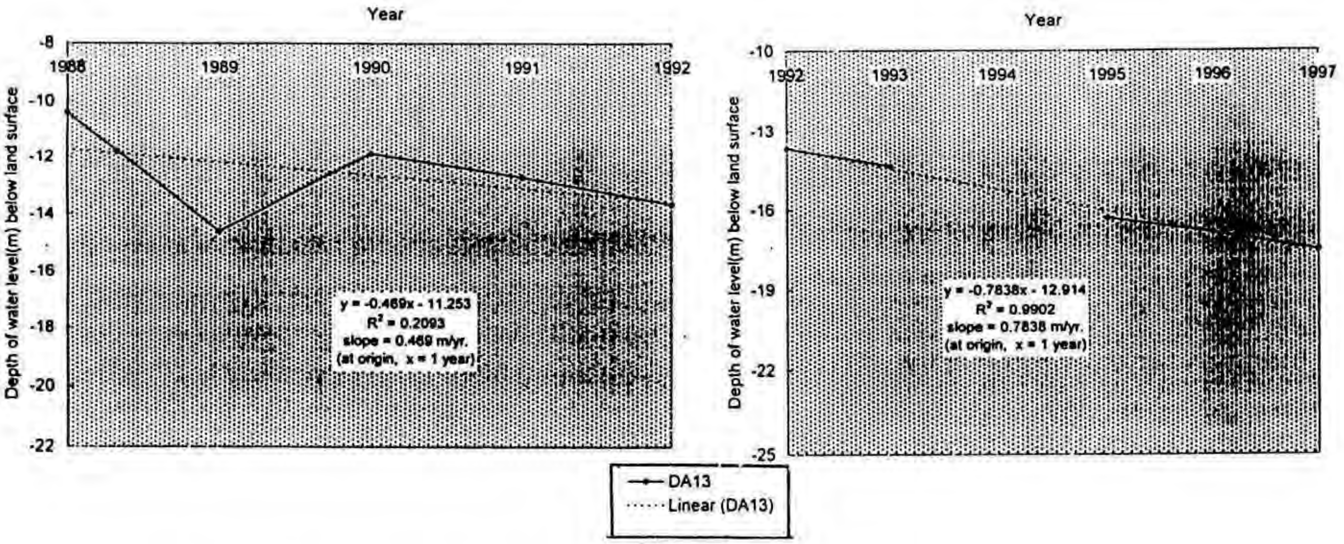


Fig. 4.24: Yearly Water Level Variations at the Observation Well no. DA13(Sutrapur)

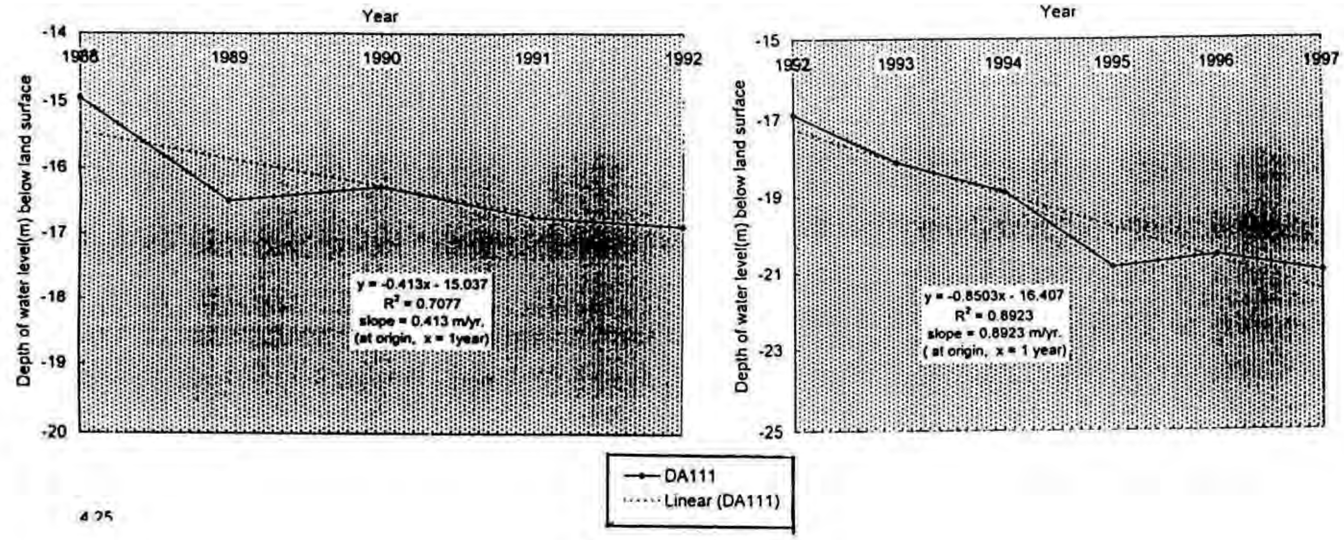


Fig. 4.25: Yearly Water Level Variations at the Observation Well no.DA111(Sultangonj,Mohammadpur)

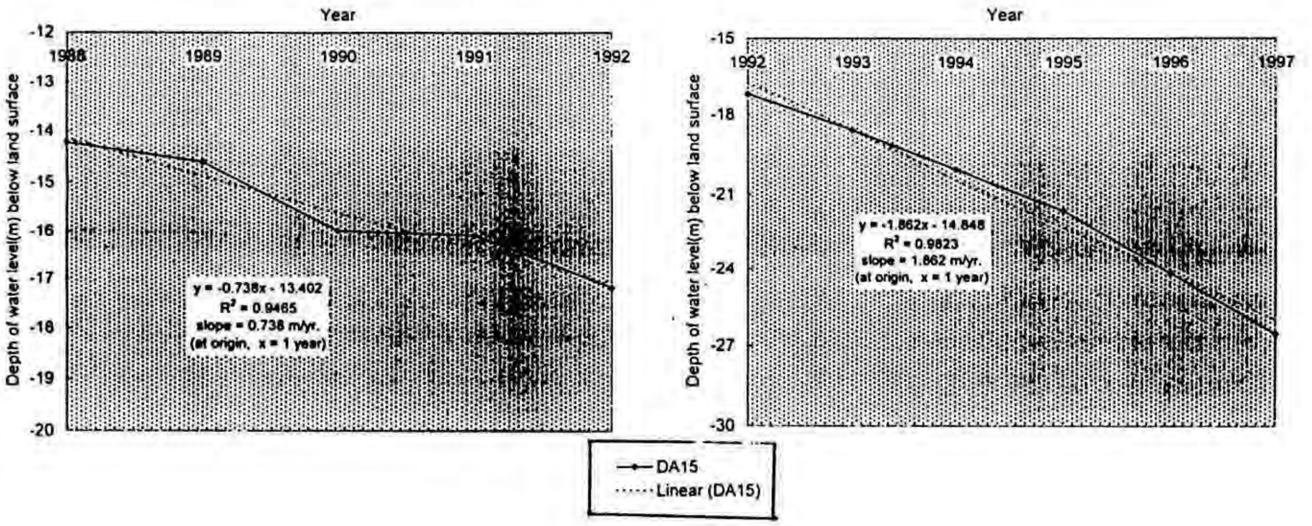


Fig. 4.26: Yearly Water Level Variations at the Observation Well no. DA15(Mirpur)

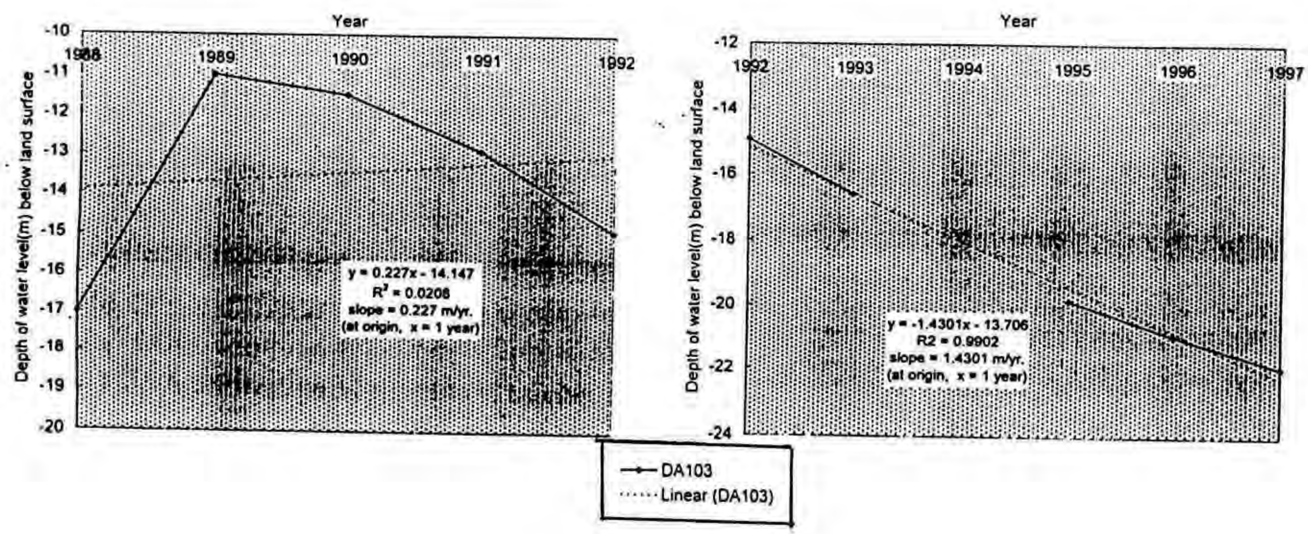


Fig. 4.27: Yearly Water Level Variations at the Observation Well no. DA103(Cantonment)

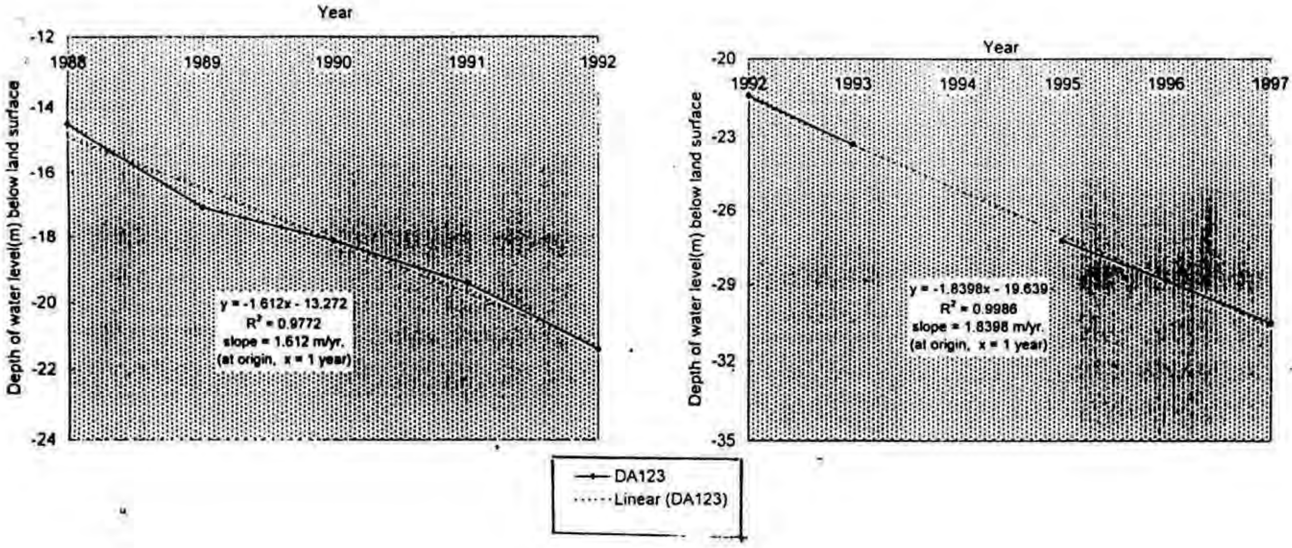


Fig. 4.28: Yearly Water Level Variations at the Observation Well no. DA123(South Basabo)

4.5 Contour Maps of Ground Water Table

Deepest static water level contour maps are shown in Fig. 4.29 and in Fig. 4.30. It is found from these two figures that the potentiometric surface for the regional ground water flow is radial (funnel shaped) towards the central part of the city. Because abstraction is higher in the central part of the city, little or no recharge as most of the areas are paved and deep piles for the construction of high rise buildings also reduce permeability of soil. In 1991 the central part of the city has shown 24m water table contour whereas the value increases to about 42m in 1998. If the situation continues, a large number of tubewells in the central part of the city may be abandoned in near future. Most vulnerable zone is shown in fig.4.30. So in the case of future well development care must be taken for the selection of pumping head strainer depth and well casing .

Moreover the cone of depression expands day by day laterally with the increasing withdrawal of ground water. It is also observed that the expansion of the cone of depression to the north is more rather than to the south-west and south-east. Moreover, the steep slope given by the contours close to the Buriganga river demonstrates that southward spread of cone of depression is countered by the river inflow.

Also the closely spaced contours on the east suggest significant recharge from low-lying, deeply flooded lands lying between Dhaka and the Balu river. In addition horizontal permeabilities are higher in these areas in the north. Expansion of the cone of depression in the north results mainly from the installation of new tubewells as the City is expanding towards the north.

Ahmed et al. (1986) performed a study on the ground water contour of Dhaka city . It was revealed from the study that the water table around the Motijheel area in the year 1975, 1980 and 1986 was respectively 4m, 8m, and 12m. So it is clear that the water table is declining at a very alarming rate.

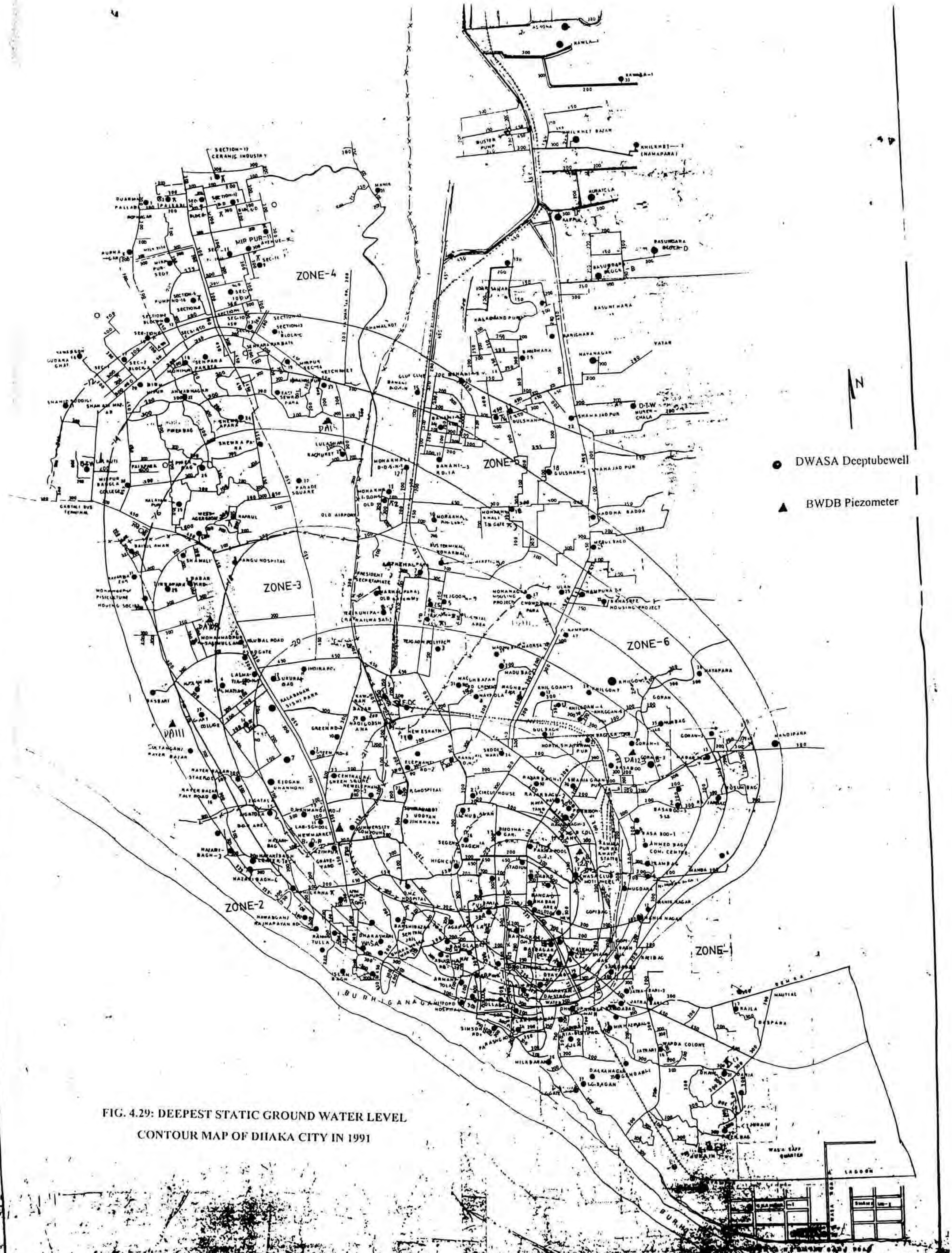


FIG. 4.29: DEEPEST STATIC GROUND WATER LEVEL CONTOUR MAP OF DHAKA CITY IN 1991

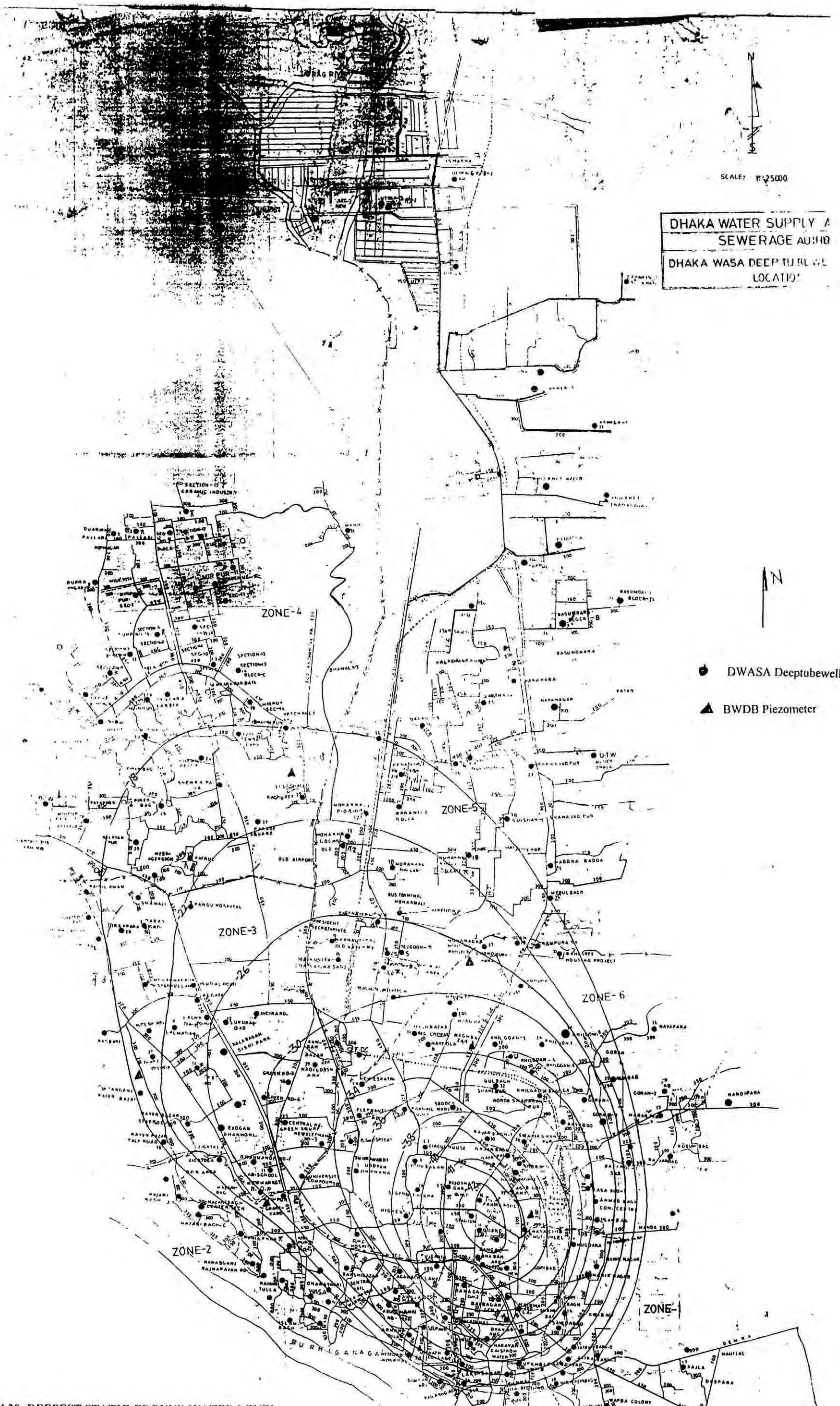
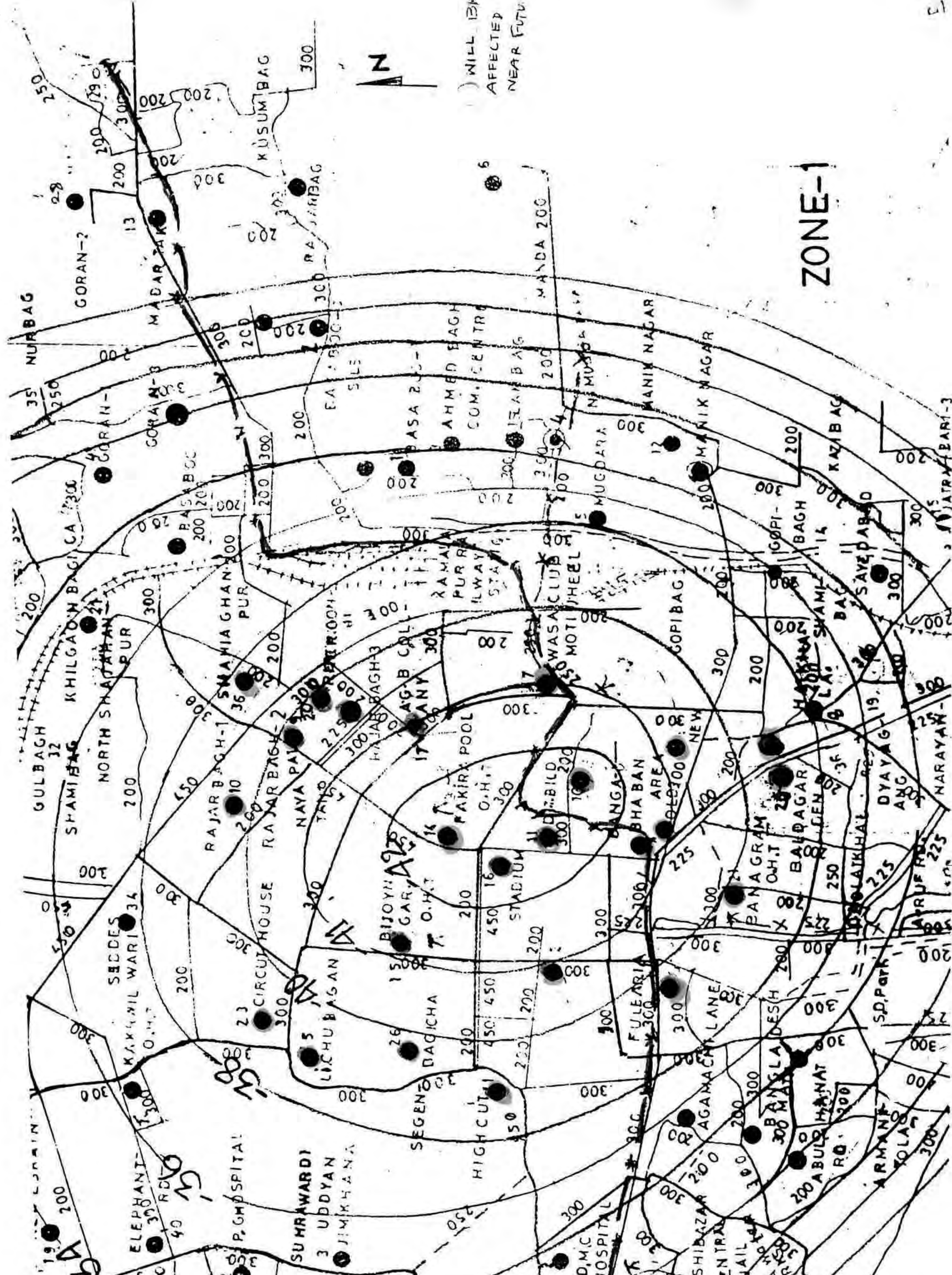


FIG. 4.30: DEEPEST STATIC GROUND WATER LEVEL CONTOUR MAP OF DHAKA CITY IN 1998


ZONE-1

4.6 Rate of Decline of Groundwater Table

The rate of decline is calculated on the basis of DWASA static water level (SWL) data and BWDB observation well data. Both are tabulated in table 4.1 and in table 4.2. Although these two tables are not solely comparable as the locations are not same, but it is clear that DWASA data show more rate of decline than BWDB observation well data. The main reason is BWDB observation well penetrates less than 45 m at depth whereas DWASA tubewells are installed greater than 50 m at depth. Actually DWASA data gives the rate of decline for the main aquifer.

Table 4.1: Maximum Rate of Lowering of Water Table of Some DWASA Tubewells

SL. No.	Name of DTW	Stationary water level (m)		Pumping water level at 2 cusec	Rate of lowering of water table (m/yr.)
		Present (1998)	Previous		
1	Gandaria (R)	28.95	-	46.63	-
2	Mirpur-1, Primary School(N)	32.91	16.76 (1989)	50.90	1.76
3	Rajarbagh(R)	41.14	23.16 (1989)	53.94	1.99
4	Gopibag(N)	35.96	Hatkhola 22.86 (1992)	64.61	2.18*
5	Circuit House (R)	38.10	22.25 (1990)	49.07	1.98
6	Gulbag(R)	41.14	28.04 (1993)	63.09	2.62
7	Sukrabad(R)	30.78	13.41 (1981)	40.23	1.08
8	Dayagonj(R)	34.74	9.14 (1976)	57.60	1.16
9	Mohakhali Lab (R)	30.78	-	47.24	-
10	Pirerbag (R)	24.08	7.31 (1982)	50.29	1.04
11	Abul Hasnat Road(R)	23.16	-	57.30	-
12	Dhanmondi E.Math(N)	25.14	23.07 (1995) DRA-7	42.97	0.69

N = New
R = Replacement

Table 4.2: Maximum Rate of Lowering of Water Table of Some BWDB Well Locations

Observation well No. and Location		Average decline per year (m/yr.)	
Well No.	**Location**	**1988 - 1992**	**1992 - 1997**
DA 124	Motijheel	0.4430	1.8698
DA108	Mohammadpur	0.4350	1.1674
DA110	Lalbagh	0.7620	0.8006
DA 112	Subujbag (Malibag)	1.4710	1.8386
DA 13	Sutrapur	0.4690	0.7838
DA 111	Mohammadpur (Sultangonj)	0.4130	0.8923
DA 15	Cantonment	0.7380	1.8620
DA 103	Cantonment	0.2270	1.4301
DA 123	Subujbag (South Basabo)	1.6120	1.8398

CHAPTER 5

ANALYSIS OF POSSIBLE EFFECTS OF EXCESSIVE GROUND WATER ABSTRACTION

5.1 General

Water is the most important biological fluid for living beings. Ancient citizen grew in river valley where the land was fertile and water was plenty. If one or both the resources deteriorate life becomes impossible. Most of the water requirement of the city comes from under ground sources. Obviously the exploitation of the ground water has its own limit. But how far this ground water could provide adequate supply for the city dwellers is the burning question for the city planners. Some possible effects associated with excessive ground water abstraction are described below.

5.2 Effect on Well Performance

Due to rapid lowering of static water level (SWL), severe problems may arise regarding tubewells management. Two types of pump namely turbine and submersible are used by DWASA to abstract groundwater. Pumps are fixed at a particular head for maximum efficiency.When water table sharply falls -

- Effective head (lifting capacity) of pumps reduces and even the pump can discharge on the ground level at zero head if the water table is at a greater depth. In that case another booster pump is needed for increasing pressure to supply water in the pipe network, thereby pumping cost increases.
- Effective aquifer thickness will be reduced. So the casing around the strainer may require to be lowered, thereby re-sinking of tubewells are required at a greater depth with more housing length . As the aquifer thickness reduces, velocity of flow

towards the well will be increased. High entrance velocity will cause to move the fine formation particles towards the well and to accumulate around the well. The process is termed as mechanical clogging which increases well losses. So regeneration is to be practiced at appropriate time to rehabilitate the clogged wells. So well management cost will be increased and water supply may also be hampered.

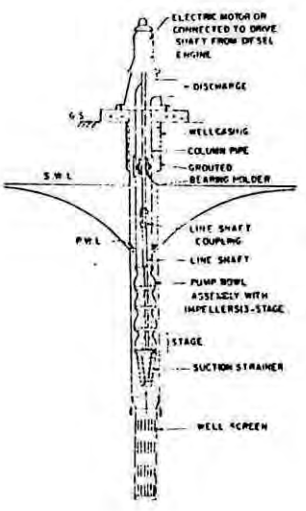


Fig. 5.1: Turbine Pump

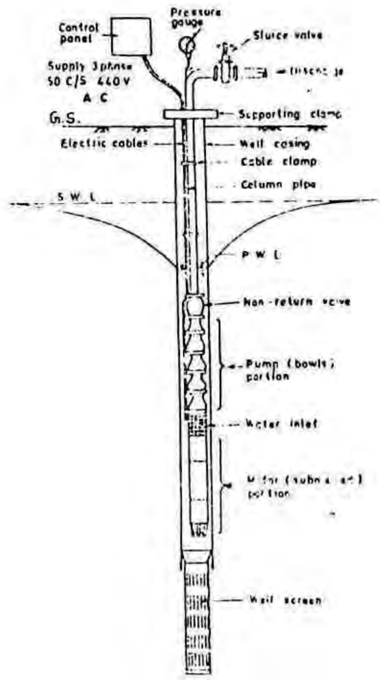


Fig. 5.2: Submersible pump

- The shaft of turbine pump and the motor of submersible pump along with its column pipe need to be lowered when the water table is considerably at a lower depth. In that case a greater tortional thrust will be induced on the shaft of turbine pump . So there is always a higher risk of failure of the pumping system. This is why submersible pumps are being used by DWASA for further tubewell installations. But repairing of submersible pump is very difficult as all mechanism is under water. Once a submersible pump goes under difficulty its performance and longevity cannot be regained further.

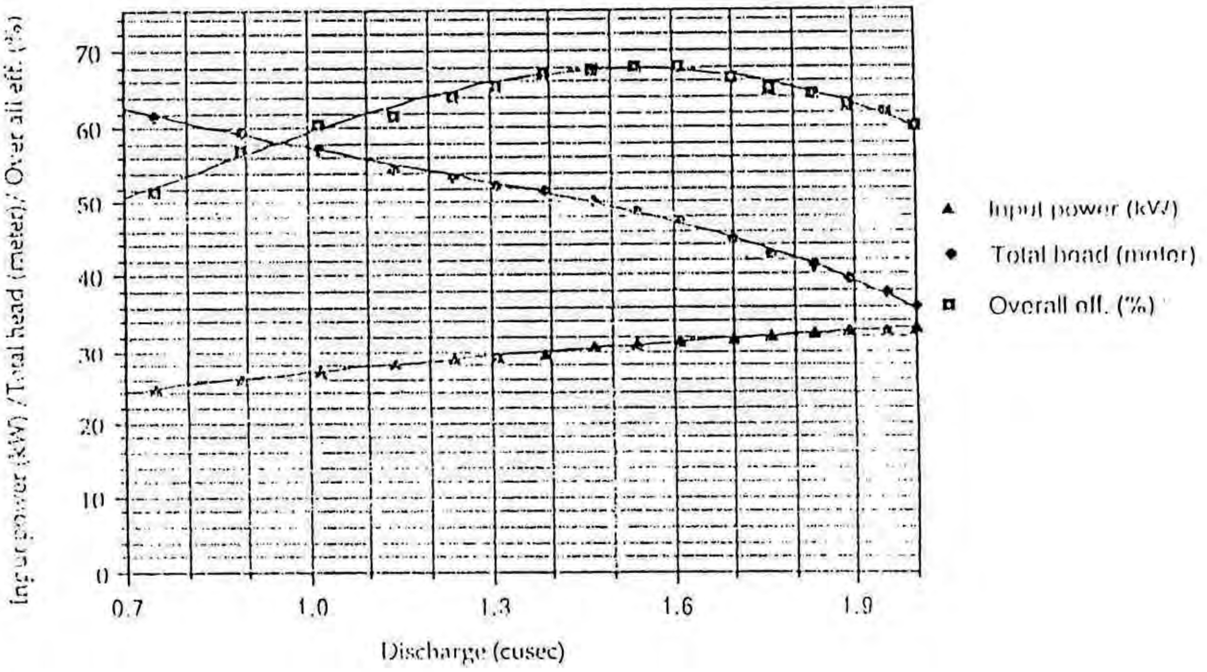


Fig.5.3: Performance Curve of a Submersible Pump
(Source: DWASA)

From fig. 5.3 it is shown that a submersible pump is fixed at 50 m head with a maximum efficiency of 67.5%. As the water table falls, the head difference increases, thereby discharge also decreases. An analysis on output of well can be performed considering the water table-fall by 5m.

At 50m head discharge = 1.47 cusec

At 55m head discharge = 1.15 cusec (From fig. 5.3)

∴ Discharge reduces by 0.32 cusec

If the pump operates 18hr./day, then the loss per day

$= 0.32 \times (18 \times 3600)$

$= 20736\ ft^3$

$= 20736 \times 28.31$ liter ($1\ ft^3 = 28.31$ liter)

$= (58.70 \times 10^4)$ liter

At 50m, discharge $= 1.47 \times 18 \times 3600$ (From fig.5.3)

$= 95256\ ft^3$

$$=95256 \times 28.31 \text{ liter}$$

$$= (269.67 \times 10^4) \text{ liter}$$

$\therefore$ % of loss w.r.t rated discharge = $[(58.70 \times 10^4)/(269.67 \times 10^4)] \times 100\%$

$$=21.76\%$$

So, from this analysis it can be concluded that as the water table falls, the discharge as well as efficiency reduces significantly.

An analysis of abstraction per tubewell vs. year in fig. 5.4 shows a declining trend of production per tubewell. Among other parameters fall of water table is one of the most important parameter for such declining trend.

Dhar (1995) performed an analysis on well performance versus water table. From his analysis it was also found that with the decrease of water table pumping rate also decreased.

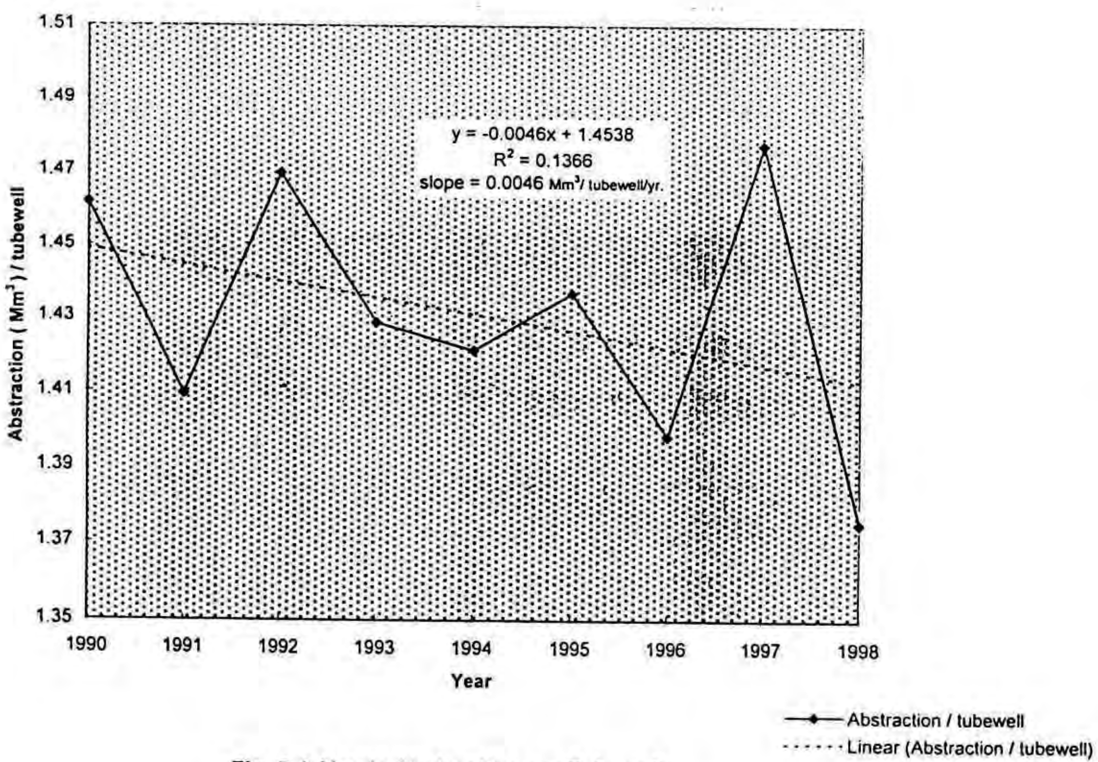


Fig. 5.4 Yearly Abstraction per Tubewell

5.3 Effect on Surface Water Reservoir and Ground Water Quality

Ground water has an important ecological function as a part of the natural water cycle. Ground water feeds surface waters and during dry season most of the surface effluents are ground water. If the water table prevails below the bottom surface of surface reservoirs or effluents, feeding of water to them cannot be possible. So the aquaculture will be hampered if alternate measures are not considered.

Ground water quality deterioration i.e. increase of nitrate may also happen due to creating of more storage space of waste water disposal. Moreover there is a threat of arsenic contamination if ground water is extracted continuously.

5.4 Effect on Soil Moisture

Soil-Water Zone:

Temporarily, the soil water zone may contain water in excess of capillary water from rainfall or irrigation. In fact, this water is used by the plants. This gravitational water drains gradually through soil under the influence of gravity. How fast this water will drain, depends on some factors such as soil texture, soil structure, hydraulic conductivity, soil profile conditions and depth of water table. Except water table other parameters can be assumed as constant. As the water table falls, the rate of drainage will be increased thereby reducing the moisture content of the root-zone.However it is not a permanent case as rain water significantly contributes to the root zone.

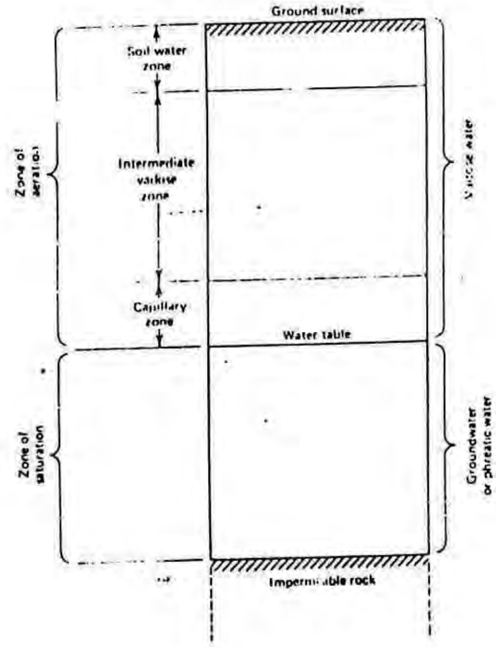


Fig. 5.5 Division of Subsurface Water.
Source: Todd (1980)

The Intermediate Vadose Zone extends from the lower edge of the soil water-zone to the upper limit of the capillary zone. The zone serves primarily as a region connecting the zone near ground surface with that near water table through which water moving vertically downward must pass. Non-moving vadose water is held in place by hygroscopic capillary forces. Water-vapor may not contribute near to the root zone when the water table is at a high depth.

The Capillary Zone extends from the water table up to the limit of capillary rise of water. The capillary zone will vary inversely with the pore size of soil. Table 5.1 shows typical capillary rise for different soils.The root zone of Dhaka City can be considered as clayey-fine sand whose capillary rise may also help to contribute to the immediate vadose zone, thereby helps to enrich soil-water zone with vadose water.

Table 5.1 Capillary Rise in Sample of Unconsolidated Materials

Material	Grain Size (mm)	Capillary Rise, cm
Fine gravel	5-2	2.5
Very coarse sand	2-1	6.5
Coarse sand	1-0.5	13.5
Medium sand	0.5-0.2	24.6
Fine sand	0.2-0.1	42.8
Silt	0.1-0.05	15.5

Source: Todd (1980)

5.5 Effect on Buoyancy

Gravitational water filling up the pores of a soil exerts buoyant forces similar to any surface water. The statement is also valid for every type of soil, even for clays. The buoyant force helps to reduce the dead-weight of a structure.

A raft-supported building with a basement extending below water table is acted on by hydrostatic uplift or buoyancy force. This force increases by 9.8 KN./m^2 as the water table rises by 1 m and decreases by the same amount as the water table falls by 1 m. Taking the beneficial effect the downward load of the structure can be increased by the same amount of buoyancy. The danger associated with buoyancy many also be encountered where the horizontal forces acting on a foundation are strong compared to the corresponding vertical ones. In this case buoyant forces can reduce the condition of stability of erected structures.

Buoyant Force Reduces the Weight of Soil Strata Significantly:

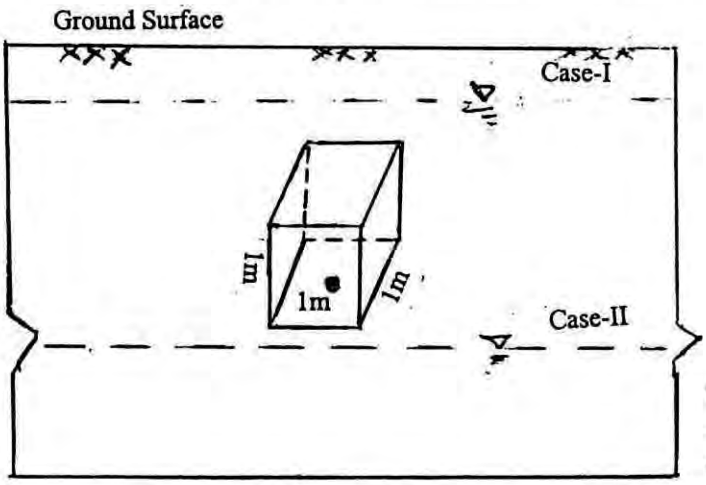


Fig. 5.6 Effect of Buoyancy on Soil Stratum Due to Fall of Static Water Level.

A (1 m x 1 m x 1 m) control volume of soil mass is considered to understand the effect.

Volume of soil mass, V = 1 m^3

Assume sp. gravity of soil (saturated) = 2.65

Density of water, $\rho = 10^3$ kg/m^3

Density of soil $\gamma_{sat} = 2.65 \times 10^3$ kg/m^3

Buoyant force = V. ρ . g

$= 1 \times 10^3 \times 9.81$

= 9810 N

Real weight of the soil mass W = V .γ_{sat} . g

$= 1 \times (2.65 \times 10^3) \times 9.81$

= 25996 N

For case-I

As the soil mass is fully submerged under water, the buoyant force will act upward on it.

So, the apparent weight of the soil mass, $W' = W - V.\rho.\ g$

$= (25996-9810)$ N

$= 16186$ N

For Case-II

The water level is lowered and the effect of buoyancy is no longer effective. So the weight becomes 25996 N

$\therefore$ The effect of unsubmergence is obviously an increase in wt.

% increase of weight = [9810 / 25996] x 100 %

= 37.7%

It is obvious that this increment of weight will be subjected to compact soil layer.

5.6 Effect on Land Subsidence

For the purpose of analysis, it is considered a one- dimensional stress equilibrium on an arbitrary plane through a saturated geological formation at depth. A one-dimensional concept means that the soils and rocks are stressed in the vertical direction.

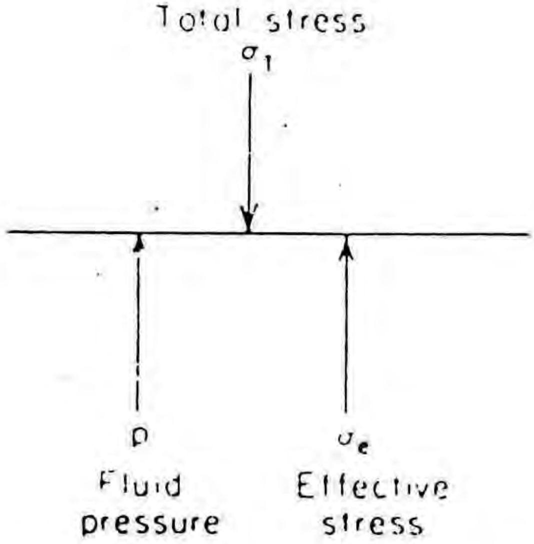


Fig. 5.7 Total stress , Effective Stress and Fluid Pressure on an Arbitrary Plane Through a Saturated Porous Medium.

Where,

σ_T = Total stress acting downward on the plane.

It is due to the weight of overlying rock and water

p = Pore water pressure

σ_e= Effective stress

σ_T (Total stress) is borne in part by granular skeleton of the pours medium and in part by the fluid pressure P of the water in pores. The portion of the total stress that is not borne by the fluid is called the effective stress . It is this stress that is actually applied to the grain of the porous medium.

Rearrangement of the soil grain and the resulting compression of the granular skeleton is caused by change in the effective stress, not by change in the total stress. The two are related by the simple equation

$\sigma_T = \sigma_e + p$................(i)

in terms of the changes

$d\sigma_T = d\sigma_e + dp$ ....(ii)

The weight of soil and water overlying each point in the system often remains essentially constant through time. In such cases, $d\sigma_T=0$ and

$d\sigma_e = -dp$ ....(iii)

since,

$dp = \rho.g.dh$

$d\sigma_e = -\rho.g.dh$ ....(iv)

Where,

ρ=density of water

g = gravitational acceleration

dh = change in hydraulic head,

+ve when water table increases

-ve when water table decrease.

From equation (iv), it can be observed that effective stress σ_e increases as water table decreases. As a result compression of granular skeleton is caused and this process continues for long time. This transient process is known as consolidation. The effect of consolidation may cause deformation of soil strata.

To illustrate the nature of the deformation that can occur in compressible aquifers, consider the aquifer of thickness b shown in Fig.5.8. If the weight of overlying material remains constant, the hydrostatic head in the aquifer is decreased by an amount -dh, the increase in effective stress $d\sigma_e$ is given by eq^n. (iv) and the aquifer compaction is given by,

$db = -\alpha.b.d\sigma_e$

$= -\alpha . b . \rho g dh$ ....(v)

where,

α = compressibility of soil,

The minus sign indicates that the decrease in head produces a reduction in the thickness b.

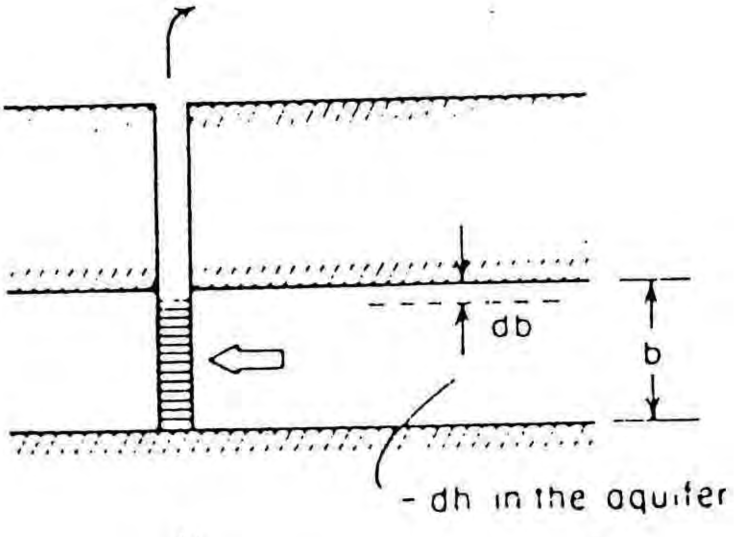


Fig.5.8 Aquifer Compaction Caused by Groundwater pumping

Table 5.2 Range of value of compressibility

Soil Type	**Compressibility, α (m^2/N)**
Clay	10^{-6} - 10^{-8}
Sand	10^{-7} - 10^{-9}
Gravel	10^{-8} - 10^{-10}
Jointed Rock	10^{-8} - 10^{-10}

Source: Hausmann (1990)

If the compaction of an aquifer-aquitard system due to ground water abstraction is propagated to the ground surface, the result is land-subsidence.

'Dhaka Region Ground Water and Subsidence Study (1991) conducted a study on bench mark (BM) levels in 1990 which indicated a subsidence of 0-16 cm over the last 16-years(1974-1990). The subsidence near Kamalapur Railway station Building, Kawranbazar DIT Market, Opposite to F.D.C. Building (Dhaka-Tejgaon Railway line) and Tejgaon Railway station was respectively 3.7 cm, 1 cm, 1.6 cm and 1.1 cm.

To evaluate the present state of subsidence Kamalapur railway Station Building area may be considered. In this area water level has declined more than 10 m for the period of (1990-1998). The aquifer in this area is considered as sandy soil with an average thickness of 50 m.

α (for sandy soil) = 10^{-8} m^2/N

Now, subsidence

$db = -\alpha.b.\rho.g.dh$ from eq^n (v)

$= (-10^{-8} x\ 50\ x\ 10^3\ x\ 9.81\ x\ 10)$ m

$= -0.04905$ m

$= -4.905$ cm

The value is not too much compared to the value of -3.7 cm in 1990. However it is very alarming situation especially for this area if differential subsidence takes place. It cannot be said that the area has subsided by this amount. Because subsidence is a complicated phenomena and it is related with several other parameters. Proper BM data can only give the actual result.

The top layer of soil in the city of Dhaka is blessed with over-consolidated clay at an average depth of 10m. The next layer is pre-consolidated upper aquifer about 35m thick consisting of silty-clay. This 50m thick upper layer can be considered as a flexible sheet spreading over the main aquifer (50-120m). So there is less possibility for this aquifer to be consolidated further.

With an aim to make an analysis of the ground level subsidence of the Dhaka City , a differential subsidence concept should be the main focus rather than overall subsidence. The uniform subsidence of the whole Dhaka City by 4.905cm as computed above would not be as much catastrophic as the subsidence of a particular locality by the same amount. However the situation may be very much detrimental for the city if a major earthquake takes place.

An analysis regarding the possibility of local (differential) subsidence can be made considering the cohesive force along the failure periphery of a segment and a reduced end bearing capacity.

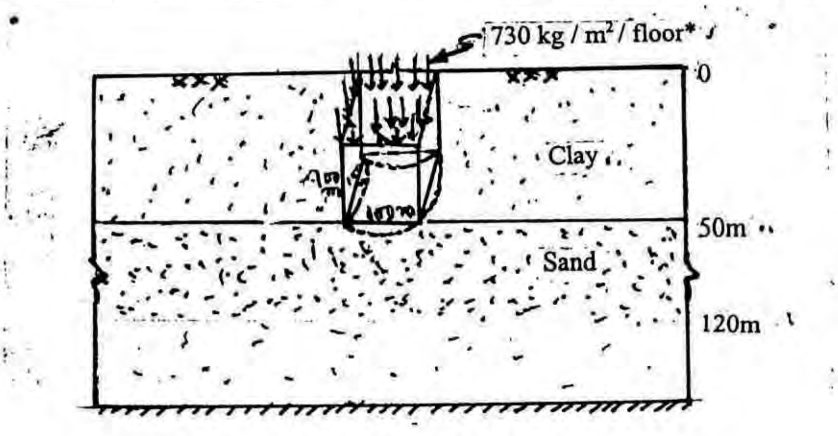


Fig. 5.9 Differential Subsidence Mechanism

* Assuming 10-storeyed building load over the area

Total vertical load acting downward

W_1 = load due to soil column + 10-storeyed building load

= 2000× (100× 100 ×50) +(10×730) (100×100)

= 107.3×10^7 kg

Assuming, density of soil

= 2000 kg/m^3

C (cohesive force) of clay

= 20000 kg/m2

N_c (bearing capacity factor)= 5.6

Total Upward force

W_2 = cohesive force along shearing perephery + reduced end bearing capacity

= C × shearing area + C N_c A_{tip} × 0.8*

= 20000×(100×4×50) + 20000 ×5.6×(100×100) ×0.8

= 129.6×10^7 kg.

* Assuming 20% reduction of bearing capacity beneath the clay layer

So it is observed from the analysis that there is less possibility of differential subsidence as the upward force balances the tendency of a small area from subsidence.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Ground water is the main source of drinking water for Dhaka City as good quality ground water is available in an aquifer extending between 50m and 120m below ground level. The water can very conveniently be abstracted by deep tubewells and supplied to adjacent population without any major treatment. To meet the increasing demand of drinking water supply, DWASA has to install new tubewells every year, but how much this ground water can be abstracted is the burning issue for further development of water supply in Dhaka City. The major hindrances of the use of surface water sources near Dhaka City are inferior quality, inadequate quantity in dry season and high cost of treatment. Following conclusions are drawn on the basis of the study:

1. Seasonal variations of groundwater level is mainly due to the rainfall and water level of the adjacent rivers. Since the city is growing rapidly and paved area is increasing , recharge contribution from rainfall is decreasing significantly. Due to this fact and also for longer distance from river, the piezometric level in the central part of the city does not experience considerable seasonal fluctuations. Moreover, the abstraction is higher in the central part of the city and extensive construction in this densely populated area also has reduced the recharge potential . As a result, the cone of depression is centered around this part of the city.

2. The most alarming situation is the gradual declining trend of static water level. The rates of declination during 1988-1992 at South Basabo, Malibagh, Mirpur, Motijheel and Cantonment were respectively 1.612 , 1.471 , 0.738, 0.443 and 0.227 m/yr., which increased to 1.8398, 1.8386, 1.862, 1.8698 and 1.4301 m/yr. respectively during 1992-1998. But in the peripheral areas the rates of water table lowering were comparatively lower, increased to values ranging between 0.783 and 1.167 m/yr. during 1992- 97 from 0.413 and 0.767 m/yr. during 1988-92. The possible causes of this situation may be the result of the excessive abstraction of groundwater in the central city and lack of significant recharge. The situation of ground water lowering in the central region is alarming. Installation of tubewell in the periphery also has a great influence on the availability of water in the central region as water flows from the periphery to center of the city having lowest static water level. The average rate of declination for the central part of the city was 0.27 m/yr. in the early seventies whereas the value increased to 0.45m/yr. in the early eighties. The rate of mining will obviously be aggravated after implementation of fourth interim project of DWASA.

3. The lowering of piezometric water level may result in failure of some of the existing pumping wells in near future. The efficiency of a pump having 50m head is reduced by 21.76 % for a decrease of 5m static water table. Re-sinking of many tubewells will require increased length of housing pipe extended within the productive aquifer resulting a reduction in the length of strainer. This will cause high entrance velocity to move fine formation particles towards the well and to accumulate around the well-thereby clogging the tubewell and failure to abstract water.

4. Vegetation is not likely to be affected by the lowering of piezometric level in the deep aquifer as the root zone holds water during rainy season and the intermediate vadose zone also contains a part of drained water from root zone and vadose water from capillary zone. During dry season this vadose water contributes to the root zone.

This phenomena is governed by the water table in the upper aquifer which is not very much affected by the lowering of piezometric level in the deep aquifer.

Effect of buoyancy on a soil layer does not prevail as the water table falls from the respective layer. This reduction of buoyancy causes to increase the weight of a soil layer about 37.7 %. It is obvious that this increment of weight will cause incremental effective pressure and compaction of soil layer leading to land subsidence. The probable land subsidence for the city is calculated as - 4.9cm. during 1992- 1998 . A bench mark survey in 1990 indicated - 3.2cm. land subsidence during 1971-1992. However, there is no possibility of occurring differential subsidence of a small area, because the cohesion of the thick preconsolidated upper clay layer will counteract the downward load of the soil and other superstructures and distribute the effect over a large area.

6.2 Recommendations for Minimizing Excessive Ground Water Abstraction

Most of the water supplied by DWASA, PWD and private organizations are mainly based on ground water because the main aquifer in Dhaka City is of excellent quality for domestic water supply. Due to excess withdrawn of ground water static water level is declining day by day. If this situation continues, the city dwellers may face water crisis in future. So immediate measures that may be considered to alleviate such situation are pointed below.

- Withdrawal of ground water should be within the safe limit and city dwellers should be abstemious in using water.
- DWASA should immediately install surface water treatment plant to meet the growing demand for water and reduce pressure on ground water abstraction

- Possibility of development of deep tubewell (DTW) fields at safe distances from Dhaka city such as Savar, Dhamrai, Tongi, Gazipur etc., may also be taken into consideration.

- An assessment of groundwater recharge and inflow should be carried out very carefully. In this regard dredging of surrounding rivers of the city will create opportunity for more inflow towards inland.

- Reduce dependence on ground water and shift over to surface water sources. The peripheral river system around the Dhaka city comprising the Turag , Buriganga, Dhaleshwari, Lakhya, Balu and Tongi Khal should be the focus of consideration.

- DWASA must reduce unaccounted for water (i.e. water not accounted for by billing) to acceptable level by reducing leakage losses and appropriate mechanism to prevent various means of depriving DWASA tariff. There should be well defined system for leakage prevention and revenue collection.

- If possible some artificial recharge like injector wells may be set up to supplement the natural infiltration. As an alternate measure a well field or surface water reservoir may be constructed at the adjoining areas to augment groundwater.

- Some permanent bench mark (BM) monitoring station like surface settlement plates and compression indicator at different depths should be set up immediately by DWASA to monitor any evidence of land subsidence.

- A legislation regarding the safe exploitation of ground water and installment of DTWs in private sector should be made immediately.

No other measure will be able to solve the problem properly unless the exodus population rate to the city can be controlled. In this connection `Satellite Town' concept, `Industrial inceptive zone' and 'commuter rail network' from central business destination (CBD) to satellite town can be considered for long term land-use planning.

6.3 Recommendations for Further Studies

A regular monitoring of DWASA tubewells' static water level data will enable to proceed such research program properly. Following issues can be considered for further study and research in this field:

- An assessment may be carried out regarding the implementation of `fourth interim project' of DWASA involving installation of more tubewells in Dhaka City.
- A study may be conducted regarding the exact mechanism of ground water recharge and the possibility of Ground Water contamination due to rapid fall of ground water table.
- Effect on ecology and land subsidence due to abrupt fall of ground water table may be carried out.

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APPENDIX-A

(BWDB) - Ground Water Table Data (in meter) Below Land Surface

GROUND WATER CIRCLE -II
BWDB, DHAKA.

DISTRICT: DHAKA

GROUND WATER TABLE BELOW LAND SURFACE IN METRE

THANA	Motijheel	Moham-madpur	Lalbag	Malibag	Sutrapur	Moham-madpur (Sultan-ganj)	Mirpur	Canton-ment	South Basabo
	WELL NUMBER								
DATE	DA-124	DA-108	DA-110	DA-112	DA-13	DA-111	DA-15	DA-103	DA-123
06-01-97	30.50	23.63	23.25	31.20	16.45	18.77	24.21	20.50	28.87
13-01-97	30.52	23.66	23.45	31.20	16.50	18.91	24.24	20.48	28.90
20-01-97	30.51	23.68	23.37	31.19	16.60	19.10	24.28	20.50	28.92
27-01-97	30.55	23.72	23.15	31.21	16.66	19.29	24.33	20.55	28.94
03-02-97	30.58	23.77	24.02	31.22	16.85	19.59	24.34	20.63	28.99
10-02-97	30.61	23.81	24.40	31.23	17.05	19.71	24.35	20.69	28.99
17-02-97	30.60	23.86	22.80	31.23	1712	19.89	24.36	20.71	29.03
24-02-97	30.56	23.90	23.20	31.24	17.15	19.99	24.37	20.73	29.08
03-03-97	30.67	23.95	23.70	31.25	17.22	20.17	24.38	20.75	29.14
10-03-97	30.69	23.99	24.30	31.26	17.27	20.34	24.39	20.85	29.18
17-03-97	30.74	24.05	23.30	31.29	17.28	20.44	24.40	20.90	29.21
24-03-97	30.78	24.11	21.90	31.32	17.35	20.57	24.51	20.96	29.08
31-03-97	-------	24.16	21.13	31.35	17.37	20.65	24.51	21.03	29.14
07-04-97	30.85	24.26	21.60	31.39	17.47	20.78	24.58	21.12	29.34
14-04-97	30.88	24.32	22.10	31.42	17.48	20.86	24.65	21.35	29.39
21-04-97	30.92	24.38	23.30	31.40	well	20.93	24.72	------	29.43
28-04-97	31.01	24.45	22.90	31.55	clogged	20.99	24.79.	21.18	29.47
05-05-97	31.08	24.54	23.00	31.59	“	21.07	24.87	21.10	29.51
12-05-97	31.10	24.61	22.90	31.68	“	21.01	24.91	21.12	29.56
19-05-97	31.19	24.69	22.72	31.75	“	20.94	24.96	21.42	29.60
26-05-97	31.23	24.76	22.30	31.84	“	20.85	25.01	21.57	29.65
02-06-97	31.31	24.79	22,55	31.93	“	20.74	25.06	21.60	29.71
09-06-97	31.36	24.81	22.65	31.98	“	20.65	25.12	21.65	29.76
16-06-97	31.42	24.84	23.10	32.06	“	20.54	25.18	21.68	29.82
23-06-97	31.50	24.87	23.16	32.09	“	20.45	25.23	21.71	29.86
30-06-97	31.56	24.89	22.30	32.11	“	20.36	25.24	21.74	29.91
07-07-97	31.69	24.90	22.59	32.13	“	20.25	25.76	21.70	29.94
14-07-97	31.69	24.92	22.89	32.14	“	20.18	25.81	21.75	29.98
21-07-97	31.74	24.95	23.19	32.16	“	20.16	25.85	21.77	30.02
28-07-97	31.78	24.97	23.92	32.18	“	20.01	25.90	21.80	30.07
04-08-97	31.93	24.99	22.72	32.20	“	19.92	25.96	21.70	30.13
11-08-97	32.12	25.03	22.08	32.21	“	19.83	25.02	21.72	30.18
18-08-97	32.19	25.07	21.90	32.23	“	19.74	26.08	21.75	30.24
25-08-97	32.24	25.10	23.97	32.26	“	19.67	26.13	21.73	30.29
01-09-97	32.31	25.15	24.15	32.28	“	19.62	26.18	21.70	30.35
08-09-97	32.37	25.19	22.70	32.29	“	19.55	26.22	21.71	30.39
15-09-97	32.42	25.23	22.62	32.29	“	19.51	26.26	21.52	30.43
22-09-97	32.47	25.27	24.66	32.30	“	19.46	26.31	21.54	30.48
29-09-97	32.58	25.32	23.33	32.37	“	19.52	26.36	21.55	30.54
06-10-97	32.52	25.36	23.30	32.47	“	19..56	26.40	21.56	------
13-10-97	32.69	25.40	23.75	32.58	“	19.59	26.45	21.55	------
20-10-97	32.84	25.43	23.50	32,68	“	19.68	26.47	21.58	------
27-10-97	32.97	25.46	23.87	32.81	“	19.75	26.50	21.61	------
03-11-97	33.01	25.50	23.22	32.95	“	19.82	26.52	21.63	------
10-11-97	33.12	25.53	------	33.14	“	19.94	26.55	21.62	------
17-11-97	32.99	25.56	------	33.27	“	20.16	------	------	------
24-11-97	33.02	25.58	------	33.42	“	20.28	------	21.85	------
01-12-97	33.04	-------	------	------	“	-------	------	21.91	------
08-12-97	33.10	-------	------	------	“	------	------	21.93	------
15-12-97	33.12	-------	------	------	“	------	------	21.95	------
22-12-97	33.14	-------	------	------	“	------	------	------	------
29-12-97	33.16	-------	------	------	“	------	------	------	------

GROUND WATER CIRCLE -II
BWDB, DHAKA.

DISTRICT: DHAKA

GROUND WATER TABLE BELOW LAND SURFACE IN METRE

THANA	Motijheel	Moham-madpur	Lalbag	Malibag	Sutrapur	Moham-madpur (Sultan-ganj)	Mirpur	Canton-ment	South Basabo
	WELL NUMBER								
DATE	DA-124	DA-108	DA-110	DA-112	DA-13	DA-111	DA-15	DA-103	DA-123
01-01-96	28.26	22.70	21.31	29.15	15.88	19.26	21.64	19.10	27.28
08-01-96	28.22	22.71	21.40	29.19	15.94	19.30	21.65	19.18	27.31
15-01-96	28.24	22.73	21.52	29.18	16.01	19.34	21.68	19.10	27.33
22-01-96	28.31	22.74	21.64	29.16	16.10	19.41	21.70	19.12	27.36
29-01-96	28.39	22.76	22.10	29.15	16.13	19.50	21.73	19.41	27.38
05-02-96	28.37	22.78	22.26	29.15	16.27	19.62	21.74	19.50	27.41
12-02-96	28.32	22.79	22.30	29.16	16.35	19.69	21.76	19.45	27.44
19-02-96	28.51	22.81	22.34	29.17	16.43	19.73	21.82	19.43	27.47
26-02-96	28.49	22.82	22.44	29.16	16.49	19.80	21.85	19.41	27.50
04-03-96	28.71	22.84	22.51	29.15	16.49	19.92	21.88	19.70	27.53
11-03-96	28.79	22.85	22.62	29.14	16.53	20.06	2.90	19.73	27.5
18-03-96	28.65	22.87	22.79	29.13	16.61	20.10	21.93	19.73	27.57
25-03-96	28.68	22.99	22.90	29.12	16.66	20.16	21.96	19.80	27.59
01-04-96	28.71	23.00	23.08	29.15	16.72	20.29	22.00	19.88	27.60
08-04-96	28.79	23.01	21.70	29.20	16.73	20.37	22.04	19.92	27.62
15-04-96	28.86	23.02	21.81	29.24	16.79	20.43	22.09	20.05	27.65
22-04-96	28.88	23.04	21.90	29.26	16.83	20.49	22.15	20.41	27.67
29-04-96	28.89	23.07	22.08	29.29	16.79	20.55	22.20	20.70	27.69
06-05-96	28.91	23.09	22.70	29.30	16.75	20.50	22.25	20.95	27.70
13-05-96	28.94	23.10	23.04	29.32	16.76	20.41	22.30	20.90	27.71
20-05-96	28.95	23.12	23.19	29.33	16.75	20.27	22.35	20.70	27.73
27-05-96	29.12	23.15	23.40	29.33	16.68	20.22	22.40	20.58	27.74
03-06-96	29.17	23.16	23.50	29.37	16.66	20.14	22.45	20.60	27.75
10-06-96	29.29	23.18	23.40	29.42	16.62	20.05	22.60	20.30	27.77
17-06-96	29.32	23.19	24.21	29.46	16.50	19.94	22.75	20.220	27.77
24-06-96	29.39	23.19	24.40	29.51	16.00	19.87	22.85	20.10	27.78
01-07-96	2 9 . 43	23.21	24.55	29.53	16.50	19.82	22.98	20.18	27.80
08-07-96	29.52	23.27	20.01	29.58	16.49	19.76	23.05	20.14	27.85
15-07-96	29.60	23.30	19.80	29.61	16.44	19.70	23.11	20.95	27.89
22-07-96	29.66	23.33	20.21	29.66	16.30	19.64	23.17	19.79	27.95
29-07-96	29.71	23.35	20.35	29.69	16.29	19.57	23.23	19.85	28.03
05-08-96	29. 76	23.37	20.80	29.74	16.25	19.42	23.30	19.89	28.11
12-08-96	29.81	23.39	21.45	29.79	16.21	19.34	23.37	19.98	28.17
19-08-96	29.89	23.40	22.00	29.85	16.13	19.28	23.45	19.95	28.22
26-08-96	29.90	23.41	22.15	29.91	16.01		23.50	19.88	28.20
02-09-96	29.91	23.43	22.40	30.00	15.94	19.22	23.56	19.95	28.18
09-09-96	29.90	23.44	21.45	30.10	15.85	19.10		1.81	28.14
16-09-96	29.93	23.44	22.82	30.18	15.77	19.07		19.40	28.14
23-09-96	29.97	23.44	23.03	30.27	15.71	18.97		19.87	28.25
30-09-96	30.06	23.44		30.40	15.68	18.88		19.98	28.34
07-10-96	30.12	23.45		30.52	15.69	18.79		19.47	28.35
14-10-96	30.17	23.46		30.63	15.68		23.90	19.99	28.39
21-10-96	30.21	23.77		30.73	15.65	18.77	23.95	20.02	28.81
28-10-96	30.27	23.49		30.64		18.85	24.01	20.05	28.43
04-11-96	30.29	23.50		30.71	15.63	18.98	24.07	20.13	28.45
11-11-96	30.38	23.51		30.88	15.71	19.04	24.07	20.19	28.52
18-11-96	30.37	23.52		30.95	15.82	19.01	24.09	20.25	28.60
25-11-96	30.39	23.54		31.00	15.99	18.96	24.10	20.26	28.65
02-12-96	30.40	23.56		31.03	16.01	18.90	24.12	20.31	28.70
09-12-96	30.43	23.57		31.08	16.10	18.84	24.14	20.29	28.74

GROUND WATER CIRCLE -II
BWDB, DHAKA.

THANA	Motijheel	Moham-madpur	Lalbag	Malibag	Sutrapur	Moham-madpur (Sultan-ganj)	Mirpur	Canton-ment	South Basabo
	WELL NUMBER								
DATE	DA-124	DA-108	DA-110	DA-112	DA-13	DA-111	DA-15	DA-103	DA-123
16-12-96	30.44	23.58		31.12	16.21	18.77	24.15	20.30	28.77
23-12-96	30.48	23.60		31.15	16.27	18.71	24.16	20.38	28.80
30-12-96	30.49	23.61		31.17	16.36		24.18	20.43	28.84

GROUND WATER CIRCLE -II
BWDB, DHAKA.

DISTRICT: DHAKA

GROUND WATER TABLE BELOW LAND SURFACE IN METRE

THANA	Motijheel	Moham-madpur	Lalbag	Malibag	Sutrapur	Moham-madpur (Sultan-ganj)	Mirpur	Canton-ment	South Basabo
	WELL NUMBER								
DATE	DA-124	DA-108	DA-110	DA-112	DA-13	DA-111	DA-15	DA-103	DA-123
02-01-95	25.41	21.80	22.78	27.60	15.34	18.96	20.06	17.58	29.40
09-01-95	25.59	21.82	22.75	27.53	15.41	19.05	20.08	17.59	25.44
16-01-95	25.72	21.85	22.79	27.58	15.49	19.12	20.09	17.68	25.47
23-01-95	25.88	21.86	22.82	27.60	15.55	19.20	20.10	17.70	25.53
30-01-95	26.03	21.88	22.84	27.61	15.61	19.30	20.12	17.79	25.60
06-02-95	26.19	21.90	22.88	27.69	15.66	19.36	20.14	17.85	25.67
13-02-95	26.14	21.91	22.90	27.66	15.70	19.47	20.13	17.88	25.75
20-02-95	26.05	21.94	22.89	27.65	15.66	19.57	20.18	17.90	25.83
27-02-95	26.17	21.99	22.90	27.63	15.80	19.65	20.21	17.95	25.87
06-03-95	26.29	22.02	22.92	27.78	15.87	19.74	20.24	17.96	25.92
13-03-95	26.20	22.05	22.98	27.86	15.91	19.81	20.25	17.98	25.96
20-03-95	26.16	22.85	23.00	27.83	15.94	19.86	20.26	17.99	26.00
27-03-95	26.24	22.12	------	27.82	15.98	19.90	20.28	18.37	26.04
03-04-95	26.53	22.19	21.10	27.85	16.10	20.06	20.35	18.63	26.07
10-04-95	.26.57	22.18	21.18	27.82	16.13	20.19	20.36	18.71	26.10
17-04-95	26.54	22.26	21.90	28.04	16.20	20.33	20.36	18.80	26.12
24-04-95	26.58	22.24	22.40	28.11	16.17	20.50	20.38	18.88	26.15
01-05-95	26.55	22.29	22.80	28.19	16.25	20.61	20.45	18.94	26.19
08-05-95	26.72	22.32	22.00	28.30	16.30	20.77	20.45	18.98	26.22
15-05-95	26.86	22.34	21.80	28.29	16.18	20.86	20.47	19.06	26.27
22-05-95	26.94	22.35	21.40	28.35	16.32	20.62	20.53	19.02	26.33
29-05-95	26.83	22.36	21.00	28.38	16.30	20.34	20.55	19.01	26.37
05-06-95	26.69	22.38	21.60	28.39	16.29	20.19	20.59	19.85	26.42
12-06-95	26.54	22.41	20.80	28.45	16.28	19.90	20.64	19.22	26.48
19-06-95	26.67	22.44	20.79	28.45	16.23	19.73	20.68	19.16	26.53
26-06-95	26.74	22.46	20.70	28.48	16.10	19.57	20.72	19.15	26.59
03-07-95	26.89	22.47	20.73	28.49	16.01	19.44	20.72	18.62	26.64
10-07-95	26.86	22.49	20.77	28.50	15.81	19.32	20.75	18.96	26.62
17-07-95	26.87	22.51	20.72	28.53	15.68	19.16	20.90	18.68	26.59
24-07-95	26.74	22.51	20.88	28.56	15.62	19.10	20.90	18.37	26.05
31-07-95	26.66	22.52	20.95	28.59	15.51	19.04	20.91	18.65	26.55
07-08-95	26.97	22.54	21.10	28.53	15.43	18.97	20.90	18.63	26.55
14-08-95	27.11	22.55	21.37	28.55	15.34	18.92	21.00	18.25	26.57
21-08-95	27.23	22.57	21.60	28.45	15.20	18.90	21.05	18.38	26.60
28-08-95	27.35	22.58	20.25	28.45	15.16	18.96	21.00	18.35	26.62
04-09-95	27.49	22.60	20.80	28.51	15.12	19.01	21.05	18.36	26.65
11-09-95	27.62	22.60	21.40	28.60	15.15	19.10	21.12	18.34	26.68
18-09-95	27.74	22.61	22.00	28.66	15.10	19.21	21.10	18.06	26.72
25-09-95	27.83	22.60	22.60	28.68	15.10	19.27	21.15	18.20	26.74
02-10-95	27.89	22.59	20.30	28.70	15.09	19.35	21.20	18.23	26.76
09-10-95	27.81	22.58	20.35	28.71	15.07	19.38	21.25	18.35	26.78
16-10-95	27.87	22.57	20.28	28.76	15.10	19.31	21.27	18.35	26.91
23-10-95	27.83	22.55	20.40	28.82	15.15	19.27	21.30	18.31	26.83
30-10-95	27.71	22.54	20.65	28.88	15.20	19.15	21.32	18.30	26.88
06-11-95	27.77	22.54	20.50	28.87	15.35	19.02	21.35	18.33	26.94
13-11-95	27.92	22.55	20.42	28.91	15.39	18.94	21.38	18.35	26.99
20-11-95	27.93	22.57	20.70	28.93	15.42	18.86	21.42	18.37	27.04
27-11-95	27.96	22.59	20.85	28.96	15.52	18.80	21.47	18.38	27.10
04-12-95	27.97	22.62	20.76	29.02	15.56	18.91	21.50	18.45	27.13
11-12-95	27.99	22.65	20.98	29.08	15.65	19.02	21.55	18.50	27.16

GROUND WATER CIRCLE -II
BWDB, DHAKA.

THANA	Motijheel	Moham-madpur	Lalbag	Malibag	Sutrapur	Moham-madpur (Sultan-ganj)	Mirpur	Canton-ment	South Basabo
	WELL NUMBER								
DATE	DA-124	DA-108	DA-110	DA-112	DA-13	DA-111	DA-15	DA-103	DA-123
18-12-95	28.02	22.69	21.20	29.09	15.71	19.11	21.57	18.68	27.19
25-12-95	28.17	------	21.23	29.10	15.80	19.20	21.63	18.92	27.23

GROUND WATER CIRCLE -II
BWDB, DHAKA.

DISTRICT: DHAKA

GROUND WATER TABLE BELOW LAND SURFACE IN METRE

THANA	Motijheel	Moham-madpur	Lalbag	Malibag	Sutrapur	Moham-madpur (Sultan-ganj)	Mirpur	Canton-ment	South Basabo
	WELL NUMBER								
DATE	DA-124	DA-108	DA-110	DA-112	DA-13	DA-111	DA-15	DA-103	DA-123
03-01-94	------	20.92	22.35			17.75	18.63	14.99	
10-01-94	------	20.93	22.37			17.84	18.64	------	
17-01-94	------	20.93	------			17.94	18.64	-------	
24-01-94	------	20.95	22.59			17.04	18.65	------	
31-01-94	23.79	20.96	22.39			18.10	18.67	------	
07-02-94	23.74	20.96	22.53			18.13	18.70	------	
14-02-94	23.65	20.97	22.46			18.22	18.73	15.45	
21-02-94	23.66	20.99	22.73			18.31	18.75	15.52	
28-02-94	23.67	21.01	22.66			18.39	18.77	15.75	
07-03-94	23.82	21.04	22.53			18.48	18.80	15.85	
14-03-94	24.02	21.06	22.53			18.45	------	15.90	
21-03-94	24.03	21.08	22.61			18.50	18.84	15.97	
28-03-94	24.06	21.11	22.68			18.55	18.86	16.04	
04-04-94	24.14	21.14	22.80			18.61	18.87	16.10	
11-04-94	24.23	21.18	22.74			18.49	18.88	16.14	
18-04-94	24.27	21.20	22.30			18.53	18.89	16.13	
25-04-94	24.35	21.23	22.66			18.57	19.00	16.20	
02-05-94	24.39	21.27	22.71			18.60	19.04	16.29	
09-05-94	24.42	21.31	22.74			18.63	19.07	16.23	
16-05-94	24.46	21.34	22.80			18.67	19.16	16.65	
23-05-94	24.48	21.37	22.60			18.71	19.18	16.48	
30-05-94	24.53	21.41	23.10			18.66	19.21	16.60	
06-06-94	24.56	21.43	22.90			18.60	19.26	16.65	
13-06-94	24.57	21.45	22.80			18.56	19.28	16.69	
20-06-94	24.59	21.46	22.90			18.48	19.32	16.71	
27-06-94	24.61	21.48	22.29			18.39	19.37	16.70	
04-07-94	24.63	21.50	22.52			18.34	19.44	16.50	
11-07-94	24.69	21.51	20.25			18.28	19.45	16.60	
18-07-94	24.56	21.90	20.37			18.38	19.46	16.75	
25-07-94	24.52	21.54	19.95			18.47	19.52	16.75	
01-08-94	24.68	21.56	18.91			18.50	19.53	16.74	
08-08-94	24.62	21.57	20.48			18.71	19.63	16.72	
15-08-94	24.51	21.59	21.02			18.28	19.64	16.73	
22-08-94	24.48	21.60	22.18			18.05	19.66	16.68	
29-08-94	------	21.62	22.80			17.94	19.69	16.67	
05-09-94	24.49	21.64	22.23			17.88	19.72	16.65	
12-09-94	24.57	21.61	22.60			17.87	19.76	16.69	
19-09-94	24.52	21.65	22.70			17.96	19.80	16.64	
26-09-94	24.49	21.65	22.90			17.91	19.84	16.78	
03-10-94	24.59	21.67	-------			17.99	19.87	16.82	
10-10-94	24.67	21.68	-------			18.07	19.88	16.58	
17-10-94	24.70	21.68	-------			18.16	19.92	16.69	
24-10-94	24.74	21.69	-------			18.22	19.96	17.02	
31-10-94	24.99	21.71	------			18.27	19.98	17.15	
07-11-94	25.28	21.72	------			18.31	19.95	17.18	
14-11-94	25.30	21.72	------			18.40	19.95	17.26	
21-11-94	25.36	21.72	------			18.48	19.98	17.30	
28-11-94	25.33	21.73	------			18.59	19.97	17.32	
05-12-94	25.37	21.74	------			18.66	20.01	17.35	
12-12-94	25.36	21.75	------			18.71	20.04	17.38	

GROUND WATER CIRCLE -II
BWDB, DHAKA.

THANA	Motijheel	Moham-madpur	Lalbag	Malibag	Sutrapur	Moham-madpur (Sultan-ganj)	Mirpur	Canton-ment	South Basabo
	WELL NUMBER								
DATE	DA-124	DA-108	DA-110	DA-112	DA-13	DA-111	DA-15	DA-103	DA-123
19-12-94	25.24	21.77	------			18.80	20.03	17.43	
26-12-94	25.13	21.79	------			18.89	20.05	17.42	

GROUND WATER CIRCLE -II
BWDB, DHAKA.

DISTRICT: DHAKA

GROUND WATER TABLE BELOW LAND SURFACE IN METRE

THANA	Motijheel	Moham-madpur	Lalbag	Malibag	Sutrapur	Moham-madpur (Sultan-ganj)	Mirpur	Canton-ment	South Basabo
	WELL NUMBER								
DATE	DA-124	DA-108	DA-110	DA-112	DA-13	DA-111	DA-15	DA-103	DA-123
04-01-93	23.97	20.11	20.09	25.40	13.71	17.10	17.20	14.40	21.44
11-01-93	24.03	20.11	20.05	25.60	13.73	17.29	17.22	14.48	21.49
18-01-93	24.09	20.12	20.18	24.00	13.79	17.26	17.24	14.54	21.54
25-01-93	24.11	20.13	21.07	25.40	13.90	17.34	17.28	14.51	21.60
01-02-93	24.14	20.14	20.24	25.50	13.96	17.41	17.30	14.55	21.65
08-02-93	24.13	20.15	20.04	25.50	14.00	17.47	17.32	14.61	21.69
15-02-93	24.10	20.16	20.19	23.88	14.04	17.53	17.34	14.68	21.73
22-02-93	24.12	20.16	20.46	24.00	14.12	17.60	17.36	14.81	21.76
01-03-93	24.15	20.18	20.50	25.50	14.15	17.67	17.37	15.12	21.76
08-03-93	24.18	20.21	18.30	26.00	14.18	17.73	17.43	15.14	21.77
15-03-93	24.20	20.23	20.50	25.53	14.22	17.81	17.45	15.25	21.80
22-03-93	24.23	20.24	20.60		14.27	17.81	17.50	15.30	21.82
29-03-93	24.25	20.26	20.49		14.30	17.90	17.55	15.43	21.85
05-04-93	24.29	20.32	20.77		14.27	17.95	17.56	15.45	21.90
12-04-93	24.32	20.39	20.71		14.32	17.46	17.55	16.60	21.99
19-04-93	24.38	20.47	20.86		14.34	18.02	17.58	15.64	22.03
26-04-93	24.40	20.56	20.45		14.37	18.12	17.62	15.49	22.08
03-05-93	24.36	20.49	20.69		14.32	18.06	17.66	15.54	22.13
10-05-93	24.39	20.48	20.40		14.17	17.99	17.66	15.31	22.20
17-05-93	24.47	20.44	20.81		14.04	17.95	17.70	15.47	22.15
24-05-93	24.54	20.45	20.80		13.79	17.93	17.73	15.49	22.25
31-05-93	24.58	20.52	19.95		13.80	17.95	17.77	15.50	22.30
07-06-93	24.61	20.57	20.30		13.78	17.99	17.80	15.54	22.30
14-06-93	24.53	20.59	20.60		13.60	17.90	17.83	15.14	22.33
21-06-93	24.48	20.60	20.78		13.52	17.74	17.88	14.45	22.35
28-06-93	24.56	20.63	20.39		13.45	17.61	17.95	14.80	22.40
05-07-93	24.64	20.60	20.65		13.36	17.56	17.96	14.72	22.42
12-07-93	24.67	20.73	20.63		13.21	17.45	17.97	14.41	22.45
19-07-93	24.69	20.77	20.56		13.33	17.36	18.00	14.20	22.48
26-07-93	24.54	20.76	20.45		13.25	17.30	18.07	14.33	22.50
02-08-93	24.51	20.76	20.20		13.22	17.18	18.08	14.20	22.51
09-08-93	24.48	20.77	20.35		12.12	17.11	18.18	14.20	22.52
16-08-93	24.66	20.77	20.15		12.00	17.04	18.13	14.21	22.55
23-08-93	24.67	20.79	20.21		12.91	16.87	18.17	14.10	22.57
30-08-93	24.63	20.79	20.17		12.80	16.74	18.25	13.47	22.58
06-09-93	24.56	20.79	20.26		12.46	16.66	18.28	13.42	22.60
13-09-93	24.53	20.78	20.20		12.48	16.66	18.28	13.35	22.64
20-09-93	24.47	20.78	19.72		12.56	16.64	18.29	13.60	22.69
27-09-93	24.42	20.77	19.84		12.60	16.56	18.30	13.62	22.75
04-10-93	24.40	20.78	19.95		12.66	16.63	18.35	13.70	22.80
11-10-93	24.39	20.79	19.87		12.85	16.70	18.40	13.82	22.85
18-10-93	24.37	20.79	21.80		12.69	16.69	18.44	13.61	22.90
25-10-93	24.32	20.80	21.84		12.60	16.80	18.50	13.56	22.96
01-11-93	24.29	20.82	21.84		12.80	16.91	18.50	13.72	22.98
08-11-93	24.2	20.84	21.80		12.87	17.00	18.45	13.98	22.99
15-11-93	24.27	20.85	21.76		13.04	17.13	18.45	14.17	23.00
22-11-93	24.04	20.86	21.74		13.17	17.26	18.50	14.21	23.02
29-11-93	23.71	20.87	21.72		13.28	17.38	18.50	14.47	23.07
06-12-93	23.09	20.80	21.73		13.47	17.47	18.55	14.56	23.13
13-12-93	23.74	20.88	21.65		13.51	17.00	18.60	14.71	23.18

GROUND WATER CIRCLE -II
BWDB, DHAKA.

THANA	Motijheel	Moham-madpur	Lalbag	Malibag	Sutrapur	Moham-madpur (Sultan-ganj)	Mirpur	Canton-ment	South Basabo
	WELL NUMBER								
DATE	DA-124	DA-108	DA-110	DA-112	DA-13	DA-111	DA-15	DA-103	DA-123
20-12-93	23.01	20.90	21.60		13.56	17.59	18.60	14.80	23.24
27-12-93	23.39	20.92	21.31		13.70	17.67	18.60	14.90	23.30

GROUND WATER CIRCLE -II
BWDB, DHAKA.

DISTRICT: DHAKA

GROUND WATER TABLE BELOW LAND SURFACE IN METRE

THANA	Motijheel	Moham-madpur	Lalbag	Malibag	Sutrapur	Moham-madpur (Sultan-ganj)	Mirpur	Canton-ment	South Basabo
	WELL NUMBER								
DATE	DA-124	DA-108	DA-110	DA-112	DA-13	DA-111	DA-15	DA-103	DA-123
06-01-92	18.48	18.99	17.70	NA	12.30	15.91	15.61	11.22	19.45
13-01-92	19.07	18.99	17.90		12.42	16.51	15.65	11.42	19.51
20-01-92	19.20	19.01	17.88		12.41	16.80	15.66	11.35	19.55
27-01-92	19.32	19.01	18.10		12.55	15.12	15.67	11.40	19.60
03-02-92	19.22	19.02	18.98		12.60	16.21	15.76	11.52	19.62
10-02-92	18.95	19.05	18.89		12.63	16.30	15.70	11.63	19.62
17-02-92	18.66	19.07	18.20		12.66	16.36	15.60	11.75	19.70
24-02-92	18.72	19.09	18.19		12.77	16.40	15.78	11.75	19.00
02-03-92	18.14	19.11	18.34		12.82	16.50	15.75	11.81	19.81
09-03-92	19.99	19.13	18.49		12.89	16.51	15.70	11.98	19.63
16-03-92	20.04	19.14	18.51		12.95	16.60	15.79	12.10	19.87
23-03-92	20.10	19.07	18.90		13.05	16.65	15.80	12.13	19.90
30-03-92	20.11	19.22	18.69		13.12	16.69	15.84	12.44	19.93
06-04-92	20.14	19.25	18.70		13.17	16.73	15.85	12.65	19.95
13-04-92	20.31	19.29	18.80		13.23	16.77	15.94	10.80	19.98
20-04-92	20.57	19.30	19.10		13.32	16.80	15.97	11.35	20.00
27-04-92	20.72	19.32	19.15		13.37	16.87	16.02	12.15	20.05
04-05-92	20.81	19.33	19.10		13.45	16.89	16.02	12.50	20.07
11-05-92	21.01	19.35	20.50		13.55	16.85	16.05	12.87	20.18
18-05-92	21.48	19.38	19.30		13.35	16.84	16.06	12.09	20.20
25-05-92	22.09	19.43	19.38		13.61	16.83	16.12	12.95	20.23
01-06-92	22.23	19.48	20.63		13.65	16.83	16.15	12.98	20.25
08-06-92	22.38	19.49	19.50		13.68	16.81	16.19	13.03	20.32
15-06-92	21.52	19.51	19.65		13.65	16.80	16.25	13.04	20.45
22-06-92	22.13	19.48	19.70		13.64	16.77	16.27	12.52	20.45
29-06-92	20.04	19.55	19.71		13.61	16.78	16.36	12.57	20.48
06-07-92	19.95	19.55	19.65		13.57	16.70	16.43	12.83	20.50
13-07-92	20.67	19.54	19.71		13.44	16.61	16.50	12.90	20.52
20-07-92	19.99	19.57	19.70		13.20	16.52	16.50	12.54	20.53
27-07-92	19.89	19.63	19.65		13.06	16.44	16.54	12.65	20.55
03-08-92	20.72	19.65	19.70		13.02	16.38	16.50	12.66	20.57
10-08-92	22.55	19.81	19.59		12.90	16.31	16.61	13.22	20.57
17-08-92	22.49	19.82	19.57		12.87	16.29	16.65	13.24	20.62
24-08-92	22.97	19.84	19.80		12.92	16.25	16.74	13.15	20.65
31-08-92	22.74	19.84	19.77		12.90	16.26	16.74	13.30	20.67
07-09-92	22.90	19.86	19.27		12.89	16.23	16.76	13.37	20.70
14-09-92	22.92	19.87	20.27		12.91	16.22	16.86	13.41	20.75
21-09-92	22.97	19.90	19.69		12.88	16.27	16.84	13.65	20.77
28-09-92	22.99	19.90	19.89		12.92	16.27	16.93	13.78	20.78
05-10-92	23.06	19.91	19.70		12.80	16.26	16.94	13.77	20.80
12-10-92	23.10	19.92	19.69		12.81	16.28	16.91	13.41	20.81
19-10-92	23.12	19.94	20.24		12.83	16.32	17.00	13.85	20.82
26-10-92	23.29	19.93	18.69		12.89	16.36	17.06	13.86	20.86
02-11-92	23.45	19.94	19.70		12.95	16.43	17.07	13.92	20.95
09-11-92	23.51	19.97	19.80		13.07	16.45	17.07	13.85	21.04
16-11-92	23.48	20.05	19.81		13.14	16.54	17.06	14.10	21.10
23-11-92	23.53	20.06	19.92		13.22	16.63	17.10	14.20	21.20
30-11-92	23.62	20.08	19.89		13.34	16.77	17.12	14.19	21.24
07-12-92	23.70	20.01	19.88		13.41		17.13	14.35	21.30
14-12-92	23.74	20.09	19.90		13.48		17.14	14.33	21.39

GROUND WATER CIRCLE -II
BWDB, DHAKA.

THANA	Motijheel	Moham-madpur	Lalbag	Malibag	Sutrapur	Moham-madpur (Sultan-ganj)	Mirpur	Canton-ment	South Basabo
	WELL NUMBER								
DATE	DA-124	DA-108	DA-110	DA-112	DA-13	DA-111	DA-15	DA-103	DA-123
21-12-92	23.77	20.16	19.95		13.54	17.06	17.15	14.36	21.35
28-12-92	23.84	20.10	19.69		13.64	16.87	17.18	14.92	21.40

GROUND WATER CIRCLE -II
BWDB, DHAKA.

DISTRICT: DHAKA

GROUND WATER TABLE BELOW LAND SURFACE IN METRE

THANA	Motijheel	Moham-madpur	Lalbag	Malibag	Sutrapur	Moham-madpur (Sultan-ganj)	Mirpur	Canton-ment	South Basabo
	WELL NUMBER								
DATE	DA-124	DA-108	DA-110	DA-112	DA-13	DA-111	DA-15	DA-103	DA-123
07-01-91	20.77	----	18.06	23.01	11.84	15.86	15.99	11.81	18.15
14-01-91	20.7 7	15.91	18.09	23.05	11.92	16.01	15.98	11.85	18.19
21-01-91	21.24	16.11	18.17	23.14	11.95	16.09	16.02	11.34	18.23
28-01-91	21.43	15.86	18.21	23.18	11.99	16.18	16.00	11.34	18.26
04-02-91	21.35	15.58	18.27	23.22	12.07	16.23	16.05	11.45	18.30
11-02-91	20.75	16.81	18.28	23.27	12.11	16.40	16.08	11.48	18.34
18-02-91	21.19	17.28	18.29	23.29	12.26	16.37	16.00	11.65	18.43
25-02-91	21.24	17.81	18.67	23.30	12.29	16.46	---	11.70	18.45
04-03-91	21.37	17.92	17.77	23.33	12.34	16.48	---	11.78	18.50
11-03-91	21.42	18.07	17.84	23.34	12.31	16.54	----	11.79	18.52
18-03-91	21.43	18.57	17.87	23.28	12.41	16.56	----	11.94	18.60
25-03-91	21.48	----	17.91	23.38	12.47	16.60	14.21	12.80	18.60
01-04-91	21.27	18.42	17.94	23.42	12.53	16.65	14.20	12.05	18.64
08-04-91	20.49	18.49	17.99	23.44	12.60	16.68	14.37	12.85	18.70
15-04-91	20.41	18.54	18.13	23.48	12.65	16.70	14.35	12.90	18.75
22-04-91	20.40	18.61	18.25	23.55	12.70	16.73	14.50	12.23	18.78
29-04-91	20.47	18.63	18.22	23.60	12.72	16.73	14.51	12.22	18.81
06-05-91	20.98	18.62	18.47	23.65	12.73	16.75	14.39	12.25	18.76
13-05-91	21.20	18.72	18.41	23.67	12.48	16.62	14.70	12.21	18.70
20-05-91	21.49	18.76	18.37	23.69	12.19	16.42	14.75	12.08	18.87
27-05-91	20.47	18.75	18.30	23.62	12.05	16.35	14.74	11.94	18.80
03-06-91	21.87	18.73	18.17	23.57	11.83	16.27	14.78	11.58	18.85
10-06-91	21.76	18.65	18.14	23.52	11.78	16.14	14.88	11.40	18.82
17-06-91	21.59	18.62	17.98	23.50	11.41	16.02	14.88	11.06	18.81
24-06-91	21.59	18.70	17.71	23.70	11.42	15.92	14.98	1090	18.80
01-07-91	21.96	18.77	17.79	23.79	11.84	15.95	15.04	10.94	18.80
08-07-91	22.02	18.80	17.77	23.80	11.36	15.83	15.13	10.85	18.78
15-07-91	22.18	18.82	17.78	23.81	11.35	15.70	15.15	10.72	18.77
22-07-91	22.20	18.82	17.74	23.80	11.17	15.56	15.18	10.54	18.76
29-07-91	21.71	18.83	17.71	23.82	11.13	15.51	15.22	10.61	18.69
05-08-91	21.63	18.83	17.68	23.91	11.02	15.46	15.28	10.52	18.70
12-08-91	21.14	18.82	17.70	23.96	11.08	15.41	15.28	10.43	18.78
19-08-91	21.29	18.87	17.75	23.98	11.19	15.40	15.36	10.55	18.73
26-08-91	20.64	18.84	17.66	24.01	11.24	15.35	15.35	10.53	18.73
02-09-91	20.33	18.76	17.67	24.09	11.12	15.29	15.42	10.46	18.75
09-09-91	20.55	18.83	17.60	24.12	10.65	15.20	15.36	9.97	18.76
16-09-91	20.62	18.89	17.42	24.16	10.65	15.03	15.43	9.47	18.70
23-09-91	20.89	18.81	17.22	24.24	10.66	14.96	15.44	9.49	18.66
30-09-91	20.71	18.84	17.14	24.31	10.48	14.95	15.43	9.44	18.64
07-10-91	20.59	18.81	17.06	24.39	10.63	14.96	15.42	9.53	18.62
14-10-91	2044	18.82	17.07	24.44	10.70	14.96	15.45	9.41	18.62
21-10-91	20.49	18.84	17.10	24.48	10.75	15.06	15.48	9.36	18.66
28-10-91	19.72	18.86	17.03	24.51	10.95	15.15	15.46	9.66	18.70
04-11-91	19.03	18.88	17.11	24.47	11.14	15.11	15.43	9.89	18.80
11-11-91	18.08	18.88	17.26	24.42	11.35	15.07	15.42	10.34	18.91
18-11-91	17.21	18.90	17.33	24.40	11.56	15.40	15.44	10.50	19.00
25-11-91	15.93	18.72	17.30	24.38	11.69	15.50	15.46	10.81	19.10
02-12-91	15.59	18.97	17.38	24.35	11.97	15.66	15.53	10.68	19.02
09-12-91	16.14	18.97	17.47	24.34	11.99	15.73	15.51	10.82	19.28
16-12-91	16.82	18.98	17.61	24.37	12.11	15.80	15.55	11.20	19.32

GROUND WATER CIRCLE -II
BWDB, DHAKA.

THANA	Motijheel	Moham-madpur	Lalbag	Malibag	Sutrapur	Moham-madpur (Sultan-ganj)	Mirpur	Canton-ment	South Basabo
	WELL NUMBER								
DATE	DA-124	DA-108	DA-110	DA-112	DA-13	DA-111	DA-15	DA-103	DA-123
23-12-91	17.37	----	17.86	24.39	12.22	15.92	15.54	--	19.38
30-12-91	17.52	18.99	17.76	24.42	12.25	15.85	15.60	11.21	19.42

GROUND WATER CIRCLE -II
BWDB, DHAKA.

DISTRICT: DHAKA

GROUND WATER TABLE BELOW LAND SURFACE IN METRE

THANA	Motijheel	Moham-madpur	Lalbag	Malibag	Sutrapur	Moham-madpur (Sultan-ganj)	Mirpur	Canton-ment	South Basabo
	WELL NUMBER								
DATE	DA-124	DA-108	DA-110	DA-112	DA-13	DA-111	DA-15	DA-103	DA-123
01-01-90	22.80	17.25	17.44	21.20	11.12	15.46	14.65	10.42	17.10
08-01-90	22.80	17.36	17.51	21.24	11.23	15.62	14.65	10.58	17.09
15-01-90	22.18	17.45	17.46	21.29	11.29	15.67	14.68	10.60	17.10
22-01-90	22.82	17.43	17.55	21.29	11.36	15.75	14.70	10.78	17.12
29-01-90	22.84	17.50	17.62	21.32	11.42	15.82	14.70	10.82	17.15
05-02-90	22.85	17.53	17.67	21.30	11.48	15.86	14.70	10.95	17.23
12-02-90	22.85	17.57	17.17	21.32	11.59	15.97	14.71	11.10	17.27
19-02-90	22.87	17.56	17.79	21.40	11.63	16.19	14.72	11.10	17.31
26-02-90	22.88	17.55	17.75	21.40	11.68	16.25	14.73	11.13	17.39
05-03-90	------	17.57	17.90	21.35	11.76	16.15	14.75	11.16	17.37
12-03-90	8.80	17.59	18.06	21.38	11.89	16.17	14.79	11.30	17.38
19-03-90	6.79	17.57	18.01	21.40	11.81	16.21	14.78	11.32	17.40
26-03-90	4.57	17.55	18.09	21.38	11.73	16.24	14.80	11.32	17.40
02-04-90	5.88	17.52	18.15	21.45	11.52	16.21	14.85	11.34	17.35
09-04-90	5.11	17.48	18.11	21.60	11.47	16.21	14.85	11.34	17.38
16-04-90	6.70	17.45	18.15	21.60	11.63	16.29	14.87	11.42	17.40
23-04-90	6.73	10.71	17.85	21.65	11.69	16.27	14.88	11.50	17.40
30-04-90	7.11	9.86	17.79	21.70	11.71	16.20	14.93	11.42	17.42
07-05-90	7.66	N.A	17.87	21.70	11.63	16.20	14.98	11.48	17.45
14-05-90	10.95	13.81	17.83	21.70	11.53	16.16	15.04	11.35	17.50
21-05-90	12.62	14.47	17.89	21.80	11.43	16.16	N.A	11.36	17.53
28-05-90	14.36	9.51	17.94	21.80	11.43	16.09	15.20	11.32	17.55
04-06-90	15.85	9.40	17.85	21.82	11.27	16.07	15.25	11.36	17.60
11-06-90	15.99	9.93	17.72	21.90	11.19	15.95	15.30	11.17	17.63
18-06-90	17.42	12.05	17.98	22.00	11.10	15.82	15.30	11.04	17.65
25-06-90	21.35	13.37	18.10	22.00	11.03	15.77	15.34	10.98	17.67
02-07-90	20.95	13.76	18.06	22.14	11.09	15.08	15.34	11.90	17.68
09-07-90	21.28	8.66	18.09	22.20	10.80	15.53	N.A	11.70	17.70
16-07-90	20.97	6.09	17.94	22.30	10.59	15.40	15.39	10.48	17.71
23-07-90	20.86	7.05	17.85	22.35	10.60	15.30	15.40	10.23	17.71
30-07-90	20.33	8.93	17.81	22.40	10.40	15.15	15.42	10.00	17.69
05-08-90	20.28	10.55	17.63	22.45	10.30	15.00	15.45	9.63	17.69
13-08-90	20.24	11.39	17.51	22.50	10.24	14.86	15.50	9.55	17.69
20-08-90	20.15	12.89	17.39	22.50	10.25	14.95	15.55	9.45	17.67
27-08-90	20.11	13.61	17.48	22.52	10.22	14.85	15.50	9.80	17.64
03-09-90	20.08	14.44	17.43	22.50	10.31	14.84	15.59	9.70	17.60
10-09-90	19.83	13.97	17.49	22.54	10.45	14.94	15.71	9.99	17.63
17-09-90	19.86	14.41	17.55	22.50	10.53	14.94	15.80	9.99	17.65
24-09-90	19.80	14.89	17.39	22.55	10.68	14.98	15.85	9.99	17.68
01-10-90	20.36	15.13	17.42	22.65	10.35	14.90	15.95	9.00	17.71
08-10-90	20.43	15.44	17.38	22.63	10.25	14.85	15.99	9.47	17.71
15-10-90	20.58	15.79	17.37	22.85	10.14	14.75	15.99	9.67	17.72
22-10-90	18.85	16.01	17.33	22.90	10.35	14.81	15.05	9.89	17.73
29-10-90	17.93	16.08	17.39	23.05	10.62	14.97	15.98	10.94	17.75
05-11-90	18.41	16.11	17.35	23.08	10.82	15.04	15.94	10.45	17.78
12-11-90	18.42	15.81	17.51	22.95	10.95	15.15	15.97	10.47	17.80
19-11-90	18.43	13.92	17.61	N.A	11.05	15.26	15.95	10.60	17.86
26-11-90	18.50	9.82	17.68	22.95	11.20	15.35	15.90	10.64	17.87
03-12-90	18.67	10.13	17.76	N.A	11.35	15.51	15.94	10.78	17.95
10-12-90	17.43	10.86	17.82	N.A	11.45	15.54	15.96	10.85	18.00
17-12-90	17.55	11.72	17.91	23.05	11.55	15.65	15.95	10.83	18.03
24-12-90	18.68	11.97	17.98	23.07	11.66	15.70	15.97	10.92	18.08
31-12-90	19.21	12.97	N.A	N.A	11.75	15.82	15.93	10.95	18.12

GROUND WATER CIRCLE -II
BWDB, DHAKA.

DISTRICT: DHAKA

GROUND WATER TABLE BELOW LAND SURFACE IN METRE

THANA	Motijheel	Moham-madpur	Lalbag	Malibag	Sutrapur	Moham-madpur (Sultan-ganj)	Mirpur	Canton-ment	South Basabo
	WELL NUMBER								
DATE	DA-124	DA-108	DA-110	DA-112	DA-13	DA-111	DA-15	DA-103	DA-123
02-01-89	20.83	17.07	15.91	19.94	10.50	14.23	13.30	9.04	7.21
09-01-89	20.88	17.38	15.95	19.92	10.50	14.28	13.40	9.40	7.51
16-01-89	20.93	17.57	15.93	19.94	10.60	14.45	13.40	9.44	7.93
23-01-89	20.88	17.70	16.08	19.97	10.70	14.54	13.50	9.53	8.97
30-01-89	20.88	17.88	16.13	19.99	11.00	14.64	13.51	9.68	9.25
06-02-89	20.98	17.79	16.19	19.97	11.00	14.71	13.60	9.78	9.50
13-02-89	21.04	17.89	16.27	19.94	11.10	14.74	13.61	9.90	6.58
20-02-89	21.09	17.98	16.46	19.97	11.20	14.90	13.61	10.01	6.63
27-02-89	21.34	17.25	16.53	19.99	11.20	14.96	13.64	10.03	6.40
06-03-89	21.34	16.80	16.62	20.04	11.30	15.03	13.67	10.28	6.76
13-03-89	21.70	16.40	16.29	20.13	11.20	15.04	13.70	10.31	6.65
20-03-89	21.77	15.90	16.37	20.20	11.30	15.30	13.74	10.41	NA
27-03-89	21.85	15.60	16.92	20.02	11.40	15.32	13.80	10.51	--
03-04-89	21.75	15.75	17.03	20.13	11.50	15.37	13.85	10.62	----
10-04-89	21.70	15.95	17.13	20.13	11.60	15.48	13.90	10.80	----
17-04-89	21.34	15.75	17.29	20.00	11.60	15.49	13.95	10.87	----
24-04-89	21.29	14.00	17.38	19.94	11.61	15.55	13.88	10.96	---
01-05-89	21.24	10.30	17.49	20.50	11.70	15.57	13.88	10.99	---
08-05-89	21.29	12.39	17.61	20.52	11.70	15.52	13.91	11.01	---
15-05-89	21.32	13.07	17.69	20.49	11.70	15.69	13.95	10.98	------
22-05-89	21.88	12.91	17.33	20.52	11.62	15.80	13.98	10.96	-----
29-05-89	21.88	12.73	17.28	20.51	11.51	15.97	14.00	10.81	16.53
05-06-89	22.08	12.98	17.25	20.50	10.78	16.16	14.02	10.67	16.60
12-05-89	22.13	12.63	17.19	20.52	10.63	16.50	14.04	10.51	16.65
19-06-89	22.20	13.15	17.13	20.55	10.68	16.05	14.08	10.25	16.69
26-06-89	22.25	14.77	17.23	20.58	10.75	15.35	14.08	10.18	16.70
03-07-89	22.30	15.17	17.10	20.61	10.73	15.10	14.10	10.12	16.71
10-07-89	22.35	15.37	16.92	20.62	10.50	15.05	14.12	10.02	16.72
17-07-89	22.26	15.62	16.80	20.60	10.49	14.88	14.15	9.85	16.73
24-07-89	22.35	15.02	17.19	20.68	10.38	14.85	14.17	9.80	16.75
31-07-89	22.32	16.49	17.23	20.75	10.22	14.70	14.18	9.72	16.72
07-08-89	22.35	15.97	17.09	21.05	10.27	14.57	14.19	9.63	16.70
14-08-89	22.40	15.92	17.06	21.10	10.39	14.65	14.19	9.62	16.70
21-08-89	22.40	15.89	17.17	21.05	10.57	14.35	14.20	9.68	16.68
28-08-89	22.35	15.83	17.23	21.04	10.59	14.62	14.20	9.79	16.65
04-09-89	22.41	15.76	17.19	21.00	10.52	14.60	14.22	9.69	16.64
11-09-89	22.38	15.72	17.12	20.74	10.23	14.60	14.23	9.68	16.66
18-09-89	22.49	15.69	17.03	21.03	10.18	14.58	14.25	9.68	16.69
25-09-89	22.50	15.45	16.92	21.00	9.60	14.50	14.30	9.25	16.69
02-10-89	22.56	15.35	15.92	21.03	9.79	14.48	14.28	9.10	16.60
09-10-89	22.53	15.25	16.87	21.00	9.78	14.49	14.30	8.90	16.60
16-10-89	22.50	15.43	16.60	21.04	9.55	14.51	14.32	8.75	16.62
23-10-89	22.59	15.54	16.80	21.10	9.65	14.47	14.38	8.74	NA
30-10-89	22.95	15.64	16.80	21.12	10.03	14.52	14.40	8.95	NA
06-11-89	22.67	15.95	16.70	21.18	10.76	14.68	14.42	9.20	16.65
13-11-89	22.66	16.35	16.90	21.16	14.46	14.78	14.46	9.52	16.70
20-11-89	22.69	16.53	17.10	21.20	14.50	14.90	14.50	9.68	16.82
27-11-89	22.70	16.74	17.20	21.30	14.51	15.04	14.05	9.90	16.88
04-12-89	22.74	16.85	17.26	21.07	14.55	15.14	14.54	10.05	16.97
11-12-89	22.77	16.94	17.33	21.10	14.58	15.25	14.58	10.17	16.05

GROUND WATER CIRCLE -II
BWDB, DHAKA.

THANA	Motijheel	Moham-madpur	Lalbag	Malibag	Sutrapur	Moham-madpur (Sultan-ganj)	Mirpur	Canton-ment	South Basabo
	WELL NUMBER								
DATE	DA-124	DA-108	DA-110	DA-112	DA-13	DA-111	DA-15	DA-103	DA-123
18-12-89	22.75	17.09	17.27	21.12	14.58	15.34	14.58	10.32	16.08
25-12-89	22.76	17.18	17.36	21.15	14.60	15.44	14.60	10.54	17.10

GROUND WATER CIRCLE -II
BWDB, DHAKA.

DISTRICT: DHAKA

GROUND WATER TABLE BELOW LAND SURFACE IN METRE

THANA	Motijheel	Moham-madpur	Lalbag	Malibag	Sutrapur	Moham-madpur (Sultan-ganj)	Mirpur	Canton-ment	South Basabo
	WELL NUMBER								
DATE	DA-124	DA-108	DA-110	DA-112	DA-13	DA-111	DA-15	DA-103	DA-123
04-01-88	20.74	17.21	16.18	19.51	------	14.05	13.50	16.31	13.95
11-01-88	20.81	17.25	16.35	19.56	------	14.10	13.61	16.44	13.96
18-01-88	20.74	17.30	16.33	19.56	------	14.16	13.64	16.52	13.98
25-01-88	20.86	17.33	16.31	19.51	-------	14.40	13.65	16.61	13.99
01-02-88	20.89	17.35	16.29	19.84	------	14.45	13.66	16.72	14.05
08-02-88	20.91	17.38	16.32	19.87	------	14.58	13.73	16.70	14.08
15-02-88	20.94	17.42	16.51	19.82	------	14.59	13..74	16.80	14.11
22-02-88	20.94	17.45	16.72	19.82	-----	14.62	13.80	16.83	14.15
29-02-88	20.94	17.49	16.70	19.84	------	14.71	13.87	16.87	14.21
07-03-88	20.96	16.89	16.82	19.82	------	14.75	13.90	16.84	14.28
14-03-88	20.96	16.82	16.54	19.87	-----	14.67	14.10	16.88	14.35
21-03-88	21.02	16.77	16.88	19.82	----	14.71	14.12	16.92	14.42
28-03-88	21.04	16.74	17.01	19.89	-----	14.45	14.20	16.90	14.50
04-04-88	21.06	16.85	16.89	19.90	------	14.73	14.18	16.95	14.48
11-04-88	21.09	16.81	16.81	20.02	------	14.83	14.21	16.97	14.45
18-04-88	21.14	16.76	17.13	19.92	------	14.80	14.23	17.00	14.40
25-04-88	21.14	16.71	17.19	19.99	------	14.90	14.19	16.95	14.39
02-05-88	21.14	15.05	17.15	20.04	------	14.88	14.15	16.90	14.36
09-05-88	21.14	14.96	17.26	20.02	------	14.85	14.14	16.84	14.32
16-05-88	21.14	13.70	17.21	20.07	-----	14.83	14.15	16.80	14.28
23-05-88	21.16	N.A	17.25	20.07	------	14.87	14.11	16.80	14.25
30-05-88	21.16	N.A	17.05	20.13	------	14.51	14.10	16.70	14.19
06-06-88	21.16	5.08	17.11	19.92	------	14.41	14.04	16.50	14.17
13-06-88	21.17	4.40	16.28	19.89	-----	14.31	13.90	16.35	14.14
20-06-88	21.18	4.10	16.08	20.04	------	14.10	13.80	16.23	14.09
27-06-88	21.16	4.00	16.02	20.15	-----	13.98	N.A	16.10	14.02
04-07-88	12.14	4.05	16.07	20.12	-----	13.99	N.A	16.15	14.00
11-07-88	21.14	4.00	16.05	20.17	-----	14.45	N.A	16.20	13.88
18-07-88	21.12	3.98	15.96	20.20	------	14.55	N.A	16.15	13.76
25-07-88	21.09	N.A	15.86	20.12	----	14.54	N.A	16.10	13.63
01-08-88	21.07	4.20	15.81	20.04	-----	14.53	N.A	16.05	13.61
08-08-88	20.96	4.09	16.25	20.02	----	14.60	N.A	16.95	------
15-08-88	21.01	4.00	15.88	19.97	-----	14.71	N.A	16.88	------
22-08-88	20.48	3.50	15.83	19.97	9.30	14.72	N.A	16.80	------
29-08-88	20.55	3.00	15.86	19.89	9.10	14.73	N.A	16.72	------
05-09-88	20.60	Flood	15.61	19.82	5.50	14.51	N.A	Flood	------
12-09-88	20.63	4.12	15.43	19.87	5.70	14.61	N.A	N.A	------
19-09-88	20.68	4.67	15.26	19.82	7.00	14.62	N.A	N.A	------
26-09-88	20.45	4.88	15.23	19.89	8.00	12.36	12.40	14.65	------
03-10-88	20.50	5.70	15.29	19.97	7.80	12.54	12.85	14.75	------
10-10-88	20.50	6.95	15.45	20.02	8.50	12.37	13.00	14.84	------
17-10-88	20.55	3.02	15.31	19.92	8.70	14.01	13.05	15.15	------
24-10-88	20.60	3.55	15.17	19.97	8.40	14.12	13.10	15.52	------
31-10-88	20.63	6.90	15.12	19.92	9.00	14.21	13.19	15.88	------
07-11-88	20.65	9.82	15.34	19.92	9.40	14.42	13.21	16.20	------
14-11-88	20.70	10.72	15.96	19.84	9.50	14.51	13.25	8.19	-----
21-11-88	20.68	11.95	15.45	19.89	9.70	13.52	13.24	8.45	------
28-11-88	20.65	1293	15.62	19.82	9.80	13.53	13.15	8.57	-----
05-12-88	20.66	13.85	15.41	19.87	9.20	13.80	13.20	8.64	-----
12-12-88	20.68	14.49	15.69	19.89	9.40	13.91	13.21	8.48	-----

GROUND WATER CIRCLE -II
BWDB, DHAKA.

THANA	Motijheel	Moham-madpur	Lalbag	Malibag	Sutrapur	Moham-madpur (Sultan-ganj)	Mirpur	Canton-ment	South Basabo
	WELL NUMBER								
DATE	DA-124	DA-108	DA-110	DA-112	DA-13	DA-111	DA-15	DA-103	DA-123
19-12-88	20.73	15.75	15.01	19.87	10.20	14.01	13.25	8.65	------
26-12-88	20.78	16.98	15.78	19.89	10.40	14.02	13.30	8.84	------

APPENDIX- B

DWASA- Deep Tubewells Inventory

DEEP TUBEWELLS
DHAKA WASA
MODS ZONE - I

Well No	Location	Date of Tube Well Completion	Ficture Depth (m)	Installation Time	
				PWL (m)	SWL (m)
101	Basaboo-1 R1	1994	126	41.76	28.17
102	Basaboo-2	1991	156	45.9	21.4
103	Ahmedbag	1989	171	26.50	16.40
104	Mugdapara(North R1)	1988	164.6	37.2	15.24
105	Maniknagar(R1)	1996	150.1	35.1	16.31
106	Golapbag	1990	166..5	30.53	18.00
107	Hatkhola(F.M.D R3)	1992	165.7	35.9	22.8
108	Saidabad(B.T)	1998	155.8	42.3	21.43
109	Doyagonj(Old)	1998	155	25.66	9.04
110	Rajuk(DIT)	1983	160	30.7	18.72
111	Baldagarden(R2)	1997	154	52	38.82
112	Bonogram (Near OHT R1	1991	155	68.5	40.12
113	Narinda	1992	156.56	35.0	20.40
114	Lakshi Bazar(WASA) (R)	1990	159.56	30.38	16.64
115	Forashgonj (R1)	1983	165.14	22.54	10.82
116	Jatrabari (Brkige)	1995	179	38.48	25.50
117	Jatrabari 3	1998	111	34	18.32
118	Jatrabari-2(W.C)	1989	152.6	22.46	11.28
119	Donia (R1)	1996	166	30.64	19.91
120	Jurin	1989	158	20.73	7.6
121	Peterbag	1991	142	22.71	9.35
122	Dhupkhola	1980	125	21	11.05
123	Gandaria-(R1)	1994	157	38.6	21.08
124	Gandaria -2 (DIT)	1998	170	32.6	20.35
125	Mill Barak	1980	150	18	8.00
126	I.G.Bagan	1984	145.12	24.5	12.29
127	Banga Bhaban(R2)	1990	157	41.58	23.4
128	Shampur	1990	156	21.49	8.53
129	Pagla(R1)	1994	164	15.3	6.92
130	Manda	1992	174	27	17.17
131	Kamlapur	1992	180	42	21.8
132	Kazla	1993	158	24	15
133	Kazi A. Rouf Rd.	1993	158	30.8	21.25
134	Mirhazirabag	1994	163	34.89	19.1
135	Sha-shaheb Lane	1995	150	39.45	27.5
136	South Mugdapara	1995	168.62	42	30
137	Gupibagh(Rajuk)	1998		64.61	35.96

DEEP TUBEWELLS
DHAKA WASA
MODS ZONE - II

Well No	Location	Date of Tube Well Completion	Ficture Depth (m)	Installation Time PWL (m)	SWL (m)
201	Dhakiswari(WASA) (R1)	1992	136	30.8	18.4
202	Water Works	1971	129.1	14	8
203	Bakshabazar (R1)	1983	137	22	14.14
204	Lalbagh (R1)	1992	10	26.7	16.8
205	Nawabgonj (R1)	1994	132.11	30.8	21.0
206	Azimpur-6 R1	1994	132	31.7	20.44
207	Azimpur (near OHT)	1998	10	28.20	22
208	B.D.R-2	1970	121.9	11	5.49
209	B.D.R-3 (R3)	1995	13.8	29	21.9
210	Hazaribagh-5 (Leather)	1986	139.3	22	12.5
211	Hazaribagh-3 (OHT) (R1)	1980	142	18.5	9.55
212	Hazaribagh-4 (OHT) (R1)	1991	124	20.1	13.6
213	Abul Hasan Road (R2)	1998	149	35.40	23.16
214	Jagannath College (R1)	1998	168.5	37.5	25.36
215	Mitford Hospitall (R2)	1987	150	29.25	21.85
216	Simson Road (R1)	1998	158	33.15	18.42
217	Fillbaria (Near OHT) R3	1991	154	34.9	22.8
218	Agamashi Lane (R1)	1985	144	19.3	14
219	S.D.Park	1978	142	25	9.3
220	Amanitola Math	1977	135.6	25.6	9
221	Bangladesh Math	1993	147	34.3	19.9
222	Dholaikhall (Nawabpur) (R1)	1976	140	----	----
223	Rajnarayandor Road	1990	132	19.65	13.53
224	Islambagh R1	1997	139.8	24	13
225	Nazir Bazar	1994	146	29	21
226	Saitha Khan	1997	138	29	20.47

DEEP TUBEWELLS
DHAKA WASA
MODS ZONE -III

Well No	Location	Date of Tube Well Completion	Ficture Depth (m)	Installation Time	
				PWL (m)	SWL (m)
301	Shamoli Ring Road (R2)	1988	134.10	27.50	12.60
302	Babar Road (Md.pur)(OHT)	1970	120.40	13.71	6.30
303	Asadgate R2	1992	132.30	34.10	19.65
304	Solimullah Road(Md.pur)	1995	130	33.99	15.09
305	Nazrul Islam Road (Md.pur)	1985	138	35	22
306	Lalmatia-4(R3) Near Woman College)	1991	125.4	28.61	18.17
307	Lalmatia-5 (near OHT) (R1)	1998	120.93	27.70	18.20
308	Pangu Hospitall	1998	120.93	48.90	22.99
309	Indira Road R1	1997	131.78	40.67	30.25
310	Green Road-3	1974	129.27	13.31	6.63
311	Laboratory School (R)	1990	125.02	27.18	18.54
312	Sukrabad (R)	1998	128	40.23	30.78
313	Green Road-4	1995	129	37.95	28.19
314	New Elephant Road-3	1994	135	52.71	26.92
315	Jhikatola R1	1992	119	29.60	18.40
316	Rayer Bazar (Tall)	1992	137	39.20	15.80
317	Dhanmondi-8 (Near OHT)	1986	117	15.22	7.90
318	Tikkapara (Md.pur)	1994	176.12	26.11	7.60
319	Dhanmondi Road-1 (R1)	1986	140	18.34	7.44
320	Mohila Hostel (Nilkhat)	1986	135	28.86	18.57
321	Sultangong (Royer-Bazar)	1989	134	17.40	12.20
322	Baitul Aman	1998	113	33.95	18.10
323	Central Road	1990	132	23	18.47
324	P.I.S.C.I. Cultural	1990	121	23.93	11.63
325	Baraboo (Shamoli)	1990	174	31.30	14.30
326	Salek Road PWD	1992	136.17	27.3	16.1
327	Graphic Arts	1994	133	30.21	17.78
328	Monipuri Para	1995	138	36.07	27.58
329	Nodi Gobasona	1995	133	35.26	27.13
330	Dhanmondi (7A)	1995	128.08	31.17	23.70
331	Iqbal Road	1996	124	38.86	25.76
332	Sonargaon Road	1996	130.56	39.27	30.25
333	Tajmohal Road (Md.Pur)	1996	130	31.80	16.9
334	Basabari (Md.pur)	1996	124	26.57	19.89
335	Kalabagan (Shishu Park)	1996	136	41.83	27.13
336	Eidgah Math Rd.-7/A	1998	130	42.97	25.14

DEEP TUBEWELLS
DHAKA WASA
MODS ZONE - IV

Well No	Location	Date of Tube Well Completion	Ficture Depth (m)	Installation Time	
				PWL (m)	SWL (m)
401	Mirpur Sec-II P.S-7(O.H.T)	1990	102	33	19
402	Mirpur sec-II P.19 Zoord	1996	114.6	44.44	26.7
403	Mirpur Sec-VI P.16	1988	121.6	22.7	12.7
404	Mirpur Sec-VII. R1 P/S-14 R1	1997	118.5	41.8	28
405	Mirpur Sec-X P-18 R1	1995	132	36.7	25
406	Mirpur Sec-X p-28	1990	137	23	12.9
407	Mirpur Sec-XI p-17 R1	1995	128	37.2	25
408	Mirpur Sec-XII p-24 B-D	1988	129	28.30	10.2
409	Mirpur Sec-XII p-26 B/C	1989	112	31.4	13.5
410	Mirpur Pallabi-P-21	1991	119	28	15
411	Mirpur Sec-XII p-23	1983	133	16	9.45
412	Mirpur Sec-XIV (H&5)	1991	138	31	13
413	Mirpur Lalasarai	1994	133	39	22
414	West Sheorapara R1	1996	129	34	20.8
415	Bangla College	1980	97.5	20.3	7.1
416	Pirebagh	1998	129	30.5	16.8
417	Kallayanour	1995	162	50	22.5
418	Rupnagar	1983	108	18.6	7.05
419	Monipur	1990	149	21	12.4
420	Duaripara	1990	147	27.3	10
421	Kafrul	1989	129	32	22
422	B.I.B.M	1991	118	25.7	13.4
423	Agargoan	1989	129	28	13
424	Avenue-5 Mir-11	1992	133	34.45	20.46
425	Parade Square	1989	127.6	28.30	17.36
426	Manidi	1991	160	25.6	12.7
427	Mirpur Sec-12 Ceremic	1992	120	33	15.26
428	Shahid Buddijibi	1992	87	28.6	12.9
429	Ibrahimpur	1995	133	32	21.7
430	Haji Road Block (H)	1995	112.2	44	26
431	Ahmad Nagar	1995	123	33	20
432	Gudarghat Sec-1 Mirpur	1991	109	36.5	13.7
433	East Sewrapara	1997	132	34	26
434	Lal Kati	1997	97.9	30.5	18.4
435	Sangbadik Palli	1997	129	38	23.5

DEEP TUBEWELLS
DHAKA WASA
MODS ZONE - V

Well No	Location	Date of Tube Well Completion	Ficture Depth (m)	Installation Time PWL (m)	SWL (m)
501	Banani-3(Rd.1A) R1	1997		36	23
502	Banani-4 (Rd.8) R1	1997	153	37	26
503	Banani-5	1990	160	22.5	11.5
504	Gulshan-4(Near OHT) R2	1984	135	16.3	9.91
505	Gulshan-5 R1	1995	153	33	21
506	Kuralali	1990	166	14	7.5
507	T.B.Gate (Mkhalkhali)(OHT) Zone-5 R1	1998	164	32.21	21.63
508	D.O.H.S-1 (R) OHT	1996	136	40	24
509	D.O.H.S-2	1990	146	25.9	15.2
510	shahjadpur	1990	159	25.5	13.5
511	Mohakhali Lab R2	1998	154	47.24	30.78
512	Noorerchaia	1989	160	18.8	9.8
513	F.D.C	1995	143	42	30
514	Khilkhet-1	1990	153	17.5	7.9
515	Kawran Bazar	1997	142	47	33
516	Mid Badda	1990	159	22.5	13.3
517	Uttara-P/S (S-6)	1983	136	14	6.6
518	Uttara P/S-1 S-3 R1	1997	155	20.4	13.2
519	Uttara-3 B	1991	162	10	4.7
520	Uttara-4	1989	159	16.6	7.1
521	Tejgaon-9 R1	1993	150	38.8	26.2
522	Nilkhet	1989	160	23.3	16
523	Tejgaon-8	1995	148	44	31
524	Basundhara (Block-B)	1990	152	22.6	10.5
525	Baridhara	1984	151	19.7	9.00
526	Menul Badda	1990	159	22.5	13.3
527	Old Assembly	1989	132	36	21
528	Kalachanpur	1989	167.5	19	10.2
529	Tejkunipara	1993	138	37	23
530	Khilkhet-2	1990	153	15.2	6.6
531	Uttara-9/A OHT	1989	171	16.5	7.3
532	Kuril	1990	159	18.9	8
533	Uttara-5	1989	149	18	8
534	Uttara-9B	1989	165	12.5	6.4
535	Kaolar-1	1990	143	13.8	7.8
536	Kaolar-2	1990	159	19.6	7.2
537	Nayanagar	1989	142	23	10
538	Tejgaon Poly Tech	1994	148	42	27
539	Ashkona	1989	147	16.3	6.7
540	Dakhin Khan	1990	150	18	11.72
541	D.O.H.S (Banani)	1998	155	31	17.55
542	East Nakhalpara	1995	149	41	18
543	Joar Shahara (D.OH.S)	1995	158	30	18
544	Mohakhali T&T	1996	158	39	18

DEEP TUBEWELLS
DHAKA WASA
MODS ZONE - VI

Well No	Location	Date of Tube Well Completion	Ficture Depth (m)	Installation Time	
				PWL (m)	SWL (m)
601	High Court	1998	133	13	6
602	Segun Bagicha	1991	146	32	22
603	Dhaka Medical College(R1)	1986	141	27	17.3
604	P.G. Hospital	1986	137	37	20.4
605	Jimkhana R1	1997	139	30	12
606	Lichu Bagan R1	1996	152	46	33
607	Bijoy Nagar R2	1994	159	48	29
608	Bonosree	1993	167	33	21
609	Rampura East R1	1996	164	45	30.5
610	Khilgaon-8 (N.M.Q)	1997	169	48	26
611	Khilgaon-5 R1	1997	163	50	35
612	Khilgaon-7 (Near M.N)	1995	161	43	32
613	Khilgaon-6 R1	1993	151	44	27
614	Goran (Chapra)	1997			
615	Madartek	1998	154	24	16
616	Meradia	1996	178	38	25
617	Nandipara	1991	170	28	16
618	Goran-2 (EHL)	1990	169	26	16
619	Noorbag	1994	156	42	27
620	Modhubag old	1989	142	40	21
621	Mohanagar	1994	157	38	17
622	Modhubag Madrasa	1996	159	38	29
623	Mogbazar (Wireless)	1989	156	31	21
624	Malibag (D.I.T)	1997	147	50	35
625	Nayatola R1	1989	164	40.5	21
626	Ulon	1990	154	22	13
627	Red Crecent (Mogbazar)	1992	158	29	20.87
628	Rajarbag New	1983	152	53.94	41.14
629	Rajarbag Old	1989	155	40	23
630	Circuit House	1990	151	34	22
631	Kakrail O.H.T.R	1991	142	32	25
632	Elephant Road-2 R1	1996	141	43	33
633	Eskaton Garden	1995	157	45	33
634	Siddeshari	1994	164	45	32
635	Khilgaon(Bagicha)	1996	152	46	36
636	Gulbagh	1993	151	48	28
637	Santibagh	1996	171	49	36
638	Stadium R1	1991	159	40	24
639	Fakirapoll R2	1994	157	47	29
640	A.G.B Colony R1	1997	103	45	36
641	Pir Jangi Mazar	1984	162	21	8
642	Shahjahanpur R1	1995	162	46	32
643	Rajarbag (Store)-3	1995	152	45	34
644	Eskaton R1	1997			
645	Osmani Udyan	1996	158	56	29
646	Goran-3 R1(Shantipur)	1996	176	43	21

DEEP TUBEWELLS
DHAKA WASA
MODS ZONE - VI

Well No	Location	Date of Tube Well Completion	Ficture Depth (m)	Installation Time	
				PWL (m)	SWL (m)
601	High Court	1998	133	13	6
647	Khilgaon-4/R3	1997	164	53	39
648	Rampura T.V	1997		45	34
649	Goran Chapra Mosque	1997			