CHAPTER IV
HYDROGEOLOGY
HYDROGEOLOGY

The Ganga basin is one of the biggest repositories of groundwater in India. The state of U.P. covers about 42% of the basin and has been divided into five distinct hydrogeological zones (Fig. 4.1) viz. Intermontane valley fills, Bhabar or Piedmont zone, Terai or Wetland zone, Central Ganga Plain and Southern Marginal Plain.

The Bhabar belt stretches parallel to the Himalayan foot-hills in a 10-30 km width due south up to the spring line. The Bhabar consists of bouldary strata mixed with sand, which is highly transmissive in nature. The southern limit of this zone is marked by the spring line. This is followed immediately by Terai belt which extends from the spring line in the north to south and consists of alternate beds of clay and coarse sand mixed with granules. The groundwater in this zone occurs under great artesian pressure where free flowing wells below 50 m is a common phenomenon. This zone has the best quality of groundwater in the Ganga basin. However, the southern limit of Terai imperceptibly merges with the Central Ganga Plain. The fifth hydrological unit that is the Southern Marginal Plain, lies between Central Ganga Plain and the Bundelkhand Craton.

The Central Ganga Plain which is the vast alluvial track lying south of Terai zone and bounded in west by the river Yamuna up to Allahabad and further eastward by the river Ganga. This is characterised by low relief and numerous depositional features like old channels, natural levees, meander scrolls suggesting that the Ganga river systems have occupied and abandoned several courses while the plain has been in the making. The shifting rivers carved newer meander belts at lower topographic levels. In
HYDROGEOLOGICAL ZONES OF UTTAR PRADESH
(After Pathak, 1978)
the process, the ancient Meander Floods Plain were left-off as extensive highlands or ridges that act as present day water divides. Thus, the Central Ganga Plain presents, surficially two distinct sub-units. The Highlands or the Composite Flood Plain and the Meander Flood Plain (Dubey and Husain, 1991). The Composite Flood Plain comprises a northwest - south east trending highlands lying between various tributaries of the Ganga system which are located about 10 to over 30 meters above the adjoining low-lying areas. The low levelled peripherals fore - land regions of the highlands are frequented by over-bank flows from the adjoining rivers during flood periods and receives fine grained deposits. On the other hand, the present day meander belts of the rivers form the Meander Flood Plain. The Ganga and its tributaries show an abundance of recent ox-bow lakes, meander scrolls and channels scars.

**EVOLUTION OF AQUIFERS:**

The evolution of aquifers in the fluvial system is dependent upon hydrodynamics of the flow regime, geology and topography of the terrain, leading to the terrigenous clastic deposition system, which are typically represented as channels, flood plain and back - swamp deposits.

**CHANNEL DEPOSITS:**

The typical channel deposits in the study area from bottom to upward comprise medium to fine sand, occasionally mixed with coarse sand and gravel, and a very thick clay layer on the top. The top clay and some fine sand layers are washed away during the successive flood season and a fresh body of sand with fining upward sequence is deposited each year, forming their by a reasonably thick terrigenous clastic deposits till the river changes its course due to some tectonic disturbances. The thick bodies of sand deposited as channel deposits from the areally extensive and highly potential aquifers.
Flood Plain Deposits:

During the flood season when the flood water overflows the banks, medium to fine sand bodies of limited areal extend and moderate thickness are deposited over the flood plain. These lenticular bodies of sand form moderately potential aquifers in comparison to the highly potential aquifers of the channel deposits. The lenticular shape of the aquifers is due to the fact that the flooding takes place in a limited stretch of the river banks at a time.

Back - Swamp Deposit or Ox-bow Lake Deposit:

The flood water from the high banks further moves down the slope towards the low lying areas where it is left predominantly with the suspended materials only, which get settled under the influence of gravity and form a lensoid body of sand which is later on overlain by clayey horizon. Thus, the lensoid sand bodies generated occur as intercalation within the thick bodies of clay. Such bodies of sand characterise the back - swamp environment and form the poor aquifers, very often associated with the quality problem due to the lack of recharge. The enclosed nature of such aquifers obstruct the regular flushing or recharge rendering thereby to poor quality of formation water.

Further, as the river changes its course, the position of the channel, flood plain and back - swamp deposits also continue changing with the passage of time. This is the reason that no continuos body of sand or clay are found in a borehole except under the extraordinary geologic situation. Thus, the lithological variations are attributed to their mode of deposition by the constantly shifting nature of the streams draining the area.

The various aquifers system, thus, generated by the river Ganga and its tributaries like Sengar and Kali, are as follows:
MAP SHOWING THE AREA SURVEYED WELLS AND TUBEWELLS INVENTORIED IN ALIGARH DISTRICT (U.P.)

INDEX

- WELL INVENTORIED
- STATE TUBEWELL
A—A' SECTION LINE

Fig 4.2
(b) Flood plain deposits - the lenticular aquifers of limited thickness are areal extent and only moderately potential.

(c) Back-swamp deposits - the lensiod bodies of sand occurring as enclaves or stringers within the thick clay bed, generally forming the low potential aquifers with quality problems.

We find that in a thick Ganga alluvium, the complexes of the channel, flood plain or back-swamp reappear several times in the wells drilled at places in the area. Thus, the terrigenous clastic depositional system of the river Ganga in the study area is an index of its complex hydrodynamic regime which has generated various aquifers in the great Ganga plain.

AQUIFER GEOMETRY:

In order to study the aquifer disposition and their lateral and vertical extent a Fence diagram and two hydrogeologic cross-sections (Fig. 4.3 to 4.5) have been drawn utilising the lithological logs of the existing tubewells (Appendix II) constructed by the Central Ground Water Board (CGWB) and the U.P. State Groundwater Department as also the Irrigation Department of the U.P. State Government in the district. The deepest borehole in the district has been drilled by the Central Groundwater Board down to a depth of 383.26 m.b.g.l. at the Aligarh Railway Club Compound where as the drilling by the State Irrigation Department has been restricted to a maximum depth of 204.21 m.b.g.l. The location of tubewells and lines along which cross-section have been prepared are shown in Fig 4.2.

A perusal of the Fence diagram (Fig. 4.3) depicts the aquifer disposition in the district which also shows the variations of then aquifers
FENCE DIAGRAM SHOWING AQUIFER SYSTEM IN ALIGARH DISTRICT (UP)

INDEX
- CLAY
- SAND
- BED ROCK

Scale: 0 5 10 15 Km

0 30 60 90 120 M 150

Fig 4.3
thickness between the Ganga and Yamuna banks. The granular zones dominate between the Ganga - Sengar sub - basin while the clay bed dominate close to the Yamuna bank. However, a brief detail are as under: North- eastern part of the district, especially the area in vicinity of the Ganga river, has an extreme preponderance of coarser sediments so much so that a borehole at Hardoi drilled down to a depth of 121.92 m.b.g.l. has almost a complete column of sand in the borehole. But as one moves from north - east to north - west or to the central part of the district, the degree of preponderance of coarser sediments tend to reduce, nevertheless, they still predominate over finer sediments in these areas. However, in the southern and south-western part of the district, it is the clay that out-numbers the granular horizons. In Aligarh city, the granular zone dominates over clayey horizons from ground level to about 200 m.b.g.l. and thereafter there is a continuous clayey zone down to the bed rock encountered at the depth of 340.00 m.b.g.l. In this area, though the number of sandy horizons is less but they are quite thick and form potential aquifers. The thickest granular zone attain a thickness of 56.62 m in the area. In the southern and south - western part of the district, though the number of sandy zones is more but they are generally not so thick.

**Hydrogeological cross - section along the line A-A’ :**

This section line runs in a WSE - ENE direction from Surir Kalan (Mathura district) to Kaka Begpur through Dhantauli, Aligarh Railway Club, Sikandarpur, Paharipur and Hardoi. The length of the section is about 90 km.

A point of considerable hydrogeological significance is the preponderance of sand in the eastern part of the section and the occurrence of sand as top soil in the area around Kaka Begpur and Hardoi. At Hardoi, the entire borehole has recorded sand throughout its drilled depth except the
HYDROGEOLOGICAL CROSS SECTION ALONG AA'

INDEX

CLAY

SAND

BED ROCK

Fig 4.4
occurrence of two minor clayey horizons with the predominance of sand in the depth range of 21.33 and 30.48 m and 73.15 and 76.20 m. Clayey top soil which occurs as a thin veneer around Paharipur borehole gradually attains thickness towards west. The clayey top layer has a maximum thickness of 31.39 m at Dhantauli. At Surir Kalan, there occur six granular zones, of 16.50, 15.00, 12.00, 13.50, 46.50 and 34.00 m. The fifth granular zone is the thickest, extents towards east and attains maximum thickness of 70.03 m at Aligarh. However, a minor clayey horizon is found embedded in this granular zone as a lense. Dhantauli borehole is 121.92 m deep and two granular zones 33.77 and 21.03 m thick are met within the depth range of 31.39 and 101.19 m at this location. However, these two granular zones merge together east of Dhantauli to form a single, most potential aquifer in the area. Top aquifer extends eastward throughout the length of the section line. At Sikandarpur, it is traversed by two clayey lenses 3.05 m thick each in the depth range of 6.09 and 32.00 m. At Paharipur, eight granular zones are encountered in the borehole, out of which the top two belong to the above mentioned 1st aquifer. The 3rd and 4th granular zones are sand lenses and do not extent far laterally. In this area, lot of interfingering of granular and non-granular materials has taken place due to splitting and coalescence. Thus, the 5th and 6th granular zones, in fact, form two digitations of 2nd aquifer. The 7th and 8th aquifers are again of lensoid nature. But east of Paharipur, the top aquifer attains maximum thickness of more than 122 m. At Hardoi, the entire depth of the borehole is represented by the presence of sand, barring two minor clayey horizon with marked sand predominance. At Kaka Begpur, four minor clayey horizons 7.85, 2.90, 7.70 and 7.30 m thick are encountered in the depth range of 9.15 and 91.50 m. These clayey horizons seems to have a lenticular nature.
So, the overall hydrogeological picture obtained with the help of this section, indicates that there exists a 2-tier aquifer system in the area of which the top aquifer has fresh and good quality groundwater. The top aquifer is the most potential granular zone in the area. At places, as many as eight granular zones have been recorded but they are, infact, the result of either the branching and splitting of single aquifer into two or more granular zones or the occurrence of sand lenses admits the clay beds.

**Hydrogeological cross-section along the line B-B’:**

This section runs roughly in a south - north direction along Chandopa, Lutsan, Madrak, Aligarh Railway Club and Imloth. The depth of the boreholes ranges from 91.13 m (Madrak tubewell) to 379.36 m (Aligarh Railway Club).

There occurs a thin clay top soil throughout the line of section. At Chandopa, there occur seven granular zones in all in the depth range of 7.54 and 302.04 m. The first to seventh granular zones are 32.09, 10.70, 17.25, 5.85, 32.85, 4.08 and 41.04 m thick, respectively. However, the 2nd and 3rd, and 5th to 7th granular zones constitute one aquifer each as they merge together and coalesce to form sufficiently thick and potential aquifers between 8 and 12 kms north of Chandopa. The sixth granular zone is, infact, a sand lense within a clayey horizon and divides the latter into two portions at Chandopa. The Chandopa tubewell taps only the second and third granular zones which constitute a single aquifer. The Lutsan tubewell which is 124.05 m deep situated due north of Chandopa has encountered four granular zones in the depth range of 6.40 and 122.68 m. The first and second granular zones form a single aquifer which is, infact, interspersed with a clay lense. The clay lense divides the aquifer into two granular zones. Madrak tubewell which is 91.13 m deep has two
HYDROGEOLOGICAL CROSS SECTION ALONG BB'

Fig. 4.5
granular zones in the depth range of 3.04 and 38.70 m. The upper granular zone is 6.10 m thick and the lower one is 12.80 m thick. The two granular zones constitute a single aquifer interspersed by a clay lens. Aligarh Railway Club borehole has encountered four granular zones in the depth range of 10.10 and 340.00 m. The individual granular zones are 56.62, 10.33, 70.03 and 25.93 m thick. Here the first aquifer tends to swell and attains maximum thickness. It is followed by a relatively thinner aquifer (2nd aquifer). A clayey horizon 30.97m thick, separates the 1st and 2nd aquifers. Another clayey horizon 21.80 m thick, intervenes between 2nd and 3rd aquifers. Quantitatively, the 3rd aquifer is the most potential aquifer but its quality of groundwater is not good. The 4th granular zone at Aligarh lies in the depth range of 342.33 and 368.16 m. Imloth State tubewell is located 12.25 km north of Aligarh Railway Club tubewell, is 122.53 m deep and taps only the 2nd, 3rd and 4th granular zones (1st and 2nd aquifers).

The general hydrogeological picture obtained from this section indicates that there is a 3-tier aquifer system in the area. The aquifers have a pinching and swelling disposition. At places, an individual aquifer splits into two or more granular zones and at others two individual granular zones coalesce to form a single aquifer thus giving deceptive picture of the multiplicity of aquifers in the area.

Overall, the district has the 2-3 tier aquifer system. The 1st aquifer which occurs in the depth range of 0.00 to 122.00 m is the most potential granular zone in the district in both the quantitative and qualitative terms. The 2nd and 3rd aquifer which occur in the depth ranges of 99.69 to 144.00 and 132.00 to 300.00 m respectively, have got great quantitative potential but unfortunately, their quality formation of water is not good and not fit either for drinking or agriculture purposes. All other granular
zones encountered in boreholes at different depths at various places have little spatial extension and are of lenticular nature. The quality of their water is not good. All the aquifers in the area have a pinching and swelling disposition. They have a tendency to dilate at one place due to the coalescence of two or more granular zones and attenuate at other, due to the splitting of one aquifer into several granular zone thus giving the deceptive look of the multiplicity of aquifers in the area.

**Mode of Occurrence of Groundwater:**

In Aligarh district groundwater occurs under water table condition at shallow depth. Dugwells generally tap the phreatic aquifer. The depth of the dugwells ranges from 5.34 to 28.90 m.b.g.l. In places where aquifer material is overlain by less permeable horizon of clay, silt etc., groundwater occurs under semi - confined conditions. However, the deeper aquifers are under confined to semi - confined conditions.

**DEPTH TO WATER TABLE:**

The water table is the upper surface of an unconfined aquifer, where hydrostatic pressure is at par with the atmospheric pressure. It is mainly defined by the water level in the wells penetrating the aquifer just enough to hold the standing water. However, in general the water levels standing in the dugwells are considered accurate enough to represent water table of an area.

The recharge and discharge areas are deciphered accurately enough by the water table maps. Recharge area is characterised by deeper water table, whereas, shallow water table indicates discharge area (*Fetter, 1988*).

Water level data of observation wells (Appendix - III) spread over the entire district were utilised to prepare depth to water level maps of Aligarh district.
Fig. 4.6 shows the depth to water level for the pre-monsoon (June 1991) and Fig. 4.7 shows the depth to water level for post-monsoon period (Nov. 1991)

**Depth to water table (Pre-monsoon, June 1991):**

The depth to water level map depicts the variation in the water level in the entire district. The depth to water levels during the pre-monsoon period ranges between 3.23 and 16.20 m.b.g.l. in the district. It is revealed that the shallowest (less than 4 m.b.g.l) water level exists in the north-central part of the district at Jawan in Jawan block near the northern boundary of the district. The deepest water level (more than 16 m.b.g.l) is recorded in the south-central part of the district at Sasni in Sasni block. There exists a sort of trough between Ibrahimpur, Hanuman chauki and Sasni where the water level is deepest i.e., between 13 and more than 16 m.b.g.l. There is another trough between Atrauli in the north-eastern part and Barla in the east-central part of the district where the depth to water level ranges between 14 and more than 15 m.b.g.l. Again, the water levels are rather deep in the north-western part of the district. It is to be noted that observation wells located near the canals network in the district have shallow to moderate depths to water level i.e., between 3 and 6 m.b.g.l. As such, all observation wells lying near the main Upper Ganga Canal and its branches, namely, the Kanpur, Etawah and Hathras branches and also those near the Lower Ganga Canal have water level between these depths. In the rest of the area the depths to water level range between 6 and 12 m.b.g.l.

**Depth to Water Table (Post-monsoon, November 1991)**

Study of the depth to water table data during the post-monsoon period shows that the water level ranges between 2.05 and 16.48 m.b.g.l. Perusal of the post-monsoon depth to water table map reveals that the
DEPTH TO WATER LEVEL MAP OF ALIGARH DISTRICT
(JUNE, 1991)

INDEX
10 DEPTH TO WATER LEVEL
CONTOUR IN METRES

Fig. 4-8
DEPTH TO WATER LEVEL MAP OF ALIGARH DISTRICT
(NOVEMBER, 1991)

INDEX
10 — DEPTH TO WATER LEVEL
CONTOUR IN METRES

Fig. 4.7
shallowest water level is 2.05 m.b.g.l. at Harduaganj in Dhanipur block in the north-central part and the deepest water level is 16.48 m.b.g.l. at Sasni in the Sasni block in the south-central part of the district. Here again, a trough is being formed by the counter lines between Ibrahimpur, Hanuman Chowki and Sasni in the south-central part of the district where depth to water level are recorded between 14 and 16 m.b.g.l. Similarly, another trough is observed around Atrauli in the north-eastern part and Barla in the east-central part where depth to water level exceeds 14 m.b.g.l. The extreme north-western area is Khair tehsil experiences deeper water levels ranging between 9 and 11 m.b.g.l around Tappal and Jattari. A patch of considerable dimensions occur around Gorai, Mursan and Hathras in Iglas and Hathras block where depth to water level exceeds 9 m.b.g.l. Shallow water levels (between 2 and 5 m.b.g.l) are again recorded at the observation wells situated near the main canals and their distributaries. The contours during the post monsoon period follow more or less the same pattern as that of the pre-monsoon period but the difference between the pre and post-monsoon depth to water level maps is that the areas with deeper water levels - barring the Ibrahimpur - Hanuman Chowki - Sasni trough have generally shrunk in dimension and those with shallower depth have enlarged and expanded.

WATER LEVEL FLUCTUATION:

The groundwater level fluctuates as a function of time and space in response to precipitation. Fluctuation in water level indicates both changes in the actual quantity of water stored in aquifers and movement of groundwater.

Water level fluctuation is a direct response of the groundwater recharge and discharge in an area. Since the rainfall is the principal source of groundwater recharge, water level rise has sympathetic relation
WATER LEVEL FLUCTUATION MAP OF ALIGARH DISTRICT
(IN 1991)

INDEX

- < 1.0 M
- 1.0-2.0 M
- 2.0-3.0 M

2.0 - Water Table Fluctuations
    Contour in m

Fig. 4.8
to rainfall in a particular period. Intensity, duration and distribution of rainfall are the controlling factors on groundwater recharge. In addition, topography and soil types play important role on the water level fluctuation and quantum of recharge. There will be more recharge if the top soil is sandy and less when the top soil is clay and moderate when the top soil is sandy clay. It is commonly observed that the water table is deep in topographic highs and shallow towards the topographic lows, correspondingly, the annual fluctuation of water table is more in the up lands and less in the depressions, while the amount of rainfall remaining the same in the area. The sub-surface outflow, inflow component of groundwater makes this difference, while there would be sufficient space available for groundwater infiltration and accumulation in the upland areas, shallow water table and water logged conditions in the low lying areas leave little space for groundwater recharge. As a consequence there would be more surface run-off in the low lying areas (G.K. Rao, 1987).

Water levels in wells are almost constantly fluctuating and decline or rise by few centimetres or a metre within a relatively short time. Water level in water table aquifers are affected by direct recharge from precipitation, evapotranspiration, withdrawal from wells, discharge to stream and some times changes in atmospheric pressure.

Water level in wells, near surface water bodies, like lakes and streams fluctuate in response to changes in surface water stages. The fluctuation from the effect of surface-water -stage changes decrease with distance from surface water bodies. Discharge of groundwater to nearby stream like Kali, Neem, Sengar, Yamuna and Ganga is greatest during periods when the water table is high and is least during periods when the water table becomes deep. A large portion of stream flows are the
groundwater run-off, therefore, stream flows are in considerably influenced by groundwater levels.

Under water table conditions the fluctuations are largely due to actual movement of water into and out of the aquifer.

Water level respond to alternating series of wet and dry years in which recharge from precipitation is above or below the mean (Walton, 1970).

Figure 4.8 has been prepared to depict the fluctuation in water levels between pre and post - monsoon periods in 1991. The difference in groundwater levels shows a seasonal patterns of fluctuations. This is resultant of the recharge through rainfall, evapotranspiration that follow well define seasonal cycles (Todd, 1980). Study of the map (Fig. 4.8) shows that the minimum fluctuation (rise) of water levels is 0.03 m at Hathras railway junction and the maximum is 2.73 at Iglas respectively. In a major part of the district, the seasonal water level fluctuation ranges below one metre. Three isolated patches show 2.00m fluctuation around Khair, Iglas and Safedpur. These are surrounded by wider stretches where the water level fluctuation ranges between 1.0 and 2.0 m. So, the areas representing the three genres of water level fluctuation in the order of preponderance are as follows:

(i) Area with less than one metre fluctuation.
(ii) Area with more than one but less than two metres fluctuation.
(iii) Area with more than two metres fluctuation

In addition, there few wells which register a negative fluctuation (fall instead of rise) between the pre and post - monsoon periods during 1991. They are Jattari in Tappal block with a negative figure 0.03 m, Atrauli with a negative fluctuation of 1.30m and at Hanuman Chowki - Sasni trough area. In all the above mentioned areas this situation has
resulted because of heavy withdrawal of groundwater for intensive agricultural activities.

**GROUNDWATER MOVEMENT:**

Water level data of observation wells for the year 1991 (pre-monsoon) were utilised to prepare water table contour map. The collected water level data of each observation wells was subtracted from the mean sea level of the particular location. The final values were utilised to prepare the water table contour map.

This map is used to determine the groundwater flow direction, areas of recharge and discharge, hydraulic gradient and the nature of the stream draining the area. In a water table contour map, convex contours indicates region of groundwater recharge, while concave contour are associated with groundwater discharge (*Todd, 1980*).

Moreover, the convergence of flow lines depict the area of discharge and divergence of flow line indicates area of recharge (*Fetter, 1980*).

**Form and slope of water table:**

A perusal of the map (Fig. 4.9) shows certain prominent hydrological features such as groundwater divides and depressions. In the overall hydrological picture, the contours show a general flow direction of groundwater from north-west to south-east which coincides well with the regional groundwater flow pattern of the Central Ganga Basin. However, deviations on micro level are discernible within the framework of the district boundaries.

Three prominent groundwater divides are identified in the area. These occur along the courses of lower and Upper Ganga Canals and their main branches and are found in the extreme north-eastern part of the district along the lower Ganga canal in Atrauli tehsil; and along
WATER TABLE CONTOUR MAP OF ALIGARH DISTRICT
(JUNE, 1991)

Figure 4.9

INDEX
170 = WATER TABLE ELEVATION CONTOUR ABOVE M.S.L
172 170 = FLOW DIRECTION

Fig. 4.9
the Upper Ganga Canal (Etawah and Kanpur branches) extending from the north-central part to the south-eastern part of the district in a north-west to south-east direction in Koil and Sikandra Rao tehsils, and in the western part of the district along the Upper Ganga Canal (Hathras branch) in a north-west to south-east direction, in Khair, Iglas, and Hathras tehsils. In all the above three cases, the main canals act as potential recharge zones which contribute to groundwater quite substantially. These canals form groundwater ridges or divides. In between the above three ridges, to groundwater depressions are discernible. One occurs in the eastern part of the district along Barla and Gangiri in Atrauli tehsil, the other occurs in the south-central part of the district between the Upper Ganga Canal and Hathras branches respectively in parts of Koil and Hathras tehsils. All the rivers like Yamuna, Kali and the Ganga show effluent nature as they are fed by the groundwater run-off.

The altitude of the water table in the district ranges between 164 and 190 m.a.m.s.l. The general slope of the water table in the district is from north-west to south-east corresponds with the general topography of the area. The general gradient of the water table is about 0.35 m per km. By and large, the water table contours are moderately spaced thus, representing good to moderate permeability.

GROUNDWATER BEHAVIOUR

Hydrograph:

In order to study the groundwater behaviour with respect to time and space, the water levels of CGWB’s permanent hydrograph stations were analysed (Table 4.1) and hydrographs of the same were prepared. The hydrographs of the water level fluctuation covering periods ranging from 12 to 18 years up to 1994 from some selected and representative observation wells are presented in figure 4.10. Table no. 4.1 shows the
HYDROGRAPHS OF PERMANENT NETWORK STATIONS IN ALIGARH DISTRICT

(Aligarh)

Fig. 4.10(a)

(Atrauli)

Fig. 4.10(b)
HYDROGRAPHS OF PERMANENT NETWORK STATIONS IN ALIGARH DISTRICT

(SIKANDRA RAO)

Fig. 4.10(c)

(KHAIR)

Fig. 4.10(d)
HYDROGRAPHS OF PERMANENT NETWORK STATIONS IN ALIGARH DISTRICT

(JATTARI)

Fig. 4.10(e)

(CHHARRA)

Fig. 4.10(f)
HYDROGRAPHS OF PERMANENT NETWORK STATIONS IN ALIGARH DISTRICT

(IGLAS)

YEARS
1974 76 78 80 82 84 86 88 90 91 1991

Fig. 4-10(g)

(AKRABAD)

YEARS
1976 80 82 84 86 88 90 91 1992

Fig. 4-10(h)
Table 4.1: Trend and magnitude of water level fluctuation in Aligarh district, U.P.

<table>
<thead>
<tr>
<th>WELL NO.</th>
<th>LOCATION</th>
<th>BESTFIT</th>
<th>FLUCTUATION</th>
<th>PERIOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALG01</td>
<td>ALIGARH</td>
<td>$Y=-0.023X+$</td>
<td>6.16</td>
<td>1973 - 92</td>
</tr>
<tr>
<td>ALG02</td>
<td>ATRAULI</td>
<td>$Y=-0.032X+$</td>
<td>5.63</td>
<td>1973 - 94</td>
</tr>
<tr>
<td>ALG03</td>
<td>IGLAS</td>
<td>$Y=-0.018X+$</td>
<td>0.86</td>
<td>1973 - 94</td>
</tr>
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<td>ALG04</td>
<td>SIKANDARA RAO</td>
<td>$Y=0.023X+$</td>
<td>9.72</td>
<td>1973 - 94</td>
</tr>
<tr>
<td>ALG05</td>
<td>HATHRAS</td>
<td>$Y=0.026X+$</td>
<td>4.94</td>
<td>1973 - 94</td>
</tr>
<tr>
<td>ALG06</td>
<td>KHAIR</td>
<td>$Y=-0.006X+$</td>
<td>7.33</td>
<td>1973 - 94</td>
</tr>
<tr>
<td>ALG07</td>
<td>AKRABAD</td>
<td>$Y=0.000X+$</td>
<td>2.85</td>
<td>1977 - 94</td>
</tr>
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<td>ALG08</td>
<td>CHARRA</td>
<td>$Y=-0.003X+$</td>
<td>3.16</td>
<td>1977 - 94</td>
</tr>
<tr>
<td>ALG09</td>
<td>JATTARI</td>
<td>$Y=-0.048X+$</td>
<td>-1.68</td>
<td>1977 - 94</td>
</tr>
<tr>
<td>ALG10</td>
<td>SOMNA</td>
<td>$Y=-0.014X+$</td>
<td>3.93</td>
<td>1977 - 93</td>
</tr>
<tr>
<td>ALG10A</td>
<td>GABHANA</td>
<td>$Y=-0.017X+$</td>
<td>2.34</td>
<td>1991 - 94</td>
</tr>
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<td>ALG11</td>
<td>THULAI</td>
<td>$Y=-0.048X+$</td>
<td>-5.08</td>
<td>1991 - 93</td>
</tr>
<tr>
<td>ALG12</td>
<td>SASNI</td>
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<td>-17.16</td>
<td>1982 - 91</td>
</tr>
<tr>
<td>ALG13</td>
<td>RATWANPUR</td>
<td>$Y=-0.020X+$</td>
<td>-0.21</td>
<td>1979 - 94</td>
</tr>
<tr>
<td>ALG14</td>
<td>NANU BRIDGE</td>
<td>$Y=0.001X+$</td>
<td>4.16</td>
<td>1979 - 94</td>
</tr>
<tr>
<td>ALG15</td>
<td>SAFEDPUR</td>
<td>$Y=-0.001X+$</td>
<td>4.33</td>
<td>1979 - 94</td>
</tr>
<tr>
<td>ALG16</td>
<td>TAQUIPUR</td>
<td>$Y=-0.008X+$</td>
<td>1.54</td>
<td>1979 - 94</td>
</tr>
<tr>
<td>ALG17</td>
<td>ANDLA</td>
<td>$Y=-0.039X+$</td>
<td>1.47</td>
<td>1979 - 94</td>
</tr>
<tr>
<td>ALG18</td>
<td>KANSAERA</td>
<td>$Y=0.047X+$</td>
<td>23.09</td>
<td>1991 - 94</td>
</tr>
<tr>
<td>ALG19</td>
<td>ROOPNAGAR</td>
<td>$Y=-0.018X+$</td>
<td>7.18</td>
<td>1988 - 93</td>
</tr>
<tr>
<td>WELL NO.</td>
<td>LOCATION</td>
<td>BESTFIT</td>
<td>FLUCTUATION</td>
<td>PERIOD</td>
</tr>
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<tr>
<td>ALG21</td>
<td>GONDA</td>
<td>Y= 0.001X+</td>
<td>5.18</td>
<td>1988 - 94</td>
</tr>
<tr>
<td>ALG20</td>
<td>SANKARA</td>
<td>Y=-0.002X+</td>
<td>4.17</td>
<td>1988 - 94</td>
</tr>
<tr>
<td>ALG22</td>
<td>MALSAI</td>
<td>Y=-0.010X+</td>
<td>5.53</td>
<td>1988 - 94</td>
</tr>
<tr>
<td>ALG23</td>
<td>HASSAIN</td>
<td>Y=-0.018X+</td>
<td>-0.49</td>
<td>1988 - 94</td>
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<tr>
<td>ALG24</td>
<td>GORAI</td>
<td>Y= 0.009X+</td>
<td>11.69</td>
<td>1988 - 94</td>
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<tr>
<td>ALG25</td>
<td>JAWAN</td>
<td>Y= 0.002X+</td>
<td>2.95</td>
<td>1988 - 94</td>
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<tr>
<td>ALG26</td>
<td>RATI-KA-NAGLA</td>
<td>Y= 0.029X+</td>
<td>10.68</td>
<td>1988 - 94</td>
</tr>
<tr>
<td>ALG27</td>
<td>MURSAN</td>
<td>Y=-0.024X+</td>
<td>3.06</td>
<td>1988 - 94</td>
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<td>ALG28</td>
<td>HATHRAS JN</td>
<td>Y=-0.028X+</td>
<td>3.04</td>
<td>1988 - 94</td>
</tr>
<tr>
<td>ALG29</td>
<td>HANUMAN CHOWKI</td>
<td>Y=-0.142X+</td>
<td>-24.08</td>
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<td>ALG30</td>
<td>HASTPUR</td>
<td>Y= -</td>
<td>-</td>
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<tr>
<td>ALG31</td>
<td>BARAULI</td>
<td>Y= 0.016X+</td>
<td>8.19</td>
<td>1989 - 93</td>
</tr>
<tr>
<td>ALG32</td>
<td>VIJAYGARH</td>
<td>Y= 0.041X+</td>
<td>-5.37</td>
<td>1989 - 93</td>
</tr>
<tr>
<td>ALG33</td>
<td>SUDIYAL</td>
<td>Y= 0.005X+</td>
<td>7.75</td>
<td>1989 - 93</td>
</tr>
<tr>
<td>ALG34</td>
<td>PANAITHI</td>
<td>Y= 0.018X+</td>
<td>9.10</td>
<td>1989 - 93</td>
</tr>
<tr>
<td>ALG35</td>
<td>PILKHANA CHOWKI</td>
<td>Y= 0.014X+</td>
<td>8.88</td>
<td>1989 - 93</td>
</tr>
<tr>
<td>ALG36</td>
<td>BARALA</td>
<td>Y=-0.010X+</td>
<td>11.55</td>
<td>1989 - 93</td>
</tr>
<tr>
<td>ALG37</td>
<td>PALACHAND</td>
<td>Y= 0.008X+</td>
<td>10.10</td>
<td>1989 - 93</td>
</tr>
<tr>
<td>ALG38</td>
<td>TAJPUR</td>
<td>Y=-0.081X+</td>
<td>-11.10</td>
<td>1989 - 93</td>
</tr>
<tr>
<td>ALG39</td>
<td>BHATIKRA</td>
<td>Y=-0.054X+</td>
<td>-7.46</td>
<td>1989 - 93</td>
</tr>
<tr>
<td>ALG40</td>
<td>GOPI</td>
<td>Y= 0.003X+</td>
<td>7.30</td>
<td>1989 - 93</td>
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<tr>
<td>ALG41</td>
<td>IBRAHIMPUR</td>
<td>Y=-0.036X+</td>
<td>5.10</td>
<td>1989 - 93</td>
</tr>
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<td>ALG42</td>
<td>HARDUAGANJ</td>
<td>Y= 0.003X+</td>
<td>2.91</td>
<td>1989 - 93</td>
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</table>
trend and magnitude of fluctuation at the permanent hydrograph stations of the CGWB in Aligarh district.

Perusal of the table 4.1 reveals that the groundwater levels in the district show, by and large, a declining trend. The minimum decline of 0.24 m is recorded at Safedpur in Atrauli block over a period 15 years (1979 to 1993) and the maximum decline is recorded at 13.81 meter at Sasni in Sasni block in the span of 12 years (1982 to 1991). It is to be noted that the intensity of decline is more in comparison to that of rise both in the quantitative and qualitative senses. Out of 42 hydrograph stations where the long term water level trends have been studied, 27 (64.29 %) show a declining trend and the rest 15 (35.71 %) register a rising trend. It is also worthnoting that wherever a rising trend has been observed, it is not substantial. The minimum rise of 0.08 meter is recorded at Gonda in Gonda block over a period of 6 years (1988 to 1993). The maximum rise of 5.48 meter is recorded at Sikandra Rao over a period of 21 years (1973 to 1993). Most part of the district except those areas which are under the influence of canal network are facing a declining trend. The average figure as obtained from the table 4.1 comes to -3.45m over a period ranging 4 to 21 years. This is mainly due to the fact that the groundwater is the only source of irrigation in the western part of the district as example the Aligarh city with its 7 lacks population where the groundwater is the only source of the water supply. The trend may aggravate in future due to increase in population, up coming of new colonies, extensive agricultural activities and escalating industrialisation in the western part of the district.