# Estimation of Ground Water Balance and Seepage from Different Canals and Rivers of District Nowshera

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***Abstract* - The value of agricultural land is becoming valuable by increasing population with time. Some land is becoming Bad Land because of lack of water, where as some is water logged due to the increasing water table. So, to calculate ground water balance is the emergency of the time. For this reasons the seepage from lot of rivers and canals flowing in the study area are calculated by different empirical equations using Nazir Ahmad Formula, Mortiz Formula, Molesworth and Yennidunia Empirical Formula, Pakistanian Formula, Indian Formula and Kostiakov A.N Formula. The total seepages in to the study area are 3516447.5, $m^3$/day. The total area of the district is 1825.28 $km^2$. For recharge due to precipitations simply the runoff should be excluded from total rainfall. To calculate runoff the curve number is necessary, which is calculated from Land Use Map and comes out to be 88. The runoff by SCS-Curve Number Method is calculated and comes out to be 570.4894 mm/year. The recharge from rainfall is calculated and comes out to be 200741, $m^3$/day. The withdrawals from study area are due to tube wells and Hand pumps. The discharge by tube wells is calculated by the collected data from WAPDA and Irrigation Department which is 257105.016, $m^3$/day. For Hand Pump discharge a rough survey is conducted and statistically found the withdrawals which are 42818.25, $m^3$/day. The inflow and outflow is estimated 37820, $m^3$/day and 199650.5, $m^3$/day, respectively. The evaporation losses are estimated, which comes out to be 2957890, $m^3$/day. The total inflow and total outflow are estimated 3755008.5, $m^3$/day and 3457463.766, $m^3$/day, respectively. The net recharge to the area is 3.4438, $m^3$/sec which is 59.518, mm/year.**

***Keywords: Water logged, discharge, seepage, empirical, runoff, curve number, recharge***

## 1. *Problem Statement*

At the time of establishing irrigation system the level of water table in Mardan, Nowshera, Pabbi, Swabi and areas in the vicinity of Kabul River in Khyber Pakhtunkhwa was about 21.34-24.39 m (70-80 ft) below the ground level. Water table came up to 12.20 m (40 ft) in 1925 and in 1940 up to 7.62 m (25 ft) below ground level. It reached 3.05-3.66 m (10-12 ft) below ground level in 1960, and finally in 1970 it reached as close as 0.61-0.91 m (2-3 ft) of the ground level and in rainy season even touched the ground surface (Masud et al. 2013). During the flood 2010 the maximum ground water recharge occurs, and most of the area "where no proper drainage systems are installed" becomes water logged. This is an ultimate effect on crops field and indirectly by economy of people. So to evaluate the present situation of groundwater balance in the area under study is an exigency of the time and to take the remedial measures in case of the risk of water logging.

## 2. *Introduction*

The district Nowshera is situated in the center of Khyber Pakhtunkhwa, Pakistan. The area is between the latitude 33º 42' to 34º 09' and longitude 71º 41' to 72º 15'. The total area of the district is about 1825.28 $km^2$. In which 682.25 $km^2$ (37.37% of total land) is agricultural land (GOP, 2008). As this district is largely depends on agricultural products and crops. So, the availability of water is a pre- requisite for agricultural production. With a few local exceptions generally groundwater occurs under water table conditions. The water table depth from ground surface is generally within 10 m in canal irrigated areas whereas in barani areas it varies from 13 to 50 meters below ground level (WAPDA, 2008).

The groundwater occurrence is controlled particularly in barani areas, by climatic and hydro-geologic conditions. For groundwater recharge rainfall is the main source. The flow coupled with varying properties of the upper soil strata deep percolation from fields and stream losses at various stages are occurs, and for varied availability of groundwater across the district the underground aquifer are responsible. For groundwater recharge deep peculation from Irrigation system, rainfall and seepage from canal are the main sources. Outflow from ground water are through hand pumps, tube wells, seepage to river and springs in hilly areas. The movement of groundwater generally follows the natural topography which significantly varies particularly in Hilly areas. From groundwater elevation contours map it is clear that groundwater is being discharged to River Kabul in Northern parts of the district and to River Indus in Southern part (Basharat et al. 2008).

During 1988-2007, the average annual rainfall at Risalpur and Cherat is 684 mm and 585 mm respectively. The maximum rainfall (i.e. about 60% of the total rainfall) in the months of February, March, July and August are receives to the area. It is thought that winter rains contribute relatively more to groundwater recharge than


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monsoon rains which are in form of thunder storms and have more runoff (WAPDA, 2008).

The part of the rain water falling on the ground is infiltrated into the soil. The infiltrated water is partly utilized in filling the soil moisture deficiency and part of it is reaching the water table percolated downward. The water reaching to the water table is known as the recharge to the aquifer from rainfall. The various factors like hydro-meteorological and topographic factors, soil characteristics and depth to water table affects rainfall recharge. For estimation of rainfall recharge the methods of ground water estimation committee norms, empirical relationships established between recharge and rainfall developed for different regions, water balance approach, and soil moisture data based methods (Kumar, 1993).

### *3.1 Water Balance Study*

To make quantitative estimates of water resources water balance techniques have been extensively used and the impact of man's activities on the hydrologic cycle. Under the influence of man's activities, it is possible to make a quantitative evaluation of water resources on the basis of the water balance approach and its dynamic behavior. To understand and evaluate the various recharge and discharge components of ground water balance equation, Kumar (1996) made an attempt to describe the methodologies and to establish the recharge coefficient with a view to work out the ground water potential of an area.

In view of increasing demand of water for various purposes like agricultural, domestic, industrial etc, for a planned and optimal utilization of water resources a greater emphasis is being laid. The surface water resources are unevenly distributed due to uneven distribution of rainfall both in time and space. Rise of water table due to increasing intensities of irrigation from surface water creating problems of water logging and salinization, affecting crop growth adversely and rendering large areas unproductive.

Masud et al. (2013) reported that the adjacent areas of Kabul River in the Pabbi region have suffered from water logging for a long time due to heavy rainfall, excessive irrigation and seepage from irrigation canals. It has been calculated that due to seepage from canals and their distributaries flowing in the Pabbi Region the recharge to groundwater storage is 26 mm/year. He further concluded that the average increase in groundwater level in the study area is 37.63 mm/year.

Water resources with planning based on conjunctive use of surface water and ground water an appropriate strategy will be to develop. To make a realistic assessment of the surface and ground water resources would be the first task and then their use will be plan in such a way that full crop water requirements are met and also prevent water logging and excessive lowering of ground water table. In a state of dynamic equilibrium it is necessary to maintain the ground water reservoir over a period of time and the water level fluctuations have to be kept within a particular range over the monsoon and non-monsoon seasons (Kumar, 1996).

The study of water balance is defined as for a specified period within a geographic region the systematic presentation of data on the supply and use of water. With water balance approach, due to changes in components of the system to establish the degree of variation in water regime it is possible to evaluate quantitatively individual contribution of sources of water in the system, over different time periods.

The basic concept of water balance is shown in equation no. 01

$$I - O = \Delta S \qquad ..1$$

Where,

I = Input to the system

O = outflow from the system

ΔS = change in storage of the system (over a period of time)

The general methods of computations of water balance include:

(i) Identification of significant components,
(ii) Evaluating and quantifying individual components, and
(iii) Presentation in the form of water balance equation.

### *3.2 Seepage Theory*

For estimate of seepage rates from canals a number of different empirical equations have been developed. The equations Christopher (1981), USBR (1967) and Kraatz (1977) has reported to give good results when calibrated for a given canal and its surrounding conditions. However, darcian condition is the basic equation for seepage from canal that may be expressed by the following equation:

$$Q = K_e.H.A \qquad ..2$$

Where, "Q" is seepage rate in $ft^3.sec^{-1}$, "$K_e$" is effective hydraulic conductivity in and under the canal bed in ft/sec, "H" is the hydraulic gradient in ft/ft and "A" is cross-sectional area of seepage flow in $ft^2$.

Sonnichsen (1993) reported that, because of the varied nature of canal locations and surrounding conditions seepage losses are differ widely. The soil, topography, conveyance material, and ground water of any given area vary greatly both individually and in their total effect. Many factors discussed by Netz (1980) for controlling seepage rates from canals, and outlined it by how they affect each component of equation number 2.3. The factors surface seal in canal by silt, entrained air in soil, temperature of water and soil, underlying soil type, and canal base material affects the effective hydraulic conductivity. The factors slope of sub grade soil structure, atmospheric pressure, depth of water in canal, capillary attraction, soil and water chemistry, and water table depth affects the hydraulic gradient. The witted perimeter is affected by cross-sectional area of the canal. Flow velocity in the canal, phreatophytic vegetations and aquatic weeds which may cause water to become backed up in the canal and increase seepage loss are the other factors which determine the amount of seepage losses.

In controlling seepage loss the main factors of concern are the depth f the ground water and effective hydraulic conductivity of base material. Including any


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confining soil layers, the effective hydraulic conductivity is determined by base soil underlying the canal and conveyance materials. Deep soil layers and their permeability affect ground water level. A good analysis is provided by Wachyan (1987) that, how a deep permeability or impermeable base controls the ground water level and in consequence changes the seepage rate from a canal.

*3.3 Rainfall and Runoff Study*

Recharge to ground water in the soil water system rainfall is the principal means for replenishment of moisture. In the unsaturated zone moisture movement is controlled by capillary pressure and hydraulic conductivity. The natural ground water recharge is the amount of moisture that will eventually reach the water table. The amount of this recharge depends upon the duration and rate of rainfall, the subsequent conditions at the upper boundary, the antecedent soil moisture conditions (AMC), the depth of water table and the types of soil. (Kumar, 1993)

The hydrologic analysis of Lindley and Son's (1986) quantified the flow rate under predevelopment conditions in some parts of the watershed in the Flint Creek waterway. An indication of the impact of urban development on floods for different storm frequencies was relative transport rate of floodwaters per unit area. In the Southgate depression and other areas adjacent to the downstream side of the waterway he suggested several alternatives to solve the matter of increased flooding potential. Included construction of detention ponds their recommendations are to limit the relative net flow rate to 0.06 $ft^3.sec^{-1}$ (cfs) per acre; alternative locations are creates to accommodate the excess floods; "flood-proofing" to protect floodplain areas from storm water damage; and improving the capacity of the downstream drainage structures to transport flood volumes efficiently. An expenditure of funds or losses of land are required for their suggested solutions involved the kind of structural flood control.

To calculate storm water runoff a procedure has been developed from smaller sub-watersheds and then route the runoff down the main streams, considering the storage capacities of upland and floodplain wetlands. In this procedure rainfall values are used for selected design storms, land-use and soil data to determine SCS CNs (Weshah et al., 1993).

## 3. METHODOLOGY

*4.1 Seepage Analysis*

The process of water movement into and through the bed and wall material from a canal refers as seepage. To ground water system, seepage losses from canals often constitute a significant part of the total recharge. Hence to properly estimate these losses for recharge assessment to ground water system is very much important. A number of investigations and calculations have been carried out to study the seepage losses from different canals and rivers.

*4.2 Data Collection*

The discharge, area, velocity, perimeter, depth, slop, roughness coefficient, hydraulic radius and other data of the following canals and rivers flowing in the study area are collected from Irrigation Department and Hydrology Department Peshawar.

*a) Canals*

The above parameters are collected from Irrigation Department at each section for the following canals.

- Kabul River Canal (KRC)
- Warsak Gravity Canal (WGC)

*b) Rivers and Khawars (Channels)*

The above eight (8) year hydrological data are collected from Hydrology Department for the following rivers and khawars. All the parameters are available only for Kabul River and Indus River and for other small river and khawars only discharge is available.

- Kabul River
- Indus River
- Bara River
- Chilla Nullah
- Chinkar Nullah
- Dagi Nullah
- Garandai Nullah
- Khudrizai Nullah

*4.3 Canals Seepages Calculation*

The seepages from canals are calculated from collected data by different empirical formulas. A number of empirical formulae are available but here only six different equations Nazir Ahmad Formula (Ahmad et. al., 2007), Mortiz Formula USSR quoted by (Mowafy, 2001), Molesworth and Yennidunia empirical equation quoted by (Bakry and Awad, 1997), Molesworth and Yennidunia analytical equation quoted by (Kavita and Khasiya, 2014), Pakistanian Formula quoted by (Kavita and Khasiya, 2014), Indian Formula quoted by (Mowafy, 2001), Kostiakov A.N Formula (Abu Gulul, 1975) are used.

***a)*** *Rivers and Khwars (Channels) Seepages Calculations*

The eight (8) year hydrological data are collected from Hydrology Department for rivers and khawars and for other small river and khawar. The discharge is measured at Mardan bridge in Nowshera section for Kabul River and attock bridge is taken as section for Indus River, because the discharge throughout the river is considered approximately the same.

***b)*** *Seepage of Small Channels*

The seepages from small channels are calculated by Nazir Ahmad (2007) formula because of limitation of data. Only discharge is available for these small channels. So, the only equation which is a function of seepage is used.

*4.5 Infiltration Due to Precipitations*

The recharge from precipitation can be simply calculated by excluding surface runoff from precipitation. Rain gauges in the study area are installed at Resalpur,


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Pirsabak and the nearby station Tarnab Form Rain gauge. The sixteen years (1997-2013) hydrological data for tarnab station and thirty eight year (1970-2008) for Resalpur station are collected from these stations. The mean annual rainfall is calculated for all stations and for surface runoff the SCS method is used to calculate peak runoff.

*4.6 Rainfall Analysis*

The mean annual rainfall is calculated for Resalpur and Tarnab stations which come out 653.10 mm and 471.80 mm respectively.

The total area of the district is 1825.28 km$^2$ in which 427.5 km$^2$ is come under the area of Tarnab station and rest of the area 1397.78 km$^2$ is come under the area of Resalpur station. Let A is total area, P is Mean Annual Rainfall, $A_1$ is area, $P_1$ is Mean Annual Rainfall of Tarnab station and $A_2$ is area, $P_2$ is Mean Annual Rainfall of Resalpur station. Then the mean annual rainfall of the study area is calculated as given in Eq. No. 03.

$$P = \frac{(P_1 * A_1) + (P_2 * A_2)}{A} \qquad ..3$$

*4.7 Land Use and Land Cover Analysis, Curve Number Estimation*

The soils of the area vary in characteristics due to differences in physiography, parent materials and landuse types. Parent materials play an important role in determining soil characteristics. Soil thickness, texture and content of coarse and fine fragments, calcareousness and mineralogy and to some extent colour are closely related to parent materials. Most of the soils are however, similar in certain characteristics, like soluble salts contents (ECe x 10$^3$) and acidic reaction. Most of the soils are high in base saturation, which is very favourable for their agricultural use. The main soil variables are:

- Colour
- Texture
- Depth or thickness of effective soil material
- Structural development
- Drainage
- Topography/surface slope
- Gravel/stone content
- pH or soil reaction

Depending upon the relative intensity of the soil forming factors, especially parent material and landforms, soils of the area have developed different characteristics. Department of Soil Survey of Pakistan divided the whole district in the following land use and land cover shown in Figure No. 01

- Agricultural Land
- Bad Land
- Rock Out crop
- Rough mountainous land
- Gravelly and stony land
- Marsh land
- River/ Water Bodies
- Built up area

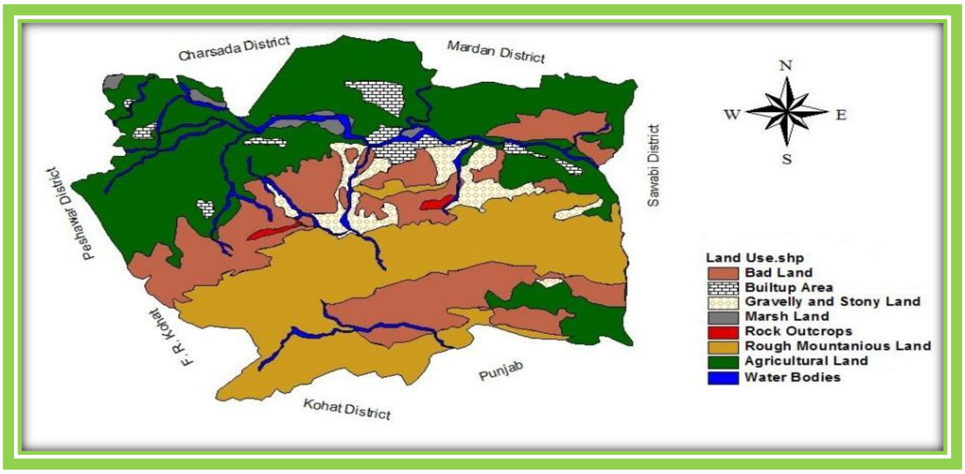


FIGURE NO. 01 Land Use Land Cover Map of District Nowshera

*4.8 Runoff Estimation*

Equation No. 04 is used to calculate runoff. In this equation S is soil moisture retention for which equation no. 05 is used.

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \qquad ..4$$

An empirical analysis led to the following relationship for S.

$$S = \frac{25400}{CN} - 254 \qquad ..5$$

*4.9 Groundwater Extraction Estimations*

Extraction of water is the amount of water lifted from the aquifer by means of various lifting devices. State tube wells, private tube wells and hand pumps are used to withdraw the water. For computation of ground water use an inventory of wells and a sample survey of ground water draft are pre-requisites from various types of wells.

For the case of tube wells, information up to year 2012 about their number, running hours per day, discharge and number of days of operation in a season is collected


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from the following Departments, to calculate the volume pumped in each season.

- Public Health Engineering Department Nowshera
- Irrigation Engineering Department Peshawar
- WAPDA House Lahore
- Agricultural Engineering Department Tarnab, Peshawar

All types of data are available in these departments but only the latitude and longitude is not available for 480 tube wells out of 805. The coordinate of these tube wells are obtained manually by means of GPS, all the tube wells are shown in Figure No. 02.

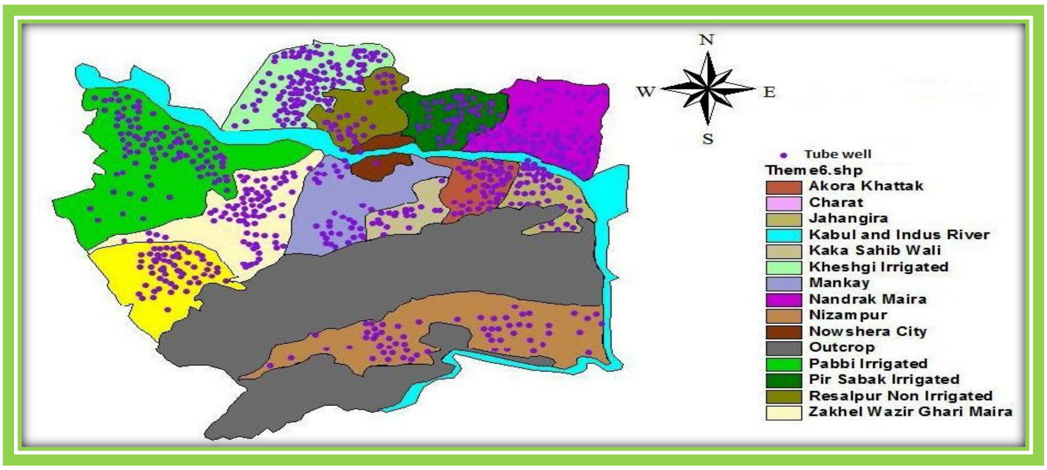


FIGURE NO. 02 Location of Tube Wells in Whole District

In order to determine the draft from hand pumps, sample surveys have to be conducted regarding their number (of each type), discharge and withdrawals over the season. According to the local people, 35% people of the study area have their own hand pumps. On the basis of data collected by general survey of District Nowshera.

*4.10 Inflow and Outflow of River*

The water coming into the study sub-area is inflow of the rivers while the water exported by the river from the study sub-area is outflow of the rivers.

All sub-rivers water flowing to the sub-area is calculated from the collected data from Hydrology department and the entire outflow from sub area is also calculated. The difference of inflow and outflow is calculated by using equation no. 06

*4.11 Ground Water Balance*

Considering the various inflow and outflow components to the study area, the ground water balance equation can be written as:

$$\Delta S = I - O \qquad ..06$$

Where,

$\Delta S$ = Change in storage
I = Input to the catchment
O = Output from the catchment

*a) Input Components*

Ri = recharge from rainfall;
Rc.s = recharge from canal seepage;
Ir = inflow of rivers to sub-area;

*b) Output Components*

Ev = Evaporation losses
Td = Tube wells discharge from ground water;
Hp = Hand pump discharge;
Or = outflow of rivers from sub-area;

Using the input output components in Equation No. 06, it yields the following Ground Water Balance Equation.

$$\Delta S = (Ri + Rc.s + Ir) - (Ev + Td + Hp + Or) \qquad ..07$$

This equation 07 is used only for one aquifer system and thus does not deliberate for the interflows between the aquifers in a multi-aquifer system. However, if sufficient data of ground water aquifer system is available, the additional terms for these interflows can be included in the governing equation.

## 4. RESULTS AND DISCUSSIONS

*5.1 Seepage Analysis*

Seepage of all rivers and canals flowing in the study area are calculated and the following results are given in Table No. 01 and Figure No. 03 and 04.


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TABLE NO. 01 Seepage results in $m^3$/sec

| S. No. | Equations | Seepage of *KRC $m^3$/sec | Seepage of *WGC $m^3$/sec |
|---|---|---|---|
| 1 | Nazir Ahmad Formula | 0.2293 | 0.2614 |
| 2 | Mortiz Formula | 0.2734 | 0.2920 |
| 3 | Molesworth and Yennidunia Empirical Formula | 0.2268 | 0.2551 |
| 4 | Pakistanian Formula | 0.2880 | 0.3068 |
| 5 | Indian Formula | 0.1511 | 0.1967 |
| 6 | Kostiakov A.N Formula | 0.2060 | 0.2335 |
| 7 | Molesworth and Yennidunia Analytical Equation | 0.1728 | 0.1812 |

*KRC = Kabul River Canal
*WGC = Warsak Gravity Canal

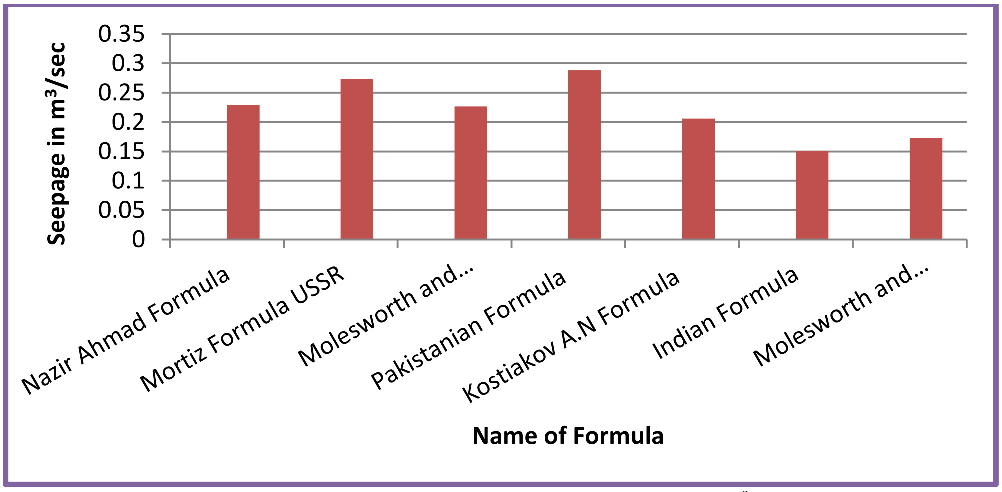


FIGURE NO. 03 Seepage from Kabul River Canal in $m^3$/sec

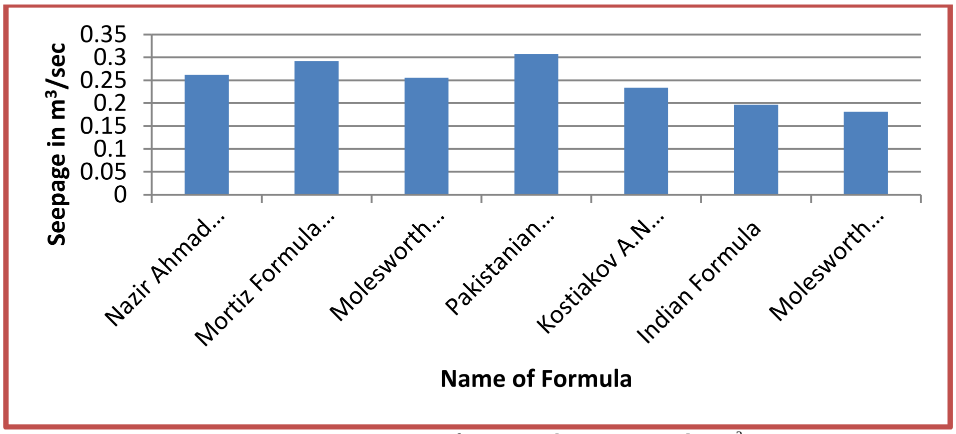


FIGURE NO. 04 Seepage from Warsak Gravity Canal in $m^3$/sec

The seepage results of rivers Kabul River (KR) and Indus River (IR) and natural small channels are shown in Table No. 02 and in Figure No. 05 and 06.

TABLE NO. 02 Seepage Results in $m^3$/sec

| S. No. | Equations | Seepage of *KR $m^3$/sec | Seepage of *IR $m^3$/sec |
|---|---|---|---|
| 1 | Nazir Ahmad Formula | 35.28 | 28.369 |
| 2 | Mortiz Formula | 11.237 | 8.738 |
| 3 | Molesworth and Yennidunia Empirical Formula | 15.037 | 9.641 |
| 4 | Pakistanian Formula | 15.196 | 10.822 |
| 5 | Indian Formula | 13.697 | 16.730 |
| 6 | Kostiakov A.N Formula | 35.772 | 29.179 |

*KR = Kabul River
*IR = Indus River


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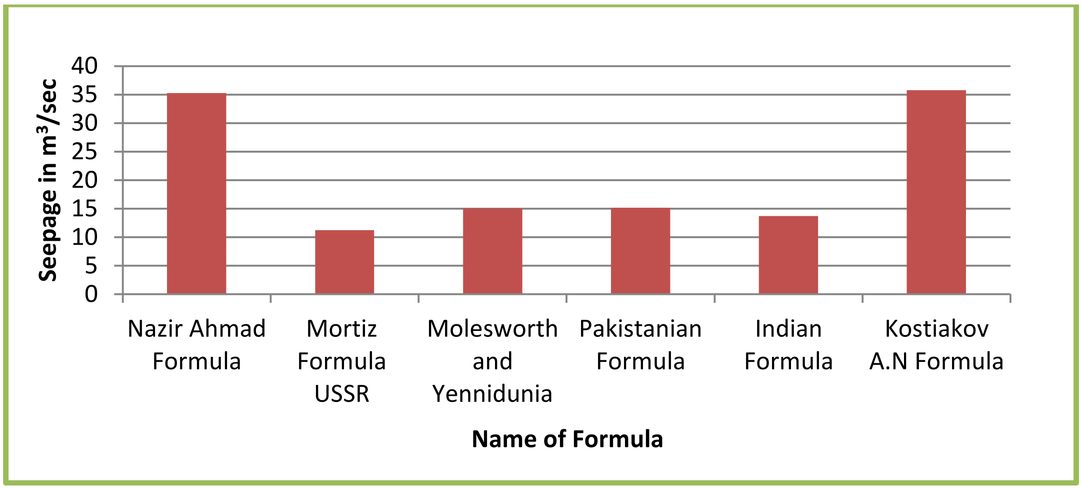


FIGURE NO. 05 Seepage from Kabul River (KR) in $m^3$/sec

For small channel eight year hydrological data 2004-2012 are analyzed but used only Nazir Ahmad formula (Ahmad, 2007) to calculate seepage because of data limitation. The results are given in Table No. 03 and Figure No. 07.

The total seepages from all consider small channels are 1.9355 $m^3$/sec, from all consider canals are 0.4867 $m^3$/sec while from big rivers are 38.2830 $m^3$/sec. So, the total seepage from all rivers and canals are 40.7052 $m^3$/sec, as the total area of the district (study area) is 1825.25 $Km^2$. So that, 703.2895 mm/year seepage is occurs to the study area.

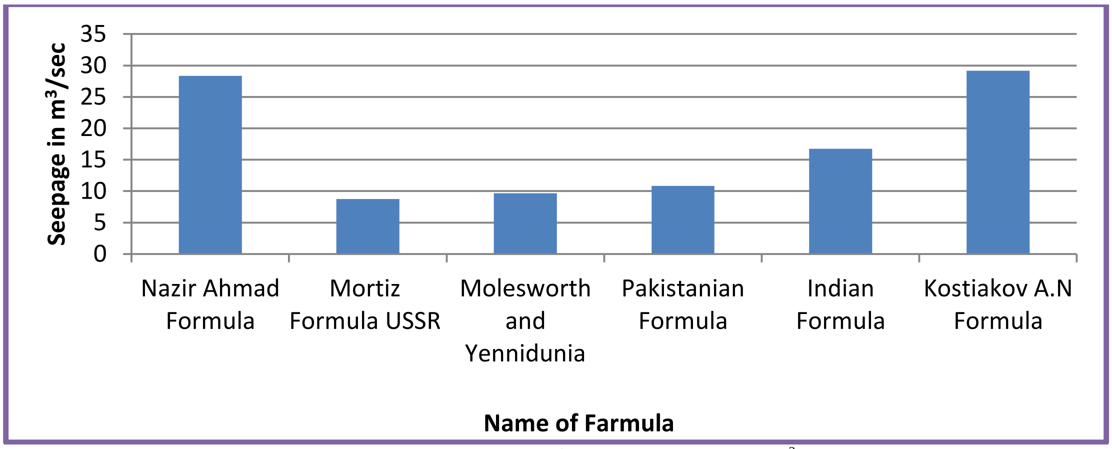


FIGURE NO. 06 Seepage from Indus River (IR) in $m^3$/sec

TABLE NO. 03 Seepage Results in $m^3$/sec

| S. No. | Channels and Khawars | Seepage |
|---|---|---|
| 1 | Bara River | 1.2984 |
| 2 | Chilla Nullah | 0.1462 |
| 3 | Chinkar Nullah | 0.1136 |
| 4 | Dagi Nullah | 0.0756 |
| 5 | Garandai Nullah | 0.2149 |
| 6 | Khudrizai Nullah | 0.0869 |


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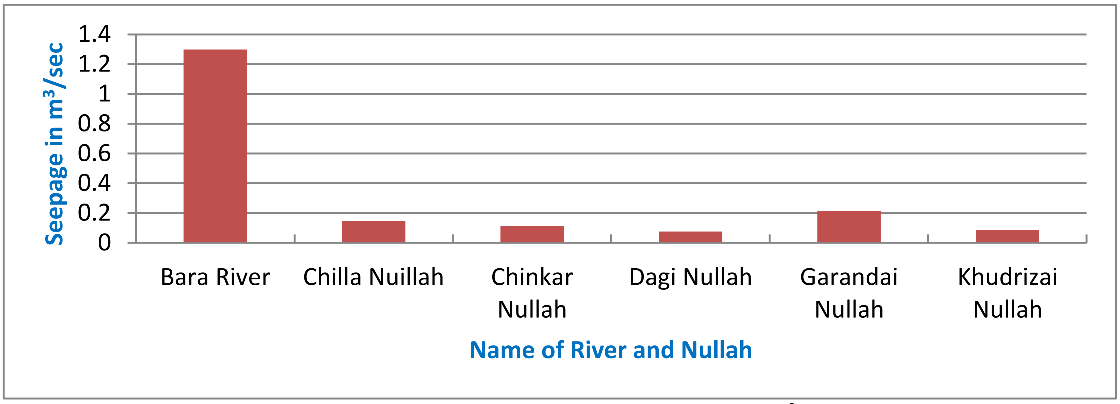


Figure No. 07 Seepage from Small Channels in $m^3$/sec

*5.2 Result of Land Use Land Cover (LULC): For Land use fig. 08 is given below.*

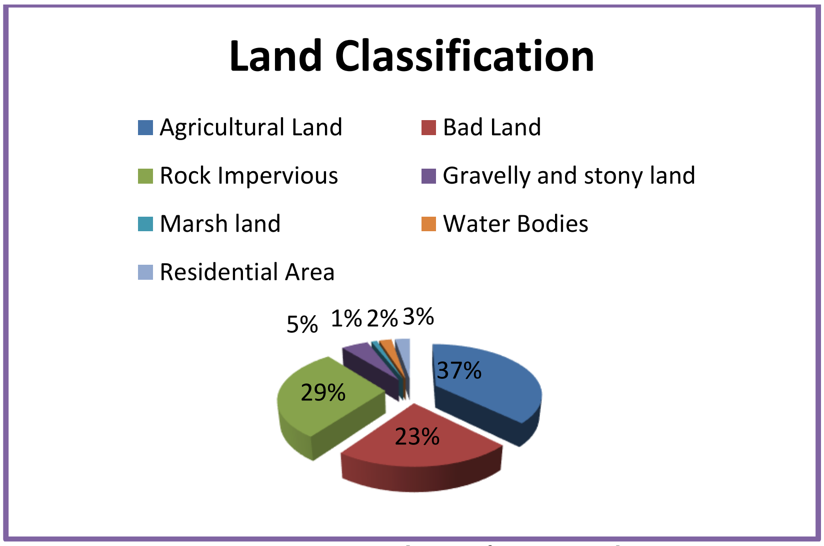


FIGURE NO. 08 Land Cover of District Nowshera

*5.3 Result of Rainfall Analysis*

The mean annual rainfall (MAR) is calculated for Resalpur and Tarnab stations which come out to be 653.10 mm and 471.80 mm respectively. The result analysis is given in Figure. 09. and 10.

The total area of the district is 1825.28 $km^2$ in which 427.5 $km^2$ is come under the area of Tarnab station and rest of the area 1397.78 $km^2$ is come under the area of Resalpur station. Let A is total area, P is Mean Annual Rainfall, $A_1$ is area for Tarnab, $P_1$ is Mean Annual Rainfall of Tarnab station and $A_2$ is area of Resalpur, $P_2$ is Mean Annual Rainfall of Resalpur station. Then the mean annual rainfall of the study area is calculated as under.

$$P = \frac{(P_1 * A_1) + (P_2 * A_2)}{A} \qquad ..08$$

The Mean Annual Rainfall for the study area is calculated which comes out to be 610.6376 mm.


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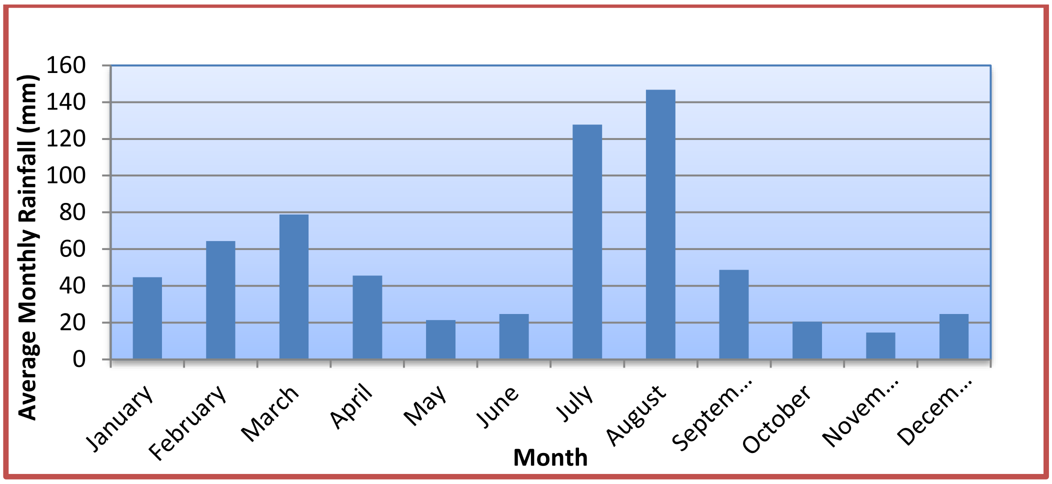


FIGURE NO. 09 Average Monthly Rainfall (mm) of Resalpur (1970 - 2008)

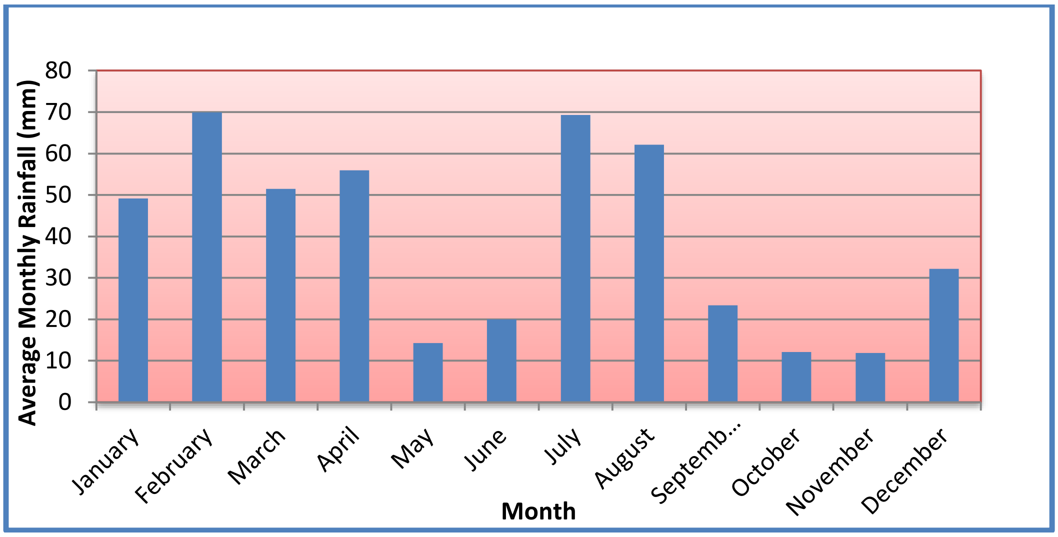


FIGURE NO. 10 Average Monthly Rainfall (mm) of Tarnab station (1997 - 2013)

*5.4 Result of Runoff Estimation*

Using equation no. 04 and 05 the following result of runoff is estimated. Putting the CN 88 the soil moisture retention is come out to be 35.0608, The runoff is come out to be 570.4894 mm/year.

*5.6 Result of Recharge due to Precipitation*

Recharge ($R_i$) due to precipitation is the amount of water which infiltrate to the ground due to rainfall. It is calculated simply excluding the surface runoff from total mean annual rainfall. For the case study the recharge by SCS-Curve Number Method is come out to be 40.1482 mm/year.

*5.7 Result of Tube Wells Discharge*

To estimate the ground water extraction by tube wells the whole study area is divided into different sub-classes. The number of tube wells, coordinates and discharge for each sub-area is collected from different department. Coordinates of maximum wells is not available, so that it may found out by means of GPS. The results are given in Table No. 05.

Total withdrawal by tube wells are 5668100 Gallon per Hour (GPH). If tube wells are running for 12 hours (Information by WAPDA and Irrigation Department) then 68017200 Gallon per Day withdrawals will occurs. This amount of water is equal to 257105.016 cubic meters per day ($m^3$/day). Considering the total study area the total withdrawals is 51.4131 mm/year.


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TABLE NO. 05 Discharges by Tube wells from Sub_Area of District Nowshera

| S. No. | Sub-Class Name | Discharge in GPH | Number of Tube wells |
|---|---|---|---|
| 1 | Nizampur Area | 407600 | 57 |
| 2 | Jehangira | 422700 | 57 |
| 3 | Nowshera city | 455700 | 62 |
| 4 | Akora Khattak | 183000 | 27 |
| 5 | Kaka Sahib Walai | 147500 | 23 |
| 6 | Manki | 119900 | 18 |
| 7 | Zakhel Wazir Garhi Maira | 645300 | 90 |
| 8 | Pabbi Irrigated | 662300 | 93 |
| 9 | Charat | 304100 | 44 |
| 10 | Kheshgi Irrigated | 1013400 | 144 |
| 11 | Risalpur Non Irrigated | 129400 | 21 |
| 12 | Pirsabak Irrigated | 360600 | 53 |
| 13 | Nandrak Maira | 816600 | 116 |
| TOTAL | | 5668100 | 805 |

*5.8 Result of Hand Pump Discharge*

To calculate the amount of water withdrawn through hand pumps, a survey of the entire district is conducted and divided the entire district into sub-classes i.e. 50 to 60 houses of each sub-class area are visited. Number of people in these houses is counted and discharge through hand pumps is found by estimating the average per capita demand. The detail of result is given in Table No. 06.

TABLE 06 Hand pump Survey and Estimations

| 3 | %age of own Hand pump | No. of people per House | Total No. of House | Total Population | Per Capita Demand LPCD | Total Consumption | %age used |
|---|---|---|---|---|---|---|---|
| Pabbi Irrigated | 60 | 7 | 15300 | 107100 | 160 | 17136000 | 10281600 |
| Zakhel Wazir Garhi | 55 | 6 | 14800 | 88800 | 150 | 13320000 | 7326000 |
| Cherat | 10 | 6 | 7800 | 46800 | 140 | 6552000 | 655200 |
| Mankay | 8 | 5 | 9300 | 46500 | 130 | 6045000 | 483600 |
| Akora Khattak | 30 | 7 | 17000 | 119000 | 140 | 16660000 | 4998000 |
| Resalpur | 30 | 6 | 8500 | 51000 | 150 | 7650000 | 2295000 |
| Kheshgi | 60 | 7 | 9700 | 67900 | 150 | 10185000 | 6111000 |
| Pirsabak | 65 | 6 | 9200 | 55200 | 140 | 7728000 | 5023200 |
| Nandrak | 30 | 5 | 8000 | 40000 | 120 | 4800000 | 1440000 |
| Nezampur | 3 | 5 | 14600 | 73000 | 110 | 8030000 | 240900 |
| Kaka sahib | 0 | 7 | 11200 | 78400 | 110 | 8624000 | 0.0000 |
| Jehangira | 30 | 7 | 9500 | 66500 | 135 | 8977500 | 2693250 |
| Walai | 5 | 6 | 7000 | 42000 | 125 | 5250000 | 262500 |
| Nowshera City | 15 | 6 | 8000 | 48000 | 140 | 6720000 | 1008000 |
| Total in Liter Per Day | | | | | | | 42818250 |

Total withdrawal by Hand pumps are 42818250 Gallon per Day (GPD). This amount of water is equal to 42818.25 cubic meters per day ($m^3$/day). Considering the total study area the total withdrawals is 8.5625 mm/year.

*5.9 Result of Evaporation Losses*

Evaporation is the amount of water losses due to escape of water molecule from liquid surface, Land wet surface or other vegetation surface, in special case of crop, plant and vegetation this is termed as Evapo-transpiration.

Nine (9) year 2005-2013 the pan evaporation data are collected from Metrological Department Peshawar and calculate the Mean Annual Evaporation for the study area. This comes out to 591.5777 mm/year. The monthly evaporation records (Average of Nine year) are shown in Figure No. 11. This clearly shows that the evaporation losses are at high rate during the month June and July, while at low rate during December, January and February.


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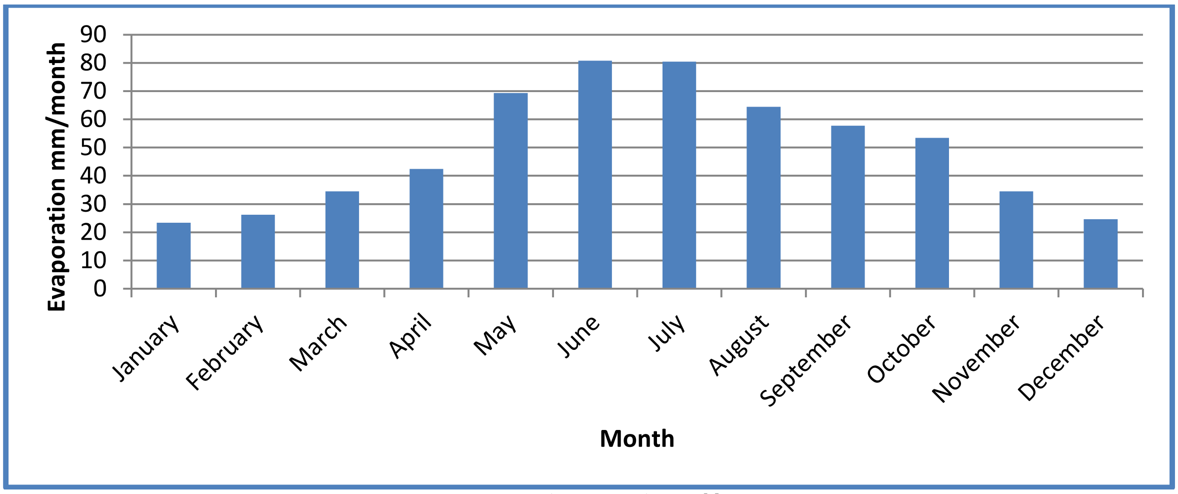


FIGURE NO. 11 Average (2005-2013) Monthly Evaporation Losses

*5.10 Result of Inflow and Outflow of River*

The inflow is the amount of water that is transported by the river to the study area while outflow is the amount of water that is exported by the river out of the study area. The estimation is very simple, take the summation of all inflow of sub area and also sum up all the outflow of sub area. The storage in the study area simply excluded total inflow from total outflow. The total inflow to the study area is 37819.77, $m^3$/day, while total outflow from the study area is 199650.30 $m^3$/day. The storage remains in the area is 161830.53, $m^3$/day. Due to this storage the area is recharging 32.3661 mm/year. Table No. 07 shows the results, and Figure 12 shows the sub area of entire District.

TABLE NO. 07 Result of inflow and outflow

| AREA | Inflow Cubic meter per day | Out Flow Cubic meter per day |
|---|---|---|
| Nezampur | 2456.67 | 40234 |
| Jehangira | 12693.7 | 22105.6 |
| Resalur | 17107 | 72017.7 |
| Pabbi | 5562.4 | 65293 |
| TOTAL | 37819.77 | 199650.3 |

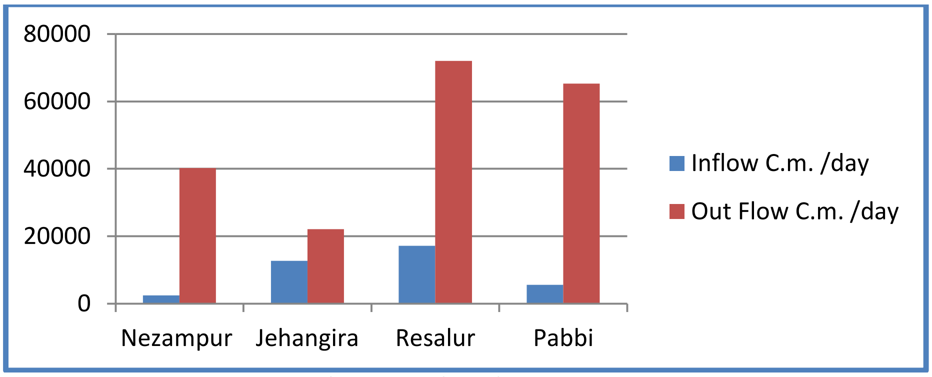


FIGURE NO. 12 Inflow and Outflow of Rivers Flowing in District Nowshera

*5.11 Result of Ground Water Balance*

The last objective is the result of all the above parameters. The total inflow and outflow of the study area is considered and using Equation No. 06 the ground water balance is obtained. All the result is given in the following Table No. 08. The total recharge to District Nowshera is 3.4438, $m^3$/sec, OR the ground water level 59.518 mm/year is increasing due to recharge.


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TABLE NO. 08 Ground Water Balance of District Nowshera

| S. No. | Parameter | Inflow ($m^3$/day) | Outflow ($m^3$/day) | Inflow (mm/yr) | Outflow (mm/yr) |
|---|---|---|---|---|---|
| 1. | Seepage From River and Canal | 3516447.5 | --- | 703.2895 | --- |
| 2. | Recharge From Rainfall | 200741 | --- | 40.1482 | --- |
| 3. | Discharge From Hand Pump | --- | 42818.25 | --- | 8.5625 |
| 4. | Discharge From Tube Well | --- | 257105.016 | --- | 51.4131 |
| 5. | Inflow and Outflow of Rivers | 37820 | 199650.5 | 7.5640 | 39.9301 |
| 6. | Evaporation | --- | 2957890 | --- | 591.5780 |
| | Total | 3755008.5 | 3457463.766 | 751.0017 | 691.4837 |

## 5. CONCLUSIONS

- As a whole the area of Nowshera is recharging 59.52 mm/year.
- The maximum seepage occurs from Kabul River and Indus River. Nazir Ahmad and Kostiakov A. N. formula gives the maximum seepages then other used empirical equations.
- Agricultural Land was dominant land cover class followed by Rock Impervious Land.

## 6. RECOMMENDATIONS

- The Pakistani and Indian formula gives good results so, it is recommended for seepages estimation of rivers in the study area. The seepage losses should be minimized by lining the canals and by stone pitching of small rivers.
- The water logged area should be drained out by installing sub surface drainage system.
- In uncultivable land the runoff water should be utilized to make the land cultivable.

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