Determination of Aquifer Characteristics in the Command of Muhammad Khan Distributary Using AQTESOLV

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***Abstract*: The Muhammad Khan distributary is located in the region of Lower Indus Basin (LIB) towards the southern part of the Sindh province of Pakistan in district Tando Muhammad Khan. This distributary branches from the Rohri canal at RD-1038 to the right side on Almani X-regulator.Since the management of groundwater resources in any area knowledge of hydraulic characteristics of the aquifer system is essential, hence, the objective of this study is to determine aquifer parameters in the command of Muhammad khan distributary. In this regard, piezometers are installed at the head and tail of the distributary for the conduct of pumping tests to derive the fundamental/basic parameters for the groundwater model AQTESOLV. In this paper, the experimental and analytic work has been presented: drawdown versus time data has been collected from the field during pumping tests, and field data has been analyzed using the AQTESOLV computer model to determine S and T parameters choosing two methods viz. Theis method and the Cooper-Jacob method. The average values of Transmissivity and Storativity at Head reach using the AQTESOLV computer model were obtained as 2.730167m^2/min and 0.005556, respectively. Similarly, the average values of Transmissivity and Storativity at Tail reach using the AQTESOLV computer model were obtained as 4.5998m^2/min and 0.004429, respectively. Comparison of the transmissivity and storativity values, obtained through the analysis at the head and tail of the Muhammad Khan distributary indicates that transmissivity at the tail reach is more than that at the head reach, whereas the Storativity at the head reach is higher than that at the tail.**

***Keywords:* Muhammad khan distributary, Lower Indus Basin (LIB), Aquifer characteristics, AQTESOLV**

I. INTRODUCTION

Water is one of the most important and efficient sources for all living organisms. Groundwater is the major resource of freshwater and billions of people around the world entirely depend upon this resource. Groundwater is one of the most phrased entities and likely to be safer against pollution as compared to surface water. The main cause of not getting an optimum outcome of this resource is lack of awareness and insufficient data. Hence, to obtain the relevant data for achieving the optimum outcome of this precious resource of groundwater pumping tests were conducted. The main purpose of the pumping test is to determine aquifer characteristics that will help to prescribe pumping time. Theis was the first who provided solution of differential equations governing the unsteady radial groundwater flow through porous media towards a discharging well. In his method, he assumed that the aquifer is homogenous, isotropic and of infinite areal extent having constant transmissivity, whereas the well was assumed to be of infinitesimal diameter penetrating to the full depth of the aquifer. His graphical solution method contains the well function of an argument introduced as a limit in the integral equation. He defined the well function as an infinite series of the argument [1]. Later on, Cooper-Jacob proposed only the first two terms of the series be taken because as per his calculations remaining terms become negligible for small values of radial distance at the large time elapsed after the start of pumping test [2]. Study conducted on the hydraulic and hydro-salinity behavior of the Indus basin aquifer in Pakistan under different field conditions at farmer's wells. Pumping tests at two different sites were carried out on skimming wells with a varying number of strainers i.e. 1, 4, 6 and 16 to evaluate the hydraulic and hydro-salinity behavior of fresh-saline aquifer under different pumping regimes. The results showed that the specific drawdown is higher for single-strainer well and the effect of single-strainer is also more pronounced near the well. The specific drawdown decreases with the number of strainers, signifying the advantageous role of multi-strainer well in spatially distributing the pumping stress [3]. A study proposed on the Schemes to optimize groundwater pumping for Scavenger wells installed in Shaheed Benazirabad and Sanghar districts under. They selected 2 wells along the right side of the Jamrao canal. Using MODFLOW and MT3D models they concluded that up-coning of underlying saline water can be well-ordered if daily operating hours of the wells are limited to a maximum time limit of 13.2 and 12 hours for first and second tube well, respectively [4]. A research report concluded that the use of saline groundwater had a harmful influence on crop production where there is a very low supply of surface water, resulting in plenty of usage of groundwater. The quality of groundwater worsen in middle and tail reaches because in these reaches groundwater is extremely saline due to meager amount of surface water [5]

II. MATERIALS & METHODS

A. Research Area

The Mohammad khan distributary command area has been selected as a research area. It is located in district Muhammad Khan rural. The head regulator of the distributary is located at coordinates 25.2606634 N and 68.5789813 E. The distributary has a design discharge of 59 cusecs and is off-taking from the right side of main Rohri canal at RD-1038. The study area comprises of the gross commanded area (GCA) of 22618 acres with a cultural command area (CCA) of 22213 acres. There are a total of 18 outlets of the distributary. Head of a distributary is located at co-ordinates 25.2417604° N and 68.579753°E and tail are located at 25.21235° N and 68.565833°E.

B. Piezometers Installation

According to study it is mentioned that for a single tube well there has not been always to have numbers of many piezometers, at least three are recommended to use. The expensive large diameter has not required for the pumping test [6]. Hence, for the evaluation of hydro-salinity behavior, three (03) individual piezometers at different distances around the selected tube wells have been installed in the command area of Muhammad khan distributary.. These piezometers have been used to monitor the drawdown during pumping tests. These piezometers have been inserted up to a depth of 80ft, the details are provided as shown in Table 1 and 2.

C. Pumping Test

The pumping test has been conducted on two tube wells within the command area of Muhammad Khan Distributary, one tube well at the head and the other at the tail reach. The drawdown or hydraulic heads with respect to time has been measured using water level indicators in the individual piezometers installed around the well. The relationship of drawdown (s) versus time (t) has been calculated. Theis and Cooper-Jacob methods have been adopted for analyzing the pumping test data regarding the estimation of storage co-efficient and transmissibility for unsteady-state conditions.

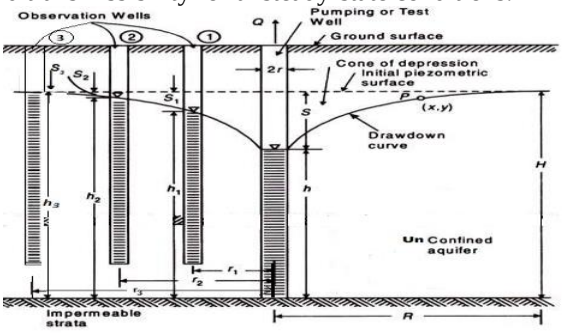

Figure 1: Individual Piezometers near the Selected Tube well

Table 1: Piezometer Details at Head

Observation Well	Distance from the Pumping Well (m)	Depth of Blind pipe (ft)	Depth of Screen (ft)	Total Depth (ft)
1	7.70	60	20	80
2	18.50	60	20	80
3	39.40	60	20	80

Table 2: Piezometer Details at Tail

Observation Well	Distance from the Pumping Well (m)	Depth of Blind pipe (ft)	Depth of Screen (ft)	Total Depth (ft)
1	18.90	60	20	80
2	39.30	60	20	80
3	62.20	60	20	80

III. RESULTS

The results obtained by AQTESOLV software by Theis and Cooper-Jacob method from each piezometer around the pumping well by pumping test at Muhammad khan distributary's head and tail reaches are shown in Table 3 and 4, respectively.

Table 3: Results Obtained at Head Reach of the Muhammad Khan Distributary's Command Area Using AQTESOLV

Sr. No	Observation Well	Theis Method		Cooper-Jacob	
		T (m^2/min)	S	T (m^2/min)	S
1	P 7.7m/24.4m	3.999	0.0000614	3.999	0.0000614
2	P 18.5m/24.4m	1.724	0.00986	1.834	0.007721
3	P 39.4m/24.4m	2.141	0.01008	2.684	0.005553

Table 4: Results Obtained at Tail Reach of the Muhammad Khan Distributary's Command Area Using AQTESOLV

Sr. No.	Observation Well	Theis Method		Cooper-Jacob	
		T (m^2/min)	S	T (m^2/min)	S
1	P 18.9m/24.4m	4.137	0.006911	4.028	0.007173
2	P 39.3m/24.4m	4.489	0.001825	4.376	0.001841
3	P 62.2m/24.4m	5.082	0.005094	5.487	0.00373

From the values produced in Table 3, the average values of transmissivity and storativity at the head reach of the distributary are calculated as 2.730167and 0.005556, respectively. Similarly, from the values produced in Table 4, the average values of transmissivity and storativity at the tail reach of the distributary are calculated as 4.5998and 0.004429, respectively.

IV. CONCLUSIONS

This research work was carried out to determine the aquifer characteristics of Muhammad Khan distributary at the head and tail reaches using AQTESOLV software. To achieve the objectives three numbers of individual piezometers were installed up to the depth of 80 ft. around each of the pumping wells at the head and tail reaches of Muhammad Khan distributary. Pumping tests were conducted at these pumping wells with a constant discharge without any interruption for a period of 480 minutes and 1380minutes at the head and tail, respectively, and drawdown vs. time data was observed. From the data analyzed using AQTESOLV the average values of transmissivity and storativity at the head reach of the distributary are calculated as 2.730167 and 0.005556, whereas, those at tail reach as 4.5998 and 0.004429, respectively. Looking into the above values it is concluded that the transmissivity at the tail is more than that at head however the storativity at the head is more as compared to tail.

V.RECOMMENDATIONS

Based on the above concluded results obtained through this study it is recommended that: optimal pumping time be prescribed and disseminated to the farmer community to safeguard the fresh groundwater resources against up-coning of saline water and subsequent contamination; similar hydro-dynamic and hydro-salinity studies be carried out on three reaches (Head, Middle, and Tail) at appropriate locations so as to develop strong database that represents the aquifer characteristics of entire command area of the distributary; and from such a rich data mapping of entire command of Muhammad khan distributary be done using ArcGIS software for easy access to all-inclusive information.

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