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TOWARDS THE MILLENNIUM DEVELOPMENT GOALS

Performance evaluation of water supply boreholes at Nguru, Nigeria

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The problem of scarcity of water experienced in Northeastern Nigeria has raised serious concern over the sustainability of this vital resource. Uncoordinated large-scale surface water development upstream of the area, which has far-reaching consequences on groundwater recharge, has been widely reported.

The performances of ten (10) water supply boreholes drilled in the quaternary sediments of the Chad Formation at Nguru, Nigeria have been evaluated using the Step Draw down test method. Specific capacity, Aquifer loss and Well loss, Well efficiency, and Transmissivity were determined using regression techniques.

The result of the tests show that the efficiency of the wells when used as the performance criteria range from 51.1% to 89.1%, this shows that the boreholes are productive indicating a good performance. The highest draw down of 24.56 m was observed in the borehole with the least transmissivity of 13 m^2/day. The study revealed that the boreholes could guarantee future supply of water; however urgent steps need to be taken to stem the increasing reduction in groundwater levels which could be attributed to reduction in groundwater recharge. The result of the test is a reference for future well testing program in the area.

Introduction

The step draw down test (SDDT) is a major tool for both aquifer and well evaluation especially when there are no observation holes and the data has to be analyzed.

The test could be described as that in which the draw down in a well is observed while the discharge rate from the well is increased in steps. The discharge rate Q is kept constant through each step and the total draw down in the well S_{wc} is composed of the aquifer loss BQ and well loss CQ^2.

The Jacob's equation ($S_{wc} = BQ + CQ^2$) has been a subject of criticism and modification in the method of analysis (Eden and Hazel,(1973); Clark,(1977), and Kruseman and Ridder(1999)) and has been widely used in evaluating the performance of wells both in confined and unconfined aquifers. The evaluation of well loss enables the efficiency of the well and aquifer characteristics to be calculated

It should be noted that a good well design can minimize well loss in a given situation but never eliminate them and comparison of well efficiencies is not really valid unless the wells are virtually identical which is the case with wells in the study location. Furthermore, the SPECIFIC CAPACITY of a well is a measure of the productivity of the well; clearly, the larger the specific capacity, the better the well performance.

Any significant decline in specific capacity of a well can be attributed to reduction in transmissivity due to a lowering of the ground water level in an unconfined aquifer or to an increase in well loss associated with clogging or deterioration of the well screen. The evaluation of the aquifer and well characteristics is therefore pertinent in determining the sustainability of the water supply boreholes.

The purpose of the study was to evaluate the performance of ten water supply boreholes drilled in the upper zone pressure aquifer of the Chad formation at Nguru and to determine some hydraulic characteristics of the tapped aquifers.

Study location

Nguru town is located in the flood plains of the Hadejia River in Yobe state of Nigeria, the town lies on Lat.12^0 52^1 N, Long. 10^0 27^1 E, within the Lake Chad basin. This basin is the largest area of inland drainage in Africa and is largely covered by superficial deposits of sand and clay (Alluvial sediments). All drainage is towards Lake Chad, but most of the streams fail to reach the Lake, their waters being dissipated in broad swamps and lost by evaporation or transpiration or by percolation to the underlying aquifers.

Materials and methods

The test was designed to be in four (4) steps, each step lasting for two hours and followed by a two hours recovery test. The data required comprise of measurements of discharge rates and water levels in each step. The discharge rate in the ten (10) boreholes was measured using flow meters and time to fill a container of known volume, and water level by an electronic sounder graduated to measure depth to water. The discharge rate was increased with step increments and water level readings taken at 1,2,3,4,6,8,10,15,20,30,50…120 minutes in each step. Grundfos submersible pumps were used in the tests.

The draw down and discharge data obtained from the pumped well was analyzed using Bierschank and Wilson approach in Clark (1977) and regression techniques was used to obtain values of aquifer loss and well loss coefficients, specific capacity and well efficiency. Transmissivity of the aquifers were also obtained using approximate equilibrium analysis for wells in alluvial plains

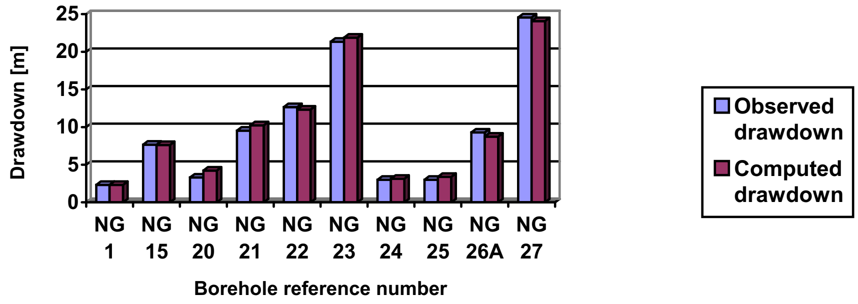

Figure 1. Comparison of observed and computed drawdown

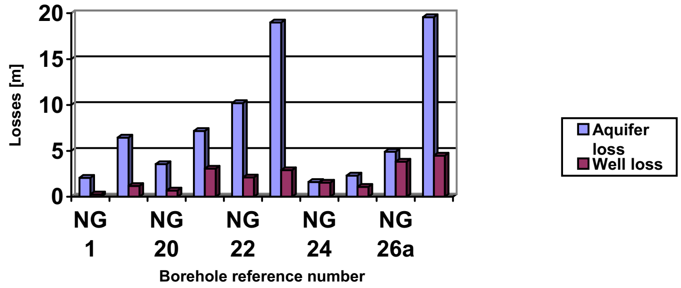

Figure 2. Comparison of aquifer loss and well loss

Table 1.0 Engineering data of tested boreholes

Nguru No.	Total Depth (m)	Pump Inst. Depth (m)	Casing Size (In)	Pump Size (Hp)	Pump Type (Grundfos)	Static Water Level (m.b.G.l.)	Pumped Yield (m^3/s) x 10^{-3}	Draw down (m.b.St.W.l.)	Location
1	54	24	6	10	SP16-16	9.26	7.0	2.32	Y.S.W.B. Premises, Nguru.
15	48.2	30	8	15	SP27-11	8.75	8.40	7.67	Along G.R.A. Road.
20	54	24	8	20	SP45-12	7.90	7.50	3.31	Behind Nguru L.G.A. Office.
21	62.2	24	8	10	SP16-16	8.40	5.51	9.54	Industrial Estate
22	71.4	30	8	15	SP27-11	8.40	7.00	12.66	“ “
23	61	36	8	20	SP45-12	9.15	14.00	21.34	“ “
24	60	18	6	5	SP8-21	6.60	2.63	3.01	Women Teacher’s College.
25	54	24	6	10	SP16-6	8.65	7.00	3.01	Primary School.
26A	54	24	6	10	SP16-16	8.4	6.73	9.30	Right side of the town’s bridge.
27	54	36	6	5	SP8-21	9.58	2.63	24.56	Eid Ground.

Result and discussions

Table 1.0 and 1.1 shows the engineering data of the boreholes and the result of the tests respectively. The specific capacity of the aquifers tapped by the ten boreholes ranges from 9.3 m^2/day – 261m^2/day. A reduction in specific capacity of a well can be attributed to either the reduction in transmissivity due to lowering of ground water level in an unconfined aquifer or to an increase in well losses associated with clogging or deterioration of the well screen.

A good fit was obtained when observed draw down in the boreholes was plotted against computed draw down derived from regression equations. A comparison of the Aquifer losses and Well losses in the boreholes shows that most of the draw down in the wells was due to the aquifer loss component especially in borehole NG 23 and NG 27 (see figure 1 and 2).

Borehole NG1 has the highest efficiency and transmissivity of 89.2% and 356 m^2/day respectively. NG24 has the least efficiency of 51.1%, it is suspected that this is due to the clogging or deterioration of the well screen, the aquifer loss component of the draw down is just slightly higher than the well loss component.

The three boreholes, NG24, NG25, and NG26A are least efficient; the borehole technical data (Table 1.0) shows that they tap the same aquifer which has a lower yield, hence can only be used to supply water to a very small population. However, they need to be inspected with closed circuit TV camera to determine the extent of damage or clogging of the screen in order to determine appropriate rehabilitation measures.

Conclusion

The performance evaluation of the water supply boreholes shows that the boreholes can still guarantee future water supply in the area; however, some of the wells need rehabilitation. The result of the test on the boreholes is a major reference for future well testing programs in the area.

Reference

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Table 1.1 Results of pumping test analysis

S/N	Ref. No.	Observed Dd S_w (m.b.st.w.l.)	Discharge $Qx10^{-3}$ (m^3/s)	Specific Dd S_w/Q ($m/m^3/s$)	Specific Cpty Q/S_w (m^2/day)	Aquifer loss Coeff. B (sec/m^5)	Well loss Coeff. C (s^2/m^5)	Aquifer Loss (m)	Well Loss (m)	Computed Dd S_{wc} (m)	Well Eff. %	Trans. T (m^2/day)
1	1	2.32	7.00	331	261	296	5200	2.07	0.25	2.32	89.2	356
2	15	7.67	8.40	913	95	767.9	16736	6.45	1.18	7.63	84.5	135
3	20	3.31	7.50	441	196	475.2	12158	3.56	0.68	4.24	83.9	218
4	21	9.54	5.51	1731	50	1304.7	101258	7.18	3.07	10.25	70	79
5	22	12.66	7.00	1809	48	1458.6	43108	10.21	2.11	12.32	82.8	71
6	23	21.34	14.0	1524	57	1355.9	14799	18.98	2.90	21.88	86.7	76
7	24	3.01	2.63	1144	75	613.7	223289	1.61	1.54	3.15	51.1	327
8	25	3.01	7.0	430	201	330.5	22080	2.31	1.08	3.39	68.1	313
9	26[A]	9.30	6.73	1382	63	730	84598	4.91	3.83	8.74	56.1	142
10	27	24.56	2.63	9338	9.3	7442	650240	19.57	4.49	24.08	81.2	13

Dd= Draw down Cpty= Capacity Coeff. = Coefficient Eff. = Efficiency Trans. = Transmissivity