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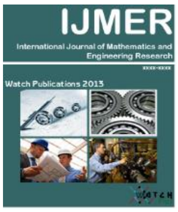

STORATIVITY AND TRANSMISSIVITY EFFECT TO PREDICT THE RATE OF FLOW IN SEMI CONFINED OVERBURDEN PRESSURED DEPOSITED FORMATION, OKIRIKA, RIVERS STATE

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Abstract

Storativity and transmissivity effect were monitored to expressed its effects on semi confined bed deposition in few location at okirika, the study were to monitor the pressure flow deposition in the formation influenced by variation of void ratio, several formation characteristics were noted for such effect in the deposition of these flow in semiconfined bed, but for these pressured flow experienced in the study location were monitor to observed the predominant effect of void ratio variation, these were observed to influenced the deposition of flow within the strata. These were noted through the explorations well developed at shallow depths, these information were noted thus applied to develop the system that generated derived model for the study. Simulation were imperative for such study as it was done to generates various theoretical data validated with experimental values, both parameters expressed faviourable fits validating the developed model, the study has express the deposition of semiconfined bed in these few locations, experts will definitely applied these model in the design of ground water well for such environment in Niger delta.

KeyWords: *Storativity, Transmissivity, Semi confined.*

INTRODUCTION

Managing ground water resources requires knowledge of aquifer property distributions, since they affect water movement and solute transport. This understanding is often developed and tested with regional numerical ground water flow models, which are used for simulation, prediction, and scenario analysis. In ground water model calibration, we seek to best represent a complex natural system with an idealized numerical model at the appropriate scale of interest. Many regional ground water studies do not attempt to build detailed heterogeneity into large-scale (tens to hundreds of kilometers) flow models, due to the prohibitive costs of detailed sampling over large areas and the computational limits on calibrating multiscale heterogeneity in the model. Regional geologic or hydrologic units are often treated as zones assumed to be homogeneous with a single effective parameter value (e.g., Barlebo et al. 2004 Kristopher, et al, 2008). This zoned representation may offer computational advantages, but it can yield only large-scale effective properties, which are best for predicting ‘‘ensemble'' behaviors of a ground water system (Yeh 1992; Yeh et al. 2007). In regional studies that include local-scale heterogeneity (i.e., heterogeneity smaller than the hydrologic unit, at the scale of several model cells), the parameter distribution is often estimated from a steady-state or predevelopment head distribution (e.g., Yeh and Mock 1996). Heterogeneous transmissivity fields are estimated by manually adjusting parameter values in model cells or zones to match simulated and observed hydraulic heads. More advanced approaches use automated calibration algorithms (e.g., PEST [Doherty 2007] or UCODE [Poeter et al. 2005]) to minimize the residual between observed and simulated heads (Barlebo et al. 2004). Steady-state calibrations are limited to estimating transmissivity (T), and few regional studies attempt to calibrate ground water flow models using transient head measurements due to the large increase in complexity and computational effort. Basin-scale transient model calibrations are often ill posed and nonunique due to difficulties collecting the necessary and sufficient information to make an inverse problem well posed (Yeh et al. 2007). Because of the uncertainty inherent in aquifer parameter and boundary condition characterization, many modelers have developed misleading predictive models of ground water flow and contaminant migration. Because of this, some have seriously questioned the ability to validate ground water flow models at all (Konikow and Bredehoeft 1992; Oreskes et al. 1994; Bredehoeft 2003). Many researchers have shown that it can be used to characterize heterogeneous hydraulic properties, including Tosaka et al. (1993), Gottlieb and Dietrich (1995), Vasco et al. (2000), Yeh and Liu (2000), Bohling et al. (2002), Brauchler et al. (2003), and Zhu and Yeh (2005, 2006). HT involves collecting responses throughout an aquifer due to a sequence of overlapping aquifer tests and then calibrating a heterogeneous ground water flow model using the observed responses from all the tests. HT has been applied successively to small-scale synthetic aquifers (Yeh and Liu 2000; Zhu and Yeh 2005, 2006; Hao et al. 2008), laboratory sandboxes (Liu et al. 2002, 2007; Illman et al. 2007), and plot-scale fields (Vesselinov et al. 2001; Bohling et al. 2007; Straface et al. 2007; Li et al 2007). In these small-scale studies, it is possible to stress the entire domain with each pumping well, providing new information throughout the domain from each pumping event.

Governing equation

$$\frac{S}{T}\frac{d^2\phi}{dZ^2} = \frac{1}{\tau}\frac{d\phi}{dZ} + Vt\frac{d\phi}{dZ} \quad \ldots\ldots.. \qquad (1)$$

Nomenclature

ϕ	=	Hydraulic head [L]	
S	=	Storativity	[-]
T	=	Transmissivity	[L^2T^{-1}]
t	=	Time	[T]
Z	=	Radial Distance [L]	
V	=	Velocity	[LT^{-1}]

$$\frac{S}{T}\frac{d^2\phi}{dZ^2} = \left[\frac{1}{\tau} + Vt\right]\frac{d\phi}{dZ} \quad \ldots\ldots\ldots\ldots\ldots.. \qquad (2)$$

Let $\phi = \sum_{n=0}^{\infty} a_n Z^n$

$$\phi^1 = \sum_{n=1}^{\infty} n a_n Z^{n-1}$$

$$\phi^{11} = \sum_{n=2}^{\infty} n(n-1) a_n Z^{n-2}$$

$$\frac{S}{T}\sum_{n=2}^{\infty} n(n-1) a_n Z^{n-2} = \left(\frac{1}{\tau} + Vt\right)\sum_{n=1}^{\infty} n a_n Z^{n-1} \quad \ldots\ldots\ldots (3)$$

Replace *n* in the 1st term by *n+2* and in the 2nd term by *n+1*, so that we have;

$$\frac{S}{T}\sum_{n=0}^{\infty}(n+2)(n+1)a_{n+2}Z^n - \left(\frac{1}{\tau}+Vt\right)\sum_{n=0}^{\infty}(n+1)a_{n+1}Z^n \qquad (4)$$

i.e. $\frac{S}{T}(n+2)(n+1)a_{n+2} = \left(\frac{1}{\tau}+Vt\right)(n+1)a_{n+1}$ …………(5)

$$a_{n+2} = \frac{\left(\frac{1}{\tau}+Vt\right)(n+1)a_{n+1}}{\frac{S}{T}(n+2)(n+1)} \quad \ldots\ldots\ldots\ldots.. \qquad (6)$$

$$a_{n+2} = \frac{\left(\frac{1}{\tau}+Vt\right)a_{n+1}}{\frac{S}{T}(n+2)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \qquad (7)$$

for $n = 0,\ a_2 = \frac{\left(\frac{1}{\tau}+Vt\right)a_1}{2\frac{S}{T}}$

……………………. (8)

for $n = 1,\ a_3 = \frac{\left(\frac{1}{\tau}+Vt\right)a_2}{2\frac{S}{T}} = \frac{\left(\frac{1}{\tau}+Vt\right)^2 a_2}{2\frac{S}{T}\bullet 3\frac{S}{T}}$

……………………. (9)

for $n = 2;\ a_4 = \frac{\left(\frac{1}{\tau}+Vt\right)a_3}{4\frac{S}{T}} = \frac{\left(\frac{1}{\tau}+Vt\right)}{4\frac{S}{T}} \bullet \frac{\left(\frac{1}{\tau}+Vt\right)^2 a_1}{3\frac{S}{T}\bullet 2\frac{S}{T}} = \frac{\left(\frac{1}{\tau}+Vt\right)^3 a_1}{4\frac{S}{T}\bullet 3\frac{S}{T}\bullet 2\frac{S}{T}}$

…………….. (10)

for $n = 3;\ a_5 = \frac{\left(\frac{1}{\tau}+Vt\right)a_4}{5\frac{S}{T}} = \frac{\left(\frac{1}{\tau}+Vt\right)^4 a_1}{5\frac{S}{T}\bullet 4\frac{S}{T}\bullet 3\frac{S}{T}\bullet 2\frac{S}{T}}$

………………… (11)

for $n;\ a_n - \frac{\left(\frac{1}{\tau}+Vt\right)^{n-1}a_1}{\frac{S}{T}^{n-1} n!}$

$$\phi(Z) = a_0 + a_1Z + a_2Z^2 + a_3Z^3 + a_4Z^4 + a_5Z^5 + \ldots\ldots. + a_nZ_n \cdots \qquad (13)$$

$$= a_0 = a_1Z + \frac{\left(\frac{1}{\tau}+Vt\right)a_1Z^2}{2!\frac{S}{T}} + \frac{\left(\frac{1}{\tau}+Vt\right)a_1Z^3}{3!\frac{S}{T}^2} + \frac{\left(\frac{1}{\tau}+Vt\right)a_1Z^4}{4!\frac{S}{T}^3} + \frac{\left(\frac{1}{\tau}+Vt\right)a_1Z^5}{5!\frac{S}{T}^4} + \ldots$$

……………… (14)

$$\phi(Z) = a_0 + a_1\left[Z + \frac{\left(\frac{1}{\tau}+Vt\right)Z^2}{2!\frac{S}{T}} + \frac{\left(\frac{1}{\tau}+Vt\right)^2Z^3}{3!\frac{S}{T}^2} + \frac{\left(\frac{1}{\tau}+Vt\right)Z^4}{4!\frac{S}{T}^3} + \frac{\left(\frac{1}{\tau}+Vt\right)Z^5}{5!\frac{S}{T}^4} + \right] \qquad (15)$$

$$\phi(Z) = a_0 + a_1\,\ell^{\frac{\left(\frac{1}{\tau}+Vt\right)}{\frac{S}{T}}x} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \qquad (16)$$

Subject equation (16) to the following boundary conditions.

$$\phi(o) = 0 \; and \, \phi^1(o) = D$$

$$\phi(Z) = a_0 + a_1 \ell^{\frac{\left(\frac{1}{\tau}+Vt\right)}{\frac{S}{T}}x}$$

$$\phi(o) = a_1 + a_2 = 0$$

i.e. $a_0 + a_1 = 0$ ………………….. (17)

$$\phi^1(Z) = \frac{\left(\frac{1}{\tau}+Vt\right)}{\frac{S}{T}} a_1 \ell^{\frac{\left(\frac{1}{\tau}+Vt\right)}{\frac{S}{T}}}$$

$$\phi^1(o) = \frac{\left(\frac{1}{\tau}+Vt\right)}{\frac{S}{T}} a_1 = D$$

$$a_1 = \frac{D\frac{S}{T}}{\frac{1}{\tau}+Vt} \quad \text{……………..} \quad (18)$$

Substitute (18) into equation (17)

$$a_1 = -a_0$$

$$\Rightarrow a_0 = \frac{D\frac{S}{T}}{\frac{1}{\tau}+Vt} \quad \text{………………..} \quad (19)$$

Hence, the particular solution of equation (16) is of the form:

$$\phi(Z) = -\frac{D\frac{S}{T}}{\frac{1}{\tau}+Vt} + \frac{D\frac{S}{T}}{\frac{1}{\tau}+Vt} \ell^{\frac{\left(\frac{1}{\tau}+Vt\right)}{\frac{S}{T}}Z}$$

$$\Rightarrow \phi(Z) = \frac{D\frac{S}{T}}{\frac{1}{\tau}+Vt}\left[\ell^{\frac{\left(\frac{1}{\tau}+Vt\right)}{\frac{S}{T}}Z} - 1\right] \text{…..} \quad (20)$$

MATERIALS AND METHOD

Standard laboratory experiment where performed to monitor the semiconfined bed flow at different formation, the soil deposition of the strata were collected in sequences base on the structural deposition at different locations, this samples collected at different location generate variation at different depth producing different fluid in semiconfined bed through pressure flow at different strata, the experimental result are applied to be compared with the theoretical values to determine the validation of the model.

RESULT AND DISCUSSION

Results and discussion are presented in tables 1 to 8 including Figures 1 to 4, representation of conynebacterium concentration.

The study expresses the behaviour of flow at predominant deposited semiconfined bed, the structure of the formation show several pressured from the predominant deposited characteristics in the study area, the deposition of these semi confined bed are base on the predominant overburden pressured in the deposit, the direction of flows are affect also by the structure of the strata, figure one and two shows the distribution deposition of flow pressured by the overburden deposition, these pressured the flow in the strata in linear exponential phase as it is express in these figures, there rate of flow were observed to experiences rapid velocity, while two and three maintained similar exponential condition but experienced slight decrease in velocity of flow, the pressure experiencing slight decrease can be attributed to slight variation of void percentage from the disintegration of the porous rocks at some deposited bed. The behaviour of flow is reflected from the deposition of the strata between the semi confined beds. Figure five and six experienced more decrease in pressure flow, the velocity reduced under the influences of permeation of the strata structured through void ratio decreasing of the strata between the porous medium, homogeneous setting were

Table 1: Experimental values for Confined Bed Flow at Different Depth

Depth [M]	Confined bed Flow
3	2.03E-02
6	4.10E-02
9	6.11E-02
12	8.15E-02
15	1.02E-01
18	1.22E-01
21	1.43E-01
24	1.63E-01
27	1.83E-01
30	2.03E-01
33	2.24E-01
36	2.44E-01
39	2.65E-01
42	2.86E-01
45	3.05E-01

Table 2: Predicted and Validate values for confined bed flow at Different Depth

Depth [M]	Predicted Confined bed Flow	Validated Values
3	2.03E-02	1.81E-02
6	4.10E-02	3.61E-02
9	6.11E-02	5.41E-02
12	8.15E-02	7.21E-02
15	1.02E-01	9.01E-02
18	1.22E-01	1.08E-01
21	1.43E-01	1.26E-01
24	1.63E-01	1.44E-01
27	1.83E-01	1.62E-01
30	2.03E-01	1.80E-01
33	2.24E-01	1.98E-01
36	2.44E-01	2.16E-01
39	2.65E-01	2.34E-01
42	2.86E-01	2.52E-01
45	3.05E-01	2.70E-01

Table 3: Experimental values for Confined Bed Flow at Different Depth

Time [T]	Confined bed Flow
10	2.50E-03
20	5.71E-03
30	8.56E-03
40	1.14E-02
50	1.42E-02
60	1.71E-02
70	1.99E-02
80	2.28E-02
90	2.56E-02
100	2.88E-02
110	3.14E-02
120	3.42E-02
130	3.71E-02
140	3.99E-02
150	4.28E-02

Table 4: Predicted and Validate values for confined bed flow at Different Depth

Time [T]	Predicted Confined bed Flow	Validated Values
10	2.50E-03	2.55E-03
20	5.71E-03	5.66E-03
30	8.56E-03	8.64E-03
40	1.14E-02	1.21E-02
50	1.42E-02	1.48E-02
60	1.71E-02	1.82E-02
70	1.99E-02	2.11E-02
80	2.28E-02	2.41E-02
90	2.56E-02	2.62E-02
100	2.88E-02	2.95E-02
110	3.14E-02	3.22E-02
120	3.42E-02	3.51E-02
130	3.71E-02	3.84E-02
140	3.99E-02	4.07E-02
150	4.28E-02	4.32E-02

Table 5: Experimental values for Confined Bed Flow at Different Depth

Depth [M]	Confined bed Flow
3	4.85E-04
6	9.71E-04
9	1.45E-03
12	1.94E-03
15	2.42E-03
18	2.91E-03
21	3.39E-03
24	3.88E-03
27	4.37E-03
30	4.85E-03
33	5.34E-03
36	5.83E-03
39	6.31E-03
42	6.78E-03
45	7.28E-03

Table 6: Predicted and Validate values for confined bed flow at Different Depth

Depth [M]	Predicted Confined bed Flow	Validated Values
3	4.85E-04	4.77E-04
6	9.71E-04	9.76E-04
9	1.45E-03	1.54E-03
12	1.94E-03	1.88E-03
15	2.42E-03	2.48E-03
18	2.91E-03	2.98E-03
21	3.39E-03	3.47E-03
24	3.88E-03	3.96E-03
27	4.37E-03	4.44E-03
30	4.85E-03	4.98E-03
33	5.34E-03	5.44E-03
36	5.83E-03	5.94E-03
39	6.31E-03	6.42E-03
42	6.78E-03	6.88E-03
45	7.28E-03	7.34E-03

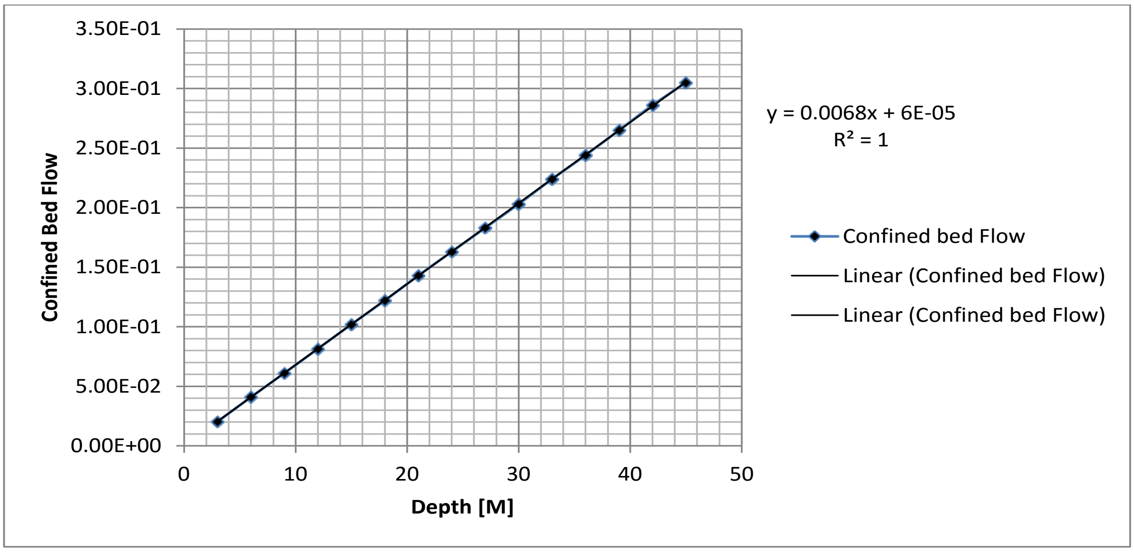

Figure 1: Experimental values for Confined Bed Flow at Different Depth

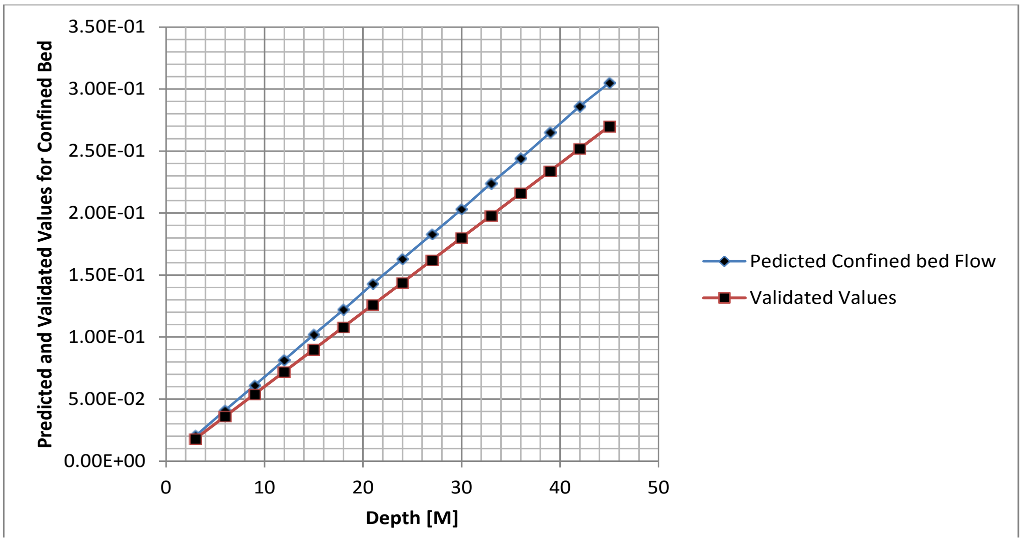

Figure 2: Predicted and Validate values for confined bed flow at Different Depth

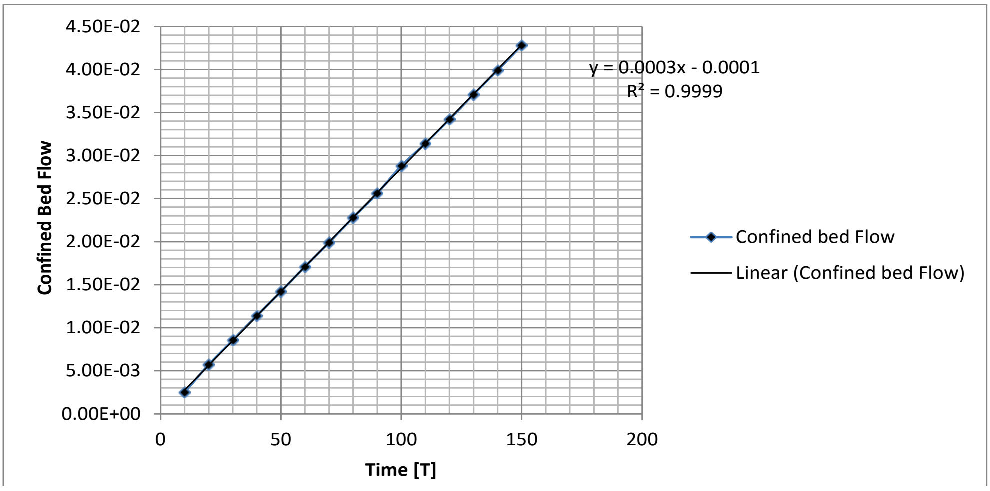

Figure 3: Experimental values for Confined Bed Flow at Different Depth

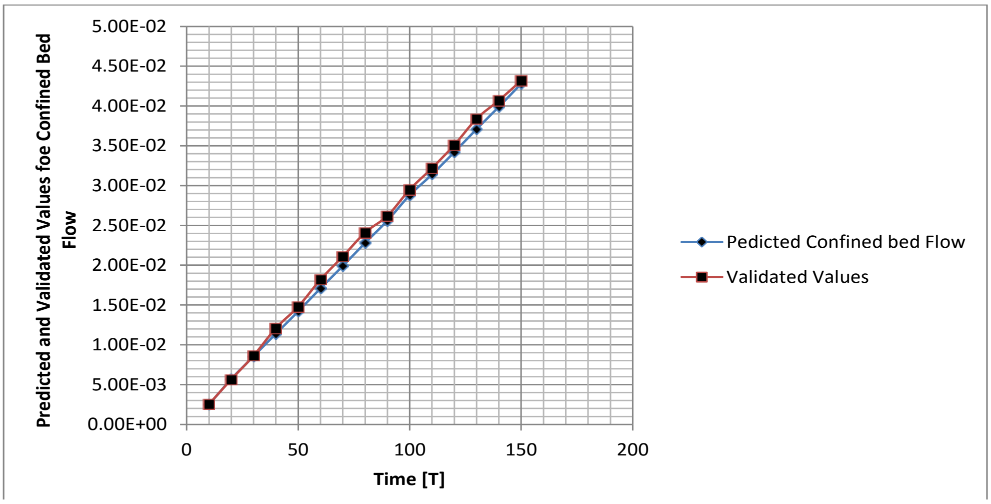

Figure 4: Predicted and Validate values for confined bed flow at Different Depth

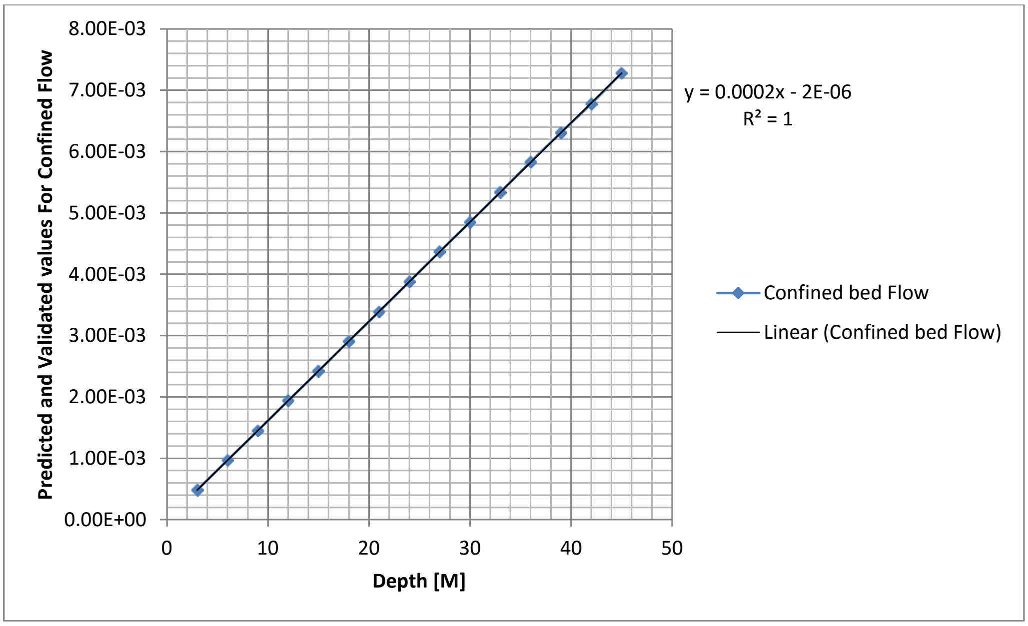

Figure 5: Experimental values for Confined Bed Flow at Different Depth

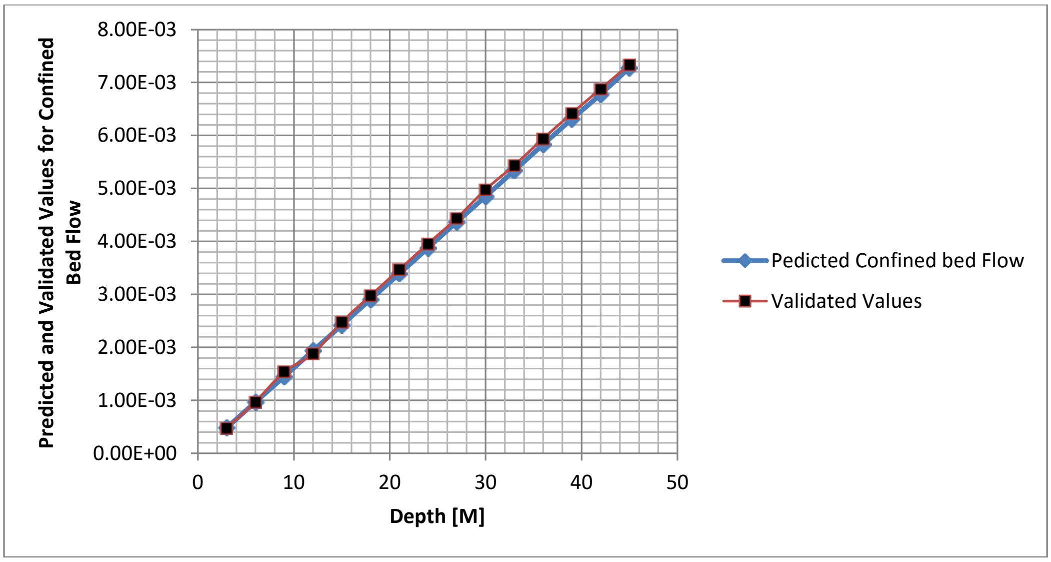

Figure 6: Predicted and Validate values for confined bed flow at Different Depth

also observed, but the predominant effect on the formation varies in void as reflected in the flow on semi confined bed. These were observed in figure five and six stated above. The generated theoretical values were compared with experimental date, both parameters expressed best fits validating the develop model simulation values.

CONCLUSION

The behaviour of flow in semi confined bed has been evaluated through the developed model application, the study were developed to monitor various flow pressure that will determine the structure of the strata thus express the type of flow in the formation. Deltaic deposition has been noted for unconfined bed, but semi confined were observed in few location at okirika through ground water exploration, the rate of from the well were observed to monitor the yield coefficient, these condition express surprises to experts in field because studied never show semiconfined bed in such deltaic environment, the deposition of Niger delta formation has always been alluvium deposit that predominant the environment thus generate homogeneous phreatic bed formation, but the deposition of semi confined bed in okirika in few location were attributed to sand depositions from porous rock, the pressured flow maintained linear exponential pressure flow from all the simulation values, experimental data were applied for validation of the developed model, both parameters express faviourable fits validating the developed model for the study.

REFERENCES

Bohling GC, X Zhan, J.J. Butler Jr., and L. Zheng. (2002). Steady shape analysis of tomographic pumping tests for characterization of aquifer heterogeneities. Water Resources Research 38, no. 12: 1324.

Brauchler, R., R. Liedl, and P. Dietrich. (2003). A travel time based hydraulic tomographic approach. Water Resources Research 39, no. 12: 1370.

Bredehoeft, J.D. (2003). From models to performance assessment: The conceptualization problem. Ground Water 41, no. 5: 571–577.

Doherty, J. (2007). PEST: Model-independent Parameter Estimation User Manual, 5th ed. Brisbane, Australia: Watermark Numerical Computing.

Gottlieb J., P. Dietrich. (1995). Identification of the permeability distribution in soil by hydraulic tomography. Inverse Problems 11, no. 2: 353–360.

Hao Y, Yeh T.-CJ, Xiang J, Illman WA, Ando K, Hsu KC (2008). Hydraulic tomography for detecting fracture connectivity. Ground Water 46, no. 2: 183–192.

Konikow LF, Bredehoeft JD (1992). Groundwater models cannot be validated. Advances in Water Resources 15, no. 1: 75–83.

Li W, Englert A, Cirpka OA, Vanderborght J, Vereecken H (2007). Two-dimensional characterization of hydraulic heterogeneity by multiple pumping tests. Water Resources Research. 43, no. 4: W04433.

Liu S, Yeh T.-CJ, Gardiner R (2002). Effectiveness of hydraulic tomography: Sandbox experiments. Water Resources Research 38, no. 4: WR000338.

Oreskes N, Shrader-Frechette K, Belitz K (1994). Verification, validation and confirmation of numerical models in the earth sciences. Science 243, no. 5147: 641–646.

Poeter EP, Hill MC, Banta ER, Mehl S, Christensen S (2005). UCODE_2005 and six other computer codes for universal sensitivity analysis, calibration, and uncertainty evaluation. USGS Techniques and Methods 6-A11. Reston, Virginia: USGS. Straface, S., T.-C.J. Yeh, J. Zhu, S. Troisi, and C.H. Lee. (2007). Sequential aquifer tests at a well field, Montalto Uffugo Scalo, Italy. Water Resources Research 43, no. 7: W07432.

Tosaka, H., K. Masumoto, and K. Kojima. (1993). Hydropulse tomography for identifying 3-D permeability distribution. In Proceedings of the Fourth Annual International Conference on High Level Radioactive Waste Management, 955– 959. New York: ASCE.

Vesselinov, V.V., S.P. Neuman, and W.A. Illman. (2001). Threedimensional numerical inversion of pneumatic cross-hole tests in unsaturated fractured tuff: 2. Equivalent parameters, high-resolution stochastic imaging and scale effects. Water Resources Research 37, no. 12: 3019–3042.

Yeh, T.-C.J. (1992). Stochastic modeling of groundwater flow and solute transport in aquifers. Journal of Hydrologic Processes 6, no. 4: 369–395

Yeh, T.-C.J., C.H. Lee, K.-C. Hsu, and Y.-C. Tan. (2007). Fusion of active and passive hydrologic and geophysical tomographic surveys: The future of subsurface characterization. In Data Integration in Subsurface Hydrology, ed. D.W.

Yeh, T.-C.J., and S. Liu. (2000). Hydraulic tomography: Development of a new aquifer test method. Water Resources Research 36, no. 8: 2095–2105

Zhu, J., and T.-C.T.J. Yeh. (2006). Analysis of hydraulic tomography using temporal moments of drawdown recovery data. Water Resources Research 42, no. 2: W02403

Zhu, J., and T.-C.T.J. Yeh. (2005). Characterization of aquifer heterogeneity using transient hydraulic tomography. Water Resources Research 41, no. 7: W07028.

Kristopher L. K1, Andrew C. Hinnell, Phoolendra K. Mishra, and Tian-Chyi Jim Yeh (2008). Basin-Scale Transmissivity and Storativity Estimation Using Hydraulic Tomography Vol. 46, No. 5—Ground Water—September–October (pages 706–715