American Journal of Engineering Research (AJER)
e-ISSN : 2320-0847 p-ISSN : 2320-0936
Volume-03, Issue-06, pp-107-119
www.ajer.org

Research Paper Open Access

Gubi Water Treatment Plant as A Source Of Water Supply In Bauchi Township

[1] I Abdullahi, [2] O I Ndububa, [3] U Tsoho, [4] H Garba, [5] S Haladu and, [6] F Bayang

[1] Department of civil Engineering Nigerian Defence Academy, Kaduna
[2] Department of civil Engineering Abubakar Tafawa Balewa University, Bauchi
[3] Department of civil Engineering Nigerian Defence Academy, Kaduna
[4] Department of civil Engineering Nigerian Defence Academy, Kaduna
[5] Department of civil Engineering Nigerian Defence Academy, Kaduna
[6] Department of civil Engineering Nigerian Defence Academy, Kaduna

Abstract: - In Bauchi Township the main source of water supply is coming from Gubi dam. It is among the overall state-wide programmes for water to be supplied to the state capital. The scheme involves the use of surface water by constructing dams and treatment works. Erecting these two major facilities will require pumping station reservoirs, pumping main and major overhaul of the distribution network to make the overall scheme meaningful and useful. The dam was started with temporary structures, which was constructed across one of the streams at the permanent dam site to provide water needed for the construction of the permanent dam. In this temporary dam about 500 million gallons of water which is equivalent to $2.27 \times 10^4 m^3$ be impounded, while the construction of the permanent dam was going on it was decided to make use of the temporary dam to supplement the water supply to the town. Consequently, intake arrangements were made; a treatment plant and pumping mains were provided. The dam is zoned earth fill clay core having a maximum height of 27m with embankment length of 3.86 km and bottom earth-fill is 2,315,000m^3 with a reservoir area of 590 hectares the catchment's area is 179km^2 with a total storage of 38. 4 x 10^6 m^3, the expected yield from reservoir is 90,000m^3/d. It is expected that an average of 7 x 10^6 gallon of water which is equivalent to 3.178 x 10^4 m^3 is pumped per day. The supplies of water depend on the availability of water in the reservoir. The seasonal variation of water in the reservoir level is generally due to seasonal rainfall temperature evaporation and daily demand.

I. INTRODUCTION

With world population growing rapidly the water reservoir of the world are becoming one of the most important assets. Water is essential for human consumption and sanitation, for the production of many industrial goods and for the production of food and fibre. Water is an important means of transport in many part of the world and a significant factor in recreation. Water is unequally distributed about the earth and its availability at any place varies greatly with time. The total supplies of fresh water on earth far exceed human demand. Most of mankind lives in areas, which receives an abundance of annual rainfall. The provision of water to urban areas requires major capital investment in storage, treatment, and supply networks. Furthermore the per capita consumption of water has generally tended to increase rather than decrease, although this can be expected to be largely a function of life style and population density Jasem (2002). Hydrological analysis and designs require information on flow rate at any point of interest along a stream. However, in most cases, this information may not be available in sufficient quantity due to lack of (inadequate of stream gauging or non-availability of records. Faced with these difficulties, engineers and planners resort to the use of mathematical approaches such as synthesis and simulation as tools to generate artificial flow data for use in design for water supply, structures sizes flood control measures e.t.c. (Mustafa and Yusuf 1997).

1.1 THE STUDY AREA

Bauchi township is the study area and is located at 10^0 04' N and 9^0 09' E. It lies within the tropical climatic zone with marked wet and dry season. Fig.1 is the map of Bauchi State showing the study area.

1.2 SOURCES OF WATER

Water can be collected from surface and subsurface for the purpose of water supply. The choice should be carefully done in order to ensure sufficient quantity and good quality water. Where streams are not available or not suitable for consumption, best option in exploiting ground water exploitation may be the only option available. air, etal (1971) in their findings concluded that the nature of the water source commonly determines the planning design and operation of the distribution work. Common sources of fresh water are: - Rain water, surface water and ground water. Hofkes, (1981) found out almost all surface water will require some treatment before it can be used for domestic purpose

1.3 THE GUBI DAM

The source of water in Gubi dam is mainly coming from three tributaries, namely Gubi River, Tagwaye river link with Shadawanka and Ran River. The function of the dam is to supply the state capital and its environs with potable water. A Temporary dam close to the site was constructed across one of the streams to provide water needed for the construction of the permanent dam. The embankment of the dam which has length of 3.86km and bottom earth-fill of 2,315, 000m^3 with a reservoir area of 590 hectares. The catchments area is 17,900 hectares with total storage capacity of 38.4 x 106m^3, the expected yield from the reservoir is 90,000m^3/d.(BSWB,1981) The cross sectional dimensions of the dam is shown in Fig. 2 below.

Figure 1. Map of Bauchi state

The dam was started with temporary structures, which was constructed across one of the streams at the permanent dam site to provide water needed for the construction of the permanent dam. In this temporary dam about 500 million gallons of water which is equivalent to $2.27 \times 10^4 m^3$ be impounded, while the construction of the permanent dam was going on it was decided to make use of the temporary dam to supplement the water supply to the town.

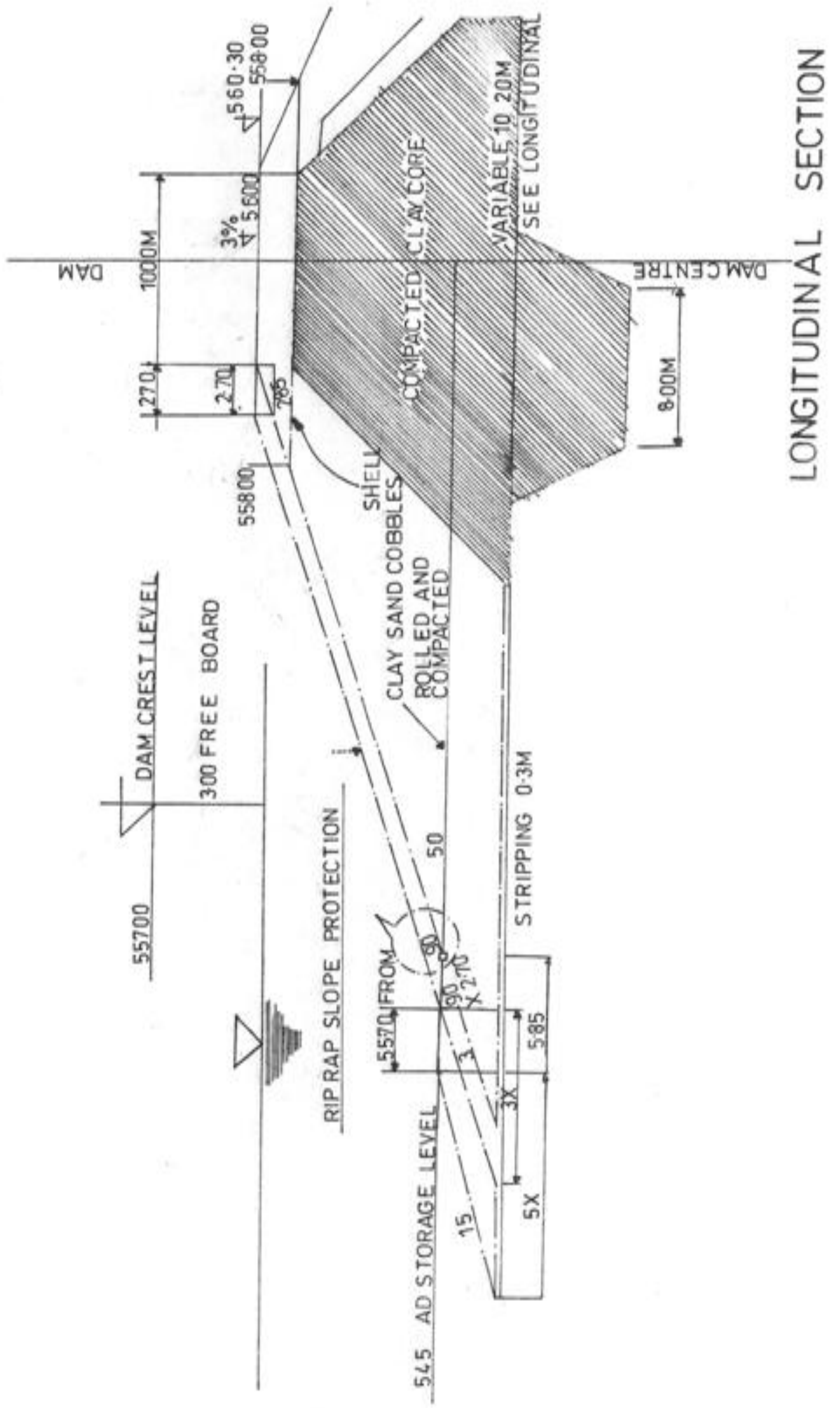

Figure 2:Cross-section of Gubi dam

Consequently in take arrangements were made, a treatment plant and pumping mains were provided. Thus the scheme with a capacity of 6,820m^3/day was put in operation on 30th may, 1980 by His Excellency the Governor of Bauchi, Late Alhaji Abubakar Tatari Ali.
The salient features of the scheme are:

(a) **The temporary dam:** this as mentioned earlier was only intended for construction purposes. The life span of the dam is only three years, but all the facilities provided can easily be removed to another dam when the main dam is ultimately commissioned.

(b) **Intake works and pumping Mains:** considering the nature of the temporary dam, the intake structure has been provided on pontoons. A total of five pumps have been installed. Four pumps working at a time discharging 340m^3/h and the fifth pump as a standby.

About three kilometer length of 300mm diameter AC raw water pumping main conveys the water to the treatment plants for purification with a 169KVA generating supplying power to the intake pumps.

(c) **Water treatment plant:** The raw water is purified in four units of the treatment plant with each unit designed to treat 85m^3/h. the raw water is mixed with chemical and then passed to a function chamber where sedimentation takes place. From this stage, the clear water is pumped for filtration. The filter media is sand of size 1.15mm thick and supported on a nozzle plate. The filtered water is disinfected with calcium hypo-chlorite solution and stored in a 1250m^3 capacity reservoir. The purified water is then pumped to the town to distribution. The power station of the treatment plant consist of two 653 KVA generator sets.

1.4 PUMPING MAIN TO TOWN

The pumps main comprise of 8.4K length of 300mm diameter DI pipeline and 200mm diameter AC pipeline one each to town centre through Ran Road and the G.R.A The treated water from Gubi dam treatment plant is conveyed to warinje hill by the help of four pumps installed in the treatment plant at pumping station. Out of four pumps, only three are now in used while the other one is kept as standby, the types of pump used in Gubi treatment plant are centrifuged pumps. Known as weir pump manufactured.

The pump has head of 152m or 15.2 bar and discharge (Q) = 1875m^3/h. the motor drive is 450 kW and 415 volt. From the pumping station the potable water is conveyed to two reservoirs at warinje hill through a steel pipe of 800 mm diameter of 12.004km length.

1.5 DISTRIBUTION SYSTEMS INTO BAUCHI ENVIRONS:

The distribution of water in Bauchi environs start from warinje reservoir. There are two reservoirs at warinje hill, each reservoir have a capacity of 11000m^3 which is equivalent to 2.million gallons of water making total of 5 million gallons. The two reservoirs at warinje hill are connected with 800mm pipe diameter. The distribution systems are classified into three zones as follows:

a) Lower north zone
b) Lower south zone
c) Upper south zone

(a) Lower north zone: this zone was connected with a 700 mm sleep pipe diameter form the reservoirs at warinje hill. This zone covers area such as Babangida square i.e Tarawa Balewa estate. Some portion of ran road down to Fadaman Mada and Maiduguri road.

(b) Lower south zone: this zone was connected with a 700 mm steel pipe diameter from the reservoirs at warinje hill which later branches into various areas at the lower south zone.
The lower zone covers area such as Bayan Ganuwa, Gombe road, Bakaro, Karolin- Madaki, Railway down to Zango area.

(c) Upper south zone: this zone was connected with 500 mm steel pipe diameter from warinje reservoirs which later spillited into different area starting from Yakubu Wanka street down to Wunti, Kobi, Gwallaga, Yan'doka road covering Wuntin Dada down to Dass road until it reach to Yelwa areas.

1.5 THE PARMANENT GUBI DAM

After the construction of the permanent Gubi dam, it was commissioned in 1981. The permanent dam consist of the following features

(1) The embankments of the dam which has length of 3.86km and bottom earth-fill of 2,315, 000m^3 with a reservoir area of 590 hectares the catchments area is 179km^2 with total storage capacity of 38.4 x 106m^3, the expected yield from the reservoir is 90,000m^2/d.
(2) The clarifier: The treatment plant consist of three clarifiers, each clarifier contains sedimentation tank and flocculation tank
(3) The chemical Building
(4) The filters: The treatment consists of six different filters. The filters are rapid sand gravity types of filter.
(5) The chlorination building
(6) Elevated tank
(7) The pumping station Details of the above feature, see figure below

Figure3: View of control well in Gubi dam treatment plant

Figure 4: View of Gubi dam water intake point

Figure 5: View of Embankment of Gubi dam

Figure 6: View of Gubi dam Treatment Plant

II. LITERATURE

2.1 RESERVOIR

The basic purpose of impounding reservoir is to hold runoff during period of high runoff, and release it during period of low runoff; the specific functions of reservoir are hydroelectric flood control, irrigation, water supply and recreation. Many large reservoirs are multipurpose.

The use of reservoir for temporarily storing stream flow often results in a net loss of total stream flow due to evaporation and seepage. While these losses may not be desired the benefits derived from regulation of water supplies from flood water storage, from hydroelectric power and from any recreational activities at the reservoir site may offset the hydrologic losses and the cost of reservoir storage capacity can be divided among three(3) major uses:-

(i) The active storage used stream flow regulation and for water supply.

(ii) The dead storage required for sediment collection, recreational development hydropower production.

(iii) The flood storage capacity reservoir to reduce potential downstream flood damage in the design of storage reservoir to serve as a water supply system for any community, it has been further recommended that judgment be based on the equalizing or operating storage which can be read from a demand curve during 12 and 24 hours respectively. The total amount storage is desirably equal to the sum of the component requirement which include domestic, industrial and commercial, public uses fire demand losses e.t.c Augustine (1997).

2.2 Consumption of water for various purposes

The total water supply of a city is usually classified according to its ultimate use or end use. The uses are:

(a) **Domestic:** These include water furnished to houses, hotels etc, for sanitary, culinary, drinking, washing, bathing and other purposes. It varies according to living condition of consumers the range usually being considered as 75 to 380L (20 to 100 gal) per capita per day, averaging 190 to 340L (50 to 90 gal) per capita. These figures include air conditioning of residences and irrigation or sprinkling of privately owned gardens and lawns, a practice that may have a considerable effect upon total consumption in some part of the

country. The consumption in domestic may be expected to be about 50% of the total in the average city; but where the total consumption is small, the proportion will be much greater.
(b) **Commercial and Industrial:** Water so classified as above is that furnished to industrial and commercial plants. Its importance will depend upon local condition such as the existence of large industries and whether or not the industries patronize the public water works. proposes the quantity of water required for a commercial and industrial use to be an average of $12.2m^3/100m^2$ of floor area per day Linsley al etal (1995).
(c) **Public Use:** Public building such as city jails and schools, as well as public service flushing streets and fire protection-require much water for which usually, the city is not paid such water amount to 50-75L per capita per day. The actual amount of water used for extinguishing fires does not figure greatly in the average consumption but very large fires will cause the rate of use to be high for short periods.
(d) **Loss and Waste**: This water is sometimes classified as "un accounted for" although some of the loss of the loss and waste may be accounted for in the sense that its cause and amount are approximately known. Unaccounted for water is due to meter and pump seepage, unauthorized water connections and leaks in mains. It is apparent that the unaccounted for water and also waste by customers can be reduced by careful maintenance of the water system and by universal metering of all water services.
(e) **Agricultural Water Use:** Water is used in agriculture for irrigation, as the world population is growing high, the demand for agricultural raw materials and food is also increasing. The world is involved in agriculture to feed its teeming population and to supply raw materials for agro-industries. It has been noted that on global level 13 percent of the available lands are under irrigation, using 1.4 million cubic metres of water per annum. These indicate that irrigation is one of the largest users of water. However, from review of water quality data as well as visual inspection of many streams, rivers, and lakes, diffuse source of pollution from agriculture has not been adequately controlled and has constituted a threat to water sources Novetny and Harvey (1994).
(f) **Recreational uses:** The world is currently experiencing a period of rapid recreational development. Public and private agencies are attempting to meet a growing demand for recreation by building new facilities and modifying old ones Michael and Clerk (1977). Often, plans for new or modified recreation facilities are centred on bodies of water that are used for water supply purposes. Multipurpose reservoirs, long desired by the recreation oriented segment of the public are becoming more and more common, especially in areas where creating new lakes or using existing ones solely for recreational activities is either physically or economically impractical.
(g) **Fishing pond uses:** Several ponds are made along with the reservoir for water supply to serve or allocated for conservative purposes such as fishing purposes. Water can also be used for wild life conservation such as Yankari Game Reserve.

III. METHODOLOGY

Data collection has been carried out to observe the effect of rainfall on seasonal variation of reservoir in Gubi treatment plant for Bauchi township water supply source. These include:
(1) Discharge record of Gubi dam.
(2) Data on important design features of the dam embankment and reservoir
(3) Rainfall data of Bauchi township
(4) MINI TAB R14 Software

3.1METHOD OF ANALYSIS

The analysis begins with setting all the data's in the computer for the mean monthly draw down/rise in the reservoirs from 1997 to 2003 of the dependent variables and the independent variables as X_1 for mean monthly rainfall as shown in Appendix 1and 2 below. In the method of analysis the software used is polymath and Mini-Tab under regression analysis the total number of sample i.e. (N) is 84 samples from the period of 1997 to 2003.
The source of data was obtained as follows:
1. Gubi dam reservoir: water level changes through Gubi dam daily records of water level reservoir in Bauchi Township carried out by their staff.
2. Hydrological data of rainfall through Bauchi airport which was obtained by their staff in meteorological centre at Bauchi airport.

3.2 DISCHARGE RECORDS OF GUBI DAM

Daily water level recording from Gubi dam reservoir obtained from Bauchi state water board showed the level of water for the period of 1997 to 2003. According to the information, the dam was established and operated in 1981 and has been the main source of water supply to the people of Bauchi township but no record of daily reservoir level since then until 1997. Where records are been kept. The values of draw down and rise in the reservoir are calculated from the daily reservoir level record as shown in Appendix 1.There is a rise in reservoir from period of May-Sept

IV. ANALYSIS OF RESULTS AND DISCUSSION

The regression analysis is applied to the research work in order to observe the effect of rainfaff on the reservoir raise for the water supply in Bauchi Township. In this research, the analyses begin with the identification of all the dependent variable and independent variables.
The dependent variable is the change/rise in the reservoir for the period of 1997 to 2003 while the independent variable is the rainfall for the same period that is 1997 to 2003.
From the previous equation that is equation.
(i) $Y = ax_1 + a_0$……………………………………………15
Where Y = dependent variables, while X, is independent variable and a, is constant.
From the equation above, the change in reservoir level take the dependent variable that is Y value, while X_1= Rainfall
The value of a is constants which can be determined by the method of least square.

Regression Analysis: Y versus X2
The regression equation is
Y = 556 - 13.4 X2

Predictor	Coef	SE Coef	T	P
Constant	555.998	0.137	4059.70	0.000
X2	-13.43	10.55	-1.27	0.207

S = 0.9088 R-Sq = 1.9% R-Sq (adj) = 0.7%
Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	1.3367	1.3367	1.62	0.207
Residual Error	82	67.7198	0.8259		
Total	83	69.0566			

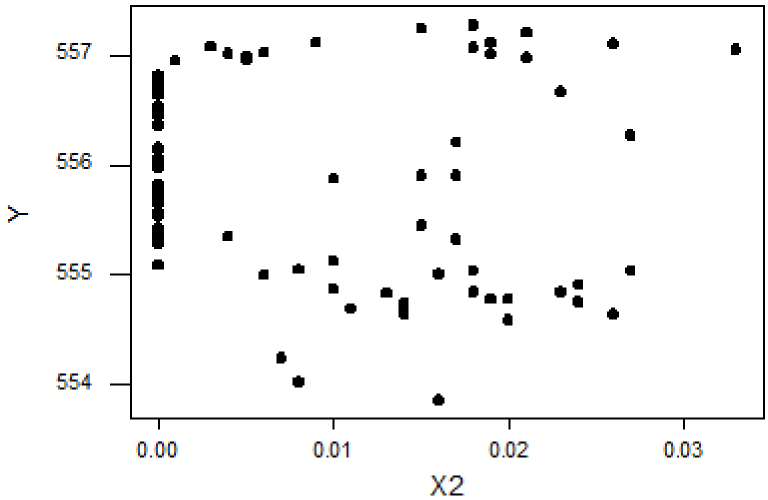

Figure 7: A line fit plot of mean monthly draw down/ rise with mean monthly rainfall

Regression Analysis: Y versus X3

The regression equation is
Y = 557 - 99.8 X3

Predictor	Coef	SE Coef	T	P
Constant	556.626	0.227	2449.79	0.000
X3	-99.82	27.64	-3.61	0.001

S = 0.8524 R-Sq = 13.7% R-Sq(adj) = 12.7%

Analysis of Variance

Source	DF	SS	MS	F	P

Regression	1	9.4766	9.4766	13.04	0.001
Residual Error	82	59.5799	0.7266		
Total	83	69.0566			

V. CONCLUSION

The Research work observed the source of water supply for Bauchi Township which was source from Gubi dam and mainly coming from three tributaries, namely Gubi River, Tagwaye river link with Shadawanka and Ran River. The embankments of the dam which has length of 3.86km and bottom earth-fill of 2,315, 000m^3 with a reservoir area of 590 hectares the catchments area is 179km^2 with total storage capacity of 38.4 x 106m^3, the expected yield from the reservoir is 90,000m^2/d. The water level in the reservoir varies seasonally due to climatic changes; the research observed the effect of rainfall on reservoir variation but the effect of rainfall is not much significant according to the result obtained.

REFERENCES

[1] Adeloye, A.J, Lallemand, F and Mcmahon,T.A (2003). Regression model for within year capacity adjustment in Reservoirs planning Hydrological science journal Vol 48 N0 4 Aug

[2] Ahmad, SH (2003), **Research on physioco chemical variations in stream water and well around Basawa environs**. Unpublished M.Sc thesis ABU Zaria.

[3] Augustine N.E (1997). Short course on Reservoir, Planning, operation, Monitoring and Management organized by Department of Hydrology (NWRI) Mando Kaduna pp 2-4.

[4] BSWB (1981). Bauchi State Water Board progress report for the period of Oct 1979 to Dec 1981.

[5] Collins, G (1983) **Villages water supply in the decade, lesson from field experience. John Willy & son** pub New York pp1 -11

[6] Donald, L.H (1982) Statistical methods 3rd edition. Adddison Wesley publishing Company, London. Pp 544.

[7] Elizabeth M.S (1994). **Hydrology in Practice 3rd edition**, Chapman and Hall Pub. London, 2-7

[8] Fair, G.M, Geyer J.C and Okun D.A (1971) **Element of water supply and wastewater disposal John Willy & son** pub. New york pp 50

[9] Faniran A (1983). A new approach to water supply in developing counties examples from Nigerian situation. National resources forum (IWRA).

[10] Frederick S.M (1976). **Standard Hand Book for Civil Engineers 2nd edition, M.C Graw Hill Book comp**. Pub. New York. pp 21-52.

[11] Gang yan, Z, Goel, N.K and Bhatt, V.K (2002). Stochastic modelling of the sediment lord of the upper Yangtze river (china). Hydrological sciences journal Vol 47, No 5 Aug.

[12] Griner A.J (1993). Development of a water supply protection model in Gis. Water Resources Bulletin Vol29, No 6 Dec

[13] Guang –Te, W and Yunsheng, T (1990). Modelling rainfall runoff process including losses water Resources Bulletin (AWRA) Vol 26,No 1

[14] Hamil L.and Bell F.G (1986). **Groundwater Resources Development**. Butter worth's. London pp 307-310.

[15] Hendricks, D.W, Janosis, B.A, Gericks,J.C and Patterson ,J.L (1982). Modelling of water supply /demand in the South Platte River basin. Water supply resources Bulletin (AWRA). Vol 18, No 2 April.

[16] Hofkes (1981) **Small Community Water Supply, John Willy & son pub New York** pp 1-14

[17] Jasen, M. A (2002). Water consumption evaluation in Kuwait. Journal of water supply research and technology. Vol 51,No 8 Dec.

[18] Linsley, R.K, Franzini, J.B, David, L.F, George T, (1995). **Water resources Engineering 4th edition M.C Graw Hill Book Comp**. Pp 497 to 506.

[19] Micheal, R, Clark, S. (1977). **The effects of recreation on water quality and treatabilit: Drinking water quality enhancement through source protection Ann Arbor science pub inv**. Michigam pp73.

[20] Mustafa S. and Yusuf M.I (1997). **A text book of hydrological and water resources 1st edition Janes print and pub**. Abuja pp 270 to 287.

REFERENCES

[1] Novotny, V. and Harvey O (1994). **Water quality prevention, identification and Management of Diffuse pollution. Van Nostratrant Rein hold pub**. New York pp 723.

[2] Okutu W.N (1988). Application of Thomas Fiering model for stream flow generation in Southern Ghana natural water Bulletin Vol.3 No 1 Jan.

[3] Reynold, J.S (1995). Modelling sub-surface Drainage and surface runoff with wepp journal of irrigation and drainage Engineering. Vol.121 No 2 March /April

[4] Richard, F, Micheal, G and Dunan, M (1977). W**ater waste and health in hot climatic. John willy & son New york pub** pp 70
[5] Steel, E.N and Terence J.M (1972**). Water supply and Sewarage 5th Ed, MC Graw Hill Book Comp.** Pub. London pp 11-18.
[6] Takyi, A.K and Lence, B.J (1995). Markov chain model for seasonal water quality management journal of water resources planning and management Vol.121, No2 March/April.
[7] Tarshish, M (1993). Combined Mathematical model of flow in aquifer vertical well system journal of ground water Vol .31 No 4 Jul/Aug.
[8] Tebbut, T. (1992). **Principle of water quality Control**. **Pernmon press pub**. London pp 48-54.
[9] Thian, Y.G Amad, Z (1992) Modeling Manson affected rainfall of Pakistan. Journal of water resources planning and management, Vol 118 No6 Nov/Dec
[10] Waltor, L (1987). **Handbook of water purification 2nd edition**. Eilis Harwood limited England .pp 30-32.
[11] Wencheng, H. Ricardo, H. and Janos J.B. (1991). Testing stochastic dynamic programming model condition on observed or forecasted in flows journal of water resources planning and management .Vol 117,no 1 Feb.
[12] WHO (World Health Organization) (1993). **Guide Lines for Drinking water quality** WHO Geneva.
[13] Wilson E.M. (1990). **Engineering Hydrology 4th edition, Macmillan education Lt.. pub London** pp 4-18.
[14] Yevjevich V.(1992).**stochastic process in Hydrology** pp 136-141

APENDIX 1
MONTHLY DRAW DOWN AND RISE
IN RESERVOR LEVEL (GUBI DAM)

Year /Month	Reservoir water level (Gubi) masl	Monthly Draw down (m)	Monthly Rise up (m)	Mean Monthly Draw Down (m)	Mean Monthly rise (m)
1997					
Jan					
Feb	555.648				
Mar	555.642				
Apr	555.359				
May	554.860				
Jun	554.702				
Jul	554.681				
Aug	554.826				
Sep	556.660		0.413	0.021	0.021
Oct	557.051	0.992		0.052	
Nov	557.015	0.201		0.007	
Dec	556.798	0.413		0.021	
	556.530				
1998					
Jan		0.247		0.021	
Feb	556.132	0.033		0.033	
Mar	555.814	0.062		0.009	
Apr	555.700	0.998		0.083	
May	555.344		0.098		0.014
Jun	554.530	0.048		0.007	
Jul	554.836		1.036		0.148
Aug	554.841		2.800		0.257
Sep	556.231	0.040		0.006	
Oct	557.259	0.370		0.046	
Nov	557.070	0.037		0.037	
Dec	556.738	0.322		0.022	
	556.445				

APPENDIX 1 (CONT)
MONTHLY DRANN DOWN AND RISE
IN RESERVOIR LEVEL (GUBI DAM)

Year/Month	Reservoir water level (Gubi) masl	Monthly Draw Down (m)	Monthly Rive up (m)	Mean month Draw Down (m)	Mean Monthly Rise up (m)
1999					
				0.035	
Jan	556.043	0.588		0.021	
Feb	555.681	0.396		0.015	
Mar	555.285	0.212		0.018	
Apr	554.014	0.274		0.012	
May	554.776	0.211		0.012	
Jun	554.587	0.243			
Jul	555.439		2.597		0.130
Aug	557.194	0.319		0.032	
Sept	557.096	0.030		0.002	
Oct	557.110	0.420		0.030	
Nov	556.814	0.286		0.014	
Dec	556.500	0.336		0.015	
2000					
Jan	556.146	0.280		0.018	
Feb	555.766	0.432		0.022	
Mar	555.414	0.496		0.025	
Apr	555.124	0.226		0.013	
May	554.780	0.333		0.017	
Jun	554.747		0.175		0.012
Jul	555.004		1.348		0.135
Aug	557.011		0.860		0.043
Sept	557.064		0.080		0.004
Oct	556.977	0.239		0.011	
Nov	556.745	0.247		0.012	
Dec	556.526	0.172		0.016	

APPENDIX 1(CONT)

Year/Month	Reservoir water level (Gubi) masl	Monthly Draw Down	Monthly Rise up (m)	Mean Monthly Draw Down (m)	Mean Monthly Rise up
2001					
Jan	555.968	0.218			
Feb	555.728	0.283		0.010	
Mar	555.383	0.372		0.018	
Apr	554.992	0.347		0.019	
May	554893			0.019	
Jun	555.038		0.004		0.002
Jul	556.204		0.870		0.046
Aug	557.277		1.286		0.061
Sept	557.243	0.250	0.145		0.006
Oct	556.938	0.210			
Nov	556.635	0.355		0.022	
Dec	556.348	0.223		0.010	
				0.017	
2002				0.014	
Jan	556003				
Feb	555.527	0.442			
Mar	555.089	0.459			
Apr	554.639	0.385		0.021	
May	554.231	0.476		0.024	
Jun	553.852	0.322		0.021	
Jul	554.742	0.319		0.024	
Aug	555.319			0.017	
Sept	556.968		0.762	0.020	0.035
Oct	556.962	0.206	1.591		0.072
Nov	556.690	0.234	0.572		0.027
Dec	556.363	0.382			
				0.009	
2003				0.012	
Jan	556.136	0.335		0.021	
Feb	555.554	0.370		0.019	
Mar	555.281	0.144		0.018	
Apr	555.048	0.121			
May	554.900		0.605		
Jun	555.026	0.162			
Jul	555.867	0.242			
Aug	555.891	0.365			
Sept	557.114		0.788	0.007	0.039
Oct	557.012		0.274	0.008	0.016
Nov	556.737		0.036	0.014	0.002
Dec	556.452		0.040	0.018	0.002

APPENDIX 2

DEPARTMENT OF METEO ROLOGICAL SERVIE

BAUCHI AIRPORT

MEAN MONTHLY RAINFALL (METRES)							
MONTH	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
JAN	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FEB	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MAR	0.000	0.000	0.000	0.000	0.000	0.000	0.000
APR	0.010	0.004	0.008	0.010	0.006	0.026	0.008
MAY	0.014	0.014	0.019	0.020	0.017	0.007	0.024
JUN	0.011	0.018	0.020	0.024	0.018	0.016	0.027
JUL	0.013	0.023	0.015	0.016	0.017	0.014	0.010
AUG	0.023	0.027	0.021	0.019	0.018	0.017	0.015
SEP	0.033	0.018	0.026	0.018	0.015	0.021	0.019
OCT	0.006	0.003	0.009	0.005	0.001	0.005	0.004
NOV	0.000	0.000	0.000	0.000	0.000	0.000	0.000
DEC	0.000	0.000	0.000	0.000	0.000	0.000	0.000