FLOOD MANAGEMENT OF LAKE NASSER AFTER THE NEW TOSHKA BARRAGES CONSTRUCTION

Nahla Sadek* and Medhat Aziz**

* Researcher, Nile Research Institute, NWRC, Egypt
** Deputy Director. Prof., Nile Research Institute, NWRC, Egypt

ABSTRACT

Flood management of Lake Nasser is subjected to different complicated conditions such as inflow flood variations, operation conditions, and the expected future scenarios. The proposed Toshka Spillway Barrages (Egypt) will be constructed at km 8.00 from the entrance to enable more control on flood water level to be able to discharge more water during high floods to ensure safety and to save more water in low floods. The current operation rules for Lake Nasser state that the water level is kept at 175.00 m at the beginning of the water year (August 1st).The purpose of this paper is to analyze Lake Nasser flood to study and to evaluate the effect of Toshka Spillway Barrages in case of raising the initial water levels upstream AHD at the beginning of the water year for both cases; low and high inflows to increase water management efficiency. This analysis supports the decision-makers to react according to different conditions. A hydrologic water routing model are developed to perform this study where the available models would not simulate this case efficiently due to the nature and the characteristics of the study case. For flood analysis, the historical flood data were considered to evaluate different probabilities of possible Nile floods. The results of this analysis and the proposed operation rules were presented during this study in addition to related conclusions and recommendations.

Key Words: Lake Nasser, Toshka Spillway Barrage, South Valley Project, Flood Routing

INTRODUCTION

From time immemorial, Egyptian civilization has depended on the live–giving waters of the River Nile. The River Nile is the second longest river in the world (about 6500 kilometers). The Nile basin consists of about three million square kilometers in different countries and a variety of different characteristics. The main water supply sources are the equatorial lakes, Bahr El Gazal water shed and the Ethiopian Plateau. The Nile River has under gone a wide variety of the floods over history. This variety of flood characteristic has necessitated the construction of the Aswan High Dam (AHD) in the 1964's to be able to have more control on the river flood. The construction of the dam has required the determination of the dam operation rules. The major task of these rules is to provide sufficient water supplies and to avoid river damages in addition to maintaining the dam structural safety. AHD has formed the second largest artificial lake in the world, where the storage capacity of the lake has a volume of 162 bcm and a surface area of about 6000 km^2 for the maximum water level 182 m upstream the dam. The uncontrolled Toshka Spillway was constructed in 1982 at 256 km upstream of AHD to control the high water levels. In order to reach better water management a decision was made to construct permanent barrage at km 8.00 DS of the channel entrance. The purpose of this barrage is to allow passing more flow discharges to Toshka Depressions during inflow in such away as to avoid increasing daily flow discharge DS AHD. While it can help to avoid spillage to Toshka Depression, at the beginning of the low inflow season. The purpose of this paper is to analyze different inflow, in addition to study, to evaluate, and to outline the proposed operations of the barrages for different scenarios.

FLOOD ANALYSIS

Reliable decisions for the operation of Lake Nasser are conditioned according to the water availability from the reservoir of AHD in the beginning of the flood season by the end of July. Therefore, statistical analysis should be performed for different flood cases to obtain the critical cases of successive floods and their probability of occurrence. The longest record on the Nile is at Aswan, where flows are available from 1869 as shown Figure 1. The inflow is ranging from a maximum value of 150 bcm/y (1878 – 1879) to a minimum value of 42 bcm/y (1913-1914). These data have a mean of 89.633 bcm/y and a median 86.03 bcm/y. While, AHD has been designed according to hydrological data collected during the period of (1900 – 1955), the average natural annual flow is 84 x 10^9 m^3 annually. By treaty with Sudan, Egypt is entitled to withdraw 55.5 bcm/y from the Lake and Sudan is entitled to divert 18.5 bcm/y, leaving 10 bcm/y for reservoir evaporation and seepage losses. The available data consist of 104 years from monthly discharges from 1900 - until now to evaluate and to analyze the flood. These data have a minimum of 42.07, mean of 84.482, a median of 83.68 and a maximum of 127.10 (1998-1999) with the standard deviation of 13.37 bcm/y. These historical data were subjected to statistical tests of fit for certain distribution, the normal distribution is considered a very good fit which gives 0.98 significance level for Kolmogorov-Simirov goodness of fit. Figure 2 shows the normal distribution fitting for 104 years historical records of water inflow.

FLOOD CLASSIFICATION

Historical naturalized inflow records can be divided into the following categories:

1-Very low flood with an average flow of 52 bcm/y.
2- Low flood with an average flow of 70 bcm/y.
3-Average flood with an average flow of 92 bcm/y.
4-High flood with an average flow of 110 bcm/y.
5-Very high flood with an average flow exceeding 110 bcm/y.

DIFFERENT INFLOWS RELATIONSHIPS

In this study, the historical monthly and annual natural inflow data for the past 104 years (1900 -2004) were used to estimate different relationships in order to give some indications for flood behavior. Also, these derived equations were affected by the operation rules for AHD, Toshka Spillway and South Valley Project operation in the future. Figure 3 shows the relationship between August inflow and the total inflow. Equation (1) was derived for the selected data with a correlation factor $R^{2\,=}$ 65.8%, a standard error 8.6 and standard deviation 12.79 bcm.

Proposed Equation $Q_{total} = 0.0097\, Q_{August.}^{0.5918}$ **(bcm/y)**

Figure 4 represents the relationship between August and September inflow and the total inflow. Equation (2) was derived from the available data to obtain a correlation factor $R^2 = 77\%$, a standard error 6.67 and standard deviation 12.34 bcm.

Proposed Equation $Q_{total} = 4.5361\, Q^{0.8086}{}_{Aug.+Sep.}$ **(bcm/y)**

Figure 5 describes the relationship between August, September and October inflows and the annual inflow. Equation (3) was estimated from these data to obtain a correlation factor $R^2 = 79\%$, a standard error 6.67 and standard deviation 12.34 bcm.

From these results, it can be concluded that the annual inflow can be predicted from the summation of monthly inflow during the period August to September. $R^2 = 81\%$, a standard error 5.97 and standard deviation 12.63 bcm.

Proposed Equation $Q_{total} = 0.0097\, Q_{Aug.+Sep+Oct.\ +0.0242.}Q_{Aug.+Sep+Oct.}+45.896$ **(bcm/y)**

From these results, it can be concluded that the annual inflow can be approximately evaluated from the summation of monthly inflow during the period August to September.

LAKE NASSER OPERATION RULES

Lake Nasser is the huge lake that was formed due to the construction of AHD for the purpose of flood control and water storage. It represents the long term storage reservoir for the water of the Nile flowing to Egypt. Therefore, special and national consideration should be given to the lake operation and development. The lake operation rules were determined by the Ministry of Water Resources and irrigation according to different restrictions such as 1) maximum allowed water outflow should not exceed 250-300 mm^3/d to avoid excessive erosion and banks overtopping. 2) the water levels upstream High Aswan Dam should be kept at 175.00 m at the beginning of water year (August 1st) to fulfill high and low flood requirements. 3) The minimum allowed water discharges should be released to fulfill irrigation, navigation, drinking and other requirements and Sudan abstractions.

Different factors should be considered and analyzed to modify the current operation conditions especially after the construction of Toshka Barrage and the operation of South Valley Canal. Raising upstream water level at the beginning of the water year may have some positive effects due to the additional water storage availability for next low floods years. However, raising water level may cause some side effects such as increasing water losses, higher risks for future high floods (dam safety risk and higher water discharges damaging).

In this study, the suggested suitable operations rules of the proposed barrages for different scenarios were evaluated and analyzed.

TOSHKA SPILLWAY BARRAGES

Toshka Spillway Barrage is located 8.00 from the Toshka Spillway canal entrance which is located at 256 km upstream of AHD. The spillway crest was set at 178 m to lead water through 22 km long open channel to about 120 km^3 storage capacity. The using of an earth dam to prevent water from flowing into the canal is only applicable for the beginning of water years and the flow can not be controlled after dam removal. The main goal of the barrage is to control the Spillway flow during both; low and high flow years. Noteworthy, some widening and deepening of the Spillway canal are carried out to increase the maximum of the Spillway canal. The entrance bed level will be 176.00 instead of 178.00; the canal bed width will be 500.00 m from the barrage location to the canal end. Side slopes will be 2:1 while the bed slope is 15 cm/km. Also, the old weir will be removed because the canal bed elevation will be lower than the weir footing.

THE DEVELOPED MODEL

Different components have to be taken into consideration to perform flood simulation analysis. One of the most important components is the operation condition, which is governed by technical and political aspects. Other components include different sources of discharge inflow and their conditions, water requirements, water losses, flow and water levels restrictions are shown in Figure 6. Due to the previously mentioned components, a developed model is used to propose and simulate different analyses. In this study, the numerical model (one dimensional model by Nahla Sadek [1] is used after modify it. The modifications include three modules; these modules are described in the following section:

1- Inflow Hydrograph Module

The used inflow discharge hydrograph is based on historical inflow during the period (1900- 2004). For a required annual inflow discharge, the inflow hydrograph is constructed using the distribution of the historical data monthly of similar and close values to form an inflow hydrograph of the realistic distribution as showing as Figure 7.

2- Outflow Discharges Downstream AHD

The outflow discharges downstream AHD were proposed in this study according to different parameters such as predicted yearly inflows which were mentioned above and different water requirements through the water year by using historical data during the period (1968 – 2004). The proposed outflows are estimated for both cases present condition and future condition such as the operational of South Valley Project as showing Figure 8. The developed model has the capability of using different outflow discharges downstream the dam and simulates different conditions to reach the optimum outflow hydrograph regarding to inflow case (low- medium- high) and outflow allowable to avoid certain damaging .

3- Toshka Spillway Outflow Module

This module is one of the most important modules of the proposed study simulation since it computes the barrage discharges. It has the capability of passing zero discharge from the barrage (gates are closed) during low flow. On the other hand, during average and high flow, it has the capability of the passing the entire (or part of it) maximum capacity of the Spillway canal according to different governing factors such as lake water level, flood inflow, outflow discharge down stream the dam and different flood management factors. The criteria of determining the amount of passed discharge is based on flood forecasting and upstream flood readings. Some of these flood forecasting techniques and flood probability computations are presents by Aziz, Ibrahim, and Sadek [2]. Also, from different relationships which mentioned above, a rough estimation about the amount of the annual inflow could be made during August through October to determine the amount of barrage discharge during this period and this estimation was tested and verified dynamically throughout the next months. The full capacity of the spillway canal was computed using Manning Equation with a roughness coefficient of 0.03 (due to the possibility of weed existence). In addition to the entrance bed level will be 176.00 instead of 178.00, the canal bed width will be 500.00 m from the barrage location to the canal end. Side slopes will be 2:1 while the bed slope is 15cm/km. Figure 9 shows the full spillway canal capacity and water level upstream AHD.

4- Model Initial and Boundary Conditions

In this study some development for model initial and boundary condition were suggested. For the model initial conditions, the capability of changing the water levels and discharges at the beginning of the water year. The purpose of this flexibility is to adopt for any future condition regard in proposed operation rules. While for the boundary conditions, these conditions include the water levels and discharges during different time steps, the dam operation rules, different proposed barrage operating conditions such as using gates, and water levels upstream the dam at the end of water year.

PROPOSED OPERATION RULES

The major purpose for the simulation process is to study the effect of the new barrage on water levels and discharges for different proposed scenarios. Consequently, the optimum usage for this barrages to avoid any unacquainted for any point of water should be proposed. Different factors should be considered and analyzed to change the current operation conditions. The current operation rules for Lake Nasser state that the water level is kept at 175.00 m at the beginning of the water year (August 1^{st}). Raising upstream water level at the beginning of the water year may have some positive effects due to the addition water storage availability for next low floods years. However, raising water level may cause some side effects such as increasing water losses, higher risks for future high floods (dam safety risk and higher water discharges damaging).

In this study, raising water level at the beginning of the water year will be analyzed and evaluated after the construction Toshka Barrage. The proposed raising water level upstream AHD are (175 the current state, 175.5, 176, 176.5). During this analysis the Sudanese abstraction, about 18.5 bcm/y, was considered and South Valley Canal, which is estimated by approximately 5.2 bcm/y Makary, Abdelbary, and Aziz, [3] was used. The following scenarios were based on releasing Spillway discharges (if required) only above the level of 179.00 for the lake. The detailed results are summarized as follows:

MODEL RESULTS

Different simulation categories according to flood classification which mentioned previously could be analyzed: 1) low inflow case for water discharge inflow for example 75 bcm/y, 2) average inflow case for water discharge inflow for example 90 bcm/y, 3) high inflow case for water discharge inflow 100 and 110 bcm/y and 4) very high inflow case for water discharge inflow 120 and 130 bcm/y. The selection of the incoming flow and the required scenario was determined according to flood prediction and actual upstream flood measurements and computations. The following scenarios were based on releasing Spillway discharges (if required) only above the level of 179.00 for the lake. In addition to the number of gates should be open according to different scenarios for high inflows are shown in Tables (1 to 4). The opened gates were evaluated by trail and error in order to reach the best condition. This condition represent in the maximum outflows downstream AHD don't exceed 270 mm^3/day to avoid any damage along the river. Also, the simulated outflow distribution should satisfy both the maximum and minimum requirements over the water year. In addition to prevent needed water from going to the spillway. Worth noting, the total losses were considered in evaluating different scenarios.

Maximum Water Level Upstream AHD

Tables from (1 to 7) illustrate the simulation model results for inflows with ranges between (70 to 130 bcm/y) for the considered cases of the raised water levels at the beginning of the water year (August, 1^{st}). From these tables, it can be concluded that the maximum water level upstream the dam, are affected by raising water level upstream AHD at the beginning of the water year. However, the maximum simulated water levels upstream AHD of all inflows within the water year did not exceed 182 m except for the inflow 130 bcm/y in case 4 which are slightly higher than the allowed limits for dam safety.

Also, from these Tables, The simulated outflows discharged to Toshka Spillway are influenced by increasing the annual inflow and raising water level upstream AHD (July 31, August). For example, for inflow 130 bcm/y, the outflows to Toshka are 34.55, 38.98, 45.88 and 47.89 bcm/year in cases (1 to 4), respectively.

Total simulated outflows down stream the Dam for inflows (100, 110, 120, and 130 bcm/y) are described in Tables (1 to 4) and these outflows affected by different parameters such as raising water level upstream AHD, the end water level upstream AHD (31 July) and the outflow to Toshka.

Table 8 shows the date of certain high water levels for both 179.00 and 181.50 since the first one is related to discharging to Toshka Spillway and the second one is related to the critical water level approaches 182.00. This table illustrates the status of lake high water level to give some indications for the lake operation. These results affected by raising of water level and gate opening ratios. From this table, it can be concluded that the critical high water levels were reached after some period which give more room to perform forecasting using the proposed equations to figure out the amount of the inflow for this water year.

Figures from (10 to 15) describes the maximum discharge down stream the dam over the water year, the effect of the raising water level was noticeable for the magnitude and the distribution of the simulated outflow discharge. For example, the inflow 110 bcm/y, the outflows increase during the period from October to December although this period is considered the duration of minimum water requirements. On the other hand, the maximum outflow discharge down stream the dam decrease within June and July (maximum requirements) influence by raising of water level. For example, for inflow 120 bcm/y, the maximum simulated outflows in July are about 259, 244, 232 and 232 mm^3/day for case1, case2, case3 and case4 respectively. From the previous results, the unique water level upstream the dam in the beginning of the water year represent in case 1 and case 2 after Toshka barrage in such away as mange the flood water, avoid the maximum water level upstream the Dam, keep away water from discharging to Toshka Depression. Finally, the optimum distribution and magnitude for outflow downstream the dam will be achieved with these cases.

Table 1: Simulation Model Results for Annual Inflow 70 bcm/year

Cases	opened gates	Q_{out} Toshka (bcm/y	Q_{out} Total D.S Dam (bcm/y)	Max.Wl. U.S Dam (m.)	Wl end U.S Dam (m.)	Losses	
						Seepage (bcm/y)	Evaporation (bcm/y)
Case1	-	0.00	50.26	177.75	172.49	0.917	8.72
Case2	-	0.00	50.26	178.19	173.00	0.923	8.89
Case3	-	0.00	50.26	178.63	173.53	0.930	9.04
Case4	20%	0.29	50.26	179.06	173.99	0.936	9.24

Table 2: Simulation Model Results for Annual Inflow 80 bcm/year

Cases	opened gates	Q_{out} Toshka (bcm/y	Q_{out} Total D.S Dam (bcm/y)	Max.Wl. U.S Dam (m.)	Wl end U.S Dam (m.)	Losses	
						Seepage (bcm/y)	Evaporation (bcm/y)
Case1	20%	0.81	50.37	177.70	174.14	0.932	9.14
Case2	20%	1.50	50.37	178.71	174.49	0.937	9.31
Case3	20%	2.16	50.37	179.08	174.84	0.943	9.50
Case4	20%	2.83	50.37	179.84	175.15	0.948	9.94

Table 3: Simulation Model Results for Annual Inflow 90 bcm/year

Cases	opened gates	Q_{out} Toshka bcm/y	Q_{out} Total D.S Dam (bcm/y)	Max.Wl. U.S Dam (m.)	Wl end U.S Dam (m.)	Losses	
						Seepage (bcm/y)	Evaporation (bcm/y)
Case1	20%	4.55	51.44	179.93	175.00	0.945	9.72
Case2	20%	5.82	50.42	180.30	175.35	0.949	10.71
Case3	20%	6.86	50.42	180.62	175.45	0.953	11.79
Case4	20%	8.00	50.42	180.93	175.55	0.956	12.87

Table 4: Simulation Model Results for Annual Inflow 100 bcm/year

Cases	opened gates	Q_{out} Toshka bcm/y	Q_{out} Total D.S Dam bcm/y	Max.Wl. U.S Dam m.	Wl end U.S Dam m.	Losses	
						Seepage bcm/y	Evaporation bcm/y
Case1	20%	7.5	56.3	180.67	175.0	0.951	12.31
Case2	20%	9.2	53.53	181.11	175.5	0.957	13.32
Case3	20%	9.4	56.55	181.19	175.6	0.958	13.34
Case4	20%	10.8	56.44	181.52	175.7	0.970	13.56

Table 5: Simulation Model Results for Annual Inflow 110 bcm/year

Cases	opened gates	Q_{out} Toshka bcm/y	Q_{out} Total D.S Dam bcm/y	Max.Wl. U.S Dam m.	Wl end U.S Dam m.	Losses	
						Seepage bcm/y	Evaporation bcm/y
Case1	30%	13.60	58.54	181.22	175.0	0.955	13.06
Case2	30%	14.22	58.70	181.40	175.4	0.957	13.20
Case3	30%	15.86	58.70	181.70	175.6	0.961	13.50
Case4	30%	17.62	58.70	181.99	175.7	0.964	13.90

Table 6: Simulation Model Results for Annual Inflow 120 bcm/year

Cases	opened gates	Q_{out} Toshka bcm/y	Q_{out} Total D.S Dam bcm/y	Max.Wl. U.S Dam m.	Wl end U.S Dam m.	Losses	
						Seepage bcm/y	Evaporation bcm/y
Case1	40%	22.49	59.87	181.22	175.0	0.955	13.06
Case2	40%	26.73	55.14	181.60	175.5	0.960	13.48
Case3	50%	28.07	56.40	181.77	175.6	0.962	13.56
Case4	50%	30.29	56.40	182.00	175.7	0.964	13.70

Table 7: Simulation Model Results for Annual Inflow 130 bcm/year

Cases	opened gates	Q_{out} Toshka bcm/y	Q_{out} Total D.S Dam bcm/y	Max.Wl. U.S Dam m.	Wl end U.S Dam m.	Losses	
						Seepage bcm/y	Evaporation bcm/y
Case1	80%	34.55	59.72	181.64	175	0.954	10.81
Case2	80%	38.96	54.60	181.98	175.5	0.959	11.66
Case3	80%	45.88	50.42	181.92	175.8	0.959	10.48
Case4	100%	47.89	50.96	182.10	175.8	0.960	10.65

Table 8: Certain high water level dates

Cases	Q100		Q110		Q120		130	
	Wl=179	Wl>181.5	Wl=179	Wl>181.5	Wl=179	Wl>181.5	Wl=179	Wl>181.5
Case1	21/9	-	13/9	30/11	12/9	19/10	8/9	26/10
Case2	14/9	-	8/9	31/10	8/9	26/10	5/9	12/10
Case3	9/9	-	5/9	23/10	4/9	20/10	2/9	8/10
Case4	5/9	24/10	1/9	10/10	31/8	11/10	29/8	28/10

THE SUGGESTED OPERATION OF THE PROPOSED BARRAGES

From the previous paragraph results, the suggested operation rules and restrictions of the proposed barrage are revealed in the water level upstream the dam in the beginning of the water year is 175 m and should not exceed 175.5 m which is represented in case 1 and case 2. These levels were selected for different reasons in such away as to mange the flood water, to avoid the maximum water level upstream AHD (182 m for dam safety consideration), to keep water away from discharging to Toshka depression. Finally, the optimum distribution and magnitude for outflow down stream the dam will be achieved from these cases.

CONCLUSIONS

Statistical analysis for historical inflow was performed to study the critical cases of successive floods and their probability of occurrence. The available data consist of 104 years from 1900 - until now were evaluated and analyzed. These data have a minimum of 42.07, mean of 84.482, a median of 83.68 and a maximum of 127.10 (1998-1999) with the standard deviation of 13.37 bcm/y. Some equations, relating monthly inflow and the total inflow were proposed. These equations were used to give some indications for the proposed lake operation. The effect of Toshka Spillway Barrages in case of raising the initial water levels upstream AHD at the beginning of the water year for both cases; low and high inflows were evaluated and analyzed. Also, different proposed Toshka Barrages operation conditions such as gate opening ratios, and water levels upstream the dam at the end of water year were suggested.

The simulated outflows discharged to Toshka Spillway and the maximum simulated water levels upstream AHD of all inflows were influenced by increasing the annual inflow and raising water level upstream AHD (July 31, August). The water levels upstream the dam in the beginning of the water year was 175 m and should not exceed 175.5 m were recommended. These levels were selected for different reasons in such away as to manage the flood water, to avoid the maximum water level upstream AHD to exceed (182 m for dam safety consideration), to keep unnecessary water from discharging to Toshka Depression. The optimum distribution and magnitude for outflow down stream the dam were performed and illustrated.

REFERENCES

1- Sadek, Nahla. Lake Nasser Flood Analysis. Unpublished Ph.D. Dissertation. Ain Shams University, 2002

2- Aziz, Medhat, Hossam Ibrahim, and Nahla Sadek. "Lake Nasser Flood and Sediment Analysis". Eighth International Symposium on River Sedimentation, (ISRS 8), Cairo, Egypt, 2001.

3- Makary, Adel, Mohamed Abdelbary, and Medhat Aziz. Expected Nile Discharges and Water Levels Hydrographs After the Operation of El-Sheikh Zayed Canal (Toshka Project). International Conference on Integrated management of Water Resources in the 21th Century, 1999.

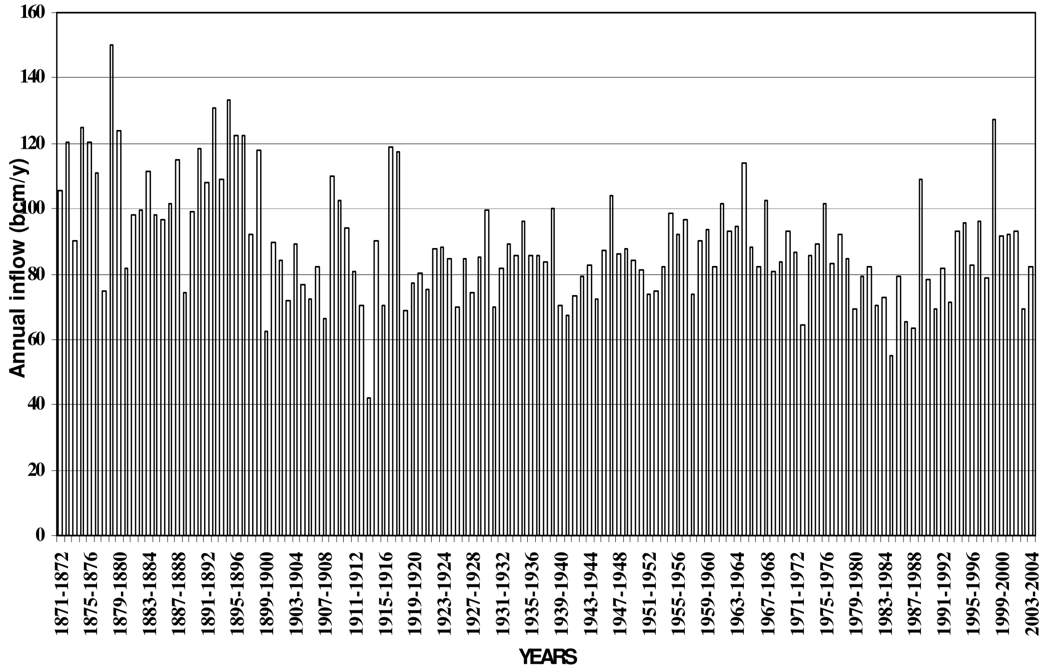


Figure 1: The Annual Inflow of the Historical Data at Aswan

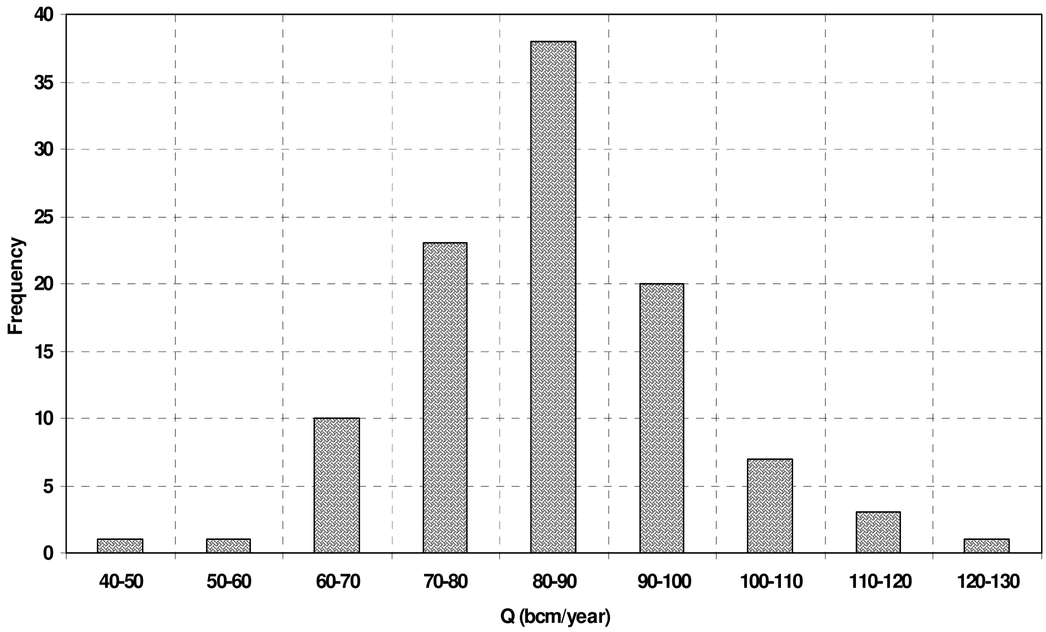


Figure 2: Normal Distribution Fitting for Historical Water Inflow

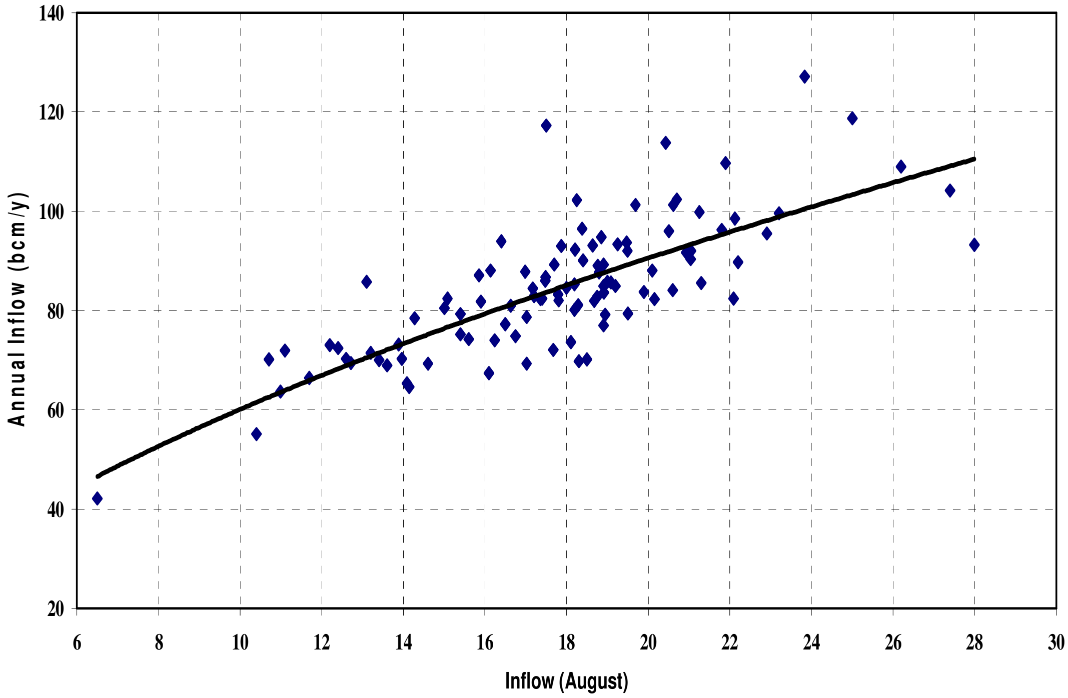


Figure 3: Relationship between $Q_{Aug.}$ and Total Annual Inflow

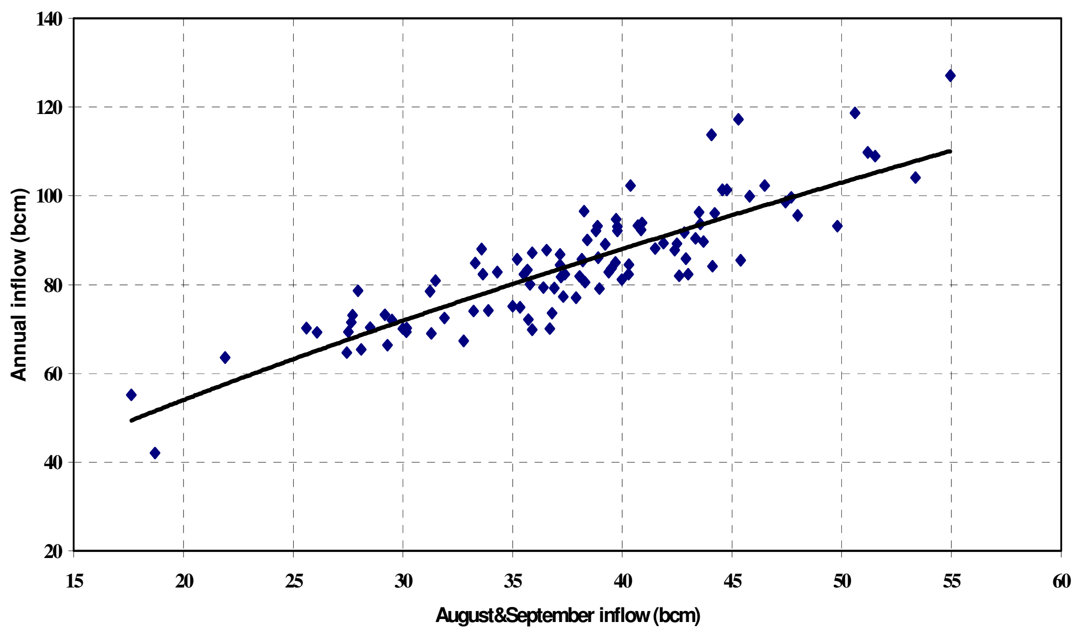


Figure 4: Relationship between $Q_{Aug.+Sep.}$ and Total Annual Inflow

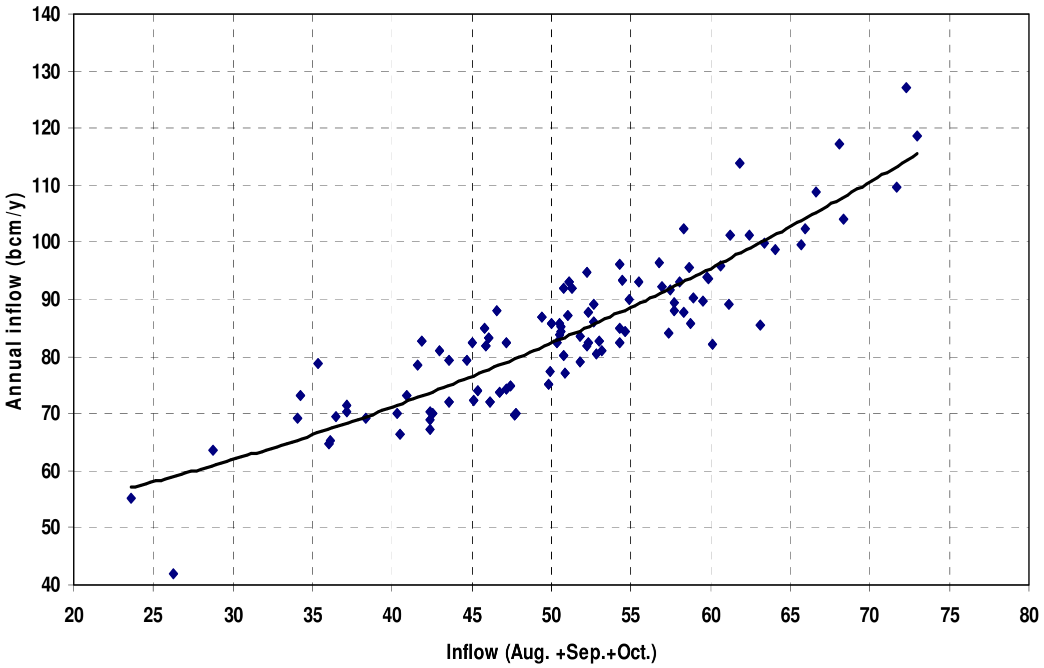


Figure 5: Relationship between $Q_{Aug+Sep+Oct.}$ and Total Annual Inflow

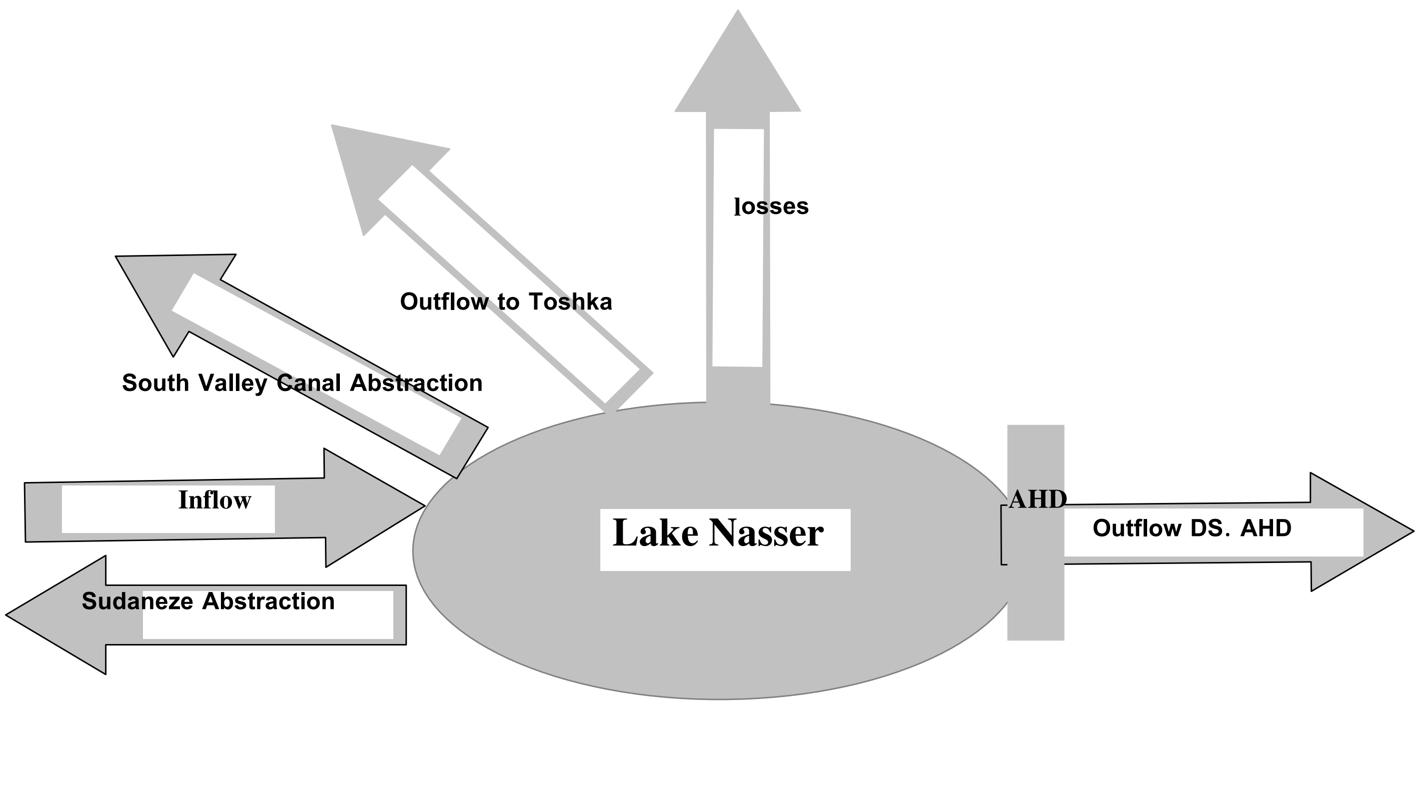


Figure 6: Flood Management of Lake Nasser

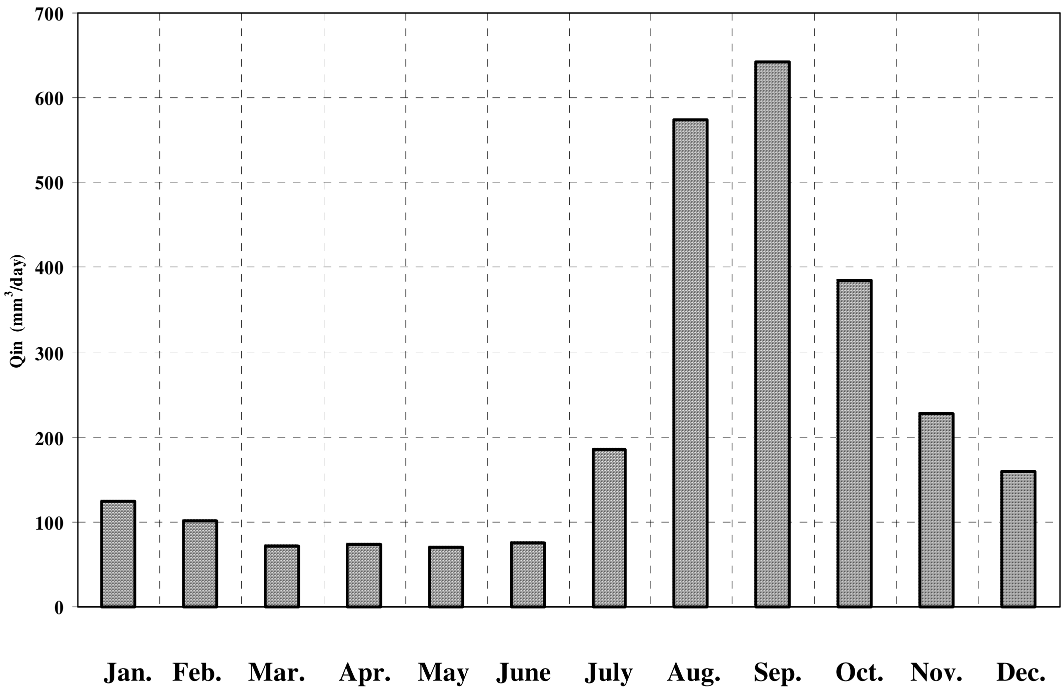


Figure 7: Monthly Inflow Hydrograph for inflow 80 bcm/y

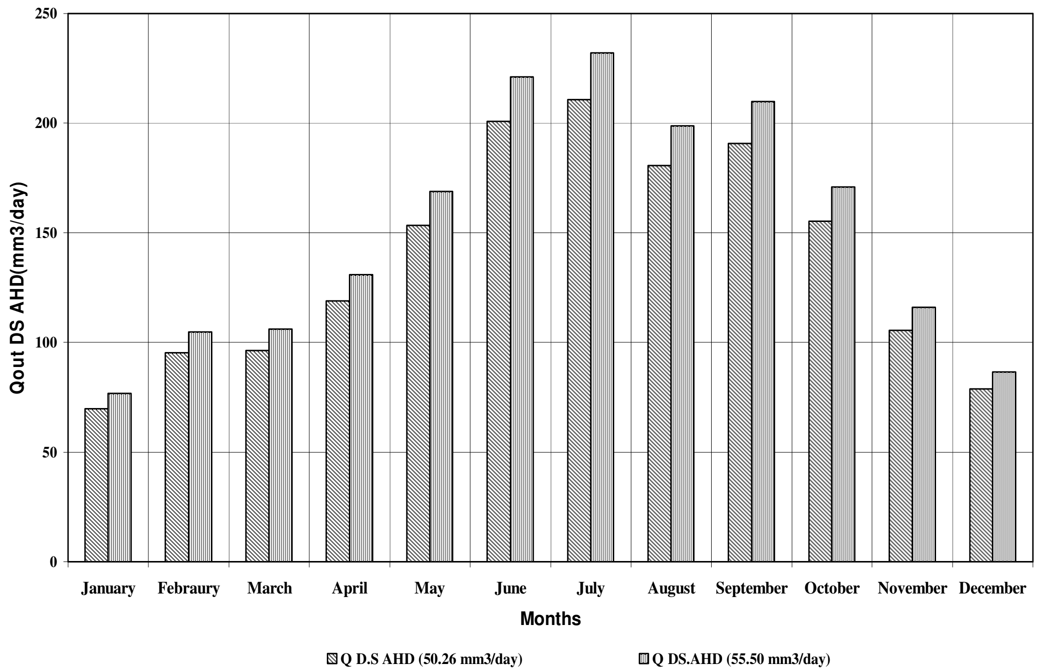


Figure 8: Outflow DS.AHD before and after Operation of South Valley Canal

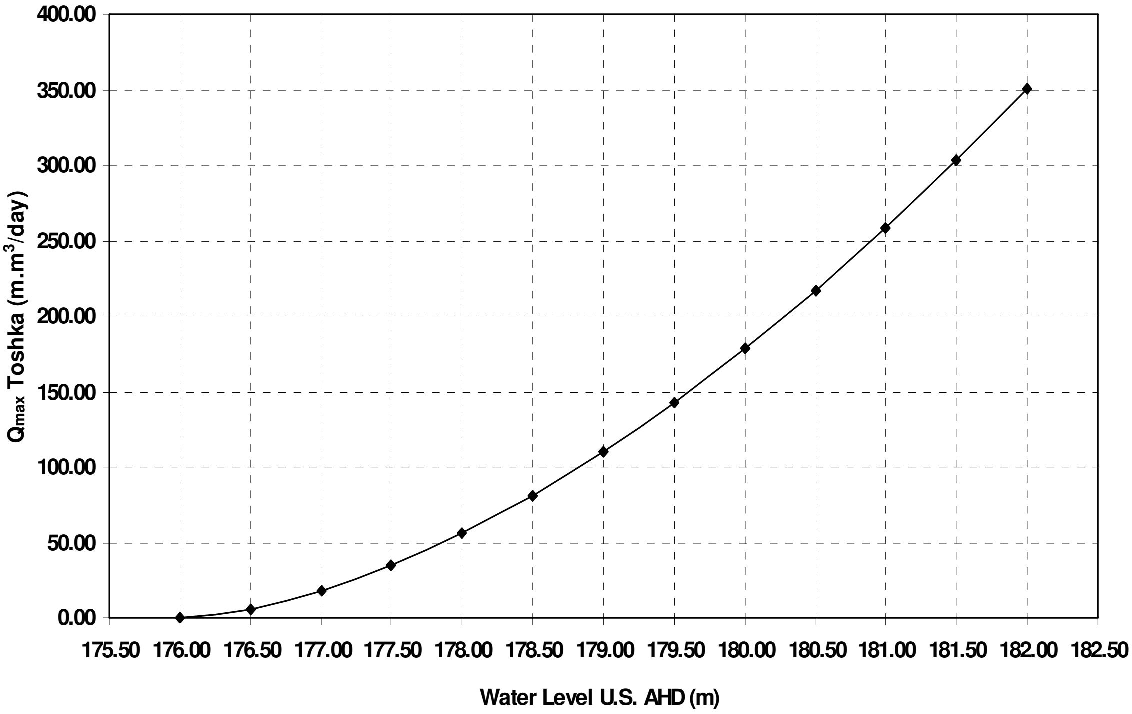
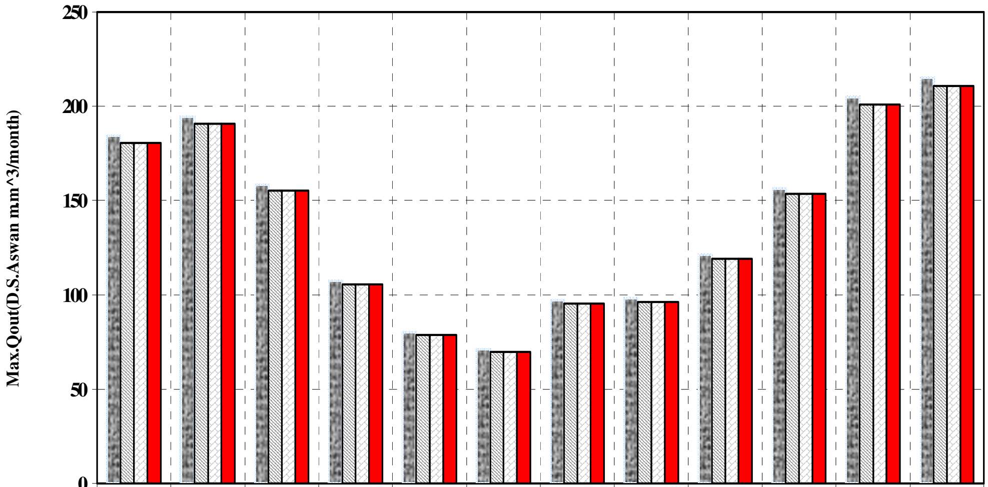
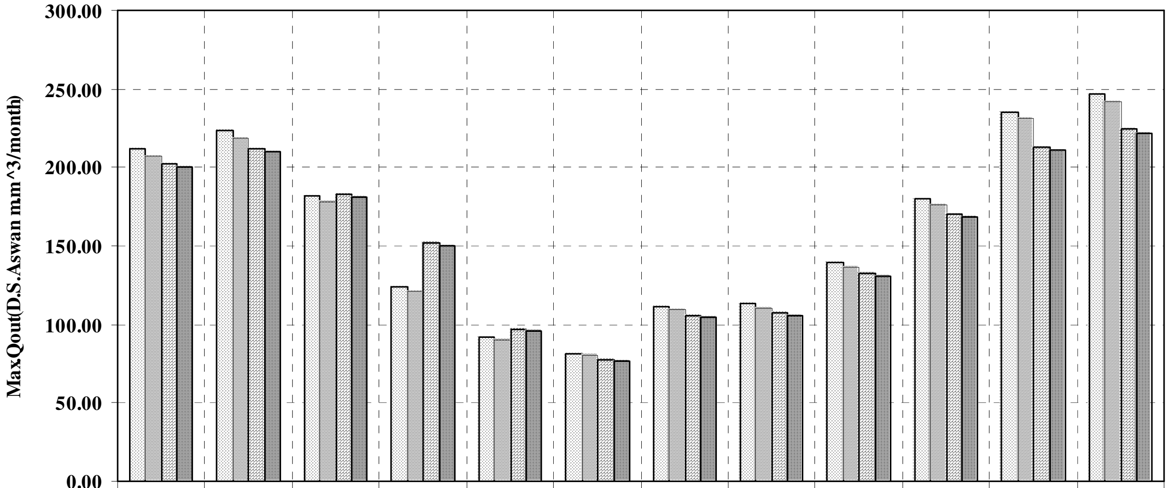


Figure 9: Water Level U.S. AHD and Max. Outflow to Toshka



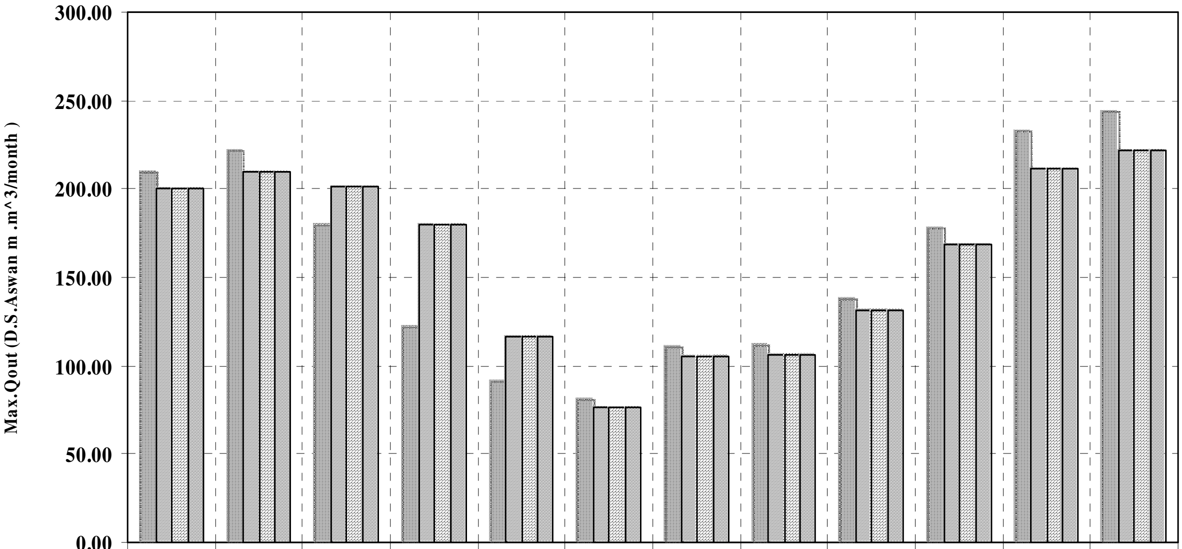
	August	September	October	November	December	January	Febraury	March	April	May	June	July
Qout.(Case1)	184.19	194.48	158.39	107.62	80.25	71.11	97.18	98.18	121.34	156.45	204.86	214.88
Qout.(Case2)	180.56	190.65	155.27	105.5	78.67	69.71	95.27	96.25	118.95	153.37	200.82	210.65
Qout.(Case3)	180.56	190.65	155.27	105.5	78.67	69.71	95.27	96.25	118.95	153.37	200.82	210.65
Qout.(Case4)	180.56	190.65	155.27	105.5	78.67	69.71	95.27	96.25	118.95	153.37	200.82	210.65

Figure 10: Outflow DS. AHD for Different Cases (Inflow 90 Mm^3/day)



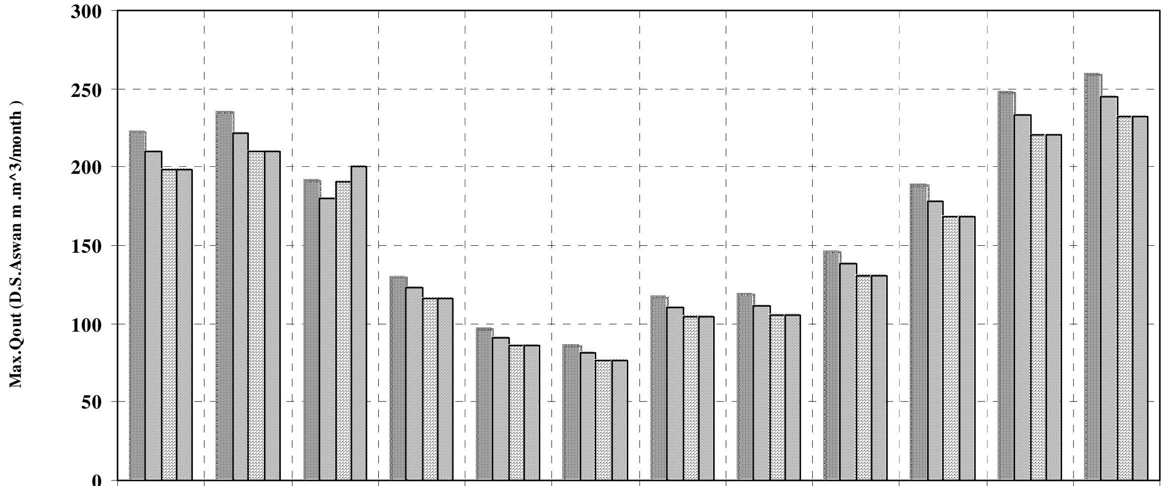
	August	September	October	November	December	January	Febraury	March	April	May	June	July
Qout.(Case1)	211.72	223.55	182.07	123.71	92.25	81.74	111.71	112.86	139.48	179.84	235.48	247.00
Qout.(Case2)	207.55	219.15	178.48	121.27	90.43	80.13	109.51	110.64	136.73	176.29	230.84	242.14
Qout.(Case3)	202.00	212.10	182.65	151.50	97.08	77.49	105.91	107.00	132.23	170.50	213.15	224.07
Qout.(Case4)	200.00	210.00	180.84	150.00	96.12	76.73	104.86	105.94	130.92	168.81	211.04	221.86

Figure 11: Outflow DS. AHD for Different Cases (Inflow 100 Mm^3/day)



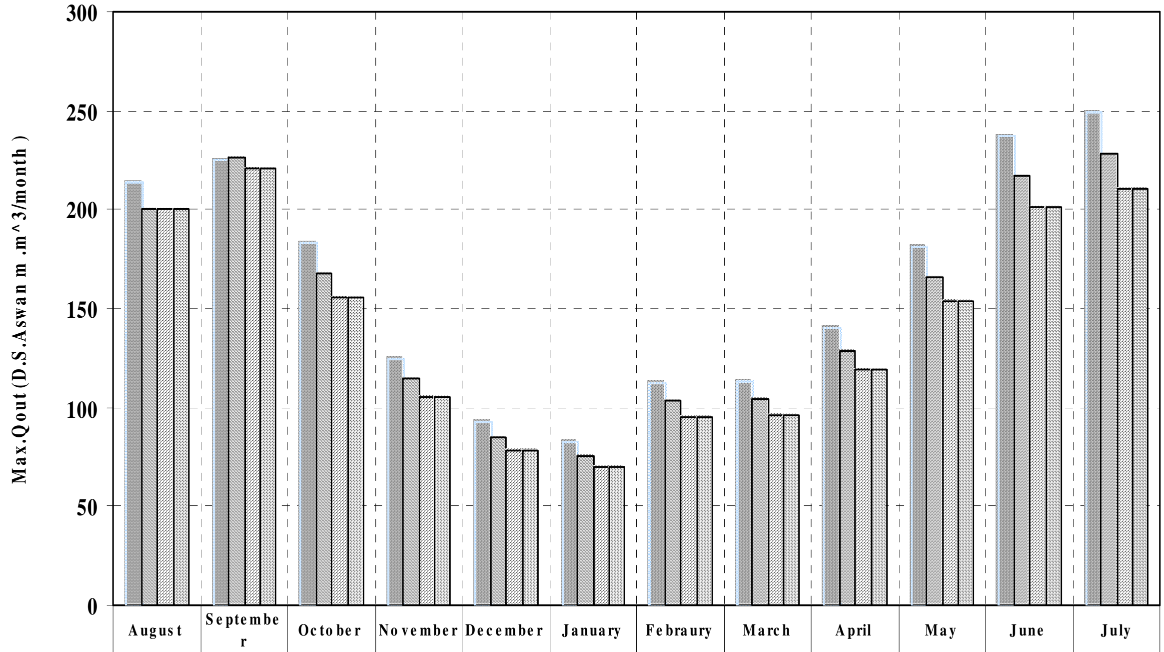
	August	September	October	November	December	January	Febraury	March	April	May	June	July
Qout.(Case1)	209.62	221.34	180.26	122.48	91.33	80.93	110.61	111.74	138.10	178.06	233.15	244.56
Qout.(Case2)	200.00	210.00	200.84	180.00	116.12	76.73	104.86	105.94	130.92	168.81	211.04	221.86
Qout.(Case3)	200.00	210.00	200.84	180.00	116.12	76.73	104.86	105.94	130.92	168.81	211.04	221.86
Qout.(Case4)	200.00	210.00	200.84	180.00	116.12	76.73	104.86	105.94	130.92	168.81	211.04	221.86

Figure 12: Outflow DS. AHD for Different Cases (Inflow 110 Mm^3/day)



	August	September	October	November	December	January	Febraury	March	April	May	June	July
Qout.(Case1)	222.52	234.96	191.35	130.02	96.95	85.91	117.41	118.62	146.59	189.01	247.49	259.6
Qout.(Case2)	209.62	221.34	180.26	122.48	91.33	80.93	110.61	111.74	138.1	178.06	233.15	244.56
Qout.(Case3)	198.74	209.84	190.9	116.12	86.59	76.73	104.86	105.94	130.92	168.81	221.04	231.86
Qout.(Case4)	198.74	209.84	200	116.12	86.59	76.73	104.86	105.94	130.92	168.81	221.04	231.86

Figure 13: Outflow DS. AHD for Different Cases (Inflow 120 Mm^3/day)



	August	September	October	November	December	January	Febraury	March	April	May	June	July
Qout.(Case1)	213.84	225.79	183.89	124.94	93.17	82.56	112.83	113.99	140.87	181.64	237.83	249.47
Qout.(Case2)	200.56	226.45	168.14	114.24	85.19	75.49	103.16	104.22	128.81	166.08	217.46	228.1
Qout.(Case3)	200.56	220.65	155.27	105.5	78.67	69.71	95.27	96.25	118.95	153.37	200.82	210.65
Qout.(Case4)	200.56	220.65	155.27	105.5	78.67	69.71	95.27	96.25	118.95	153.37	200.82	210.65

Figure 13: Outflow DS. AHD for Different Cases (Inflow 130 Mm^3/day)