Inundations by High Releases Downstream High Aswan Dam

Karima Attia[1] Nahla Sadek[2]

[1] Nile Research Institute, National Water Research Center
[2] Nile Research Institute, National Water Research Center

Abstract

The flood is a natural phenomenon defined as relatively high flow or stage in a river markedly higher than the river carrying capacity. It occurs often quite frequently in almost all rivers in the world as a result of a variety of causes. Aswan High Dam (AHD) represents a safeguard for Egypt against high and low floods for more than fourty years. However, for dam protection and safety a planned releases downstream the dam throughout the year should be applied to satisfy the dam operation rules (water level upstream the dam in the first of Aug. =175.00 m). The planned releases may have downstream impacts. Many problems for human properties and activities especially in the area of encroachment were evident in 1998 for planned releases of 181 mm3/day downstream Assiut Barrages. Rehabilitation, concepts and strategies are used by Egypt to adapt the main Nile and its two branches for the planned high releases. The main purpose of this paper is to simulate 1998 flood and its impacts on the reach located between Assiut and Delta Barrages. Mathematical model is used (HEC-RAS) to predict the impact of different high releases. The model is calibrated by using 2003 hydrographic survey data (one kilometer apart cross sections) together with maximum normal hydrological parameters downstream Assiut barrages (discharge downstream Assiut of 171 mm3/day and water level upstream delta barrage is 16.60m). Higher releases are simulated (200, 220, 250, 270, 300, and 350 mm3/day) to evaluate the impact on inundation process. Each release effect on land and infrastructure inundations are analyzed and evaluated. Management lines concept is introduced as a rehabilitation tool for land use management around the river. The main purpose is to secure the Nile against encroachments. The study concluded that management lines should be implemented and tested in the field. In addition, public awareness should be activated.

***Key words*:** River Nile, flood management, management lines, rehabilitation, mitigation, land inundation, infrastructure, Mathematical models, and Egypt.

1. INTRODUCTION

Construction of AHD in 1968 has reserved and controlled the river Nile water to protect Egypt from both high and low floods. This situation encouraged many people to dwell in more lands towards the River and river encroachments have attained its highest degree in the past few years. However, for dam protection and safety a planned releases downstream the dam throughout the year is applied. High releases more than the channel carrying capacity have great destructive and devastating forces on the river people and environment. This study investigates the impact of high releases downstream Assiut barrages (544.75 km from low Aswan Dam). However, assessment of river channel hazards requires an understanding both of natural system operation and the degree of human impact. As a result, approaches for determining the risk of hazards will have the goal of understanding river channel sensitivity to change so that mitigation measures and rehabilitation can cause appropriate response to the type of hazards. One dimensional mathematical model is used to achieve the study goals. Mitigation measures are used for remedying the assessed problems. Among these measures are management lines to control land use around the river and to secure the river against encroachments.

2. DESCRIPTION OF THE STUDY REARCH

River Nile is segregated by historical barrages to four reaches. The most downstream reach, 408.75 km located between Assiut and Delta barrages (see figure 1 for location) is used for this investigation. This reach experienced different type of problems including human interventions, bank erosion, navigation, and the channel is braided. The reach is characterized by relatively straight channel, as the sinuosity is amount to 1.1. The channel pattern is straight with gentle meandering. Valley walls, towns and bank protection works restrict the channel lateral shifting.

Therefore, the internal river processes are activated. Figure 2 indicates the range of flow variation downstream of Assiut barrage since dam construction. This data is extracted from Nile Research Institute (NRI) data base. The minimum discharge (low releases) downstream the Assiut barrages was 29.3 mm3/day and recorded in 2002 and 181 mm3/day recorded as high release during 2001 flood if the period 1968 to 2007 is considered. The average slope of the reach is amounted to 9cm/km. The average width for this reach was 1050 m before HAD and reduced to 550 m after HAD as a result of controlling the flow. The d_{50} for about 44 cross sections (the plotted value is the average of three samples collected from east, west and middle parts of the cross sections) collected in 1991 by NRI is shown in Figure 3 (DR 200-1-2, 1992). The length of the river banks (the main bank length plus the island length) has increased within this reach due to the development of new islands. However, the river bank lengths undergoing erosion is decreased from 130 km in 1981 to 90 km in 1988. This is mainly attributed to the increase of artificial bank protection works (Abdelbary, et., al., 1990). In 1998 the Ministry of Water Resources and Irrigation (MRWI) had to release more water downstream the dam to manage the high flood and guarantee the dam operation rules. The released water (181 mm^3/day downstream Assiut Barrages) resulted in many problems in the floodplain area. This area is occupied by encroachment. The floodplain and infrastrctures damage were observed by NRI hydrographic survey team within the duration 22/9/1998 to 30/9/1998 (Attia, 1999). Figure 4 indicates some of these damage. The number of encroachment activities recorded by field observation on both bank sides (right and left banks) through the reach was about 67 and 42 respectively. These activities represent permanent structures such as houses, pump stations including irrigation, water and electricity.

3. HIGH FLOOD SIMULATION

HEC-RAS model is 1-D model developed by U.S. Army Crops of Egineers, USA in 1998. The model is applied to simulate the impact of high relaeses (200, 220, 250, 270, 300, and 350 mm3/day) on the encroachment activities in the flood plain area. The model is designed for calculating water surface profiles for steady or gradually varied flow. The steady flow system can handle a full network of channels, a dendrite system, or a single river reach. The steady flow component is capable of modeling sub-critical and mixed flow regime.

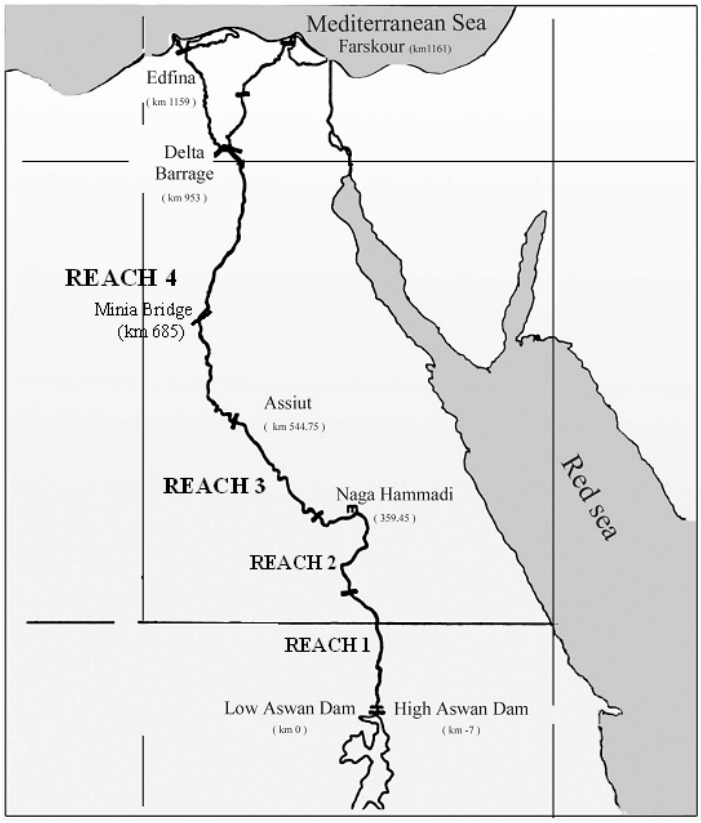

Figure 1: Location Map for the Reach between Assiut and Delta Barrage

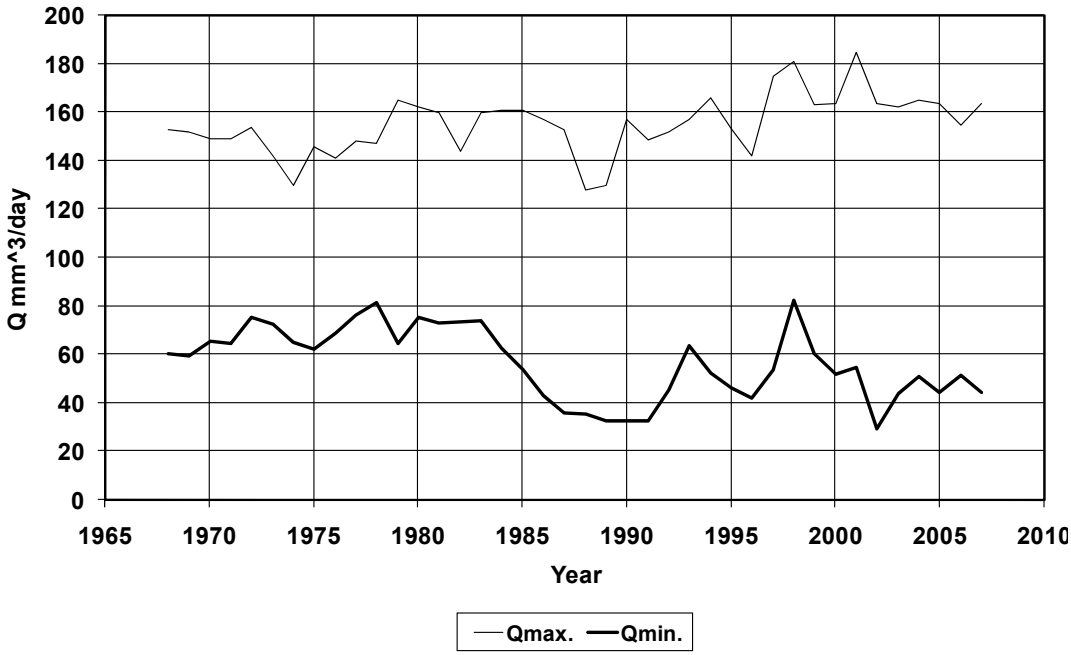

Figure 2: Planned Releases Downstream Assiut Barrage since Dam Construction

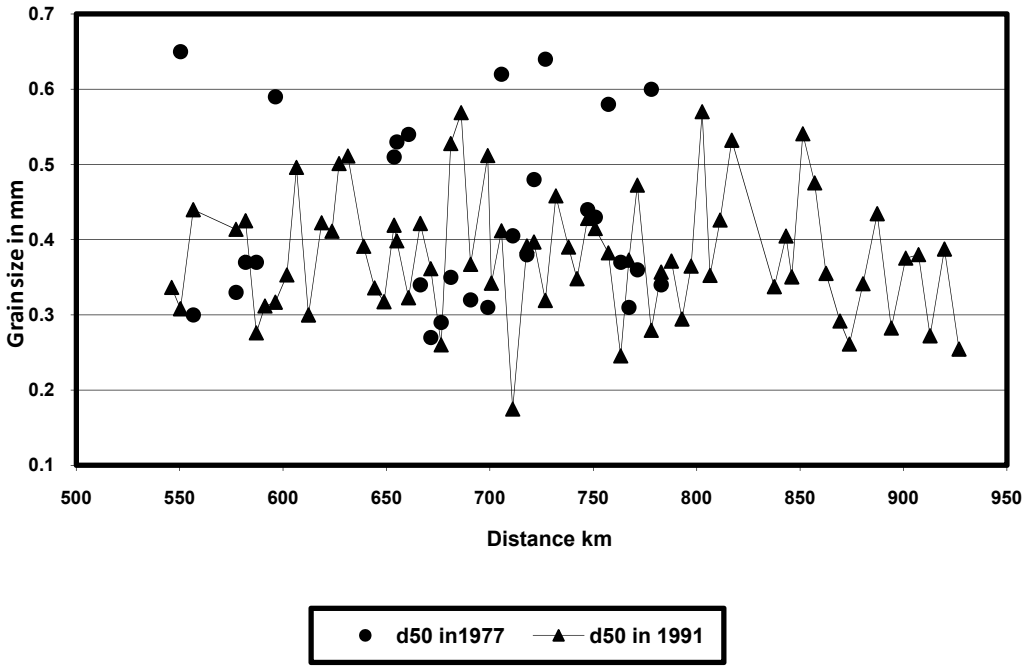

Figure 3: Median Grain Size (distance on the x-axis of the figure is measured from Old Aswan Dam)

The basic computational procedure is based on the solution of one-dimensional energy equation. The effects of various obstructions such as bridges, weirs, and structures in the floodplain can be considered in the computations. The steady flow system is designed for application in floodplain management and flood insurance studies to evaluate flood way encroachments. The model input data for calibration process includes geometric and hydrologic data, the geometric data is composed of about 400 cross-sections with spacing of one kilometer in between extracted from the hydrographic survey of 2003. The hydrologic parametrs include flow discharge and water level at all gauging stations along the study reach. The inflow boundary was defined as the inflow discharge to the study reach which is defined as the discharge downstream Assiut barrage (171 m m3/day).

Figure 4: Some of 1998 Flood Damage in the Reach between Assiut and Delta Barrage

The outflow boundary condition was used as water level at the end of the study reach upstream Delta barrage (16.60m). The simulated runs were performed to predict the effect of high releases (200-350 m m3/day) on the water surface profile. Figure 5 illustrates the model calibration results.

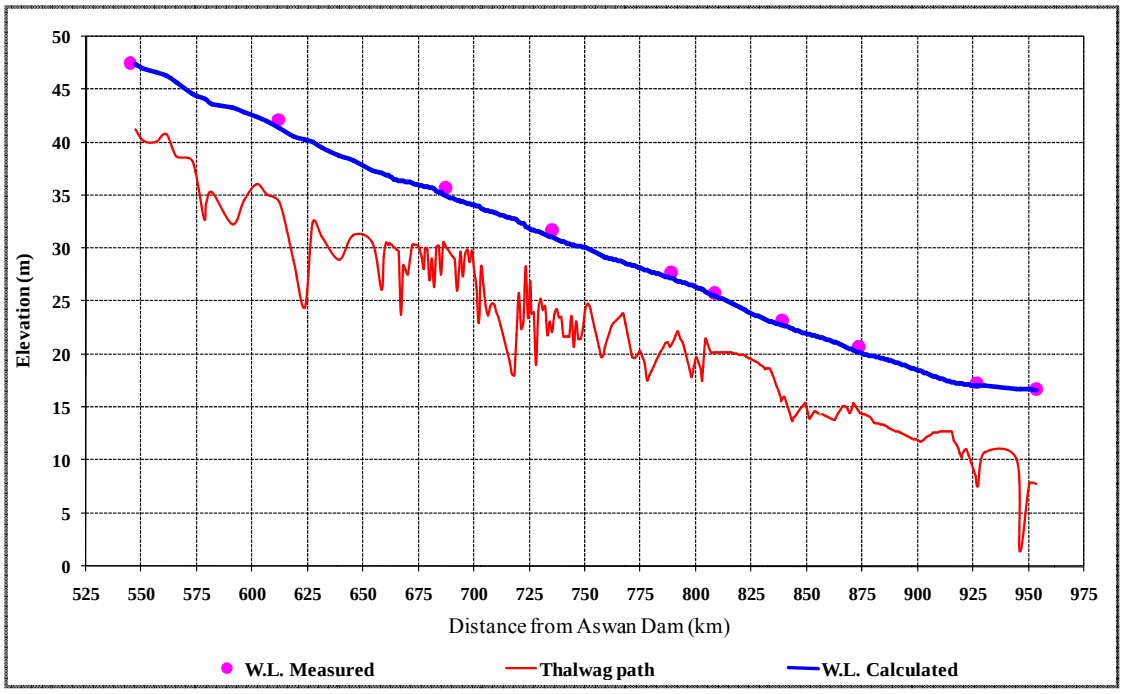

Figure 5: The Model calibration results

4. HIGH FLOOD SIMULATION RESULTS

Figure 6 represents the predicted water levels corresponding to simulated releases. The location of the inundated infrastructures is also shown in the figure. The figure also illustrates the terrace line levels (top bank levels). Figure 7 indicates enlarged sample length of 200 km of the reach between km 650 and 850.

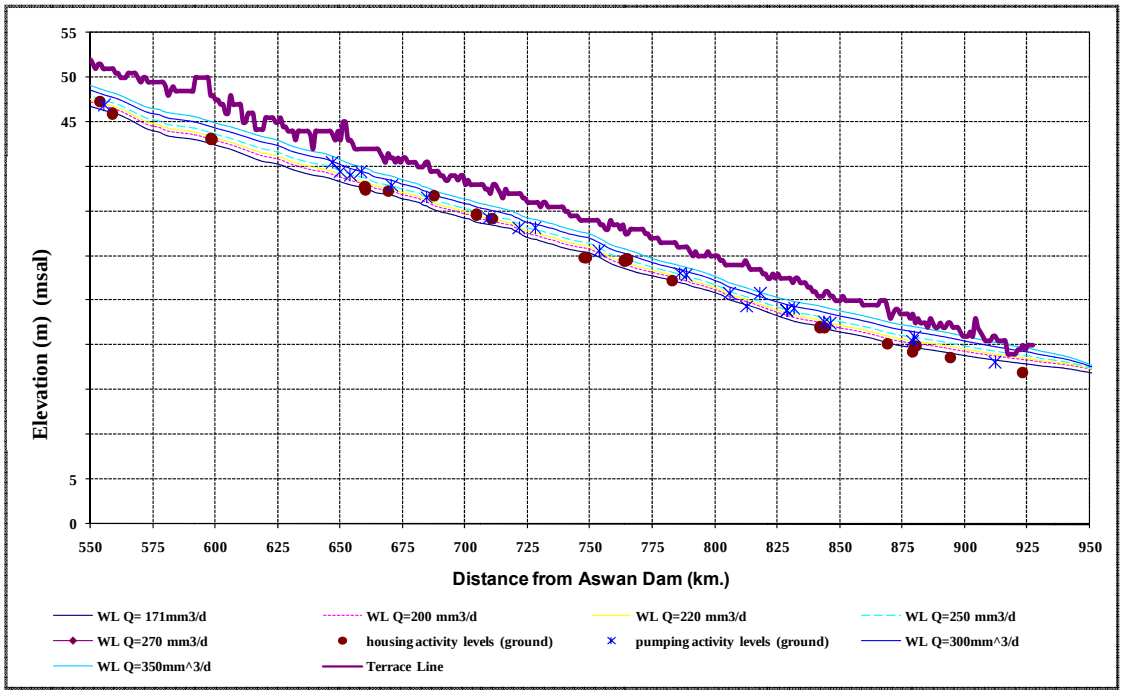

Figure 6: Water Levels for Different Simulated Discharges and Influenced Infrastructures

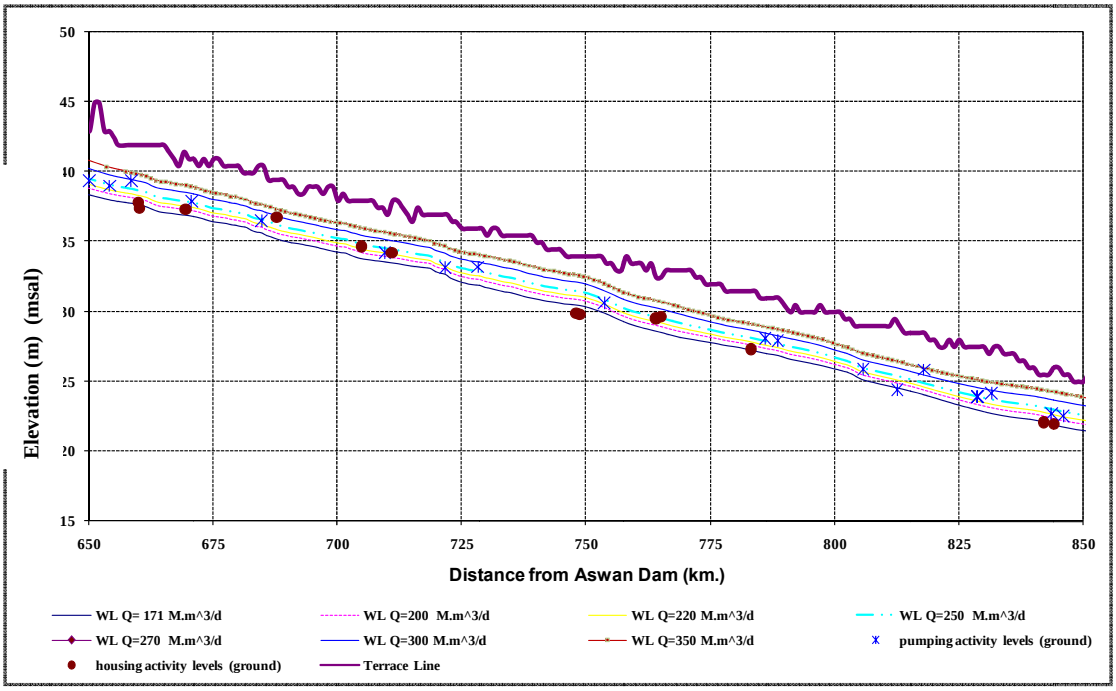

Figure 7: The inundated infrastructures between km 650 and 850 dowstream Old Aswan dam

Table (1) summarizes the number and types of the inundated infrastructures.

Table1: Number and Type of Inundated Infrastructures Related to Simulated Discharges

Simulated Discharge mm^3/day	Number of inundated infrastructures			
	East Side		West Side	
	Houses	Pump stations	Houses	Pump stations
181	13	8	11	2
200	16	20	13	2
220	18	32	16	4
250	21	33	19	15
270	24	39	21	19
300	27	40	22	23
350	**28**	**41**	**22**	**24**

5. HIGH FLOOD REHABILITATION AND MITIGATION

In the late 1940's and early 1950's, the Ministry of Water Resources and Irrigation has developed the concept of "training lines" since the ministry has the responsibility to control all development within the area between these lines. These lines defined the river bank defenses to create a stable channel capable of conveying a discharge of about 950 mm3/day. This concept has to be adapted to cope with the new regime after the construction of the dam. Therefore this concept was replaced by morphological lines called the Management Lines in 1992 by a Canadian panel of expertise through the River Nile Protection and Development (RNPD) project - phase 1 (Mercer, et. al., 1990, NRI WP 720-1, 1991 and Attia and Sadek, 2001). This concept was modified in 2007 to cope and cover different conditions of flood in the floodplain area. The new concept consists of Terrace, and Channel Lines. Land use and activity conditions are defined related to these lines. The main objective of this concept is to secure the river against encroachment.

5.1 Management Lines Design Criteria

Since management lines are tool for managing the development along the river, their assessment are based on integrated management for river development including hydraulic structures, navigation facilities, bank protection and training works, land reclamation, fishery and recreation, tourism

development, road, railways and building. The land features defined by the valley of the Nile are representing basic tool and criteria for setting the general definitions of these lines. The first feature is the old flood plain that extends beyond the old banks of the river. In general the development including land cultivation, towns and roads was built in these lands. Since the construction of the AHD, this flood plain is no longer flooded and now represents a terrace. Therefore, this land was used to define the border of the first management line, which nominated the terrace lines and the design discharge for these lines is equal to 350 mm3/day for the main Nile (Aswan to Delta Barrage, Attia, et. al., 2001). The designed discharge for Dammietta branch is 80 mm3/day while Rosseta branch is 220 mm3/day. The second feature is the active channel abundant from secondary channel, sand bars and seasonal islands*. This active channel is an area that the river is considered for its own use. The design discharge for defining the boundary of these lines is the annual maximum discharges downstream the dam (171 mm3/day downstream Assiut barrage).

5.2 Management Lines and Land Use

The area of lands outside the terrace lines after adding a safety zone of 30 m width will be available for public use and permanent structures and development and these area are outside the control of the ministry of water resources and irrigation. These lines can define in the field by the top of the old river banks and they defined easily on the 1:10000 maps as they follow the contour lines of high ground near the river bank (the starting contour of the agriculture lands) and may separate between flat and steep slopes if the cross section is considered. Some islands (the permanent ones)* contain land that rise to the level of the flood plain terrace and this land is included in the terrace lands. These lines can be extracted from maps and should be resurveyed in the field every ten years or even longer as they are more or less fixed. The area between channel lines is reserved for the river needs and belongs to the ministry of water resources and irrigation. These lines are changeable due to some factors related to river process such as maximum discharge, erosion and deposition. Therefore, they need to be updated and checked every five years or less. Any development in the area between these lines is prohibited unless it is absolutely necessary. This is including pump intakes, ferry landing facilities, bridge abutments and piers, roadway encroachments, and pipeline crossing under the river or tunnel. This development should be decided upon engineering studies approved by the ministry. The areas between channel and terrace lines can be used for temporal activities such as parks and recreation activities, seasonal agriculture, temporary farm building, fish farming, temporary storage without solid walls, wildlife refuges, access to water, ferry facilities, and borrow pits (gravel/sand) with the ministry approval. These lands may be returned to the ministry on demand. Figure 8 represents the different conditions in the field to assess these lines. However, many difficulties are asserted during the determination of the management line levels and this emphasizes the need of field reconnaissance to define the exact situation. Therefore, the current situation in the field should be addressed and the ownership of the permanent structure between the terrace line and channel lines should be informed about the special uses in these areas and may be special legislation need to be issued. Compensations should be arranged for the damage that could be happened to permanent structure now lying between terrace and channel lines. Protection and consolidation of high terrace land suffering from bank erosion should be considered and the landowners could share in that.

* Seasonal islands are that covered with water during high seasons. They are also named submerged islands

* The permanent island is that has permanent vegetation and is distinct from sand bars

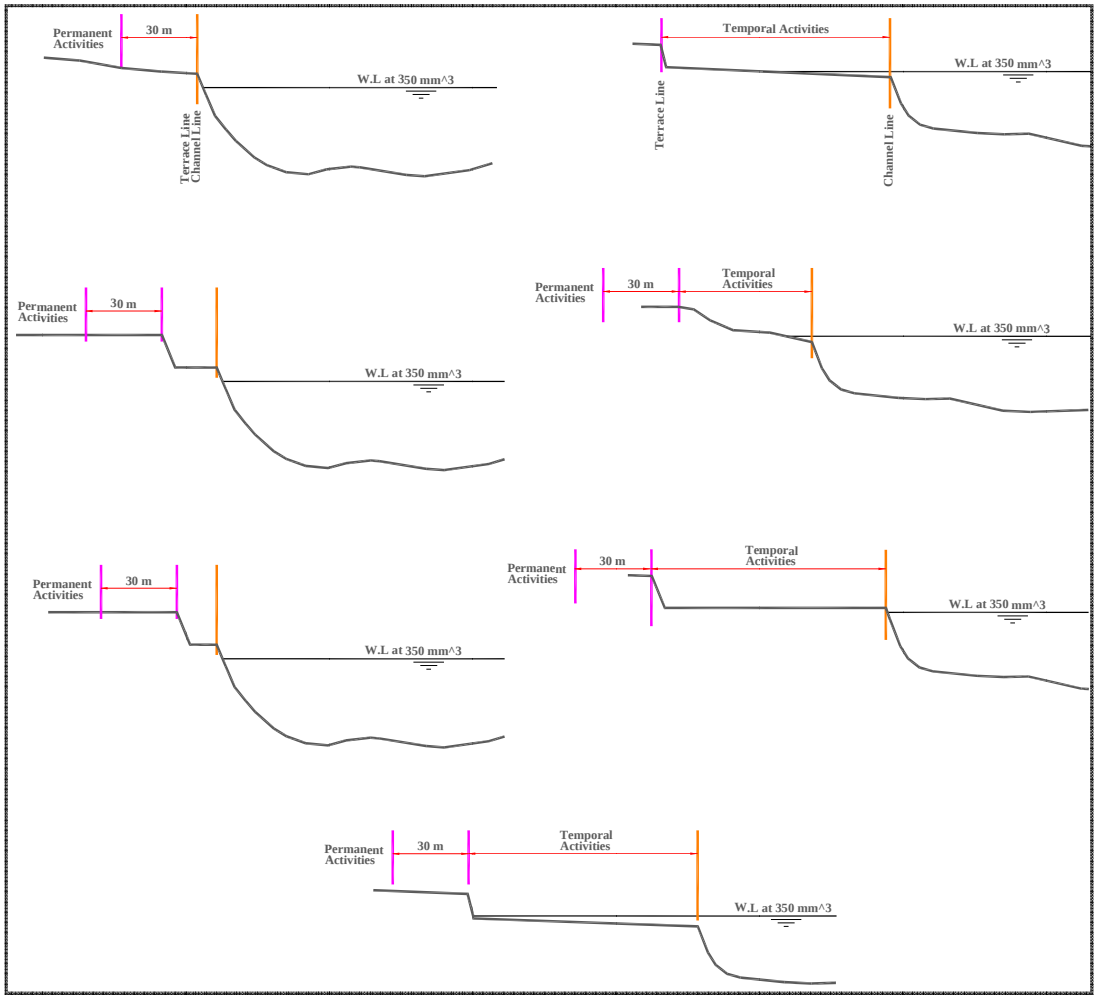

Figure 8: The Most Common Cases for Management Lines along the Nile River

6. CONCLUSION AND RECOMMENDATION

The main purpose of this paper is to investigate the impact of high floods in the most downstream reach located between Assiut and Delta barrages. The total length of the studied reach is about 408.75 km. The selection of this reach is attributed to the fact that this reach experiences different type of problems, the importance amongst them is river encroachment. The magnitude of floods (releases) downstream AHD is mainly depending on the yearly plan of the MWRI to satisfy the dam operation rules. The high flood represents the 1998 releases of 181 mm3/day downstream Assiut barrage. Higher floods are also simulated (200, 220, 250, 270, 300, and 350 mm3/day) by using 1-D model, HEC-RAS. The water level and water surface profiles related to each release are predicted. The impact on different type of infrastructures in the area of encroachment are analyzed and evaluated. A number of houses and pump stations (water, electricity, and irrigation) are inundated due to simulated releases. Management lines concept is introduced as a rehabilitation measure to classify and arrange land use around and between these lines. The main purpose is to secure the Nile against encroachments. These lines are morphological lines according to the land features defined by the Nile valley and mainly based on short-term integrated management. Various cases and examples from the Nile River are introduced. The study concluded that management lines should be implemented and tested in the field. In addition, public awareness should be activated.

7. ACKNOWLEDGEMENT

The authors are highly appreciated the effort of NRI hydrographic survey team for their support in data collections.

8. REFERENCES

1. Abdelbary, R., Attia, K., and Galay, V., (1990), *River Nile Bank Erosion Development Below the High Aswan Dam*, National Seminar on Physical Responses of the River Nile to Interventions, Edited by Anstey, T. H., and Shady, A. M., Cairo, Egypt, 12-13 November,1990.
2. DR 200-1-2, (1992), *Reach 4 Bed Material Samples Data Report*, River Nile Protection and Development Project (RNPD), 1992.
3. Mercer, A., Eid, T., and Makary, A., (1990), *Proposed Land Management Lines for the River Nile*, National Seminar on Physical Responses of the River Nile to Interventions, Edited by Anstey, T. H., and Shady, A. M., Cairo, Egypt, 12-13 November, 1990.
4. Working Paper 720-1, (1990), *River Land Management Lines for River Nile in Pilot Project Reach at Beni Mazar*, River Nile Protection and Development Project (RNPD), September, 1990, and Revised March, 24, 1991, Nile Research Institute.

AUTHERS BIOGRAPHY

Auther[1] Karima Attia is a professor, Deputy Director, Nile Research Institute, She is a member of World Association for Sediment and Erosion Research (WASER), IRTCES, China and Egyptian National Committee for Hydrology, IHP, UNESCO. She awarded The Ministry of State for Administrative Development (MSAD) prize for the distinct manger, June 2010. She also awarded Encouragement State prize in Engineering, 2004, and Dr. Moustafa Tolba prize 2001, Academy of Scientific Research and Technology.

Auther[2] Nahla Sadek is associate professor, head of Erosion and Sedimentation dept., Nile Research Institute, National Water Research Center. She received her M.Sc. and PH.D from Ain Shams University.