Flood Zoning of Golestan Dam downstream plain in Iran

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ABSTRACT

Flood is a complex natural disaster and destroying phenomenon that causes considerable annual damage. In addition, floodplain and lands alongside river beds are always in expose of flood hazards, while most of economic and social activities are conducted in these areas. Therefore, in these regions, flood zoning is necessary. Flood zoning maps, could be a suitable and lawful tool for determination of development strategies. In this research, the map of flood zoning with different return periods for a part of Gorgan Rood River, Iran was provided. Hydrological data and information were collected and analyzed. Flood routing by using Muskingum-Cunge method in different reaches was conducted. These data were used in the HEC-RAS model and its report was extracted. Finally, flooding area and flow depth in different return periods were determined. The accuracy and precision of flooding maps were evaluated by comparison with information and local investigations. The results show that by considering the HEC-RAS limitations (reach shortness), the final flooding maps are accurate enough for the aim of this kind of study.

Keywords*:* Flood, zoning, HEC-RAS, ArcView, Golestan Dam

INTRODUCTION

In many parts of the world, flooding is the leading cause of losses from natural phenomena and is responsible for a greater number of damaging events than any other type of natural hazard. Roughly half of all losses due to nature's forces can be attributed to flooding. Flood damage has been extremely severe in recent decades and it is evident that both the frequency and intensity of floods are increasing. In the past ten years losses amounting to more than US$ 250bn have had to be borne by societies all over the world to compensate for the consequences of floods. There are countries, such as China, in which flooding is a frequent, at least annual event, and others, such as Saudi Arabia, where inundation is rare but its impact sometimes no less severe. No populated area in the world is safe from being flooded. However, the range of vulnerability to the flood hazard is very wide, in fact wider than for most other hazards. Some societies (communities, states, regions) have learnt to live with floods. They are prepared. Others are sometimes completely taken by surprise when a river stage (or the sea) rises to a level neighboring residents have never experienced before in their lives.

The dramatic increase in the world's population and in particular in certain regions creates the necessity to settle in areas that are dangerous (Kron, 1999b). Additionally, the movement of political, social and other refugees, increased mobility and the attractiveness of areas that have a beautiful natural environment and a mild climate lead to people settling at places whose natural features they do not know. They are not aware of what can happen and they have no idea how to behave if nature strikes.

During the last few decades many flood plains have been occupied by residential areas and industrial parks. These areas are usually flat and not necessarily good for agricultural use. The nearby rivers have been tamed and confined in narrow strips by dikes, and cheap and attractive land has been reclaimed. Towns and villages declared these areas residential areas and, therefore, many potential buyers of property counted on there being no flood hazard to be feared.

TYPES OF FLOOD

In insurance contracts, flooding is defined as a *"temporary covering of land by water as a result of surface waters escaping from their normal confines or as a result of heavy precipitation"*. There are three main types of flood and a number of special cases (Munich Re, 1997). The main types are: storm surge, river flood, and flash flood; special cases include tsunami, waterlogging, backwater (e.g. caused by a landslide that blocks a water course), dam break floods, glacial lake outburst floods (GLOF), groundwater rise, debris flow events and others.

Storm surges can occur along the coasts of seas and big lakes. They bear the highest loss potential of water-related natural events, both for lives and for property. Improved coastal defense works have prevented very high losses in developed regions during the recent past, but the loss potential of storm surges remains huge.

River floods are the result of intense and/or persistent rain for several days or even weeks over large areas sometimes combined with snowmelt. The ground becomes fully saturated and the soil's capacity to store water is exceeded. It behaves as if it was sealed and the precipitation runs off directly into creeks and rivers. The same effect is produced by frozen ground, which also prevents the water from infiltrating the soil. River floods build up gradually, though sometimes within a short time. The area affected can be very large in the case of flat valleys with wide flood plains. In narrow valleys the inundated area is restricted to a small strip along the river, but water depths are great and flow velocities tend to become high, with the result that mechanical forces and sediment transport play a major role as a cause of damage. Although inundation due to river floods starts from a water course and is somewhat confined to its valley, the areas affected can be far greater than those hit by storm surges.

Flash floods sometimes mark the beginning of a river flood, but mostly they are local events relatively independent of each other and scattered in time and space. They are produced by intense rainfall over a small area. The ground is not usually saturated, but the infiltration rate is much lower than the rainfall rate. Typically, flash floods have an extremely sudden onset. A surge may rush down a valley that does not even have a creek at its bottom. Such a flood wave can propagate very quickly to locations some tens of kilometers away, where the rainstorm is not even noticeable. From this fact comes the – probably true – saying that "in a desert more people drown than die of thirst". Forecasting flash floods is almost impossible, with lead times for early warnings in the order of minutes. Although flash floods usually occur in a relatively small area and last only a few hours (sometimes minutes), they have an incredible potential for destruction.

Flash floods are not only associated with fast flowing water in steep terrain, but also with the flooding of very flat areas, where the slope is too small to allow for the immediate runoff of storm water. Instead, water accumulates on the surface, in – sometimes not even noticeable – depressions or in other lower lying areas such as street underpasses, underground car parks and basements. Hence, the term *flash* denotes something that happens quickly and not something that moves quickly.

RECENT FLOOD DISASTERS

Reinsurance companies, due to their worldwide activities, are among the best sources for natural disaster statistics (Kron, 2000; Munich Re, 2000). Their analyses focus on three aspects: the number of people affected (fatalities, injured, homeless), the overall economic damage to the country hit, and the losses covered by the insurance industry.

Natural disasters with thousands of deaths almost always hit poor countries and are mainly caused by earthquakes. The poverty aspect is related to the higher vulnerability in less developed countries (poorer quality of structures, more people), the cause (earthquakes) to the sudden onset of such events, which strike without warning. In the past (more than 10 years ago), floods were also responsible for a huge number of deaths. This is not so anymore today, because early warning has become more operational, more reliable and hence more effective.

In the statistics of economic losses floods take a leading position. While two earthquakes (Kobe: US$ 100bn; Northridge: US$ 44bn) still have been the costliest natural disasters so far, floods, which usually affect much larger areas than earthquakes and occur much more frequently, have at least the same importance. Not only the great disasters, but also the vast number of small and medium-sized events causes tens of billions of dollars of losses every year for economies and severe distress to people.

Probably, floods are responsible for more damage than all other destructive natural events together. Additionally, the financial means societies all over the world spend on flood control (sea dikes, levees, reservoirs, etc.) is a multiple of the costs they devote to protection against other impacts from nature.

Table 1 shows the greatest flood losses in recent years. It is apparent that China is the country whose economy suffers most and most regularly from such disasters. It also becomes clear that great flood losses can occur in practically any region of the world.

Table 1. The costliest floods of the past 10 years (original values, not adjusted for inflation)

Rank	**Year**	**Country/countries (mainly affected regions)**	**Economic losses US$ bn**	**Insured (%)**
1	1998	China (Yangtze, Songhua)	31	3
2	1996	China (Yangtze)	24	2
3	1993	USA (Mississippi)	21	6
4	1995	North Korea	15	0
5	1993	China (Yangtze, Huai)	11	0
6	1994	Italy (North)	9.3	<1
7	1993	Bangladesh, India, Nepal	8.5	0
8	2000	Italy (North), Switzerland (South)	8.5	6
9	1999	China (Yangtze)	8	0
10	1994	China (Southeast)	7.8	0
11	1995	China (Yangtze)	6.7	1
12	2001	USA (Texas)	6.0	58
13	1997	Czech Rep., Poland, Germany (Odra)	5.9	13

The insured share of flood losses from these major events has usually been relatively small. For the insurance industry windstorms are clearly the most critical loss events, simply because the insurance density is highest for this type of peril. However, a tendency towards higher insurance densities for flood may be observed worldwide and, in particular, a tendency towards extreme single insurance losses due to water. A good example of this is Tropical Storm Allison, which drenched the Houston/Texas area with over 750 mm of rain in just five days in June 2001 and caused insured losses of US$ 3.5bn. With economic losses of US$ 6bn this event ranks 12 in Table 1, having by far the highest share of insured losses of the 13 events listed.

Table 1 does not reveal any trend. However, a distinct change in flood losses over time becomes apparent in Fig. 1. Here the losses from great flood disasters for each year since 1950 are plotted vs. time. The average annual losses from such catastrophes in the period since 1990 have become a multiple of the values in the previous decades.

Natural catastrophes are classed as being *great* if they cannot be handled by the affected country/region alone, but require interregional and international assistance. This is usually the case when thousands of people are killed; hundreds of thousands are made homeless, or when a country suffers substantial economic losses, depending on the economic circumstances generally prevailing in that country. Great catastrophes can be analyzed very well in retrospect because even records that go back several decades can still be investigated today. If the statistics were based on all the loss information collected (including small and medium events), the influence of advanced communication technology over the past decades would introduce an unacceptable bias.

Losses that have been experienced describe the past. What we expect in the future must be based, on the one hand, on these experiences, but, on the other hand, on the analysis of each loss event too in order to determine the respective factors that exerted their influence on it. From this analysis we can derive an expected value for a (future) loss, which we call *risk.*

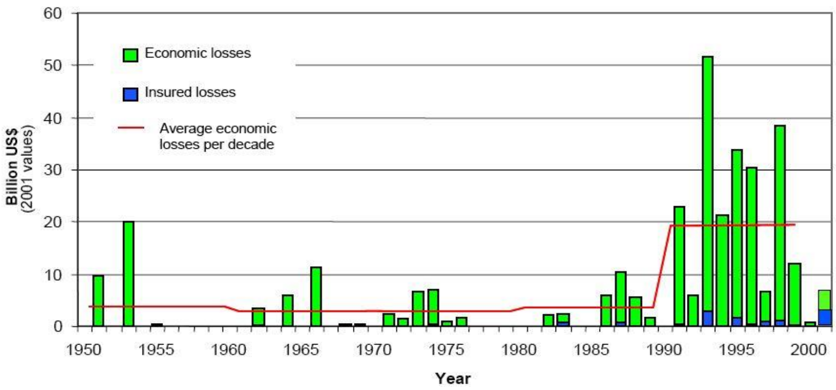

Fig. 1 Great Flood Disasters 1950 - 2001

GOLESTAN DAM CHARACTERISTICS

Golestan Dam is located 12 km north east of Gonbad Kavus in Iran. It is constructed on Gorgan Rood River to develop the agricultural farms and products. The dam is made of clay with concrete membrane over it. The main characteristics are listed in the below table:

Table.2. Golestan Dam Characteristics

Height	MAX 25 m
Crest Length	1350 m
Foundation width	200 m
Crest Elevation	66 m
Reservoir volume (N.W)	56 million m^3

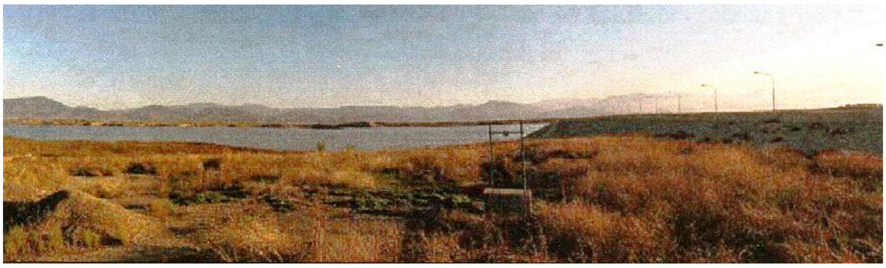

Figure. 2. View from the river and the basin

Flood routing and Boundary conditions

The Muskingun_Cunge method was used for flood routing [5]. A discharge-stage was used as upstream boundary conditions and normal depth as downstream conditions in the HEC-RAS model. After introducing the required data to HEC-RAS and executing the model, the output files and flow characteristics extracted. Then, the HEC-RAS data was imported into ArcView.

Digitizing topography map and Digital Evaluation Model (DEM)

First, the topography map (1:50,000) was digitized and it was georeferenced using some control points. The required DEM was extracted. For hydraulic modeling of river channels, a TIN model was preferred. By combining the vector and raster data to form a TIN, the intended result is a continuous three-dimensional landscape surface that contains additional details in stream channels [2]. This approach was employed to form the TIN terrain model.

Floodplain Mapping

Areas inundated by flooding occur wherever the elevation of the floodwater exceeds that of the land. After importing water surface elevation with distance from the stream centerline to the left and right floodplain boundaries into ArcView and subtracting land elevations from floodwater elevations, flooded areas were delineated.

RESULTS AND DISCUSSION

By field measuring, some cross sections with different distance (regard to river morphology) and floodplain characteristics around river were surveyed. The resulted tables and figures are shown as below:

First scenario: Maximum occurred flood

In this situation the maximum flood velocity is no more than 1.5 m/s. moreover, the flood depth is illustrated in Figures 3 and 4.

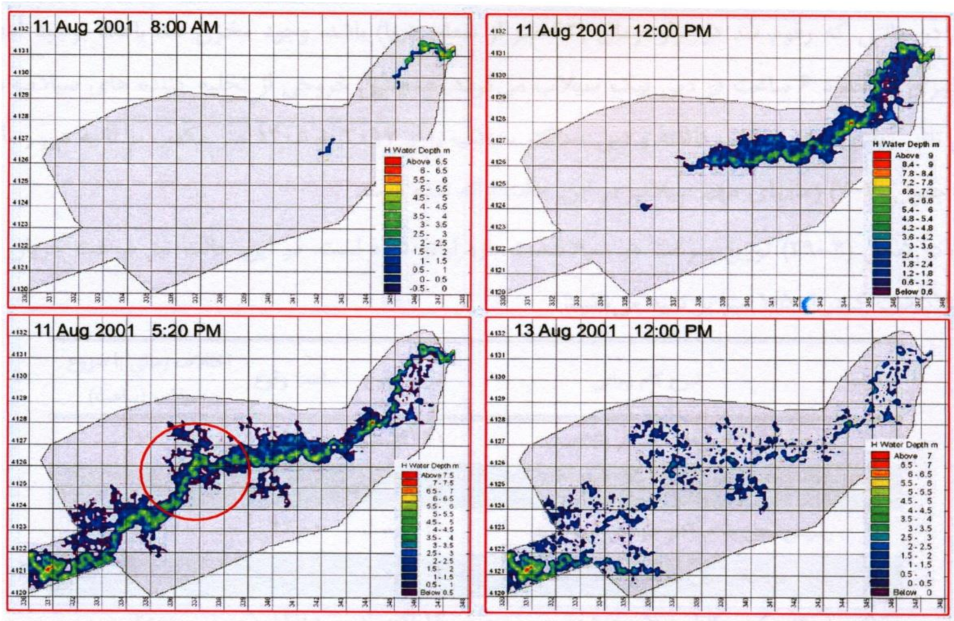

Figure 3. Flood zoning for the maximum occurred flood

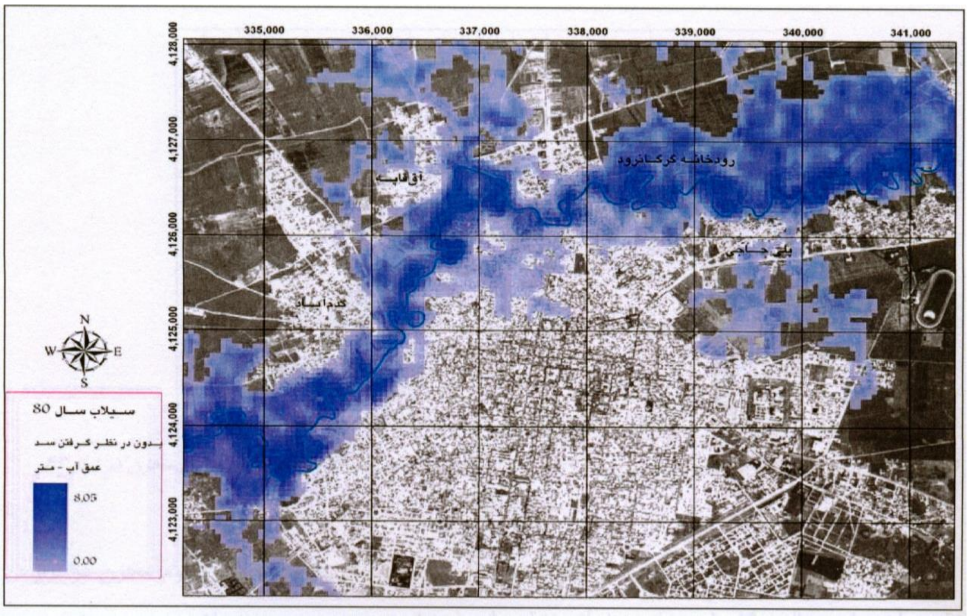

Figure 4. Maximum flood depth in the plain

Second Scenarios: Floods of various return periods

Floods with return periods of 100 year, 1000 year and 10000 year are simulated at first. In this part the effects of the presence of the Golestan dam is also demonstrated. As results the flood zoning is illustrated for both conditions: 1- presence of dam 2-if there was no dam there. For the first situation it is also assumed that the normal water level is 62 m above sea mean level.

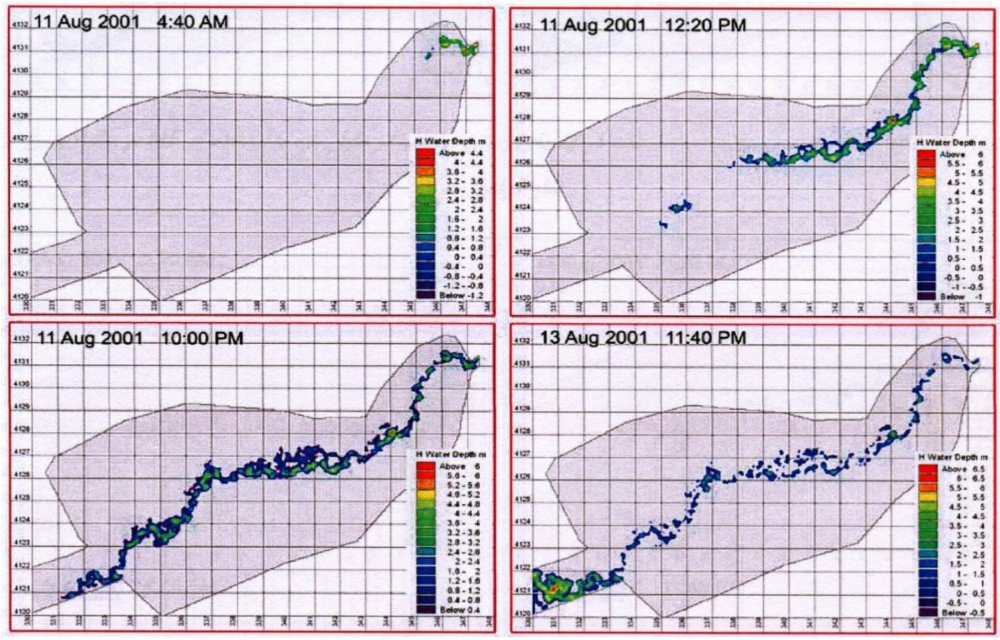

Figure.5 100 year flood zoning (No Dam)

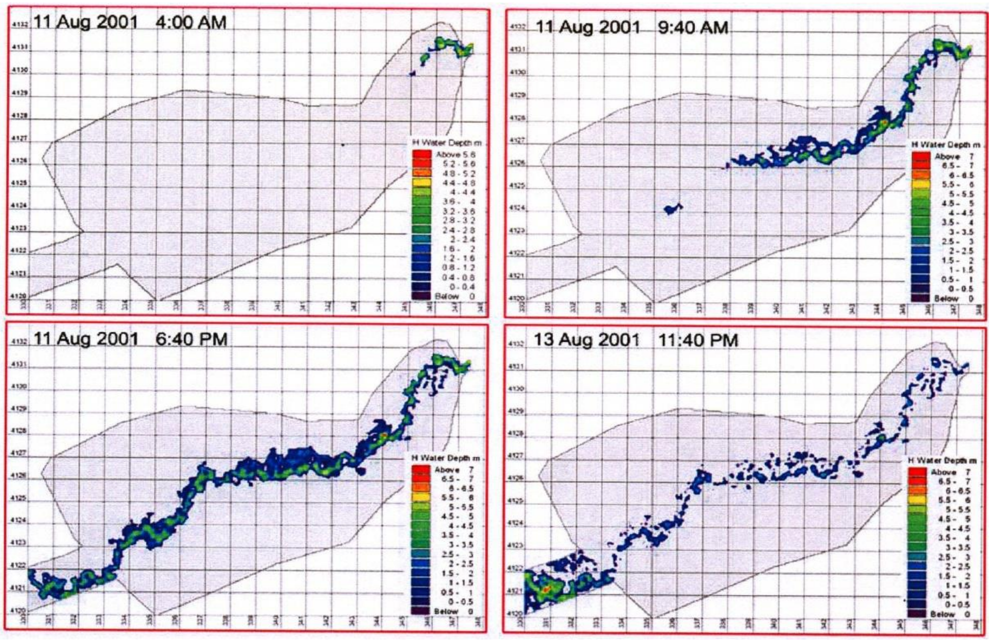

Figure.6 1000 year flood zoning (No Dam)

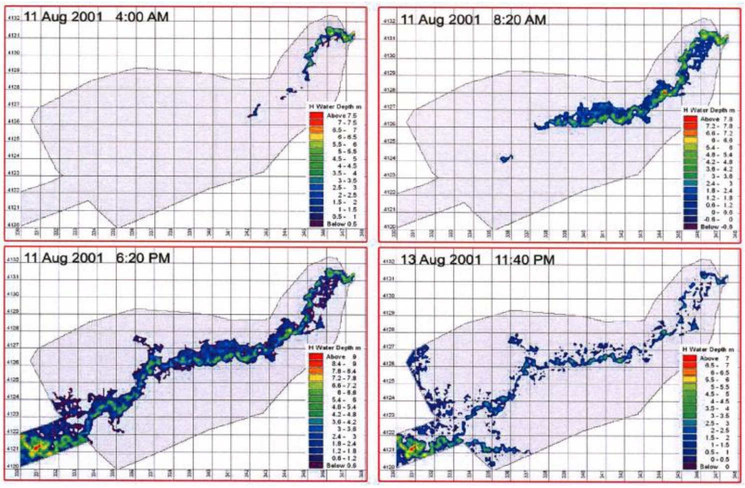

Figure 7. 10000 year flood zoning (No Dam)

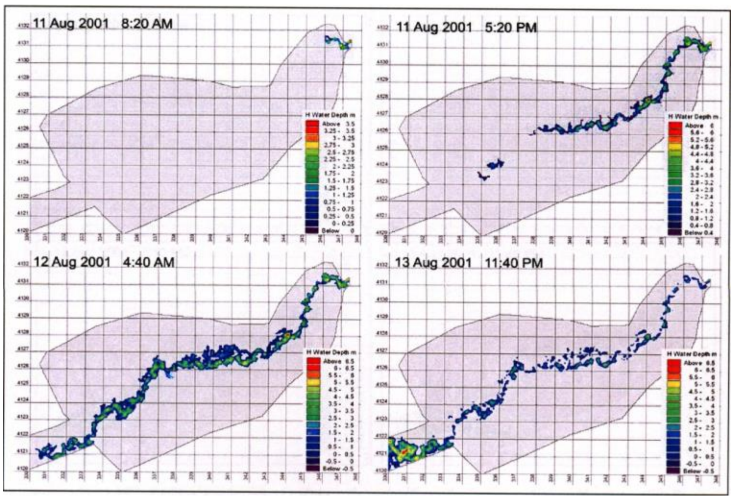

Figure 8. 1000 year flood zoning (N.W.L)

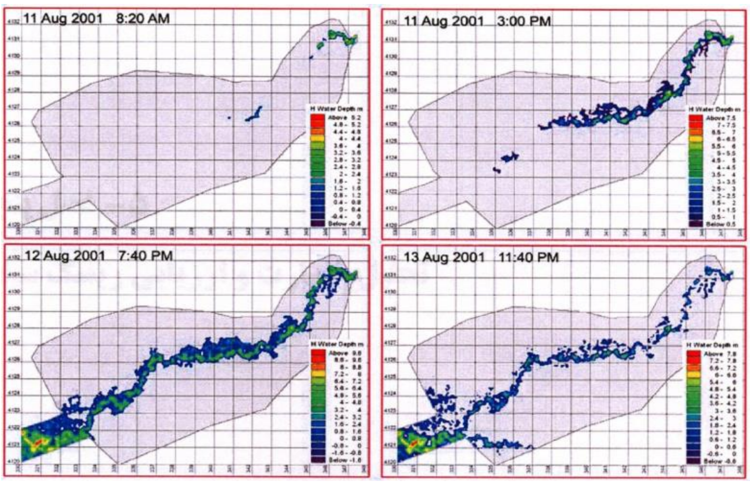

Figure 9. 10000 year flood zoning (N.W.L)

CONCLUSION

Flood zoning maps, could be a suitable and lawful tool for determination of development strategies. In this research, flooding area and flow depth in different return periods using HEC-RAS model and ArcView were determined. The accuracy and precision of flooding maps were evaluated by comparison with information and local investigations. Regard to these comparisons, the precision of resulted maps is reliable.

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