Economical Evaluation of the flood protection function of dikes

Exercise 1:

A village next to a river is threatened by flooding through higher flooding events in the recent years. Damage occurs already at a flooding with a 10 year return – period (HQ10). For the protection of the population there is a dam to be built along the river. In exercise 1 the goal is to determine the flood damage reduction through the dike. Therefore, two different dike heights are to evaluate (h_{Dike} = 4,5 m und h_{Dike} = 5,0 m). The bottom of the dike is 4 m above the channel bottom.

For an estimation of the potential damage of the flooded area a damage function S, which is depending on the water level (h) is given (fig. 1.1). At a runoff of 5.500 m³/s a maximum damage of 1,5 mio. € is reached.

Runoff peaks of selected return periods and their probabilities of exceedence are given in table 1.1. The Water level – runoff – relationship is depicted in figure 1.2.

Table 1.1: Extreme Value Statistics of floodings

	Q [m^3/s]	**$P_ü$** [1/a]
HQ2	430	0,5
HQ5	660	0,2
HQ10	860	0,1
HQ20	1090	0,05
HQ25	1180	0,04
HQ50	1500	0,02
HQ100	1960	0,01
HQ200	2570	0,005
HQ300	3020	0,0033
HQ500	3710	0,002
HQ1000	4930	0,001

Remark: The point of reference is always the bottom of the river in the following calculations (e.g. height of dike option 1 = 4m + 4,5m = 8,5m)!

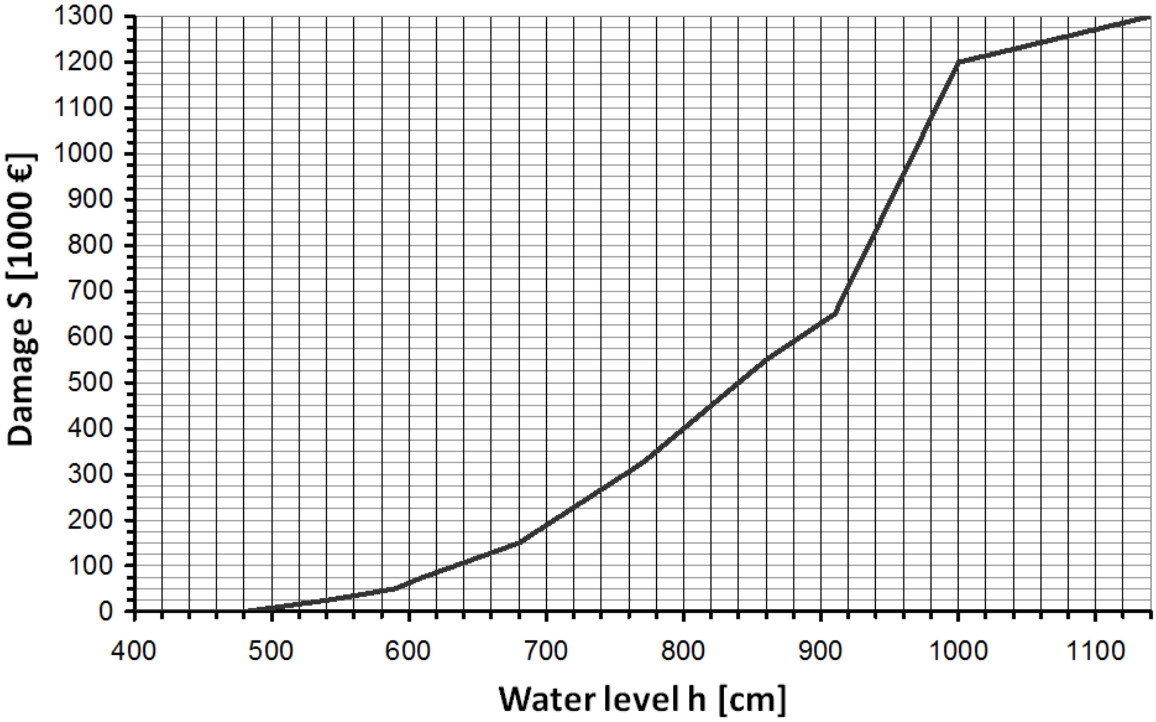


Figure 1.1: Flood Damage Function S(h)

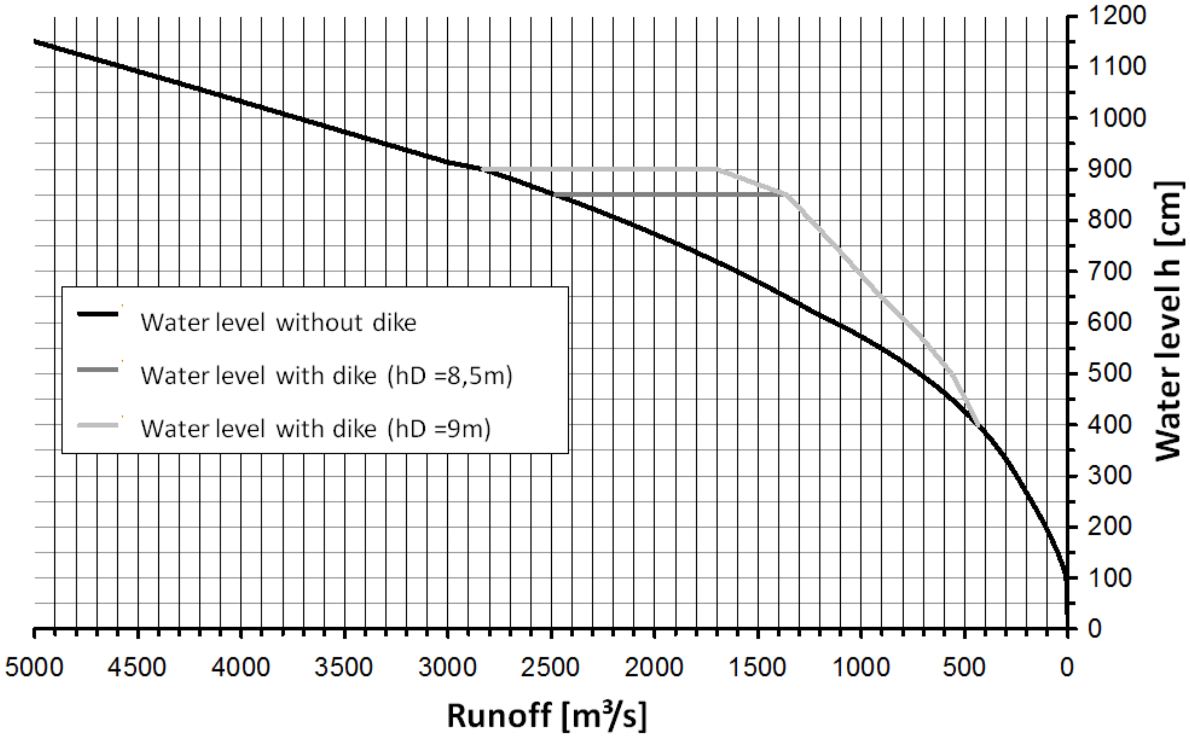


Figure 1.2: Water Level – Runoff – relationship

Expected Damage without dike

Table 1.2: Table of solutions

	Q [m³/s]	**h** [cm]	**S** [1000 €]	**Pü** [1/a]
HQ2	430			0,5
HQ5	660			0,2
HQ10	860			0,1
HQ20	1090			0,05
HQ25	1180			0,04
HQ50	1500			0,02
HQ100	1960			0,01
HQ200	2570			0,005
HQ300	3020			0,0033
HQ500	3710			0,002
HQ1000	4900			0,001

Calculation of the expected value of damage:

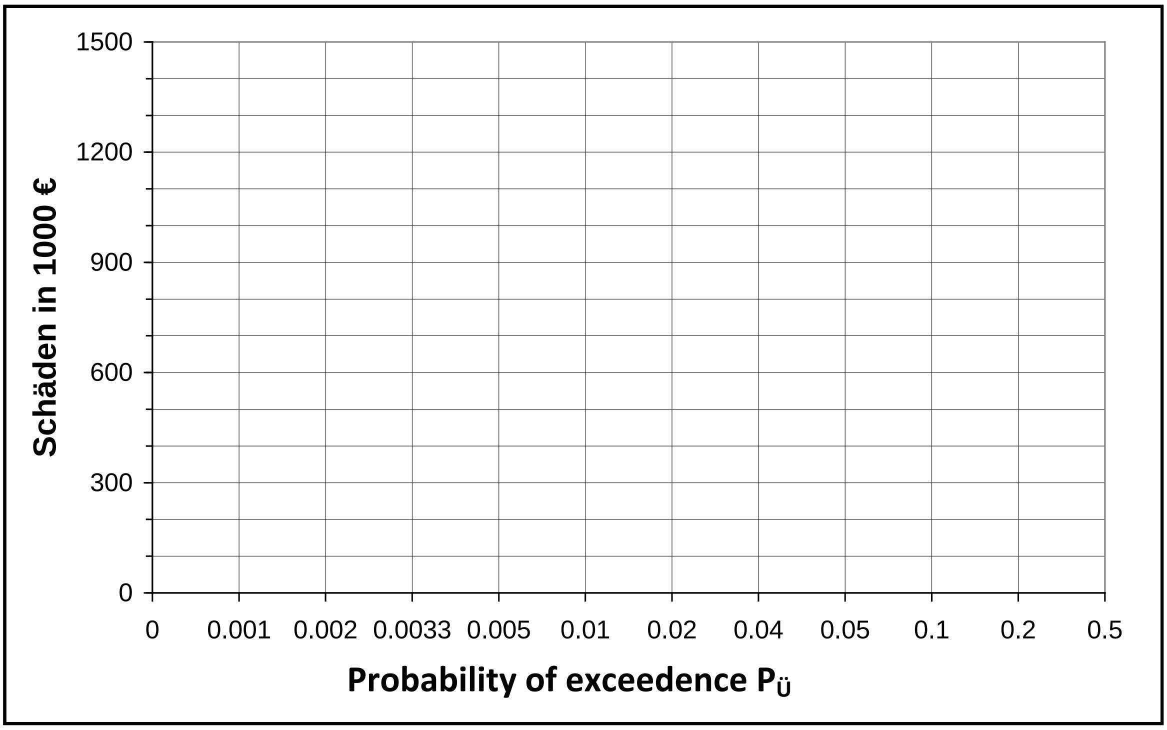


Figure 1.3: Graphic of the expected value of damage

$S_{ohne\,Deich} =$

Expected Damage with dike

For the determination of the expected damage value after building of the dikes the Water level – runoff – relationship of the flooded area is given (figure 1.4).

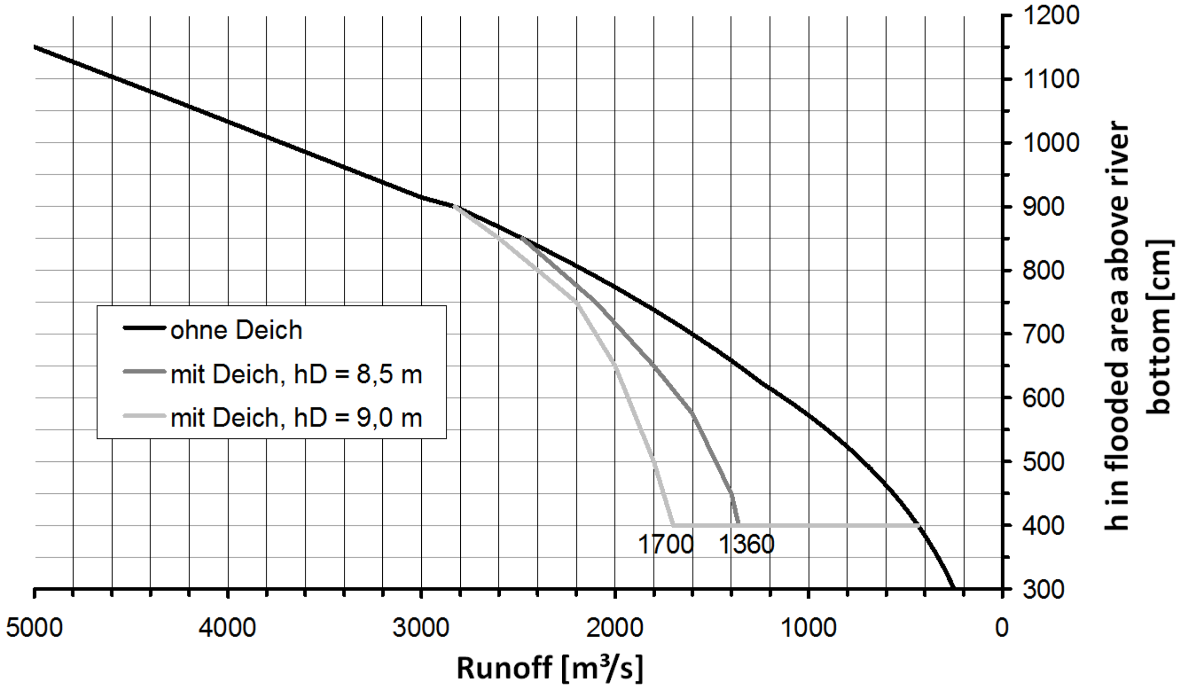


Figure 1.4: Water level – runoff – relationship of the flooded area

a) h_{Deich} = 8,5 m

Table 1.3: Table of solutions for h_{Deich} = 8,5 m

	Q [m^3/s]	**h** [cm]	**S** [1000 €]	**$P_ü$** [1/a]
HQ2	430			0,5
HQ5	660			0,2
HQ10	860			0,1
HQ20	1090			0,05
HQ25	1180			0,04
HQ50	1500			0,02
HQ100	1960			0,01
HQ200	2570	860	550	0,005
HQ300	3020	910	650	0,0033
HQ500	3710	1000	1200	0,002
HQ1000	4900	1140	1300	0,001

Calculation of the expected value of damage:

$S_{hD=8,5m} =$

b) h_{Deich} = 9,0 m

Table 1.4: Table of solutions for h_{Deich} = 9,0 m

	Q [m³/s]	**h** [cm]	**S** [1000 €]	**Pü** [1/a]
HQ2	430			0,5
HQ5	660			0,2
HQ10	860			0,1
HQ20	1090			0,05
HQ25	1180			0,04
HQ50	1500			0,02
HQ100	1960			0,01
HQ200	2570			0,005
HQ300	3020	910	650	0,0033
HQ500	3710	1000	1200	0,002
HQ1000	4900	1140	1300	0,001

Calculation of the expected value of damage:

$S_{hD=9,0m} =$

Damage reduction through dikes

a) h_{Deich} = 8,5 m

b) h_{Deich} = 9,0 m

Exercise 2:

Until now, no geotechnical failure of the dike was taken into account. In reality, this is an important factor to include into the calculation. In this exercise, the possibilty of dike failure is taken into account.

Under this aspect, use the flooding risk of the area after building of dike option 2 (h_{Deich} = 5,0 m) from exercise 1. Therefore, consider both the chance of geotechnical failure and overtopping risk of the dike.

The probability for geotechnical failure of the dike is 15 % at 500 cm of water level and 85% at a water level of 870 cm.

Solutions:

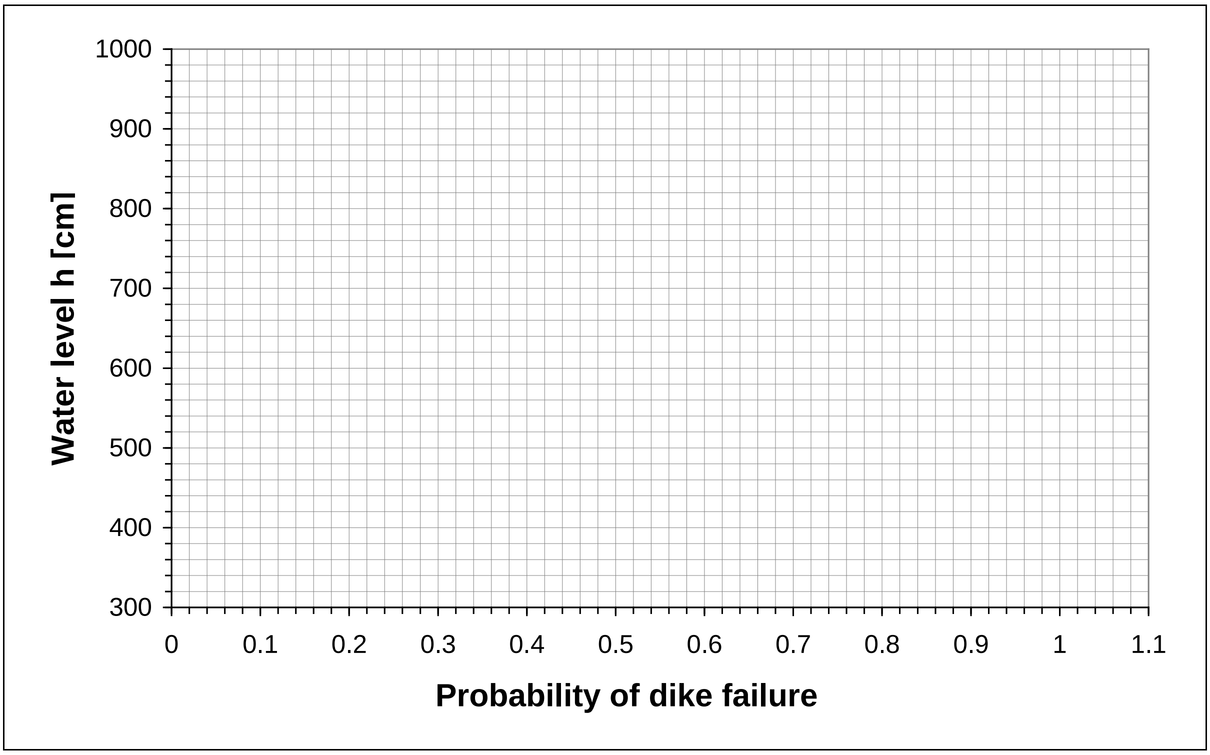
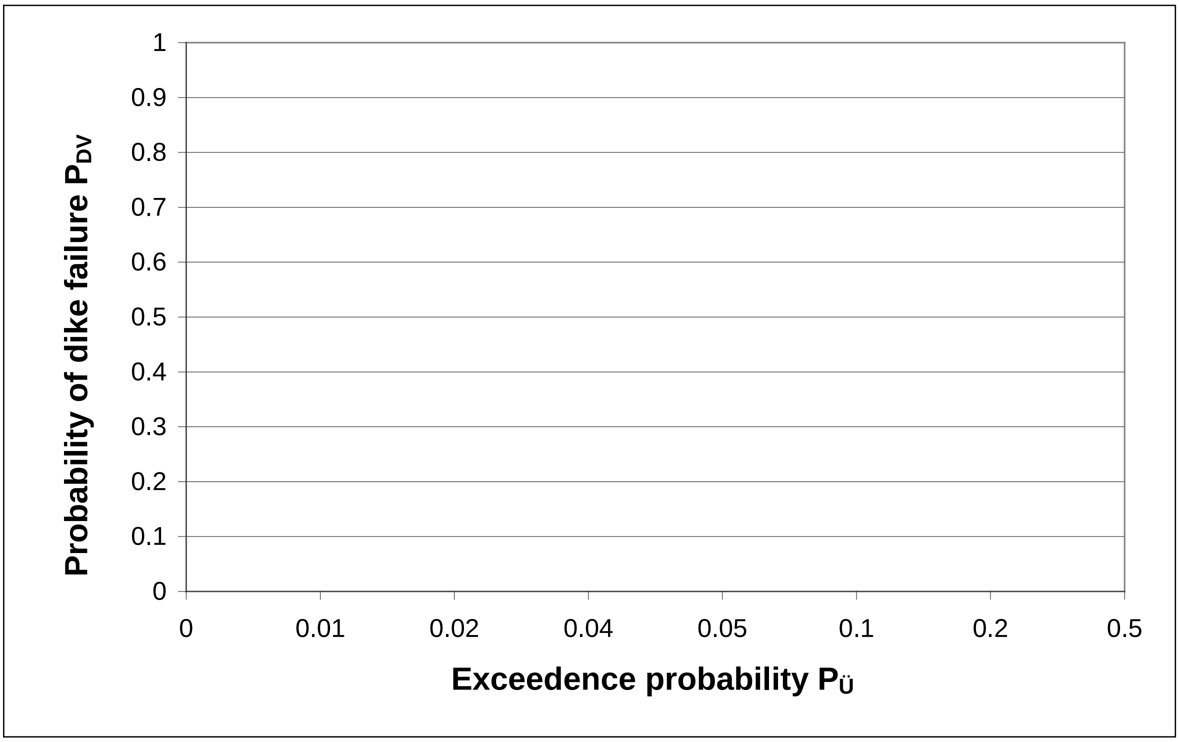


Figure 1.5: Probability of geotechnical dike failure

Table 1.5: Table of solutions

	Q [m³/s]	h [cm]	P_{DV} [-]	$P_{ü}$ [1/a]
HQ2	430			0,5
HQ5	660			0,2
HQ10	860			0,1
HQ20	1090			0,05
HQ25	1180			0,04
HQ50	1500			0,02
HQ100	1960			0,01
HQ200	2570			0,005
HQ300	3020			0,0033
HQ500	3710			0,002
HQ1000	4900			0,001

Calculation of the probability of dike failure:



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