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DAMS AND FLOOD CONTROL-SYSTEMS OF DETENTION RESERVOIRS IN SOUTHWESTERN GERMANY [(*)]

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1. INTRODUCTION

Water management measures are closely linked to the various requirements of human society. They have to facilitate the water utilization in order to satisfy many different needs, but must also provide a protection against the destructive effect of water. However, they cannot be realized without far-reaching consequences for the natural, social and ecological environment of human beings.

In many catchment areas, meaningful management of the water available in a region has to be based on storage basins. Storage reservoirs make it possible to meet a lot of multipurpose objectives, among them the essential flood protection for larger areas. Damaging flood events became more frequent during the past two decades.

Responsibility for water resources management is shared between the Federal Government of Germany and the State Governments. With the exception of the federal waterways, all main river systems including their flood control facilities are under the water management boards of the 16 German States. The water management administrations usually have a three-level-structure, the

[(*)] *Système de contrôle des crues et des barrages des réservoirs d'écrêtement des crues au sud ouest de l'Allemagne* lowest level instances in the districts and major towns being in charge of the practical execution of flood control measures. An important role in regional water management tasks is played by water associations, formed by communities bordering the same waters for the purpose of handling specific water resources management including water supply, sewage treatment, maintenance of water courses and flood protection.

2. FLOOD PROTECTION - AN IMPORTANT TASK OF WATER RESOURCES MANAGEMENT IN BADEN-WÜRTTEMBERG

Germany occupies a central location in Europe. It covers an area of 357 000 km² and has a population of 80 million. The average population density is 225 inhabitants per km². Although the country is heavily industrialized and densely populated, the area covered by building developments and traffic infrastructure is only some 12 % of the total area, 58 % of the total area is utilized for agriculture and 30 % of forest.

One of the 16 German states is Baden-Württemberg located in the Southwest with the most important two river basins of Rhine and Neckar. In December 1993 and April 1994, extreme flood events in Germany and Baden-Württemberg caused damage to water courses, built up areas, industrial facilities and communal transportation and communication infrastructure. Just in Baden-Württemberg alone, the damage was of an order of magnitude of 500 million DM. Historically, these floods were by no means unusual. Recurrence periods are, for example, at Cologne 65 years, and on the rivers in the Stuttgart region 20 to 100 years.

The main flood waves were caused by extreme precipitation falling on water saturated ground. The soil pores were largely filled by previous intensive rainfalls. Prior to the rainstorms, the storage capacity was exhausted. Thus the soils were naturally made impervious, with the consequence that almost the entire water falling during the rainstorms ran off rapidly. This meant that building over of land due to urbanization did not play any decisive part in the generation and the intensity of the floods.

Extreme floods occur along the major German rivers predominantly in the winter and spring months, whereby in many cases heavy and long-lasting precipitation falls on ground which, in part, is still frozen and on melting snow, particularly in the uplands, which reinforces flood run-off.

For flood protection, the number of alternative countermeasures available is considerably greater than generally assumed. Conventional hydraulic engineering measures like retention and water course development are an economic proposition and justifiable only when other approaches have been exploited to the full. First and foremost, provisions have to be made to reduce damage in the inundation areas of rivers like measures to match land utilization to the natural risk situation, measures to protect property (backwater gates, erecting dikes around properties, flood- and uplift-proof structural design, emergency escape routes); last but not least flood defences (action plan, safeguarding measures, placing flood fighting material at readiness, warning service).

Only after these have been implemented are expensive structural flood flow regulation installations appropriate, by the construction of water retention basins, flood channels, watercourse development, dams and protective walls.

The River Neckar, the second largest river in Baden-Württemberg, occupies a particular position. Its source as well as its outlet in the River Rhine as well as virtually its entire catchment area lie within the State boundaries. The catchment area is surrounded by the Black Forest and Swabian Alb and forms with its south-eastern boundary the European watershed between Rhine and Danube. It has a size of 14 000 km², thus covering 39 % of the total area of Baden-Württemberg of 35 751 km² - an area, where about half the population lives out of altogether 10.2 million. Apart from the water scarcity the most prominent characteristics are the relatively high mean annual temperatures, which are next to the Rhine Valley at the top of the scale in Germany, and the favourable soil and growth conditions. This explains why Baden-Württemberg has a high population density, currently amounting to 285 inhabitants per square km.

Tremendous flood flows occur in the river Neckar, which in the past have greatly influenced population and industrial development, and continue to do so. Additionally, the development of settlement in the flood plains has resulted in a reduction of natural impoundment zones and flooding areas.

In earlier times, protection against flood dangers was largely implemented by local measures, such as development of water courses and building dikes, but less by flood water retention measures. It was thus possible to achieve flood protection of settlements and transportation routes, and at the same time new industrial and residential areas could be erected in river valleys. The consequences of this, though, were that flows were accelerated, and in many places the danger of flooding downstream became more acute. The topographical and geological situation in the catchment area of the Neckar, the widespread creation of built-up areas in the valley flood plain, the exploitation of the waters for the economy, industry, transportation facilities, drinking water protection zones, as well as sewage disposal and treatment plants hinder the implementation of major damming schemes.

For this reason, protection against flooding has been realized largely by the creation of smaller retention basins and basin systems in the tributary valleys. The required impounded volume in order to protect the valley of the Lein, a tributary of the river Kocher as a first example, against flooding amounts to some 15 million m³. Up to now, some 13 million m³ has been created, costing 30 million DM.

In parallel to this, planning of surface water courses for flood protection has concentrated more on existing retention areas. At the same time, their preservation and protection serve the interests of nature conservation and contribute to stabilisation of the ecological balance. Water retention areas which have been lost by building development, can and should be replaced on principle by retention basins.

3. FLOOD RETENTION WITH STORAGE BASINS

Due to the increase of built-on areas and infrastructure systems in the valley floors, implementation of major reservoir schemes is not possible any more in the densely populated regions of Baden-Württemberg. Instead, retention basin systems have been developed for flood protection purposes in tributary valleys. Over 300 retention basins are in operation in Baden-Württemberg alone, most of them under the responsibility of water associations, set up by riparian communities under statuary laws. The flood protection associations receive funding from the State for construction, maintenance and operation as well as technical support services and support by the water resources administration.

Within the Stuttgart Administrative district there are 18 flood protection associations which from 1955 till now have constructed and operated a total of over 90 flood retention basins with capacities greater than 100.000 m³. The State government promotes this investment by a subsidy of 90 % and maintenance at a proportion of 15 % less than the capital investment subsidy.

In principle communities have to contribute at least 30 % as compensation for the benefits, they derive. This is regulated in each individual case in a contract between the State government and the community concerned.

4. ENVIRONMENTALLY COMPATIBLE FLOOD PROTECTION

In the past decades, flowing waters in Baden-Württemberg have been greatly changed from their natural course. Due to water course development, large parts of the natural flooding and retention areas have disappeared and the water courses have been greatly shortened. During this process, many ecological systems of the landscape along the rivers were lost. In part, the danger of flooding downstream was increased. Heavy urbanisation, and in particular the concentration of commercial and industrial locations as well as traffic routes along the flood plains, and also intensification of agriculture, constrained the water courses into narrow corridors. At today's state of knowledge full flood-proof development of a river is, as a rule, not a desirable solution.

Flood protection measures have to be implemented with the highest possible degree of environmental compatibility if they are to fulfil today's general aims of water management along river areas. For this reason, a sensitive approach has to be taken. Prior to their implementation, not only the locally achievable flood protection, but also their impacts as a whole on the discharge behaviour of the water course system, the ecology and the landscape appearance have to be taken into account. From this it is possible to evaluate the advantages and draw-backs of the planned measures, as well as of various combinations and options. This makes it possible to minimize impacts on the natural surroundings, and to optimize flood protection measures with respect to all important aspects.

Flood retention with storage basins has the advantages of great effectiveness, if applied just upstream of properties to be protected. Then only small areas will be flooded, no adverse impacts along the river basins, last but not least the utilization of the impounded area as public amenity. Draw-backs are the lack of topographical possibilities for reservoirs near the communities to be protected, the high maintenance costs, the adverse ecological impact on the inundated area as well as interruption to the continuity of the water course systems, furthermore the intervention in the sedimentation behaviour along the river bed and the intrusion in the landscape.

The various flood protection measures are to be evaluated and selected, depending on the hydrological, topographical, geological and ecological constraints, on the basis of the criteria degree of attainable flood protection, economic efficiency and reasonable, i. e. optimal water management.

5. TECHNICAL ASPECTS

In earlier times, flood retention basins were usually designed on the basis of actual flood events. However, the hydrological findings and processes that have been developed on a large scale since approximately the mid-seventies have opened up new perspectives and it has become possible to consider the safety and operational abilities of flood retention basins with greater accuracy.

Systematic safety examinations of impoundments have revealed shortcomings, considerable in some cases, usually as a result of the underestimation of the design flow for the emergency spillways. The aging of materials, the subsequent placing of structures in the outflow cross sections of spillways, such as the installation of accident prevention grates, changing in use in the catchment areas, the storage areas and the areas downstream of the flood retention basins - all these have led to safety - related problems which have been tackled using the improved rules of the art.

Fig. 1 shows the main features of a common flood retention basin. The layout demonstrates distinctly that for the technical solution reservoir, dam, intake structure, bottom outlet, spillway, chute and stilling basin are the significant constructions just as well as for big impounding reservoirs.

Progress in the art is reflected in an ever increasing number of standards, guidelines and codes of practice. According to them for normal operation of the flood retention basin the dimensioning follows the aspects of function and operation, in order to guarantee the protection of downstream populations from floods, for extra-normal operation the dimensioning follows the aspects of safety, in order to prevent the destruction of the installation if extreme events occur.

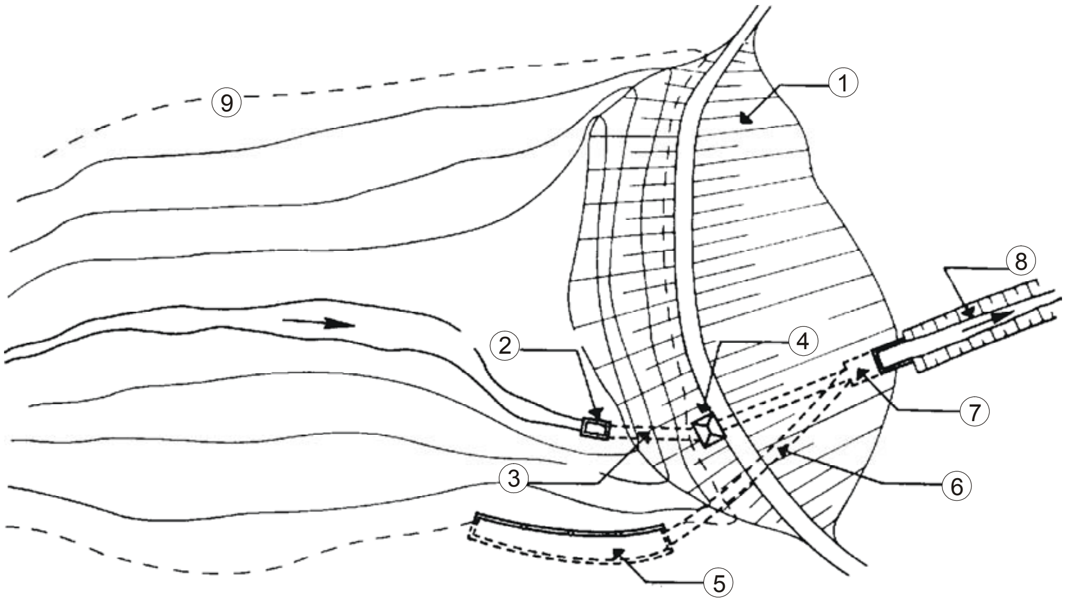

Fig. 1

Flood retention basin

Réservoirs d'écrêtement des crues

1. dam
2. inlet structure
3. bottom outlet
4. valve chamber
5. spillway
6. chute
7. stilling basin
8. developed river
9. maximum reservoir head

1. barrage
2. prise d'eau
3. vidange de fond
4. chambre de vanne
5. évacuateur des crues
6. coursier
7. bassin d'amortissement
8. section aménagée de la rivière
9. niveau d'eau maximal du réservoir

In the codes of practice guide values are given for the specification and dimensioning of storage level (permanent storage level), usual flood retention capacity, bottom outlet and operating outlet, emergency spillway, further intake structures, stilling basin and freeboard. The differences between installations with and without movable gates are the basis for the clear distinction between operation in flood-free periods and during floods. The operating instructions (together with the associated responsibilities) include the measurement-related requirements for operation, specifications of the basis discharge, control of the gates, the maintenance schedule and commissioning including test impoundment. The operation principles are the same for flood retention basins as temporary impoundment areas, or as basins with a permanent water level.

The required storage capacity of flood retention basins depends on the intended form of flood regulation (uncontrolled or controlled) and the flood frequency, with the extent of any additional channel development being determined by landscape appearance, urban character and cost. When planning flood retention basins for which, over and above the flood protection capacity, sufficient area remains in the valley for water storage, often the specific task of flood protection is superimposed on multiple water management tasks, such as the creation of permanent lakes and public amenities areas, fish breeding, groundwater replenishment, augmentation of low river flows, agricultural irrigation, and upgrading of water quality. In the case of dry basins, the opportunity presents itself of using basin areas which are only flooded over short times for agriculture and forestry.

It is self-evident that such multiple tasks, and particularly the combination of reservoir management with flood retentions, require detailed preliminary investigations in compliance with the precepts of framework for water management planning.

In most cases, it is not possible to capture completely the flood loading established on the basis of hydrological investigations in individual retention basins, and then to release these after a time delay into the discharge waters, since the available capacity is not sufficient. Only by means of operational regimes matched to local conditions is it possible to achieve retention of critical discharges, and to limit as a rule the downstream discharge to the permissible level.

The simplest operating regime of retention basins is the lake retention, which is to be understood as the smoothing effect on the discharge due to lakes or expansions of a water course bed in the nature of a lake.

In contrast to this is controlled retention for which the outflow is held as uniform as possible depending on the developed discharge in the downstream water course. This depends on the ratio of the normal flood retention capacity to the flow volume which has to be retained. Also the degree of smoothing of the peak flow depends on this ratio.

If the normal flood retention capacity is the same as the flood volume to be accommodated, the basin just fills up, without triggering operation of the spillway, although this presupposes the correctness of the flood prediction with regard to shape and content of the flood wave, and the basin capacity dimensioned to match this.

6. EXAMPLES FOR FLOOD RETENTION BASINS

As it could be seen flood protection reflects to a high degree of the basic human need of protection against the force of nature. The expansion of urban development observed in many regions has, particularly in conurbations, resulted in an appreciable reduction in the natural areas available for water retention, which has often been promoted by measures to prevent flooding along lengthy river sections. So, for example, along the middle reaches of the River Neckar between Stuttgart and Heilbronn, in the past four decades around four-fifths of the natural flooding area has been lost. The danger of flooding area has also been made more acute by water management and agricultural measures such as draining and canalisation of water courses, transformation of pastures into arable land, draining and land consolidation.

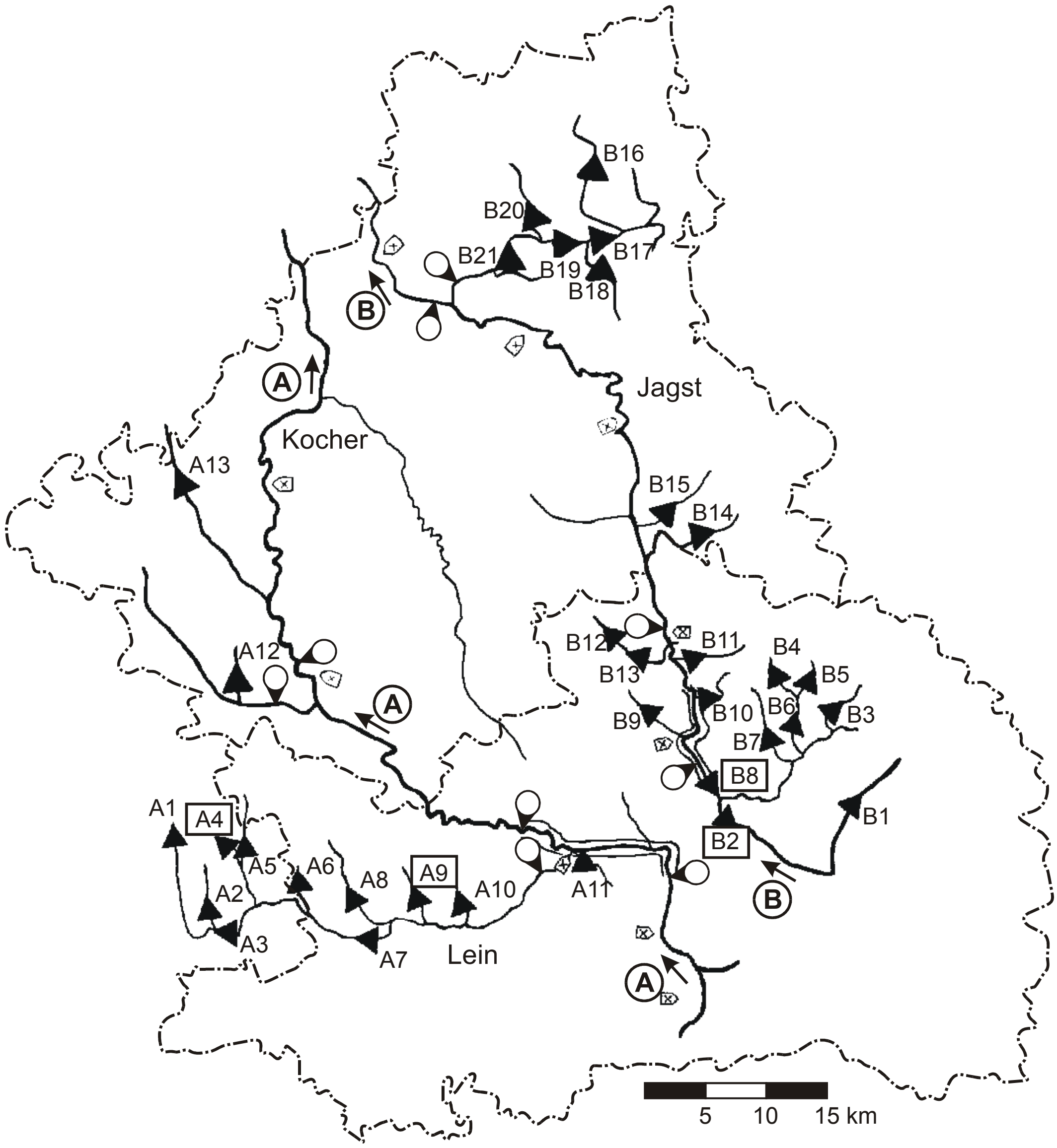

Fig. 2

Catchment area of Kocher-Lein (A) and upper Jagst (B) (Table 1 and 2) with the locations of 13 flood control reservoirs along the rivers Kocher (A) and Lein (tributary), furthermore with 21 flood control reservoirs along the river Jagst (B)

Bassins versants de Kocher-Lein (A) et haute Jagst (B) (table 1 et 2) avec les sites de 13 réservoirs d'écrêtement des crues le long de la rivière Kocher (A) et Lein (tributaire) ainsi que 21 réservoirs d'écrêtement des crues le long de la rivière Jagst (B)

Table 1

Flood retention basins along the rivers Lein (tributary) and Kocher (Fig. 2)

Réservoirs d'écrêtement des crues le long des rivières Lein (tributaire) et Kocher (Fig. 2)

No.	Name	catchment area [km²]	capacity level [m a.s.l.]	maximum flood [m a.s.l.]	max. discharge for the spillway [m³/s]	max. capacity of the reservoir [10³ m³]	max. capacity of the bottom outlet [m³/s]	height of the dam [m]
A1	Aichstrut	5,8	502,07	502,34	8,4	550	5,0	8,00
A2	Eisenbach	7,4	460,20	460,50	14,7	540	7,0	13,50
A3	Leineck	31,9	452,47	453,63	38,0	2.180	15,0	14,00
A4	Hagerwald	14,0	450,90	451,68	24,2	800	12,0	11,00
A5	Hüttenbühl	15,5	448,87	450,19	27,5	530	7,0	11,00
A6	Reichenbach	8,8	440,57	441,59	14,3	900	9,0	16,00
A7	Täferrot	108,7	417,88	419,28	99,0	2.200	27,0	14,00
A8	Rehnenmühle	45,1	427,30	428,30	48,1	2.900	32,0	16,00
A9	Götzenbach	17,4	431,93	432,91	30,2	1.750	16,0	23,00
A10	Federbach	9,6	417,84	418,92	19,7	800	16,0	25,00
A11	Laubach	2,9	392,00	392,70	3,5	190	9,0	13,00

Table 2

Flood retention basins of upper Jagst (B1-B15) and Brettach (tributary, B16-B21) (Fig. 2)

Réservoirs d'écrêtement des crues des rivières haute Jagst (B1-B15) et Brettach (tributaire, B16-B21) (Fig. 2)

No.	Name	catchment area [km²]	capacity level [m a.s.l.]	maximum flood [m a.s.l.]	max. discharge for the spillway [m³/s]	max. capacity of the reservoir [10³ m³]	max. capacity of the bottom outlet [m³/s]	height of the dam [m]
B1	Stockmühle	19	501,80	502,80	39,90	961	4,10	8,00
B2	Buch	81	449,70	450,12	86,60	1070	8,60	9,80
B3	Sonnenbach	9	488,50	489,50	23,90	599	3,30	9,40
B4	Haselbach	8	482,30	483,30	6,20	1350	5,40	10,20
B5	Häsle	10	479,50	480,60	18,50	750	6,40	7,40
B6	Rötlen	22	470,40	471,08	17,00	610	2,80	5,00
B7	Schlierbach	8	482,50	483,02	8,70	635	5,20	8,40
B8	Schwabsberg	175	447,08	447,50	80,00	2720	40,0	12,20
B9	Glasweiher	9	448,50	449,52	7,80	505	6,70	7,50
B10	Kreßbach	8	438,90	439,60	15,80	641	7,00	10,50
B11	Fischbach	17	431,90	432,56	25,50	641	4,00	11,30
B12	Holzmühle	12	?	?	?	190	?	7,80
B13	Orrot	18	437,50	440,00	32,80	1190	11,50	13,50
B14	Reiglersbach	19	431,20	432,50	59,70	964	4,20	9,00
B15	Degenbach	8	420,60	421,80	19,90	650	1,70	9,20
B16	Wiesenbach	19,1	464,77	465,75	60,0	720	10,5	8,00
B17	Breitloh	60,4	412,70	414,00	58,0	242	25,0	8,00
B18	Wallhausen	31,3	423,90	424,90	50,7	36	9,4	4,50
B19	Seebach	45,1	406,50	409,10	66,0	39	1,0	6,50
B20	Bemberg	37,1	417,60	419,00	90,0	1.800	43,0	28,00
B21	Beimbach	157,2	473,5	475,50	240,0	2.660	0,0	28,60

For this reason, protection against flooding has been realized largely by the creation of retention basins and basin systems in the tributary valleys. For the first example the required impounded volume in order to protect the valley of the river Lein, a tributary of the river Kocher (Fig. 2) flowing into the river Neckar, against flooding amounts to some 15 Mio. m³. Up to now, some 13 Mio. m³ has been created, costing 30 Mio. DM. Characteristic datas are presented in Table 1.

One typical example of an executed flood retention basin within the catchment area of the tributary Lein is the reservoir Hagerwald (Fig. 2, number A4). Following the specific datas given in Table 1 the maximum height of the earthfill dam reaches to 11 m (Fig. 3). The spillway, the intake structure of the bottom outlet and the joint stilling basin are pointed out in Fig. 4.

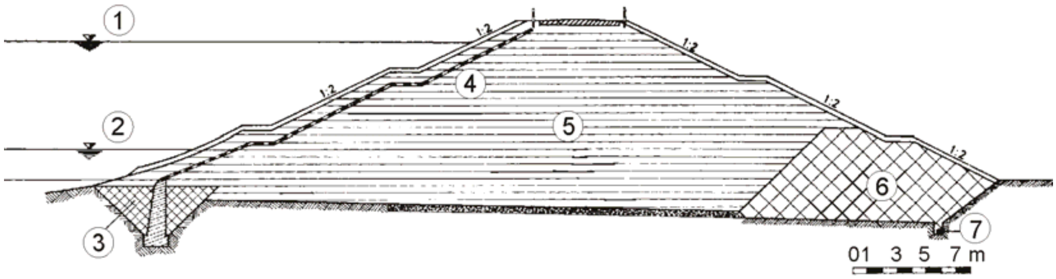

Fig. 3

Cross section of the earthfill dam Hagerwald (Fig. 2, number A4)

Section transversale du barrage en remblai Hagerwald (Fig. 2, numéro A4)

1. maximum head (451,7 m a.s.l.)
2. permanent water level (443,4 m a.s.l.)
3. cutoff wall and clay sealing embedded in rockfill
4. hydraton sealing
5. dam body
6. rock fill
7. drainage

1. niveau d’eau maximal de la retenue
2. niveau d’eau permanent
3. parafouille et matériaux argileux encastré en remblai d’emrochement
4. masque d’étanchéité en „hydraton“
5. corps de barrage
6. enrochement
7. drainage

In addition of them Fig. 5 contains the cross section of the 23 m high earthfill dam for the impounding reservoir Götzenbach, acting as the most important flood retention basin within the catchment area of the reservoir Lein resp. river Kocher (Fig. 2 and Table 1, number A9).

For the second example the river Jagst is a right hand tributary of the Neckar with the total catchment area of 1 862 km². Its catchment area (816 km²) of the upper Jagst lies in the eastern part of Baden-Württemberg and contains a system of fiteen storage basins with a capacity of around 12 Mio. m³, and whose discharges can be regulated (Fig. 2 and Table 2).

Originally in this region, despite the low long-term average annual precipitation of 865 mm, over many centuries disastrous floods have occurred. In the fifties, much thought was given to regulating the flood waves, which led in subsequent years to setting up the “Upper Jagst Water Association” and to the construction of storage reservoirs and water retention basins. Apart from the flood control function, nearly all basins serve for low-flow augmentation of the river Jagst, which carries little water during the summer months. In the past several years, at some of the larger reservoirs and retention basins, facilities have been provided for local recreation amenities, such as swimming, sailing and fishing. Some lakes and parts of lakes not greatly used for leisure activities have been converted into, and designated as, biotopes.

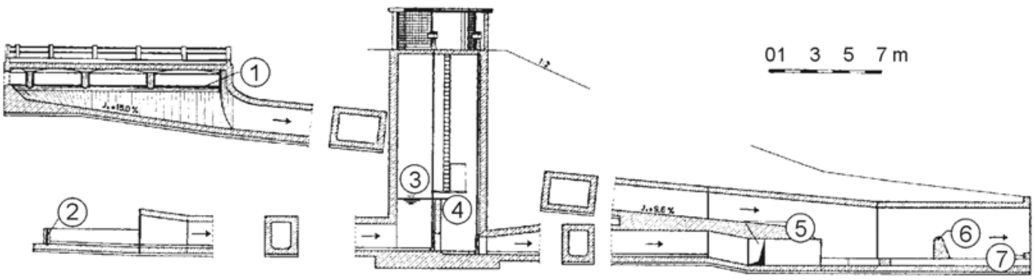

Fig 4

Hagerwald: cross sections of intake structure, spillway, bottom outlet and joint stilling basin

Hagerwald: sections transversales de l’évacuateur des crues, prise d’eau de fond et bassin d’amortissement adjoint

1. weir crest of spillway inlet (450,9 m a.s.l.)
2. bottom outlet with gate
3. valve chamber with bulkhead gate („Mönch“)
4. fixed weir for permanent water level
5. bifurcation of bottom outlet
6. ground sill
7. end sill

1. cote du seuil déversant d’entrée de l’évacuateur
2. vidange de fond avec vanne
3. chambre de vanne („Mönch“)
4. seuil déversant au niveau d’eau de la retenue permanent
5. bifourcation de la prise d’eau de fond
6. seuil de fond
7. seuil de sortie

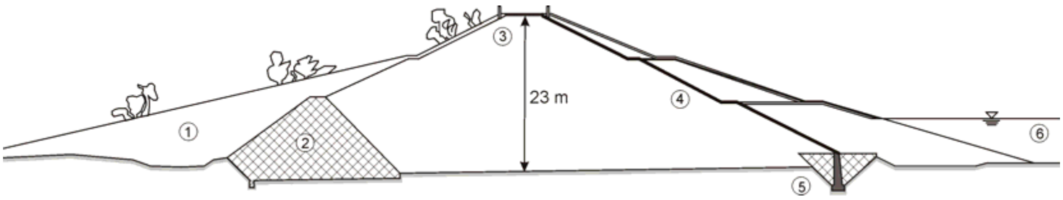

Fig. 5

Cross section of the earthfill dam Götzenbach (Fig. 2, number A9)

Section transversale du barrage en terre Götzenbach (Fig. 2, numéro A9)

1. sloped material of dam excavation
2. rock fill
3. dam body
4. asphaltic sealing
5. cutoff wall and clay sealing embedded in rockfill
6. permanent water level

1. talus en matériau de fouille du barrage
2. remblai en enrochement
3. corps de barrage
4. masque d’étanchéité asphaltique
5. parafouille et matériaux argileux encastré en remblai d’enrochement
6. niveau de retenue permanent

In the following, the focus will be on the Buch and Schwabsberg basins.

The water storage and retention basin Buch (Fig. 6) was constructed between 1975 and 1991. Its catchment area amounts to 84 km², the mean water outflow to 1.1 m³/s, and the hundred-year-flood inflow to 54 m³/s. The basin has a total reservoir capacity of 1 150 000 m³, occupying an area of 29,6 ha. During the summer months, for local amenity purposes, a permanent water volume of 680 000 m³ is retained, covering an area of 25.8 ha; which means that in summer the capacity available for flood control is 470 000 m³. In the winter time, with a lowered water level in the reservoir, flood control capacity is increased to 1 070 000 m³.

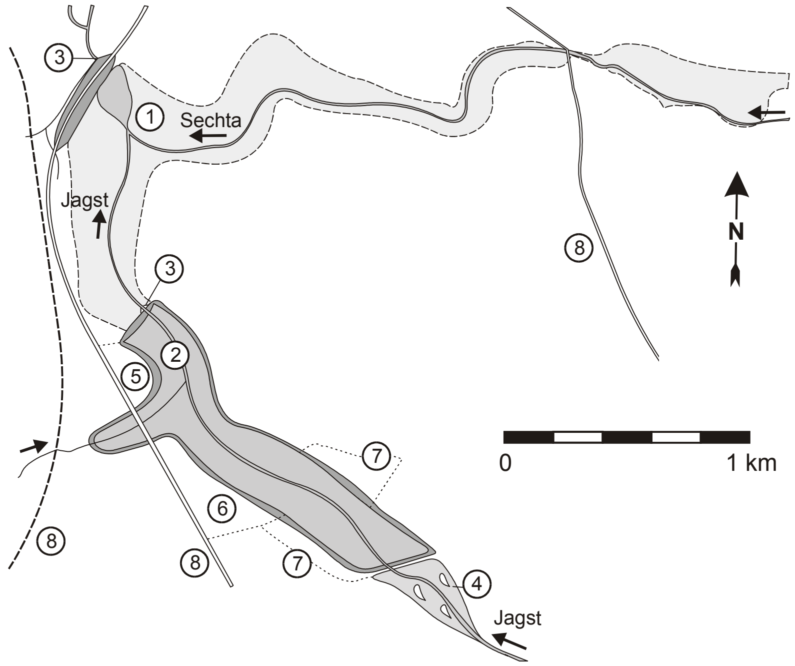

Fig. 6

Schwabsberg (1) and Buch (2) reservoirs

retenues de Schwabsberg (1) et Buch (2)

1. Schwabsberg reservoir
2. Buch reservoir
3. dam with outlet
4. sedimentation reservoir with bird islands
5. playing and swimming area
6. swimming area
7. nature area
8. road/railway

1. retenue de Schwabsberg
2. retenue de Buch
3. barrage avec prise d'eau
4. basin de sedimentation avec île d'oiseaux
5. aire de jeu et natation
6. aire de natation
7. aire naturelle
8. route/chemin de fer

The impounding structure consists of an earthfill dam with a clay core. The slope on the reservoir side is covered with concrete paving. The dam of 240 m length and up to 9.8 m in height is founded on impermeable marl, and its crest width is 7.0 m. The square (2.0 x 2.0 m) bottom outlet is located in the northern part of the dam, and leads to a gate shaft with upflow baffle. Installed in the gate shaft is a bottom outlet sluice gate (1.5 x 1.5 m). This roller sluice gate can be operated by an electrically driven spindle winch as well as manually. The discharge capacity of the gate amounts to 12 m³/s. For fine regulation of the water level or low-flow augmentation, a further regulating gate of 0.5 m diameter with mechanical drive is installed.

The spillway installation consists of two independently controllable gates of the fish belly type 0.8 m x 5.4 m and 1.5 m x 14 m in size, which drain by way of a stilling basin into the adjacent Schwabsberg basin. At the maximum water level, the total outflow capacity of these gates amounts to 77 m³/s.

The Schwabsberg retention basin was constructed between 1972 and 1974 (Fig. 7). Its catchment area is 175 km². The mean water outflow amounts to 1.9 m³/s, and the hundred-year-flood outflow to 100 m³/s. The Schwabsberg basin is located immediately downstream of the Buch basin described before. This basin has a gross reservoir capacity of 2 740 000 m³ and occupies an area of 83 ha. The low permanent storage capacity of 20 000 m³ and water covered area of 2.0 ha is negligible, which means that it can be designated as a “dry basin”. Characteristic datas are presented in Table 2 with respect to number B8 in Fig. 2.

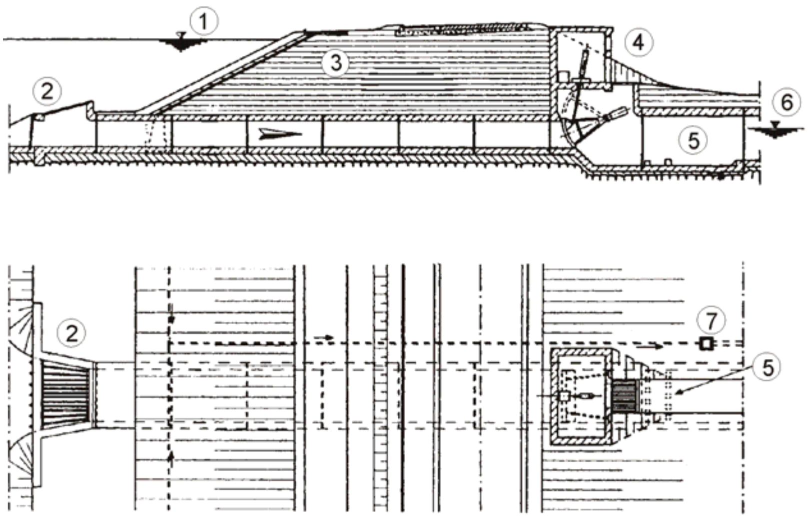

Fig. 7

Cross section and layout of the flood retention basin Schwabsberg (Jagst) with bottom outlet and stilling basin (Fig. 2, number B8)

Section transversale et vue en plan du réservoir d’écrêtement des crues Schwabsberg (Jagst) avec prise d’eau de fond et basin d’amortissement (Fig. 2, numéro B8)

1. maximum water level (446,9 m a.s.l.)	1. niveau d’eau maximal
2. inlet structure with trash rack	2. prise d’eau avec grille d’entrée
3. dam body	3. corps du barrage
4. radial gate	4. vanne segment
5. stilling basin	5. bassin d’amortissement
6. tail water level	6. niveau d’eau aval
7. drainage	7. drainage

The impounding structure comprises a rock/earthfill dam, waterproofed on the reservoir side with clay. Its length is 450 m and its height 8.5 m. The crest width is 20.4 m. The operating outlet with a cross section of 5 m x 2.5 m can be closed by a radial gate driven hydraulically and electrically. In the event of a power failure, the gate may be operated manually. The maximum discharge capacity of the operating outlet amounts to 95 m³/s. The spillway consists of a lowered dam section, 60 m long, serving as a fixed overflow sill. The discharge capacity of the overflow sill is, at maximum water level, 115 m³/s.

For the summer operation of the Buch storage and retention basin, as a rule, the basin is filled up to its permanent top water level. The water flows over the gate into the “Mönch” outlet structure. The inspection gate remains open. All other outlets are closed. In the event of impending floods, the water level is regulated up to its maximum continuous point by way of the Mönch. If the water level continues to rise, control of the basin is transferred to the automatic bottom outlet gate, which is opened in increments. If, despite opening this gate fully, the water level continues to rise, then in sequence fish belly gate 1 (small) is operated, and after an interval fish belly gate 2 (large). Control of the gates is automatic, depending on predetermined water level monitored by means of a float gauge. The levels can be adjusted according to the requirements of water management. In winter, the basin is normally emptied down to its minimum level. Basin outflow is by way of the regulating gate. The inspection gate is opened. All other water outlet devices are closed. In the event of impending floods the bottom outlet gate is opened to a clearance of 80 cm. This position is retained even if the basin level, regulation is transferred, like in summer operation, to the fish belly gates.

During normal operation, the water level of the river Jagst is regulated to its desired value by the fish belly gate in the weir downstream of the dam Schwabsberg. This gate is moved automatically in accordance with the arriving water flow, controlled by way of a level gauge switch. The radial gate in the dam outlet structure is completely open, and the radial gate drive is disconnected during normal operation of the basin. In the event of impending floods, the radial gate is regulated manually so that the basin outflow will not exceed 40 m³/s. Upon attaining the maximum impoundment level, the radial gate is opened to 95 m³/s, the maximum discharge, in order to maintain the basin water level. In the event of a still increasing flood wave, the non-controllable spillway (overflow sill) becomes effective. If the flow increases in an extraordinary way, the radial gate is opened fully. The downstream fish belly gate is operated to evacuate the arriving flow.

SUMMARY

One of the most significant benefits resulting from construction of a dam is the long-term and efficient protection that detention reservoirs provide against floods. They modify the natural flow of a river respectively its hydrograph suppressing or even avoiding the occurence of flooding downstream areas. Flood-control reservoirs, created by concrete or earthfill dams, not only store the

flood water but also reduce the peak flow and considerably slow down the discharge in the river reaches downstream of the dam. This management of flood flows depends upon the outletworks and gated or nongated spillways.

For this kind of river basin management nearly 350 flood retention basins of different size have been constructed in the state of Baden-Württemberg during the last decades. In all cases they form a unit with the river course. Therefore flood protection measures have to be implemented with the highest possible degree of environmental compatibility. A sensitive approach has to be taken. Prior to their implementation, not only the locally achievable flood protection but also their impacts as a whole on the discharge behaviour of the water course system, the ecology and the landscape appearance have to be taken into account.

For the latter criteria, together with the economic efficiency, earthfill dams are mostly preferred. The heights of them reach from a few meters to 30 m refering in particular to the mentioned flood control reservoirs. There are no differences to the conventional impounding reservoirs with respect to aspects of planning, construction, operation, maintenance and security, except the fact being temporarily used for flood retention by normally empty, i. e. agriculturally used, or partly impounded basins, advantageous for leisure centres and water sports.

The paper describes in detail the general significance of flood control basins, their constructional design including the concerning standards and regulations, furthermore the operational aspects. These principles will be illustrated by the outstanding example of a system combining 14 detention reservoirs along the river Lein with a catchment area of 247 km^2. This river basin is located in the northwestern part of Baden-Württemberg, Germany, a hilly region with a high rate of precipitation and dangerous flood events due to a small storage capacity of the underground. Thanks to the total retention volume of more than 15 Mio. m^3 the peak discharge at the mouth into the main river Kocher (tributary of the river Neckar) will be reduced to 60 %.

RESUME

Un des plus grands et importants résultat de la construction d'un barrage est la protection efficace et à long terme contre les événements de crues et d'inondations. Ces réservoirs d'écrêtement des crues modifient le cours naturel des rivières, autrement dit des hydrogrammes, en évitant la formation de crues dans les surfaces en aval.

Les barrages de contrôle de crues construits en béton ou remblai, n'emmagasinent pas seulement l'eau des crues mais réduisent aussi le débit de pointe considérablement et ralentissent l'écoulement en aval du barrage. Le management des crues dépend des travaux de vidanges des déversoirs avec ou sans vannes.

Si les avantages de tels systèmes de contrôle des crues pour les régions en aval qui sont proches du barrage est évident, il y a encore beaucoup de progrès à faire en ce qui concerne l'optimisation des lâchers d'eau lors de la superposition des ondes de crues provenant de différentes rivières.

Pour ce genre de gestion des bassins de rivière, on a construit dans l'état fédéral du Baden-Württemberg plus de 350 bassins de rétention des crues ces dernières décennies. Dans tous les cas, ces constructions forment une unité avec le cours de l'eau. C'est la raison pour laquelle l'implémentation de mesures de protection contre les crues requit une compatibilité environnementale élevée. Une approche sensible du problème est indispensable.

Avant q'une telle implémentation soit faite, ce n'est pas seulement la protection locale contre les crues mais aussi l'impact du comportement global de décharge des eaux dans un système de rivières, l'écologie, la nature environnante ainsi que l'aspect visuel qui doivent être considérés

Pour le dernier critère, en plus de l'efficacité économique, les barrages en remblai sont préférés. Leur hauteurs peut aller de quelques mètres jusqu'à 30 m, se référant en particulier aux réservoirs de contrôle des crues cités. Il n' y a pas de différence entre les dits bassins et les bassins conventionnels d'emmagasinement des eaux en ce qui concerne la planification, la construction, les opérations, l'entretien et la sécurité, excepté le fait que les bassins de rétention sont utilisés temporairement. Pendant les périodes d'écoulement normales, ils sont habituellement vidés et utilisés dans l'agriculture ou partiellement remplis, ce qui est avantageux pour des centres de loisirs et des sports aquatiques.

Cet article décrit en détail la signification générale des réservoirs d'écrêtement des crues, leur conception en construction en incluant les normes et régulations appropriées ainsi que l'aspect opérationnel. Ces principes seront illustrés par un remarquable exemple du système combinant 14 réservoirs de rétention au long de la rivière Lein avec une superficie du bassin de 247 km^2. Celui-ci est localisé au nord-est de l'état du Baden-Württemberg, Allemagne, une région de collines avec une pluviométrie abondante et des événements d'inondations dangereux dus à la capacité de rétention restreinte du sous sol. Grâce au volume de rétention total de plus de 15 millions m^3, le débit de pointe à l'embouchure de la rivière Lein dans la rivière Kocher (tributaire de la rivière Neckar) sera réduit à 60 %.