THE CONSTRUCTION OF THE LEIBIS-LICHTE DAM: ECOLOGICAL INFLUENCES AND POSSIBILITIES OF THERE MINIMISATION

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SUMMARY

The Thuringian Dam Administration plans the completion of the drinking water reservoir Leibis-Lichte in the Thueringia Slate Area. This project is necessary to avoid a serious decrease in water quality and water quantity. Indeed, the construction of this dam and the management of the new reservoir will implicate serious changes of the environment. This is why an impact study was done in order to estimate all possible environmental changes all round of the planned reservoir. Appreciable damages would result from flooding and and by the "barrier effect" of the dam. Beside these effects, the environmental authority was afraid of a negative impact on a protection zone recommended by European Union, located in the downstream of the reservoir. The approval to complete the reservoir system by a dam is connected with the compensation measures for all environmental impacts. One project of these compensation plan is the preparation of guidelines for an ecological water management of the reservoir in order to reduce the negative influence on the ecosystem downstream.

Furthermore a monitoring program takes place to investigate all natural components in the river system in the downstream of the planned dam. The aim of this program is the control and estimation of the impact on the environment before, during and after the construction of the new reservoir.

RÉSUMÉ

L'administration Thuringienne de barrage projète l'achèvement du barrage de Leibis-Lichte dans les monts ardoise de Thuringe. Ce projet est nécessaire afin d'éviter les problèmes de qualité et de quantité de l'eau. La construction du barrage et l'exploitation du barrage nouveau conduit à l'influence d'environnement. Ces influences on a constaté en résultat d' une étude de l'impact sur l'environnement. Cette analyse a compris tous les éléments concernant de barrage projeté. Il y a des influences à cause du perte de surface au réserve futur par l'inondation et dans l'effet de barrière du barrage.

En outre on attend des effets d'un CE- réserve naturelle (EU- Special Protection Area) en cours de la rivière au- dessous du barrage. L'consentement à l'achèvement du système barrage fut donné à la condition de compenser considérablement les influences du barrage. Les mesures de compensation sont compris dans un plan du paysage. Un projet de ce plan est le développement des directives pour une exploitation écologique du barrage afin de minimiser les influences négatives sur le système écologique. En outre a lieu un programme de visite afin de recenser tous les informations écologiques à la part d'en bas du barrage. Le but de ce programme est de saisir les influences du barrage pendant sa construction et sa mise en exploitation en comparaison d'état actuelle.

KEYWORDS

Drinking Water Reservoir, Dam Construction, Ecology, Environmental compatibility, Water Management, Monitoring

1 INTRODUCTION

The planning work of the Leibis-Lichte project started already in the 1970th. In fact, it became clear that the quantity of water was not enough because of growing demand. The start of the provisional operation took place in 1992. The tentative system comprises one pre reservoir, transfer tunnel of 11 km length and the drinking water treatment plant. The main dam, the Leibis-Lichte Dam (32,4 hm^3 effective storage volume) is not built yet. Nowadays, the water storage has been drastically reduced in comparison to the old plans (Fig. 1).

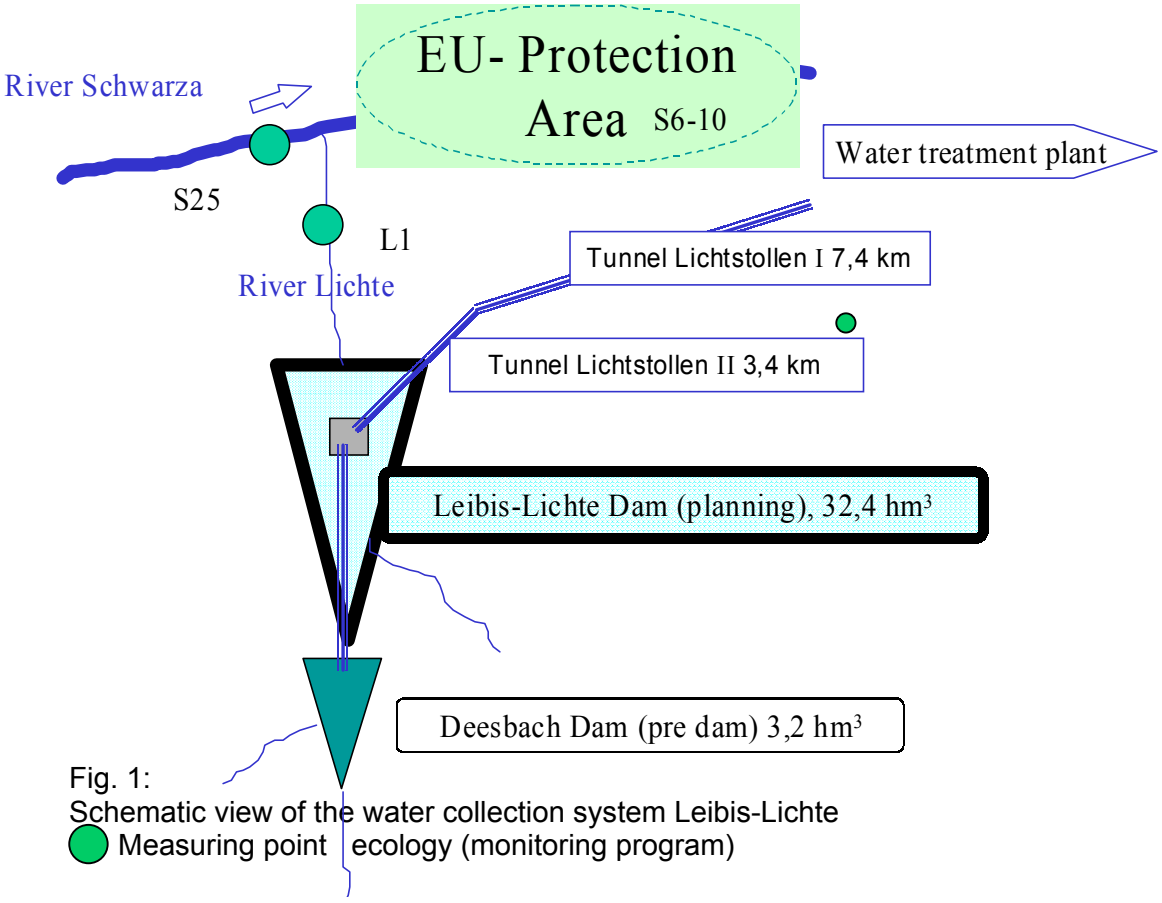

Fig. 1:
Schematic view of the water collection system Leibis-Lichte
Measuring point ecology (monitoring program)

L'aperçu schématique sur le system d'extraction d'eau de Leibis- Lichte
La station d'observation de l'écologie (le programme de visite)

The necessity to build a new dam resulted from the fact, that the production of drinking water in the eastern of Thuringia suffered from both aspects quality and the quantity. At this point, the supply is given by managing an eutrophicated reservoir system called "Weida/Zeulenroda/Lössau" and the polytrophic pre-reservoir Deesbach. The Leibis-Lichte Dam will help to stabilase the supply in drinking water in eastern Thuringia. Therefore the Thuringian Dam Administration

applied for the governmental approval in 1993 [10]. An essential precondition for the governmental approval is the control and investigation of environmental compatibility. The impact study, which costed about 3 Mio. DM, found out that negative impact can be avoided by flooding the former area in the reservoir and by the so called “barrier effect” of the dam [11]. Beside of these effects the environmental authorities and associations where afraid of a negative impact on the “special protection area” (SPA, recommended by European Union) downstream of the reservoir. The approval for starting this project was given on the 01. July 1998 released with the request for an ecological water type of management of the reservoir [2, 4]. This report shows the possibilities and methods to comply with this demand by discussing two projects: the monitoring program downstream of the dam [2] and the creation of guidelines for an ecological water management [3]. The costs of all ecological projects for compensating be amount to 22 Mio. DM [12] (costs of construction 275 Mio. DM).

2 MONITORING PROGRAM DOWNSTREAM OF THE PLANNED DAM

To minimise the impact of the reservoir on the ecosystem of the river downstream oft the dam it is necessary to describe this ecosystem. Therefore a complete monitoring program was started in 1999 [2]. The probable duration of this investigation will be of 11 years.

There are 20 measuring points where physico-chemical and biological parameters where monitored between the planned dam and the EU-special protection area (fig. 1). Furthermore exists a reference point outside of the influenced area. (fig. 1, S 25). The frequency of the investigations depends on the speed of change of the criteria. For example the sediments are investigated only once a year whereas the fauna monitoring takes place three times a year and the chemical data are analysed 12 times a year. A detailed description of the program is given in [2].

Tab. 1: Monitoring program downstream of the planned Leibis-Lichte Dam
Le programme de visite au- dessous du barrage projeté

Investigated object	**Method**
Sediments of the waters	Analyse of gravel, evaluation of geological data
Hydrology, Meteorology	Evaluation and measurement of hydrological and meteorological data
Hydrodynamic	Surveying of river profiles, Measurement of flow velocities
River morphology	Registration of gravel islands, Analysis of grains size, total organic carbon
Vegetation	Registration and investigation of vegetation
Fauna	Sampling of imagines, macrozoobenthic organisms, interstitial organisms by surber-sampling and freeze-coring, different depths in the sediment, fish fauna by electric fishing
Water chemistry	Flowing water and interstitial water, Online data – logging of physical criteria and labor-analysis of nutrients and other components

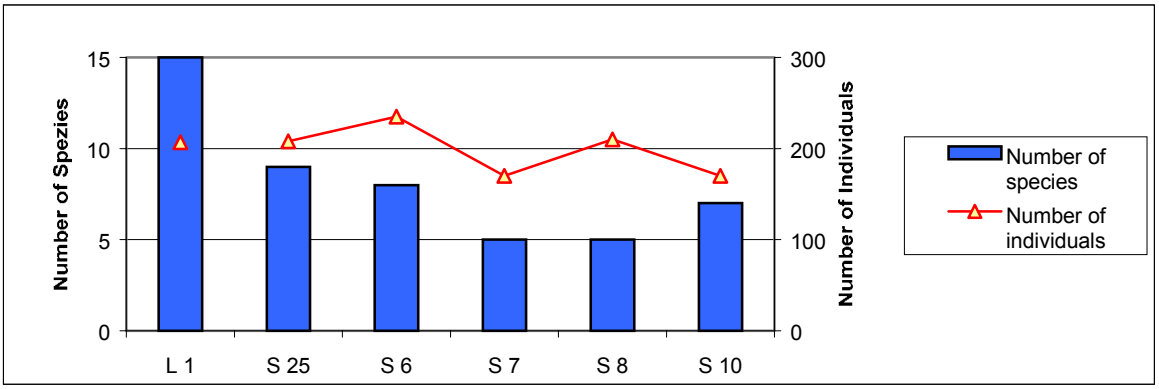

Fig. 2: Example from monitoring program: Evaluation of the number of Species and Individuals of Plecopterea, 1999 [2]
L1 = Measuring point below the planned dam
S 25 = Reference point outside of the influence of the planned dam
S 6, 7, 8, 10 = Measuring points in the influence of sewage water

Un exemple du programme de visite: Le dépouillement du nombre des sortes et des individus des Plecoptera, 1999
L1 = La station d'observation au- dessous du barrage projeté
S 25 = Le modèle de station d'observation à l'extérieur de l'influence du barrage
S 6, 7, 8, 10 = La station d'observation avec l'influence d'eaux urbaines résiduelles

The result of the investigation between 1999 and 2000 was, that the worse impact on the river ecosystem downstream of the dam is caused by sewage water. On the other hand the hydrodynamics and the river morphology are less changed and primordial. The impact of the tributary river “Lichte” (which will be directly blocked up by the Leibis-Lichte Dam) on the river Schwarza in the SPA is also less important. But other possible influences caused by the construction and operation of the dam cannot yet be forecasted. Therefore, it is necessary to undertake this investigations for a relatively long period at least eleven years.

The results of the program can help to determine the ecological changes especially after the construction of the dam and while it is utilised as a source for the production of drinking water. This study also helped to find out about the most ecological changes while the dam was under construction by means of several online measurement points.

All in all, this results are used to optimise the ecological water management of the reservoir. Quantitative water protection [9] is equally important like shelter from inputs of nutrients [1] and harmful chemicals [5].

3 ECOLOGICAL WATER MANAGEMENT OF THE LEIBIS-LICHTE RESERVOIR

Large dams more or less affect the rivers downstream of the dams [7, 13]. Generally the following influences are possible (Tab. 2).

A reduction of the described effects is possible by an integral water quality-quantity management [8, 9].

The following aspects have to be investigated:

- Which ecological status should be reached and preserved?
- Which technical management possibilities exist to manage the water discharge?
- Which hydrological background is available?

The ecological status downstream of the Leibis-Lichte-Dam will be well investigated by the monitoring program [2] (Tab. 1). Furthermore the Thuringian Reservoir Administration is undertaking an investigation to find out about the ecological conditions of other rivers downstream of their dams in order to measure the impact of these dams [4]. Both projects help to define the ecological status.

Tab. 2: Possible influences of large dams on the rivers downstream of the dam

Des influences possibles des grands barrages sur des eaux courantes au- dessous du barrage

Influence	**Possible Effects**	**Possible Control**
A) Mixed reservoir (polymictic reservoirs and dimictic reservoirs in spring and autumn)		
Uniformly aliquot discharge	Occlusion of interstitial	Dynamical discharge Simulated by inflow Dynamical discharge Controlled by time
Too less discharge small	Reduction of fish habitats Reduced dilution effect in case of waste influence downstream	Discharge increase
Keeping of sediment in the reservoir	Deepening and eluviation of the riverbed	No reservoir control If necessary artificial formation along the riverbed downstream
Barrier against migration of animals (fish, insect larvae, crustacea)	Reduction of species diversity downstream and upstream of the reservoir	Technical helps (Stairs for fish)
Drift of plankton (from eutrophic reservoirs)	More food for micro- and makrozoobentic organisms, changes in ecosystems	No control
B) Stratificated reservoir (i.e. dimictic reservoir in summer and winter, ice cover)		
Cold deep water	Changes in ecosystems, Restriction of development and growth	Change of discharge level upwards in accordance with temperature
Depletion of oxygen (deep water)	Regression of biodiversity	Change of discharge level in accordance with oxygen content (usually upwards) Buildings for aeration upstream
Increasing of H_2S and NH_4 concentrations (deep water)	Regression of biodiversity	Change of discharge level in accordance with oxygen content (usually upwards) Construction measures for aeration upstream
Increasing of soluble phosphorus and dissolved organic carbon (in case of anaerobic deep water)	Growth of algae upstream, eutrophication	Change of discharge level in accordance with SRP and DOC (usually upwards)
Drift of plankton (from eutrophic reservoirs, surface water)	More food for micro- and makrozoobentic organisms, changes in ecosystems	Change of discharge level in accordance with chlorophyll and turbidity

The main task is an optimising of the ***hydrological management***. This management will be defined in the water management guideline, which is elaborated at present.

The following steps have been done in detail:

- ***Elaboration of a water management model***
  A special software is developed (deterministic balance model; Mathcad, Excel), which considers the different management rules. The main focus refers to the calculation of the drainage of the river Schwarza and the creation of evaluation methods to simulate different system conditions.

- ***Calculation of hydrological conditions which are necessary to conserve the temporary ecological status of the river downstream of the dam***
  Parameter, which are influenced by the quantity of runoff are defined. These are:

- The dynamics of flow velocity (frequency of maximum and minimum) and
- the dynamics of water levels.

  These dynamics affect the transport of stones and gravel, the occlusion of interstitial, the living conditions of macrozoobenthic organisms and fishes and the borders of vegetation. In case of the river Schwarza the water level should f. e. not fall below 30 cm (0,7 to 1,7 m^3/s) to keep proper conditions for fish migration [3].

  Further parameter will be calculated such as transpiration, precipitation etc..

  The simulation is based on determinate daily measurement values. In the result of the simulation one gets information about:

- water level of the reservoir,
- potential discharge from the reservoir
- guaranteed quantity of water for drinking water supply
- flow statistics
- water levels in the river downstream
- frequency of minimum and maximum (fig. 3).

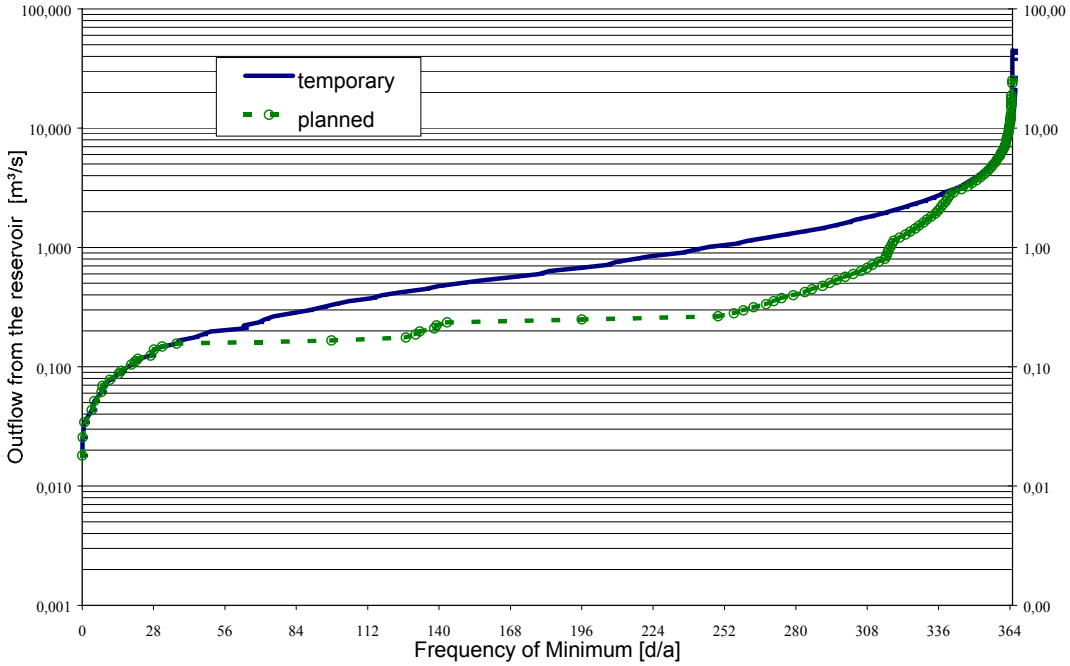

Fig. 3: Example of the simulation of the frequency of minimum outflow from the reservoir in the area of the planned dam

Un exemple pour la simulation de l'échelle de minimum de l'écoulement de l'eau du barrage au- dessous du barrage projeté

- ***Determination of concrete requirements on the water management***
  Depending on technical prerequisites and realities control regulations are defined. These regulations consider the hydrological and ecological aspects in view of the main task of the reservoir, i. e. the drinking water supply.

First results became available recently [2, 3]. Particular attention is required for dynamic control of outflow [7]. Floods and dryness will simulate. For this purpose the model TalSim (TH Darmstadt) [6] will be tested.

The new rules and water management regulations became tuned by the Thuringian authorities.

4 ASPECTS FOR THE FUTURE

The monitoring program downstream of the planned Leibis-Lichte Dam and the creation of an ecological type of water management are essential components to reduce the impacts of the new dam. A lot of further projects (projects of compensation, formation and replacement) in the vicinity of the dam and in overall Thuringia shall contribute that other ecosystems become more valuable. These are projects like the renaturalization of running waters, the implementation of an ecological project management during the construction of the dam, and the resettlement of threatened birds (*Tetrao urogallus*). It can be assumed, that after the completion of the Leibis-Lichte Dam the water supply in eastern Thuringia and the nature in the Leibis-Lichte area will be stabilised.

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