USE OF MULTIPURPOSE RESERVOIR VOGRŠČEK – STATUS AND POSSIBILITIES

Matjaž Tratnik B. Sc., PhD student[1]; Silvana Batič B. Sc.[1], Marina Pintar, prof., PhD[2]; Majda Černič – Istenič, prof., PhD [2], Franci Steinman, prof., PhD[3]

[1]Hidrotehnik d.d., Unit Nova Gorica, [2]University of Ljubljana, Biotechnical faculty
[3]University of Ljubljana, Faculty of Civil and Geodetic Engineering

ABSTRACT

Vogršček reservoir is a multipurpose reservoir, primarily used for irrigation of agricultural land (84.5 % of volume) and flood protection (15.5 % of volume). Together with Vipava River it should have been a water source for about 3,500 ha of irrigation systems. Project of new irrigation systems in wider area of the Vogršček has not been completed as planned and therefore the use of water for irrigation after 25 years of reservoir operation is far from optimal. On average less than a third of the water available for irrigation is used per year. Due to questionable safety of the reservoir dam, water level in the reservoir has been reduced for 6.8 m. After completion of planned major rehabilitation of the dam, water level should be raised to normal. When taking new investments in infrastructure it is necessary to consider whether and how reservoir potentials will be recognized and exploited. This paper deals with the use of the reservoir for irrigation purposes so far and with the potential of that use according to the existing non-irrigated areas and changes in the water balance of the reservoir. There are also discussed other uses of the reservoir that are present in and around of the reservoir, but their status in the context of the operation of the reservoir is not defined and their development is also not identified as a development opportunity of the area.

1. Introduction

Water analysts foresee increased competition among water users in meeting the growing demand for water. They predict that competition will increase among the three largest water users in global terms: agriculture (currenty accounts for about 67 % of withdrawals), industry (19 %) and municipal and domestic uses (9 %) (World comission on dams, 2002).

Water for different purposes may be stored in large accumulations constructed using large dams. Most of the dams are single-purpose dams, but there is now a growing number of multipurpose dams also. Using the most recent publication of the World Register of Dams, irrigation is by far the most common purpose of dams. Among the single purpose dams, 48 % are for irrigation, 17 % for hydropower, 13 % for water supply, 10 % for flood control, 5 % for recreation and less than 1 % for navigation and fish farming (ICOLD, 2013). The importance of non-irrigation uses to the livehoods has generally been ignored both in planning and operating these systems. An improved understanding of competition and complementarity of all water demands is essential for effective multiple-use management (Li et al., 2005). Irrigated areas contribute 40 % of agricultural production, from only a fifth of agricultural land. Based on data covering approximately 73 % of the 271 milion ha of irrigated lands worldwide, the proportion of irrigated area supplied by large dams is estimated to be between 30 and 40 %. A broad estimate of agricultural production dependent on dams can be derived by multiplying these figures by the 40 % of global agricultural production attributed to irrigation. This simple calculation indicates that 12–16 % of global agricultural production is dependent to some extent on large dams (Bird and Wallace, 2001).

Large dams designed to deliver irrigation services have typically fallen short of physical targets, did not recover their costs and have been less profitable in economic terms than expected. Under performance is most noticable during earlier periods of project life, as the average achievement of irrigated area targets increased over time from around 70 % in year 5 nearing 100 % by year 30 (Bird and Wallace, 2001). It is common perception that irrigation systems supply water only to field crops, but the true picture is more complicated. Even within the agricultural sector, irrigation systems suply water not only for the main fields, but also for home gardens cultivation and livestock (Li et al., 2005). In dry climates, evaporation from large reservoirs, estimated at close to 5 % of total water withdrawals, may also be a significant consumptive use of water (World comission on dams, 2002).

Environmental consequences should be recognized in a dam project and should be considered in project selection, planning and design. This means a significant advance of human development on a basis that is economically viable, socially equitable and environmentally sustainable. Any kinds of human development activities to transform the natural environment, especially largescale infrastructure projects, require land and other immovables (Altinbilek, 2002).

This paper deals with the use of the reservoir Vogršček for irrigation purposes so far and with the potential of that use according to the existing non-irrigated areas and changes in the water balance of the reservoir. There are also discussed other uses of the reservoir that are present in and around of the reservoir, but their status in the context of the operation of the reservoir is not defined and their development is also not identified as a development opportunity of the area.

1.1 Vogršček Reservoir

Vogršček reservoir is located in lower Vipava Valley (west of Slovenia), about 10 kilometres from Italian border. Reservoir was built in late 1980's when extensive works to ensure optimal conditions for intensive vegetable production took place in the Vipava valley. Site for the reservoir was chosen because of its favorable location in narrow valley, where the

ratio between the amount of material needed for dam construction and volume of the predicted reservoir water storage capacity was 1 : 37 (VGI, 1983). Also on the flooded area there were mainly forests, meadows and only some land with intensive production.

The reservoir is composed of two parts – the small upper and large main reservoir, separated by highway embankment. The main inflow stream called Vogršček flows into the upper reservoir, where water level is constant. The upper reservoir dam - highway embankment - is 17.9 m high (VGI. 1983).

From the upper reservoir through the fixed shaft spillway, water flows to the main reservoir where water level fluctuates depending to water use and weather conditions. Vogršček main reservoir dam is combination of earthfill and rockfill embankment with a rock and stone protection overtopping water side and grass on air side. Reservoir dam is 35.4 m high and 174.0 m long. Due to the large reservoir volume regarding small catchment area (11.25 km2), average full recharge would take 18 months (VGI, 1983).

1.1.1 Reservoir operation

Reservoir is property of Republic of Slovenia, operated by Slovenian environment agency (ARSO) and their subcontractor (concessionaire). Functioning properly (as designed), reservoir full volume is 8.50 x 106 m3, and can be divided into two parts:

a) Useful volume:
   - Irrigation water – 6.80 x 106 m3 (84.5 % of the useful volume of the reservoir)
   - Flood water retention – 1.25 x 106 m3 (15.5 % of the useful volume of the reservoir).

b) Minimum water content: 0.45 x 106 m3.

Maximum water level is defined at 100.5 m a.s.l. and minimum water level is at 80.0 m a.s.l., allowed water level fluctuaton and useful water storage is between altitudes mentioned, meaning 20.5 m of water level fluctuation. Between normal water level of the main reservoir at 98.8 m a.s.l. and maximum water level (100.5 m a.s.l.) volume for flood water retention is provided.

Normal water level of upper reservoir is at 99.3 m a.s.l. (V = 0.25 x 106 m3), maximum water level is 102.5 m a.s.l. (V = 0.54 x 106 m3) (VGI, 1983). Minimum flow downstream the dam is 15 l/s. Through the body of the dam there are three pipes; two of 1200 mm diameter with valves at downstream end of reservoir, intended for water release control (bottom outlet) and one pipe of 1000 mm diameter for irrigation water abstraction. Due to bad condition, that intake pipe was filled with concrete in 2012.

1.2 Condition of infrastructure

Since the end of 2007, due to intake pipe leakage in the air side of the dan, the reservoir does not function optimally, which means that it can not be filled to normal altitude – 98.8 m a.s.l. For safety reasons it was first determined maximum altitude at 93.6 m a.s.l., but later it was lowered to 92.0 m a.s.l., which is still the case (6.8 m lower than normal level) (Presentation ..., 2012). Since 2007 intake pipe and abstraction facility in water side of dam are out of order and water is not abstracted from top of the reservoir as constructed, but from bottom of the reservoir, using one of water release control pipes. Such a mode of operation of existing infrastructure causes problems in irrigation practice as there is more silt in the water for irrigation and water is cooler than in surface of reservoir. Reduced water level in the reservoir also causes higher operation costs of irrigation systems as more pressure has to be added to irrigation pipes (using pumps). After intake pipe leakage in 2007, the dam was already examined in great detail and it was concluded that it needs great repair works and investment maintenance. So far, only the first phase of rehabilitation has been carried out – although the water level in the reservoir is currently reduced, irrigation is still possible. It is

necessary to find an appropriate technical solution for comprehensive rehabilitation of the dam infrastructure, and provide resources for its implementation.

2. The use of the reservoir

The use of the reservoir is defined by building permit, operation details and terms of use are specified in documents named Procedure for the operation and maintenance of the reservoir Vogršček in Vipava valley (Procedure …, 2008). As has already been pointed out in the introduction, it often happens that there is a gap between the intended use of infrastructure (reservoirs) and the actual use at any given time.

2.1 Planned use

Primary purpose of the reservoir is irrigation of agricultural land. As planned, Vogršček reservoir, together with the Vipava River, should provide water for irrigation of approximately 3,500 hectares. Even before the reservoir construction, large-scale irrigation schemes throughout the lower Vipava valley were planned so that it would be possible to irrigate great part of areas suitable for irrigation, but plans were only partly realized.

Beside irrigation, reservoir as planned has a role in flood protection of villages downstream the reservoir. There is 1.25 x 106 m3 of retention volume available for flood protection in the reservoir.

Immediately after the completion of the reservoir use for tourism was also planned and some landscaping plans were done. So far no infrastructure intended for tourism development was built.

2.2 Existing use

2.2.1 Irrigation

Location of the reservoir at higher altitude as most parts of irrigation fields allows a majority of irrigated area to be supplied with water by gravity with no need to add pressure in irrigation pipes. Irrigation water intake facility on water side of dam has no pumps installed, if necessary more pressure is added to irrigation system with two pumping stations that are on the irrigation pipeline downstream in valley.

Despite the fact that the reservoir is primarily intended for irrigation, its use for this purpose is far below its potential use or planned use in the past. The gap between planned and actual use occurred primarily because irrigation project has not been completed. More than 3,500 ha were planned to be supplied with water from reservoir. The official data of Ministry of agriculture and the environment reveals that irrigation system discussed consists of 16 irrigation districts of 981 ha of total size (22 ha to 160 ha). Irrigation system's areas were built gradually (even before 1988 when Vorgršček reservoir was finished), but since 2000 no new areas has been added and also on existing irrigation districts there is poor utilization of irrigation possibilities. Water use for irrigation varies between years, from 0.72 x 106 m3 in 2008, when the irrigation season was due to urgent repair works shortened, to 3.35 x 106 m3 in 2007(Figure 1).

The average annual water consumption for the period 1996 - 2010 was 2.01 x 106 m3. On average, July is the month with highest water consumption (0.62 x 106 m3); a month with maximum water consumption was July 2004, when 1.51 x 106 m3 of water from reservoir was used.

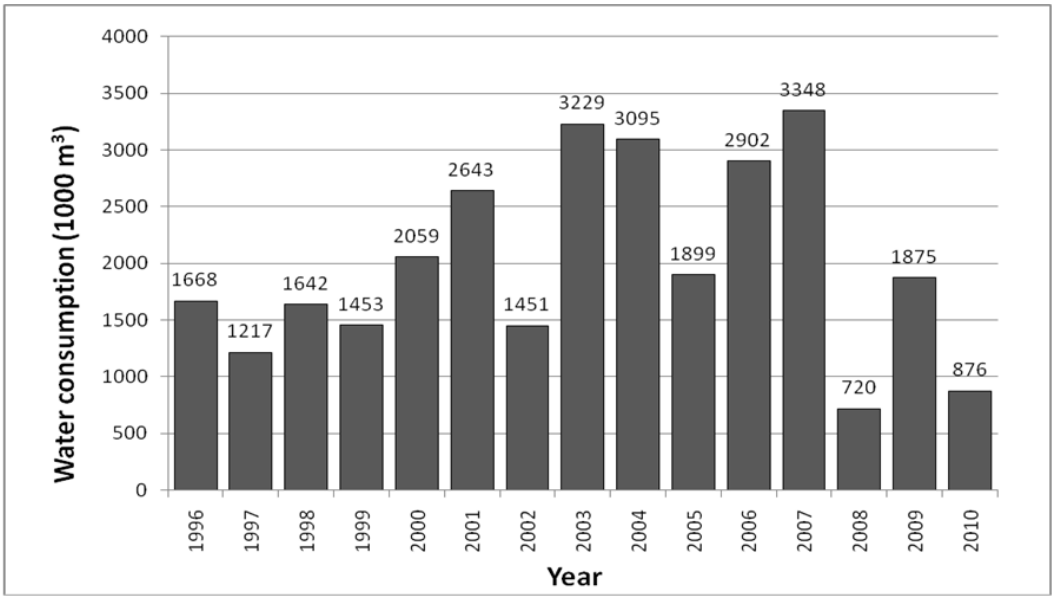

Figure 1 Use of water for irrigation from the Vogršček reservoir (in 1000 m3) per year in the period 1996 to 2010 (Source: Kmetijstvo Vipava d.d., 2012)

Interest for the use of water for irrigation also occurs in areas near the officially defined irrigation districts and also owners of individual house gardens are interested for use of water from the Vogršček reservoir. Some areas close to the existing irrigation districts and some gardens already have the option of irrigation with water from the reservoir, but these areas are not officially defined as irrigated area.

2.2.2 Flood protection

1.25 x 106 m3 of reservoir volume is considered as flood protection volume. Floodwater retention occurs when in the lower Vipava valley flood risk appears. If before flood event more water from reservoir is released, more water can be captured in case of flood danger, when only biological minimum is released from reservoir. When the danger of flood passes, level of the reservoir is decreased to normal operation level.

2.2.3 Fisheries

Investor and former manager of the reservoir (Vodnogospodarstvo Soča d.d.) and fishing association (FA) in the area of reservoir in the year 1988 conclude an arrangement (Agreement, 1988), which provided financial compensation for loss of Vogršček stream aquaculture. With this arrangement, it was agreed that the FA on his own responsibility can make experimental fish stocking in Vogršček reservoir in order to identify potentials of economic exploitation of reservoir for this purpose. For any fish kills and fish kills in the case of emptying the reservoir, the FA is not entitled to any compensation. Fish stocking was first made in 1988 in time of first filling of reservoir, meaning artificially stimulated process of recovery of the aquatic environment. Even without fishermen intervention in the aquatic environment, over time natural habitats of plants and animals would establish, but fishermen accelerate this process. The started fishing activities on the reservoir can not be stopped, because even after the suspension of fishing activities natural populations of fish in the reservoir will remain.

In accordance with the Freshwater Fishing Act (Official Gazette of the Republic of Slovenia, No. 61/2006), in 2008 the local fishing association granted the concession for the implementation of fisheries management in the whole fisheries district, including Vogršček reservoir (The concession ..., 2008). Concessionaire on its territory carries out tasks of the

public interest in the field of freshwater fisheries. The Freshwater Fishing Act provides that all activities concerning fisheries are planned on state level (12 years program) on district level (6 years program) and annual fishing association plan.

Regarding intended use of and current low level of water in reservoir, it is important that fishing activities in the reservoir are in accordance with Procedure for the operation and maintenance of the reservoir Vogršček in Vipava valley (Procedure …, 2008). Procedure permits that water in reservoir can be used until there remains only 0.45 x 106 m3 of water in the reservoir (max volume of reservoir is 8.5 x 106 m3). All fisheries management plans should consider possibility that only minimal amount of water remains in the reservoir. Problem for aquatic animals is also fast lowering of water level that occurs in the summer, when 20 cm lowering a day sometimes cause up to 10 m of dry coast. Fishes are usualy fast enough to remove to water, while shells and crustaceans often remain in dry zones where they can die. Situation mentioned requires daily intervention of responsible fishing association.

2.2.4 Tourism, recreation

Since the construction of the reservoir ideas and proposals of exploiting the reservoir and its surrounding for purposes of tourism are present. Because of the constant water level, the upper reservoir is more suitable for tourism exploitation; in case of small water level fluctuations of the main reservoir also that one can be used for tourism. Development of tourism in the area is realistically still a long way off, as it is necessary to first change physical planning documents and changes the function of the area potentially suitable for tourism development. Then it is necessary to provide adequate basic infrastructure to take care of the easy access to the lake, beach parking and basic municipal infrastructure. Currently, tourism and sports recreational activity in the area is very small. There are few marches along the reservoir organised, summer sailing school for kids (upper reservoir), fisheries association organise fishing competitions and sell fishing permissions for tourists. In particular, the fishermen want to keep the current arrangement (no mass tourism) where the surroundings of main reservoir will remain intact.

Especially in the summer every day a lot of people visit the reservoir to have a walk, to swim, to fish or to go on the reservoir with boats (liquid fuel engine boats are prohibited). In the evenings and during the night, especially at weekends there are a lot of young people that have their small parties. There should be more infrastructures to improve and regulate use of the reservoir for tourism.

2.2.5 Potential use of reservoir (future development prospects)

The potential use of the reservoir can be evaluated by the volume of water that the reservoir can store, but for different reasons drains unused from the reservoir.

As we already mentioned, there is 6.8 x 106 m3 of water foreseen for irrigation in the reservoir Vogršček, however, it is necessary to know that this amount of water is not always available. Reservoir has been designed for a multi-year balance of water level, which means that it would be in case of emptying to the minimum permissible level 80.0 m a.s.l., the average filling would be more than one year. Water balance of reservoir was calculated when reservoir was planned (1982) when time period 1948 – 1978 was observed (Table 1, Figure 2). New water balance calculations show that the average inflow into the reservoir decreases.

Table 1 Average reservoir inflow (m3/s) in different time periods (Tratnik et al., 2012)

Period	1948-2010	1948-1977	1981-2010	1996-2010
Average inflow (m3/s)	0,245	0,261	0,227	0,237

Figure 2 shows the total annual inflow (10^6 m^3/year) into the reservoir from 1948 - 2010. It is evident that there were years with a very small reservoir inflow (less than 5 x 10^6 m^3) (1954, 1957, 1973, 1981, 1983, 1986, 1994, 1999, and 2003). Two consecutive years with less than

5 x 10^6 m^3 of inflow to the reservoir occurred in 1988 and 1989. Three consecutive years of low inflow for the first time in this period appeared in the years 2005 - 2007 (Tratnik et al., 2012). The biggest inflow into the reservoir was calculated for the year 2010, when the reservoir water inflow was more than 13 x 10^6 m^3.

When calculating reservoir water use potentials it should be considered that in the period 1996 – 2010 the average evaporation from water surface was 0.77 x 10^6 m^3/year. Taking into account the ecologic acceptable discharge, prescribed by law, downstream the dam (15 l/s) at least 0.47 x 10^6 m^3/year of water is needed, but in the period 1996 – 2010 the average outflow from the reservoir was 4.9 x 10^6 m^3/year.

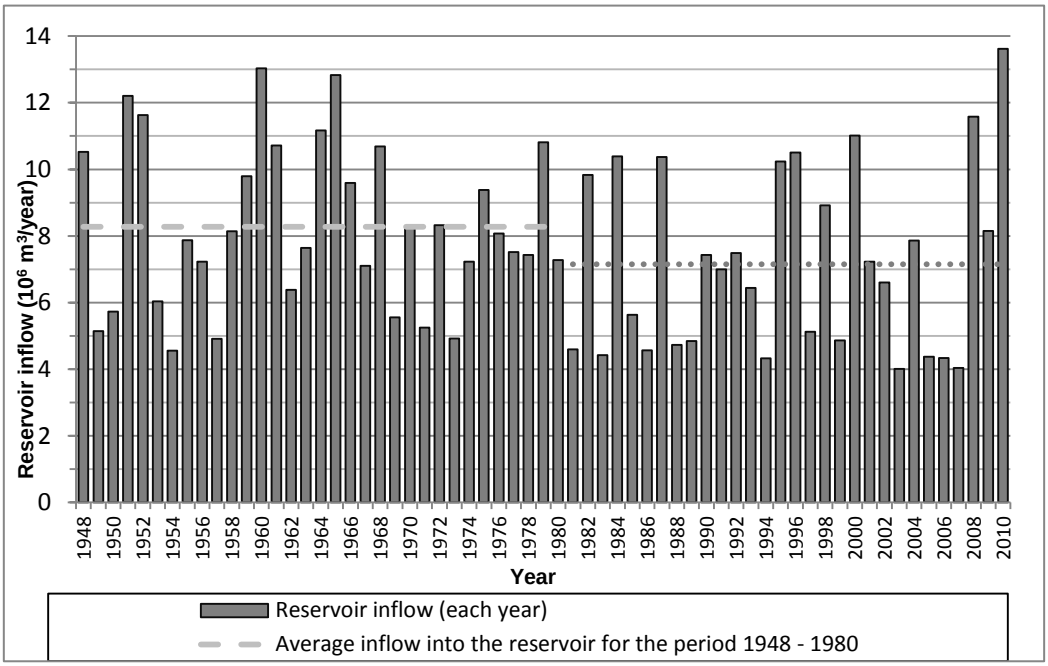

Figure 2 Inflow (106 m3/year) to the Vogršček reservoir in the period 1948-2010 and the average inflow for the periods 1948 to 1980 and 1981 to 2010 (106 m3/year) (Tratnik et al., 2012)

Beside sufficient water, good state of existing infrastructure is also important for proper functioning and optimal utilization. The planed comprehensive rehabilitation of the dam infrastructure is a first but necessary step to improve the performance of the reservoir. Due to the quantities of water remaining in the reservoir each year or enriched amount of outflow of unused water, we can conclude that all of the potentials of the reservoir have not been exploited. Infrastructure rehabilitation should be followed by optimization of land use and reservoir use management and optimization of irrigation systems use. Bad condition of infrastructure affects all users and potential users of reservoir.

Potential uses

When using natural resources we are usually faced with problem of the lack of resources, but in case of Vogršček reservoir there is not enough users of water and accumulated water remains unused. Because the importance of presence of other uses (in addition to irrigation) of the reservoir was not considered at its design, later development and implementation of other uses is much more difficult especially without sufficient support from local authorities and owners of infrastructure.

Irrigation is still defined as a primary use of the reservoir, therefore it is reasonable to optimize the use and to make further development of irrigation systems. It is possible for new irrigation systems to be connected to existing primary distribution pipeline. Construction of a new primary pipeline would enable irrigation also in the central part of the Vipava valley, but only part of that area is suitable for gravity irrigation (pump stations

needed). It is possible to extend the irrigation systems to small gardens at houses (now irrigated with drinking water), as well as irrigation of public areas (parks, public green areas).

The opportunity of reservoir as location of sport and leisure activities was not supported enough by the owners and local authorities. Especially in the summer months, the number of daily visitors of the reservoir indicates, that the development of leisure activities in the area of the reservoir is a development opportunity.

In addition to agriculture, water from the reservoir can be used by other economic sectors. Water from the reservoir could serve as firefighting water for existing companies. There was also the idea of building small hydropower plant at the reservoir outflow and despite small constant outflow the idea is not considered as unfeasible.

When designing the Vogršček reservoir and calculating water balance, options of taking water from the adjacent catchment areas to the Vogršček reservoir were also considered. In case of water deficit in the reservoir, water can be taken (gravitationally - no energy needed) to the reservoir catchment area or directly to the reservoir via pipeline. In case of increasing water demands additional quantities of water can be provided.

3. Conclusion

Water is the only natural resource which is in abundant supply in Slovenia, so it makes sense to increase the efficiency of use of this natural resource. Already built infrastructure of the reservoir Vogršček is waiting for the comprehensive rehabilitation in the near future. Expensive infrastructure rehabilitation is not enough as also plans of utilization of infrastructure are needed.

Access to water for irrigation is relatively inexpensive, but the use of water is still relatively small. Incentives in the agricultural sector to increase the demand for water are needed. It is also necessary to define other potential uses, and to examine the possibility of their development. This should involve cooperation of all stakeholders involved - infrastructure owners (the state), local authorities, farmers and other potential investors and users of reservoir.

4. Acknowledgements

Operation was partly financed by the European Union, European Social Fund.

5. References

[1] Agreement. (1988). Vodno gospodarstvo Soča and Ribiška družina Soča, Number: 0201-29/88-127, Nova Gorica 1.7.1988. (In Slovene)

[2] ALTINBILEK, D., 2002. The role of dams in development. Water resources development, 18 (1) 9-24.

[3] BIRD, J. AND WALLACE, P., 2001. Dams and development – an insight to the report of the world commission on dams. Irrigation and drainage, 50, 53-64.

[4] GABRIJELČIČ, Z., UŠAJ, H., KODRIČ, I., POŽENEL, A., GORKIČ, M., OSMUK, N., 1996. Vipava Valley yesterday, today, tomorrow. Proceedings of the Mišičev vodarski dan, 1996, Maribor. 85-98. (In Slovene).

[5] ICOLD (International Commission on Large Dams). 2013. Role of dams [online]. http://www.icold-cigb.org/GB/Dams/Role_of_Dams.asp [Accessed 3 July 2013]

[6] LI, Q., GOWING, J.W. AND MAYILSWAMI, C., 2005. Multiple use management in a large irrigation system: an assessment of technical constrains to integrating aquaculture within irrigation canals. Irrigation and drainage, 54, 31-54.

[7] Official Gazette of the Republic of Slovenia, No. 61/2006, Freshwater Fisheries Act.

[8] Presentation of the rehabilitation of the reservoir Vogršček. 2012. Ljubljana. Ministry of Agriculture and the Environment.

[9] http://www.mko.gov.si/index.php?id=1333&tx_ttnews%5btt_news%5d=6173&tx_ttnews%5bbackPid%5d=12029&L=0&no_cache=1 [Accessed 3 July 2013]

[10] Procedure for the operation and maintenance of the reservoir Vogršček in Vipava valley. Collection of documents. 2008. (In Slovene).

[11] The concession contract No. 3420-195/2008/1 to implement the concession of the Renče fisheries district. (2008). Ministry of Agriculture, Forestry and Food (in Slovene).

[12] TRATNIK, M., BURJA, D., BATIČ , S., STEINMAN, F., PINTAR, M., 2012. Water balance of the Vogršček reservoir. Proceedings of the Mišičev vodarski dan, 2012, Maribor. 47-52. (In Slovene).

[13] VGI. 1983. Vogršček reservoir – Idea study. Project code C – 417, March 1983. (In Slovene)

[14] WORLD COMISSION ON DAMS, 2000. Dams and development – A new framework for decision – making. Earthscan Publications Ltd. London, 356.