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Upravljanje z jezerom - primerjava Bleda s podobnimi kraji v Avstriji

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Izvleček

Ohranjanje naravnih vrednot, biotske raznovrstnosti in zagotavljanje zdravega življenjskega okolja so eni izmed glavnih okoljskih ciljev skupne evropske politike. Turistični kraji, katerih razvoj in promocija v večini temelji na neokrnjeni naravi, obenem z velikim številom turistov predstavljajo za naravo tudi veliko obremenitev. Še posebej občutljiva okolja na zunanje obremenitve so kraji z jezeri, ki tako zahtevajo še podrobnejšo obravnavo in dobro delujoče upravljalske modele. V pričujoči diplomski nalogi je prikazana primerjava upravljanja z jezerom na Bledu in primerljivimi kraji v sosednji Avstriji. Zaradi velikega števila jezer in tudi zaradi bližine, so v primerjavo vzeti kraji iz dežele Koroške (Land Kärnten). Najprej so podrobno opisane glavne značilnosti Blejskega jezera in našteti tudi glavni problem, ki se v zvezi z njim pojavljajo, med njimi je glavna evtrofikacija. Glede na to, da je večina potrebne infrastrukture že zgrajene, so identificirani problemi v prvi vrsti organizacijske in upravljavske narave. Nadalje so opisane osnove avstrijske okoljske zakonodaje, s poudarkom na prikazu strukture občina – regija – država. Sledi prikaz osnovnih karakteristik koroških jezer. Problem evtrofikacije se je v začetku druge polovice prejšnjega stoletja pojavil tudi na koroških jezerih in tako onemogočal nadaljnji razvoj turizma. Koroške deželna vlada je tako že leta 1964 sprejela program z vsemi nujnimi sanacijskimi ukrepi za rešitev problema evtrofikacije. Vse sanacijske in zdravstvene rešitve so prikazane in opisane tudi v nalogi. Prav tako je opisan model financiranja okoljskih projektov, ki ga v večini uporabljajo v Avstriji. Vsa infrastruktura in dokaj veliko število jezer zahtevajo celovit in načrten pristop pri upravljanju, vzdrževanju in monitoringu, zato je prikazana tudi osnova upravljalska struktura z obrazložitvijo funkcij posameznega deležnika. V zadnjem delu so podrobneje opisana tri jezera, ki so blejskemu najbolj podobna, tako z morfološkega vidika, kot tudi njihove pomembnosti za turistični razvoj okoliških krajev. Za konec je prikazana še primerjava omenjenih krajev z Bledom (upravljalski model, rezultati meritev kakovosti jezer, cene komunalnih storitev) in naštetih nekaj predlogov za izboljšanje upravljanja z našim turističnim biserom, predvsem pa za izboljšanje komunikacije med vsemi glavnimi deležniki.

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Abstract

The main goals in common European environmental policy are the preservation of natural values, biotic diversity and assuring the healthy human environment. Tourist areas, which development is usually based on an intact nature, on the other side represent with their high number of tourists a heavy load on the environment. Lake areas are especially vulnerable and therefore have to be minutely treated and need good working management models. In this graduation thesis a comparison of lake management between Bled and comparable Austrian places is shown. Areas from this region are used because the province of Carinthia (Land Kärnten) has many stagnant waters and also it lies near Slovenia. In the first part of the thesis, a detailed description of Lake Bled is shown; moreover, its main problems are presented there. Because most of the infrastructures have already been built in Bled, problems are more of the organizational and managerial nature. Then, in the second part, the basics of Austrian environmental legislation are shown, with the emphasis on the relation between municipality – region – state. The third part includes the description of the basics characteristics of the Carinthian lakes. In the middle of the previous century, the eutrophication problems emerged in the Carinthian lakes, too. Consequently, they disabled the tourist development, and for that reason the Carinthian government, already in the year 1964, passed a program with all necessary sanitation and remedial measurements. The description of these is shown in the present thesis. Furthermore, the possibilities of financing the environmental projects, which are used in Austria, are also shown. All implemented infrastructures and a quite high number of lakes claim an integral and systematic organizational, managerial and monitoring approach; therefore, the management structure with the description of certain stakeholder tasks is also part of the thesis. Three lakes, which have the comparable morphological characteristics to Lake Bled, and they are also important for the tourist development of surrounding areas, are described in details. In the last part, the comparison with Bled is made (a management model, monitoring results, prices for municipal services) and some solutions for improving the management with our tourist pearl are suggested, above all to improve the communication among the main stakeholders.

IZJAVA O AVTORSTVU / DECLARATION OF AUTHORSHIP

Podpisani **ANŽE UREVC** izjavljam, da sem avtor diplomske naloge z naslovom: **»UPRAVLJANJE Z JEZEROM – PRIMERJAVA BLEDA S PODOBNIMI KRAJI V AVSTRIJI«.**

Izjavljam, da prenašam vse materialne in avtorske pravice v zvezi z diplomsko nalogo na UL, Fakulteto za gradbeništvo in geodezijo.

Graduation thesis has been made at two institutions: at (1) The Graz University of Technology, Austria (Technische Universität Graz – Institute für Siedlugnswasserwirtschaft und Landschaftswasserbau) as the hosting institution and at (2) The University of Ljubljana, Slovenia (Univerza v Ljubljani – Fakulteta za gradbeništvo in geodezijo (Inštitut za zdravstevno hidrotehniko)) as the home institution as the result of Erasmus-Socrates scholarship No.: 2005/06-693 granted to the author.

I, Anže Urevc, the undersigned author, herewith acknowledge that I am the sole author of the present thesis with the title: "**LAKE MANAGEMENT – COMPARISON BETWEEN BLED AND AUSTRIAN LOCATIONS**".

Graz, Ljubljana, 31.08.2006

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(podpis)

DECLARATION OF SURVEY

Work was checked by the following professors:

Izr. Prof. dr. Boris Kompare

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In the memory of my father Milan

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KAZALO VSEBINE

KAZALO PREGLEDNIC

KAZALO SLIK

1 INTRODUCTION

During my childhood, I lived in one small village among the Pokljuka forests, far away from noisy and densely settled cities. I was surrounded only by clear and mostly untouched nature, while my neighbours were wild animals. At that time I did not even know what totally urbanized area, environmental pollution and fighting against that mean. My environment was perfect and I thought that it was the same everywhere. With the expansion of my life to Bled region, I saw my thinking had not been right, because there were a lot of foreign people who wanted to see our perfect area. “Why do they come, do they not have the same beauty in their home areas?” I was questioning myself. Of course, interesting and perfect environment has always attracted many people to come and check it, with one word, tourism. Later, during my ski jumping decade, I visited many areas in the central Europe and the USA. Austria, Germany and Switzerland impressed me the most, because there are a lot of places similar to my own country. But the tourist problem remained the same. Again I wondered, “Is the environmental capacity high enough to carry this entire tourist load?” During my studies I once again became interested in the environment with a wish to investigate environmental management approaches in tourist regions to check how all urban and modern agriculture load effects environment and which strategies are used by the authorities to manage that. Bled region, as one of the most popular Slovenian places with its lake and a very sensible environment, has been a perfect chance to do that. Now I have been living in Bled region for a long time and I know many things and problems, too. Because of the existing problems, I decided to check how the environmental management looks like in other regions. The Austrian region Carinthia, just near the Slovenian border, has many lake areas and it was a good choice for my examination. Lake management, which includes organizational, technical and scientific work, everything in vision to improve or stabilize the lake ecosystems, has been my main topic and goal. Increased urbanization in the previous century caused many environmental problems; consequently, quick and successful measurements were necessary to secure our perfect environment. Implementing the measurements is a complicated procedure, requiring a great public consensus and a good financial plan, because the sanitation and remedial infrastructures mostly cost a lot.

Sustainable development of regions is one of the main goals in the whole European Union. Such development does not include only environmental protection, but also future socio-economic development, which is essential for human beings and their satisfaction. Tourist areas are one example of regions where sustainable development is necessary, because of the contrasts between perfect and untouched nature on one side and tourist load on the other. Furthermore, the responsibility to manage with all and find an appropriate way between environmental protection and economic development stays on shoulders of policy and decision makers.

Present thesis deals with the lake management in tourist regions. Lakes are sensible areas, but their beauty also attracts many visitors who want to be a part of that beauty. Furthermore, visitors perform a high urban load and in most cases lake systems can not carry this load themselves; therefore, the implementation of sanitation and in some cases also remedial measurements help and protect lakes against the high urban load. High investment and operational costs, public agreement and future management of built infrastructure distinguished such projects. Management structure and cooperation among all stakeholders are the next important part, also included in the research and shown in the present thesis. The thesis begins with the introduction of Bled area and with the definition of its main problems, then continuing with the Carinthian approaches and solutions in filed of lake management (legislation, overview, sanitation and remedial measurements, results). Finally, the comparison with Bled is made and for the conclusion, suggestions for improving the lake management with Slovenian tourist beauty are listed.

This topic is now up-to-date, because the Slovenian Ministry of Environment and Spatial Planning is preparing a lake management plan for Lake Bled, and good Austrian examples can help in this project.

1.1 Description of Bled area

Bled area lies in the north-western part of Slovenia, in Upper Carniola region. In 1995, according to the local autonomy act, Bled became its own municipality with a whole area of 20.513 ha (Fig. 1). Famous and tourist attractive is Lake Bled, with an island and the church on it in the middle. Municipality has 11.305 inhabitants and 4.000 tourist capacities. There live 4.537 people in the city of Bled (STAT, 2004). The main economic branches are tourism, some small industry and agriculture. Many people also daily go to work to the other regions. Statistics show that less than 50% of Bled inhabitants deal with tourism.

Through the year, a great varying of urban load is perceivable. In the summer time, there are nearly 20.000 people in Bled, while in spring and autumn time number falls back to 12.000 or 13.000 people. This reflects in problems with infrastructures, which have to be designed for higher loads and it is not fully applied in-between the tourist seasons. But because the operational, management and maintenance costs exist all year round, it often happens that there are not enough financial sources for maintenance. In most of tourist regions they have the same problems. Furthermore, good management approach and adequate high prices for municipal services are the main factors to overcome such problems.

The urbanized area (city of Bled) is located in the eastern part of Lake Bled, while other rural areas are scattered all around the municipality. Settlements Gorje, Podhom and Zasip lie in the northern part, while Bohinjska Bela, Selo, Ribno, Bodešče and Koritno are located in the southern part. Settlements have from 600 to 3.000 inhabitants and are mostly agriculture orientated.

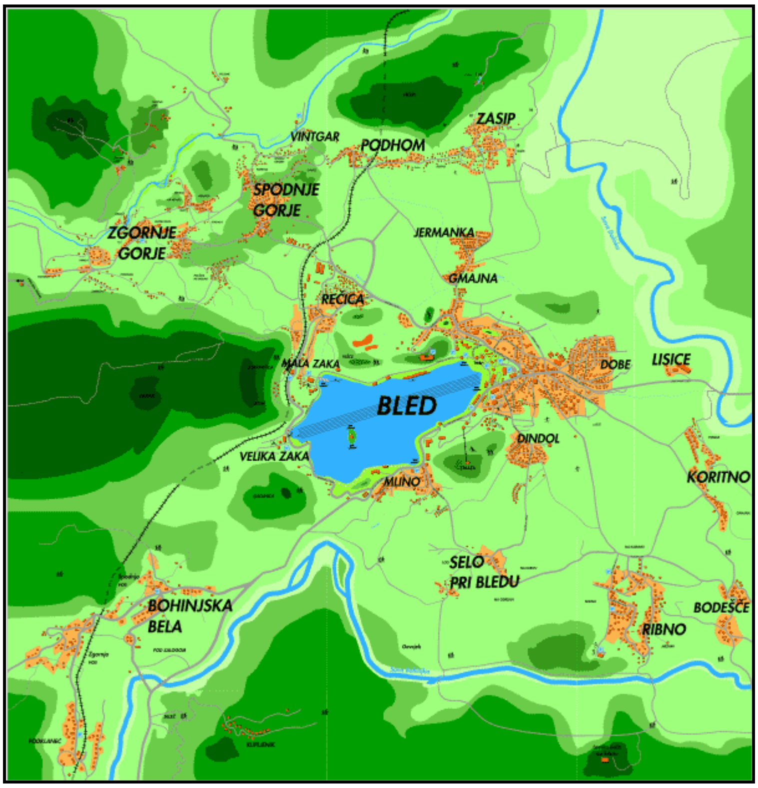

Figure 1: Area of municipality Bled (Municipality Bled, 2003)
Slika 1: Območje občine Bled (Občina Bled, 2003)

1.2 Lake Bled

1.2.1 Basic characteristics

Lake Bled is an alpine lake, basin originated 15.000 years ago (Urbanc-Berčič, 1993). It is of tectonic-glacier origin, 2.120 m long, 1.080 m wide and 32 m deep. Total volume of the lake basin is 25, 7 x 10^6 m^3, with hydraulic residence time 2, 5 years (Kompare, 2005). The main limiting factor is phosphorus like in majority of alpine lakes. Nutrients come into the lake from sewage system, air, with underground water, influent creeks and rain. In the past, watershed area increased three times. At the beginning it measured 487 ha, and then with the transferring of creek Mišca to the lake, it increased to 897 ha. Finally, when artificial connection with the river Radovna was built, watershed area enlarged to today's 10.703 ha (Rismal, 1993). That is 22-times more than an ancient area. Lake Bled has 12 influents; most of them are small creeks (Tab. 2). Other 12, which were also flowing into the lake in the past, are now connected to the sewage system, because of their pollution (Remec-Rekar, Bat, 2005). A few underground wells supply water to Lake Bled, too.

Table 1: Morphology characteristics of Lake Bled (Birsa, 2005)
Preglednica 1: Osnovne morfološke značilnosti Blejskega jezera (Birsa, 2005)

Datum	Quantity
Length	2.120 m
Width	1.080 m
Depth	deepest 32 m, average 17,48 m
Surface	147 ha
Volume	25,7 x 10^6 m^3
Hydraulic residence time	2,5 years
Extent of shoreline	6,2 km
Watershed area	107,03 km^2

Table 2: Lake Bled - Data of main inflow and outflow water (ARSO, 2003)
Preglednica 2: Glavni pritoki in iztoki iz Blejskega jezera (ARSO, 2003)

Influent	**No. in Fig. 2**	**Average Flow Q_{ave} [l/s]**	**Yearly flow [10^6 m^3/year]**
Krivca	2	20	0,6
Mišca	1	161	5,1
Ušivec	4	27	0,8
Solznik	9	6	0,2
Radovna (artificial)	3	394	12,4
Precipitation		---	1,7
SUM		**608**	**20,8**
Effluent	**No. in Fig. 2**	**Average Flow Q_{ave} [l/s]**	**Yearly flow [10^6 m^3/year]**
Jezernica	5	363	11,4
Siphon pipe (artificial)	6	284	8,9
Evaporation		---	1,6
SUM		**647**	**21,9**

1.2.2 Monitoring

In Lake Bled, the monitoring is performed every month and it includes physical (light penetration, temperature, electrical conductivity, pH, etc.), chemical (oxygen, dissolved CO_2, phosphorous, orthophosphate, ammonium, nitrite, nitrate, silica dioxide, etc.), biological (phytoplankton, chlorophyll, zooplankton, macrophyte) and hygienic (microbiological) parameters. Every four months, an extensive physiochemical analysis is made, including

COD, BOD_5, H_2S, important ions, containing of detergents, etc. Samples are taken from western and eastern basin in every two meter of depth. Moreover, most of parameters are measured in all bigger influents and effluents. In the last two years also the sediment analysis in creek Mišca was made (ARSO, 2003). In Figure 2, locations of sampling points are shown. Red points show lake water sampling places (VK – eastern basin, ZK – western basin), while blue points show sampling places in influents and effluents (numbers are included in Tab. 2).

Figure 2: Lake Bled with influents and effluents – locations of sampling (ARSO, 2003)
Slika 2: Blejsko jezero s pritoki in iztoki – mesta vzorčenj (ARSO, 2003)

1.2.3 Eutrophication problem and implemented measurements

In 1950s, lake became eutrophic for the first time, i.e. the amount of nutrients increased so much that algae blooming occurred. Because eutrophic lakes cause a lot of problems, and even worse, they are not attractive for tourism, committee of experts was established for investigation of possible solutions. First idea was an artificial surface flushing, which decreased hydraulic residence time from almost 2, 7 to 1, 4 years (Remec-Rekar, Bat, 2005). Clean with oxygen rich water was founded 3 km northern from Bled, in the river Radovna. In the year 1964 a 2,4 km long tunnel was built, with the initial design capacity of 3 m^3/s, which was then actualized to 2 m^3/s. It was never in full operation because the hydro power plant, located in downstream of the river Radovna, did not allow such water reduce (average flow through connection pipe was 300 l/s). In Figure 3, calculation of the hydraulic residence time in Lake Bled for different flows through the artificial connection with river Radovna is shown. In the case of flow of 3 m^3/s, the hydraulic residence time would be only 90 days. Because the river Radovna is very cold this short time would also decrease the temperature of the lake and would make it less attractive for the water sports.

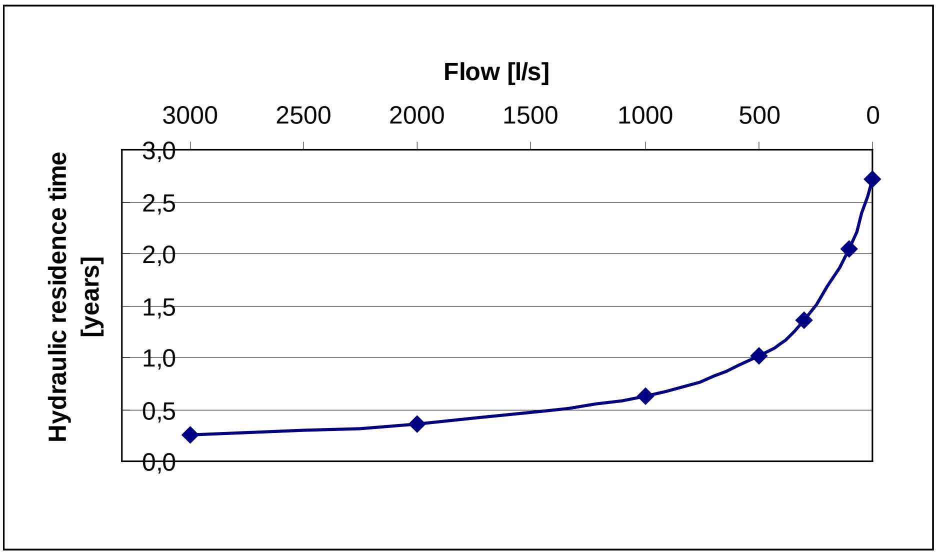

Figure 3: Hydraulic residence time in Lake Bled in dependence of the varying flow through the artificial connection with the river Radovna

Slika 3: Zadrževalni čas vode v Blejskem jezeru v odvisnosti od pretoka skozi umetno povezavo z reko Radovno

The depth of the inlet of artificial connection to the lake is 14 m (Birsa, 2005). Inflowing water is not circulating inside the lake (jet effect), but it places in the depth where there is the water with the same temperature. Because the rate of algae growth is approximately 14 days, the only possibility for the success of the artificial flushing measure is to reduce the hydraulic residence time to the same rate (Kompare, 2005). Furthermore, with such flow the temperature in the lake will decrease dramatically and for that reason the artificial flushing system cannot be appropriate.

After the implementation of the artificial flushing system, algae blooming occurred again and also the monitoring results showed worsening. It was obvious that the solution did not reach the main goal, i.e. to improve water quality, and it was necessary to find the supplementary one. According to the phosphorous load, shown in Table 3, the following solutions were proposed by the Institute of Sanitary Engineering from the University of Ljubljana (Rismal, Kompare, 1992):

- Reducing the inflow of nutrients to the lake;
- Artificial surface flushing (river Radovna);

- Siphoning of the hypolimnium water (see also Chapter 3.4.1, and Appendix A);
- Aeration (see also Chapter 3.4.4, and Appendix A);
- Chemical measures (see also Appendix A).

Table 3: Estimation of nutrients balance for Lake Bled in the year 2003 (ARSO, 2003)
Preglednica 3: Ocena bilance hranil v Blejskem jezeru v letu 2003 (ARSO, 2003)

Influent	**Phosphorous [kg/year]**	**Nitrogen [t/year]**
Krivca	10	1
Mišca	231	7
Ušivec	19	2
Radovna (artificial)	50	6
Precipitation	42	1
Sum	**352**	**17**
Effluent	**Phosphorous [kg/year]**	**Nitrogen [t/year]**
Jezernica	94	2
Siphon pipe (artificial)	308	7
Sum	**402**	**9**

In the year 1980, like the second and final solution, siphon pipe for flushing of hipolimnium water was built (Fig. 4). Meanwhile, the same idea was first implemented in Lake Kortowo, Poland. The solution had been showing good results and lake returned into the mesotrophic state. Problems happened again in the year 1999, when the operator of siphon pipe damaged air-valve and one part of pipe did not work. After this was settled, both technical solutions worked tolerably well.

Yearly amount of phosphorous in Lake Bled is now approximately 400 - 500 kg. That is still too much. Maximum phosphorous load for such lakes, to stay in mesotrophic state, should be less than 300 kg P/year (Rismal, 2005). The highest amount brings creek Misca, which springs and flows through the farm land area and at the last part it serves for the fish farm. In ancient times, creek Mišca was flowing beside the lake, but then an artificial bifurcation and channel to the lake were built. From the Table 3, it is very well evident how high is the concentration of nutrients which creek Miščа brings to the lake.

1.2.4 Urban drainage system

In Bled, the first part of wastewater drainage system was built in 1930s and it is still in use, although its depreciation period has exceeded twice. The system is composed of two main pipelines, “M” and “VS”, and it is mostly mixed (Fig. 4). “VS” pipeline takes all sewage and rainwater which does not gravitate to the lake, while "M" pipeline (older) takes majority of waste- and rainwater from the city center. Also, in the cause of lake protection, some well water is connected to the "M" pipeline. Consequently, in "M" pipeline there is a lot of nutrient-poor water, which will certainly cause problems in the future operation of the wastewater treatment plant (will go in operation in October 2006). Moreover, a few overflows and retention basins compose the system. In previous years, the management of urban drainage system was really bad and system is demolished in many parts. Future revitalizing is like that necessary.

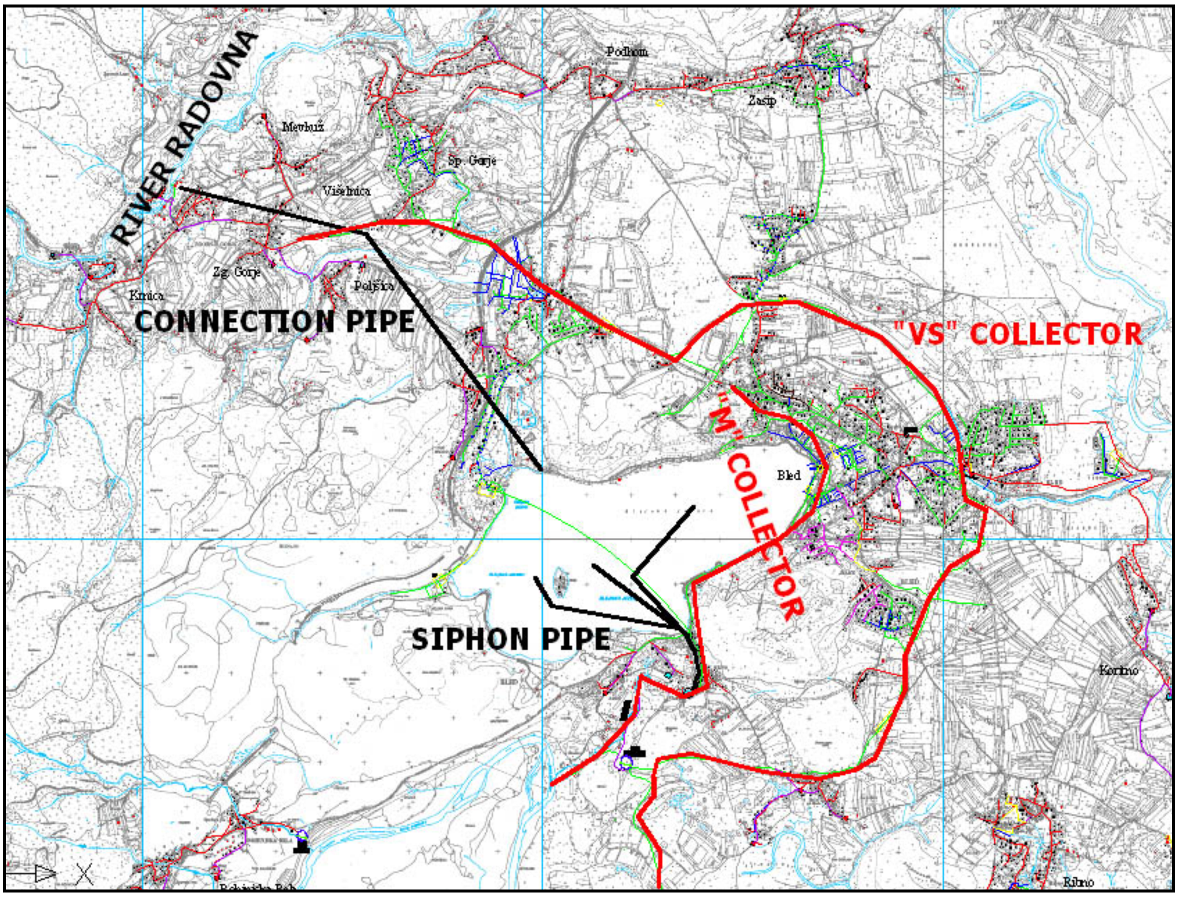

Figure 4: Sanitation and remedial measurements in Lake Bled (adopted and modified from Outline project of wastewater drainage and purification in municipality Bled (WTE, 2001))
Slika 4: Sanacijski in zdravstveni ukrepi na Blejskem jezeru (privzeto in prirejeno po Idejnem projektu odvajanja in čiščenja odpadnih voda v občini Bled (WTE, 2001))

Main "M" pipeline is egg shaped (80/120 cm) and located near the lake. Its capacity is approximately 580 l/s, which is enough to capture the critical storm flow of 20 l/sec·ha. In the case of capturing the critical storm flow of 40 l/sec·ha, it is necessary to built new retention basins in total volume of 400 m^3 (Rismal, 1981). Today approximately 34 – 63 kg P/year comes to the lake from sewage system (Rismal, 1997). If proposed retention basins will be built, max. 20 kg P/year will come to the lake, which means only 5% of the whole load (Rismal, 1997).

In Figure 4, implemented sanitation and remedial measurements are shown. Sanitation measure, i.e. wastewater drainage system, is marked with red color ("M" and "VS" main pipelines), while remedial infrastructure, i.e. connection with river Radovna and siphon pipe, is marked with black color.

1.3 Main problems in Lake Bled management

In the following chapter the problems in lake management which are occurring in Bled are emphasized. Because the sanitation and remedial measurements have been already established, problems are mostly organizational and managerial. Only, regarding to the technical problems, it is necessary to mention the urban drainage system, especially "M" pipeline, which is demolished in many places. For that reason, wastewater is running to the lake in some places, moreover, lake water is sinking through the loose pipe joints, which intensifies wastewater dilution and will slow down the biological processes in newly build wastewater treatment plant. Along the creek Mišca, approximately 100 houses have unsettled sewage system (Fig. 5). According to the time schedule of Municipality Bled, system will be built in years 2006 and 2007 (Concession contract between Municipality Bled and WTE, 2002).

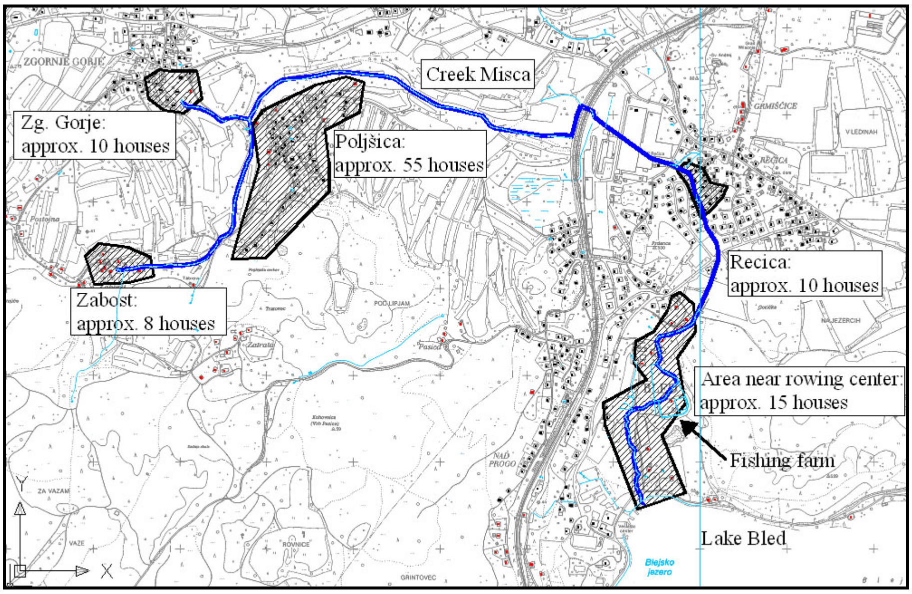

Figure 5: Areas along creek Mišca with unsettled sewage system
Slika 5: Območja vzdolž potoka Mišce z neurejeno kanalizacijo

1.3.1 Legislation

There are a lot of contrasts between the state (Ministry) and local level (Municipality Bled). The problem is that Slovenia is still without regions; e.g. Austria has strong and very independent regions, which causes better cooperation among all main partners: state – province – municipality. According to the Slovenian Water Act, all water is no man's property but the state government (Ministry of Environment and Spatial Planning or its mandatory) is the manager. On the other side, managing of shoreline area is in municipality's hands, but concession contract for shore management between state and municipality has still not been signed. Moreover, in shoreline areas both, the state and municipality, have a right to preemption of the land. The state is the first rightful claimant, ahead of municipality, which is one more step backward towards successful management of shoreline or one good reason for signing the aforementioned contract. Then, with the signed contract, municipality can start managing and maintaining all shoreline area or find a mandatory which will do that.

1.3.2 Stakeholder cooperation

In the present time, globalization is expanding very fast. One of the reasons for that is also a good cooperation among all important partners around the world. Usage of modern communication technologies makes cooperation even easier and faster. The same situation is in environmental projects where cooperation is one of the key roles for the success. Public relations are included in stakeholders' cooperation with the same importance like all others. To really reach a wide public agreement is, in most cases, hard and claims long term reconciliation of viewpoints, but on the other side it makes projects much easier to implement and manage. The following significant stakeholders are included in Lake Bled management:

- State: Ministry of Environment and Spatial Planning (The Environmental Agency – Department for Limnology), Ministry of Agriculture, Forestry and Food, Ministry of Finance, and consequently European Union;
- VGP Kranj d.d., Water management company responsible for managing water in Upper Carniola region (Bled area is included, also with the siphon pipe and artificial flushing system);
- Municipality Bled: council, mayor, administration office, public municipal enterprises (Infrastruktura Bled d.o.o.);
- Tourist enterprises: Local Tourist Agency, Sava Kranj d.d. (owner of most hotels in Bled), many private bidders. All are offering clear and healthy environment and it is also expected that they will cooperate with environmental agencies, especially at organizing educational activities and common marketing projects, financial support and helping with efforts for future sustainable development of the whole region;

- Agriculture (farmers, Agency of Agriculture and Forestry), Forestry (enterprises), Agencies of Natural and Cultural heritage;
- Private companies – especially those which are interested, maybe through concession contracts, to work on a different environmental problem, e.g. WTE Wassertechnik Essen GmbH has concession contract for building and operating with the sewage system and wastewater treatment plant (B.O.T. model);
- Universities and institutes which are occupied with environment, water, law, social affairs, etc;
- Interested public.

According to my view, all listed stakeholders have to join in one committee and establish an agency which will be responsible for preparing and implementing the future efforts in the field of sustainable lake management. Committee will then as a supervision subject accept proposed ideas and solutions at regular, at least annual, conferences or meetings. Municipality can take the same competences as the proposed agency, but here is the question if it has enough suitable labour force, financial sources and respectability in public. Local budget, which is proposed and accepted annually and any changes claim long procedures, is another disadvantage that municipality will be govern organization. Certainly, in proposed agency, it must play one of the biggest roles, being a connection partner among all stakeholders and a defender of public interests.

1.3.3 Environmental or lake management program

Urban drainage, siphoning and surface artificial flushing systems have been implemented for Lake Bled sanitation. All these claimed high investment costs in the past and good management approach in the future. Therefore, it is necessary to prepare an environmental or lake management program where all future lines will be defined, including stakeholders' competences and cooperation, management of infrastructure, financial sources, time schedule, watershed development recommendations, etc. In Graz, the program called Ökoprofit®, is one example of a successful environmental management plan which is already in use. Of course, it is earmarked for large cities and for that reason it is not useful in landscape areas. However, it is a good example how environment in sensible land has to be managed. Both, large urban and landscape areas with high tourist load, could be denote as sensible environment which deserves special treatment.

1.4 Motivation and goals

Main problems in Lake Bled management, written in previous chapter, are starting points for the proposed research of the Austrian region Carinthia and consequently for suggestions for future steps in Bled, confirmed with Austrian solutions and ideas. Austria has many similarities with Slovenia; moreover, being one of the most developed countries in the world, it is a perfect role model for future Slovenian development. In the middle of the previous century, eutrophication problem occurred in the Carinthian lakes, too. But, with a very systematic approach and a good cooperation among municipalities, province and state, conditions have improved a lot up to this day. Sanitation and remedial solutions were the first steps, followed by a successful maintaining and management of the infrastructures. Technical solutions established in Lake Bled are certainly comparable with all other world solutions for lake protection, problems arise in management and cooperation. Financing possibilities are also not finally defined and in most cases municipality stays alone in suchlike decisions.

Examination of the Carinthian lake areas includes all necessary factors for successful lake management. Beginning with the Austrian environmental legislation structure, then an overview of all Carinthian lakes with their characteristics and sanitation solutions follows. Areas comparable with Bled are extra stressed and handled. For the conclusion, financing possibilities and results, such as an examination of success, are part of a proposed research.

2 FACTS AND FIGURES ABOUT AUSTRIA

Austria, since January 1, 1995, a member of the European Union, is well known for its stable and prosperous economy, its highly skilled labor force and its geographic location in the heart of Europe. Austria is a federal republic, comprised of nine provinces (Bundesländer) and encompasses a geographic area of 83.871 square kilometers. Provinces are the following ones: Vorarlberg, Tyrol, Carinthia, Salzburg, Styria, Upper Austria, Lower Austria, Vienna and Burgenland. The population numbers more than eight million people (8.106.000 in 2004), about 1,6 million of whom live in the capital, Vienna. Other large cities are Graz, Linz, Salzburg, Innsbruck, Klagenfurt, Villach and Wels, with the populations between 50.000 and 250.000 (Preslmayr Rechtsanwälte, 2005).

2.1 Constitutional regulation

Austria is a parliamentary democracy. Parliament consists of two chambers: the National Council (Nationalrat) is elected directly by the people and has 183 members (Austrian Federal Press Service, 2000). The Federal Council (Bundesrat) represents the provinces according to their population, its members being delegated by the provincial parliaments. The nine Austrian provinces (Bundesländer) are ruled by provincial governments presided over by a Governor (Landeshauptman), who in most cases heads a government composed of all parties in the Provincial Parliament (Landtag).

Legislation can be passed on the state or provincial level, depending on each law. Fields of finance, justice and police are of the state competences and here citizens contact directly to the state, while all other administration is lead on the province level (bezirk and statutory towns are included here).

2.2 Austrian environmental regulation

Austria is, together with Finland and Sweden, on the top EU-list of the countries which devote high attention to the environmental politics. It spends approximately 3, 4 % of its gross domestic product (GDP) on environmental issues (Preslmayr Rechtsanwälte, 2005).

Environmental legislation is composed of the following laws: water, forest, waste management, environmental and soil protection, building, spatial planning and craft. Water act and forest act are of the state domains, while others are mostly provincial competence, only waste management legislation is divided between both parts (Fig. 6). In the state level Ministry of Agriculture, Forestry, Environment and Water management is responsible for the environmental affairs, which is certainly good when agriculture and environment are both under one roof. In the present time, intensive agriculture is one of the biggest polluter of the Earth, specially the underground water, therefore, agriculture and environment must be treated together. Agriculture lobbies are sometimes problematic, because European agriculture policy earmarks a great deal of money for farming and often forgets the environment. But this is the case for European commission.

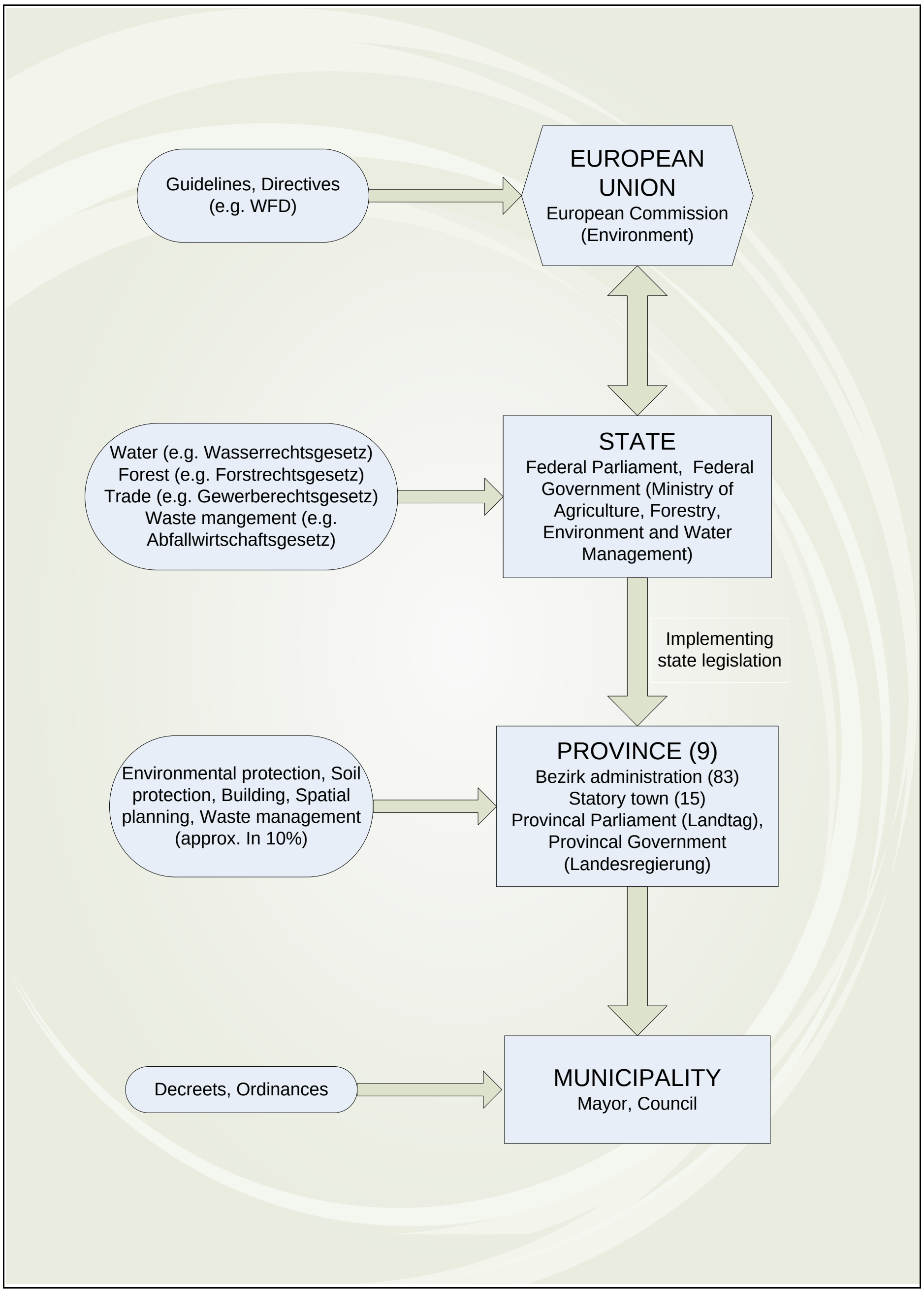

Figure 6: Structure of Austrian environmental legislation
Slika 6: Struktura avstrijske okoljske zakonodaje

2.2.1 Relationship state – province

Because building typology varies among regions, building and spatial planning legislation is of a provincial competence. Consequently, the procedure for building permission is different in every province, what is surely one of the disadvantages. For that reason, planners and designers have to learn nine different procedures in entire Austria; moreover, things are more complicated and passing slower. From this point of view, one basic law, passed by the state government, will be a much better solution.

In most provinces, one part of the environmental regulation are the land and nature protection laws. Nature protection law prohibits all actions in protected areas (building and farming), while the land protection law allows only controlled agriculture. Most of lake areas are protected by both laws. European and other environmental conventions are also a part of the regional environmental protection legislation (Natura 2000, Ramsar, etc.).

Provincial or regional administration, like a connection subject among municipalities and a state government, is a big challenge for future Slovenian development. Because Slovenia is smaller than Austria, so extensive regional structure (governor, parliament, administration) is not the right solution, a well organized and public accessible administration will be enough. Because Austrian provinces are very independent and have a lot of freedom in their decisions, they are certainly good examples of regional regulation and development. And finally, Austrian public administration is very effective and well respected, what we cannot say for the Slovenian one.

2.3 Water Act (Wasserrechtsgesetz –WRG)

2.3.1 Content

Water Act is passed by the state government and it is a basic law in the field of water. First issue dated back in the year 1959, last renewal was in 2003, according to the European Water Framework Directive (WFD). Incidentally, Austrian environmental regulation is often used as a foundation for European decisions. Contents of the federal water act are the following ones (Kodex – Wasser Recht, 2005):

- Development of water bodies;
- Water use;
- Sustainable quality and protection;
- Water treatment and sanitation.

2.3.2 Important dictions

Water Act includes very important diction, the state-of-the-art (Stand der Technik), which orders all stakeholders to follow novelties in technological development and implement them in their systems. Consequently, in certain periods, Ministry passes ordinances with maximum emissions and periods in which they must be reached.

In combination with the state-of-the-art it is also necessary to mention so called "various variants investigation" (Variantenuntersuchung) which is a part of funding regulation for urban water investments. The diction puts on municipalities and regions to investigate different solutions and tries to find the best one. There are also included solutions which connect more municipalities together. With the cooperation it is then much easier to reach regional or state financial subventions. Regional governments play the biggest role in this case.

Mentioned dictions are nothing special and are almost obvious. But, they influence a lot on involved authorities (administration officers, developers, planners, engineers, professors, etc.) and dictate many of decisions. Often legislation reaches its goal when users really accept it and talk about its dictions. In the case of state-of-the-art and variants investigation we can say that legislator reaches his goal. State-of-the-art has an important role in future water protection and for that reason many of wastewater treatment plants in whole Austria are now in reconstruction, according to the last ordinances for maximum allowed emissions to the water bodies. Variants investigation has influence on the financing of projects. It is a kind of stimulation for municipalities and other decision makers to find the best solutions and consequently to reach more subventions from different administrations (province, state, European Union).

2.3.3 Obligatory measurements and allowed emissions

Water measurements include physical (temperature, transparency, etc.), biological (biotic conditions, biological sorts, life conditions), chemical (COD, BOD, N, P, metals, etc.) and sanitary (microbiological) monitoring. Furthermore, the examination of wider ecological function is also necessary (fauna and flora, nature and economical function, morphology, hydrology, land picture). The condition of a water body is defined according to the mentioned measurements.

Fifty-three ordinances belong to the Water Act and they define the maximum emissions to the water bodies and are a consequence of state-of-the-art diction. Three ordinances cover urban polluters (Tab. 4), other fifty deal with the industrial wastewater (emissions per product for several industries). Note that that number of ordinances is changing every year.

Maximum agriculture fertilization is also prescribed in the Water Act. Like in Slovenia, execution of that is often problematic, because farmers do not respect proposed regulation and at first point they look only for higher harvest. Maximum fertilization load is limited by 175 kg N/ (year·ha) for field land and 210 kg N/ (year·ha) for grass land. In groundwater sanitation areas the load is limited with ordinance by 110 kg N/(year·ha). Moreover, maximum livestock load is 3, 5 units per hectare. Abolition of contrasts between agriculture and environmental policy is a big challenge for future European development. As it was mentioned in one of the previous chapters, both have to be treated together, assuring clean environment and healthy food for all Europeans. Of course, socio-economic development has to be assured, too.

Table 4: Maximum emissions for urban polluters – wastewater treatment plants[1] (First Austrian emission regulation for communal wastewater, 1996)
Preglednica 4: Največje dovoljene emisije za komunalne onesnaževalce[1] (Prva avstrijska uredba za komunalne odpadne vode, 1996)

	2. EmVO < 50 EW_{B60}	1. EmVO				3. Em-VO
		50-500 EW_{B60}	500-5.000 EW_{B60}	5000-50.000 EW_{B60}	> 50.000 EW_{B60}	Obj.in Extr.-L.
Subsiding soldis ml/l	0,3	-	-	-	-	0,5
BOD_5 mg/l	25	25	20	20	15	-
COD mg/l	90	90	75	75	75	-
TOC mg/l	30	30	25	25	25	-
NH_4-N mg/l	10	10	5	5	5	-
Tot-P mg/l	-	-	2,0	1,0	1,0	-
BOD_5 - elimination %	-	-	95	95	95	80
COD - elimination %	-	-	85	85	85	70
TOC - elimination %	-	-	85	85	85	-
N - elimination %	-	-	-	70	70	-
P - elimination %	-	-	85	85	85	-

Building permission is not obligatory for building water structures (wastewater treatment plants, sewage systems, hydro power plants, etc.), it is only necessary to get the water permission. Bezirk, province or state grants water permission depends on the importance of the structure.

[1] n. EmVO = Number of the ordinance defining maximal emissions; EW_{60} = Population equivalent BOD_5 = 60 g/day; note that that 2nd ordinance (2.EmVO) is only a draft and therefore not effective.

All laws, ordinances and rule books dealing with water are collected in a special yearly printed book called *Kodex: Wasser Recht* (Water Law). Because users have everything in one place, searching in extensive Federal Law Gazette is not necessary.

2.4 Organizational structures in the field of environment

Some organizational structures in the field of water (drinking, waste, underground water, flood protection, power plants, irrigation) are defined in the Water Act (cooperative societies and associations). Furthermore, other municipal services, e.g. waste management, are defined in the competent laws. Possibilities in organizational structures are the following (Kainz, 2005):

- Cooperative societies (Genossenschaften);
- Associations (Verbände);
- Municipalities (Gemeinden);
- Joint companies, Public – private partnership;
- Private companies.

2.4.1 Cooperative societies

Cooperative societies are small organizations, established for the management of drinking water supply or sewerage systems. The area of a cooperative society is always a part of a municipality. Founders are inhabitants who live in the supplied area. They name a board of representatives responsible for deputizing the society in legal affairs, management of the system and monitoring the water quality. Number of inhabitants joined in cooperative society varies from two to more than thousand, depending on largeness of the area and cooperation among residents. When they are able to organize so well and the final price for service is comparable with other organizational possibilities, cooperative society could be a very good solution.

2.4.2 Associations

Associations are the most appropriate structures for the management of bigger systems. They are established if more than one municipality takes part and they are applied in all fields of municipal services. However, they are used mostly for the management of water supply, wastewater disposal systems and flood protection. In the case of inter-municipalities or regional projects, where more partners are involved, associations are certainly the best solution. Legally they are treated as public corporations (public body), led by a management board (Geschäftsführer) and controlled by a supervision board (Obmann). In Germanic regions, associations are known as very successful and cost effective organizations for the management of public infrastructure.

2.4.3 Municipality, private companies, public – private partnership

Municipality can also build and manage the system itself. That happens mostly in projects and systems inside one municipality where establishing of associations demands more labour force and higher founding costs. Public – private partnership or totally private companies are more an exception than the rule. They are used in only today's time; furthermore, European development dictates an involvement of private sector in public projects (exception is only water supply). When the price for final user is competitive and service is assured for a long time period, the idea of public – private partnership is on the right way.

2.4.4 Decisions making process

It is not written in any of laws which of the organizational possibilities can be implemented. Therefore, municipality and region decide for one possibility on the base of their own judgment. The main guidelines are the quality of operation and low prices for final users. Similar definition is also included in the environmental protection act, saying that in every organizational formation it is necessary to examine environmental, social and economic aspects.

In the present time, the European environmental policy is common for all member states. Furthermore, legislation among countries does not vary much, especially the main development prospective. For that reason, a lot of common projects are happening through the region and newcomers in the European Union are participating with a help of old European member states. Therefore, it is a good idea to implement more intensively some of the Austrian solutions, shown in the present chapter, in the future actualizing of Slovenian environmental legislation.

3 LAKE MANAGEMENT IN CARINTHIA

Carinthia is one of the nine Austrian provinces, lying in the southernmost part of Austria (Fig. 7) and representing one of the top European tourist and technological regions. A reason for a high tourist development is also a variety of lakes which lie in the region. The whole population amounted to 547.798 inhabitants; in the capital Klagenfurt there live 91.044 people (Carinthian Government, 2003).

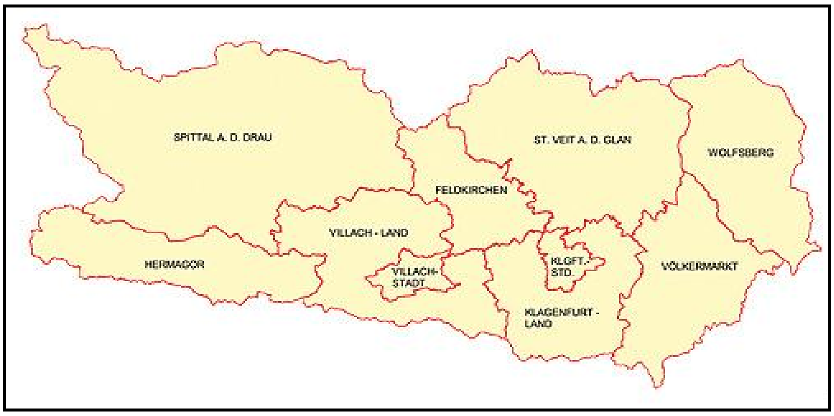

Figure 7: Map of Carinthia (Carinthian Government, 2003)
Slika 7: Avstrijska Koroška (Koroška deželna vlada, 2003)

3.1 Overview of the Carinthian lakes

In the whole Carinthia there are 1.270 lakes and standing waters with common surface of 60 km^2, placing Carintha as one of the richest water regions in Europe (Schulz, 2006). Well developed management program is a necessity for controlling and operating with such amount of water. Higher urban load, especially tourist, growing from 1950s, has increased human pollution and burdening of water, and was one of the reasons for plenty of successful measurements, which were established and implemented in Carinthia. Moreover, these programs distinct by good technical and scientific approaches and also by organizational and financial solutions.

Approximately 100 larger lakes exist in Carinthia. A few of them are: the largest and well known Wörthersee, the deepest Millstätter See, Weissensee, Faaker See, Klopeiner See, Keutschacher See, etc. A list of all them is shown in Table 5 and a map of locations in Figure 8. Most of these lakes are used for bathing. Therefore, monitoring and controlling must subject to the European bathing regulation. The results from the year 2003 show that 354 (95,4%) tests from 371 have been ranked to “very good” quality (KIS, 2004). Regarding to the very high tourist load, these results are very good.

Table 5: Carinthian lakes characteristics (summarized from the Carinthian lakes report 2004 (KIS, 2004))
Preglednica 5: Seznam in osnovne karakteristike koroških jezer (povzeto po Poročilu o stanju jezer na Koroškem v letu 2004 (KIS, 2004))

Lake	No. in map	Surface [ha]	Depth [m]	Volume [Mio m3]	Hydraulic Residence Time	Watershed Area [km^2]
Greifenburger Badesee*	1	5	max. 14,5	---	---	---
Weißensee	2	653,1	max. 99; ave. 35,1	226,1	9,2 years	49,6
Farchtensee	3	11,72	max. 8,3; ave. 4,6	0,54	---	8,64
Pressegger See	4	55,2	max. 13,7; ave. 3,4	1,87	0,6 month	28,74
Millstätter See	5	1328,1	max. 141; ave. 88,6	1204,5	7,5 years	284,5
Turracher See	6	19,4	max. 33; ave. 13,6	2,6	1,1 years	2,2
Falkertsee	7	4,32	max. 13,2; ave. 5,5	0,24		0,9
Feldsee	8	41,1	max. 26,3; ave. 15,4	6,27	2,5 years	8,3
Afritzersee	8	48,7	max. 22,5; ave. 14,2	6,9	1,7 years	8,67
Ossiacher See	9	1078,7	max. 52,6; ave. 19,6	206,3	1,8 years	162,91
Leonharder See	10	2,29	max. 6,5; ave. 3,6	0,082	---	---
Vassacher See	10	4,43	max. 10,2; ave. 5,1	0,227	---	---
Grünsee	10	1,76	max. 6,6; ave. 3,6	0,06	---	---
Magdalensee	10	14,1	max. 5,2; ave. 3,4	0,48	---	0,6
Silbersee*	10	14,3	max. 7	---	---	---
Wernberger Badesee*	11	4,5	max. 15	---	---	---
Faaker See[2]	**12**	**220**	**max. 29,5; ave. 16,1**	**35,2**	**1,8 years**	**37,09**
Aichwaldsee	13	3,32	max. 7,2; ave. 4,2	0,14	2,1 years	1,4
St. Johanner Badesee*	14	12,08	max. 13; ave. 6,2	0,69	---	---
Badesee Kirschentheuer*	15	9,024	max. 12; ave. 7,1	0,631	---	---
Ferlacher Badesee*	15	6,7	max. 10; ave. 6	---	---	---
Rauschelesee	16	19	max. 12; ave. 5,7	1,08	3,6 months	5,11
Hafner See	17	15,9	max. 10; ave. 5	0,79	1,2 months	12,7
Keutschacher See[2]	**17**	**132,7**	**max. 15,6; ave. 10,3**	**13,6**	**9 months**	**29,81**
Wörthersee	18	1938,7	max. 85,2; ave. 41,9	816,4	10,5 years	162,1
Trattnigteich*	18	5,3	max. 3	---	---	---
Saisser See	19	1,33	max. 6,6; ave. 4,3	0,575	---	---
Forstsee*	19	29	max. 35; ave. 22	6,5	---	2,4
Moosburger Mitterteich*	20	17,35	max. 3	---	---	---

to be continued…

…continuation

Moosburger Mühlteich*	20	3,9	max. 5	---	---	---
Flatschacher See*	21	3	max. 3,4; ave. 1,6	0,046	1,2 months	3,5
Maltschacher See	22	12,9	max. 6,7; ave. 4,2	0,538	9,4 years	1,5
Zmulnersee	23	1,8	max. 7,5	0,068	---	0,38
St. Urbaner See*	24	9	max. 3; ave. 1,7	0,15	1,2 months	---
Hörzendorfer See*	25	6,36	max. 5	---	---	5,89
Goggausee	26	10,5	max. 12; ave. 9,3	0,876	7,2 months	2,75
Kraiger See	27	5,1	max. 10; ave. 4,9	0,248	0,99 year	1,5
Längsee	28	74,8	max. 21,4; ave. 13,4	9,19	9,7 years	5,36
Pischeldorfer Badeteich*	29	0,75	max. 2,4	---	---	---
Linsendorfer See*	30	3	max. 7,5	---	---	---
Kleinsee	31	9	max. 9	---	---	---
Klopeiner See[2]	**31**	**110,6**	**max. 48; ave. 23**	**25,4**	**11,5 years**	**4,14**
Turner See	31	44,1	max. 13; ave. 7,5	3,3	1,2 years	7,98
Gösselsdorfer See	32	32	max. 3; ave. 1,9	0,61	0,1 year	28,81
Sonnegger See*	32	1,7	max. 4,5	---	---	---
Pirkdorfersee*	33	3,5	max. 3,5.	---	---	---
St. Andräer Badesee*	34	2,5	max. 5, ave. 3	0,0745	---	---
Lake Bled		**147**	**max. 30; ave. 17,48**	**25,7**	**2,5**	**107,3**

*artificial lake

Faaker See, Keutschacher See and Klopeiner See have very similar characteristics as Lake Bled and therefore are interesting for comparison or examination of mathematical models among them. Lakes have also Slovenian names, called Baško, Hodiško and Klopinjsko jezero, respectively. Detailed descriptions are shown in chapters 3.7 to 3.9.

[2] Lakes written in bold text are very similar to Lake Bled.

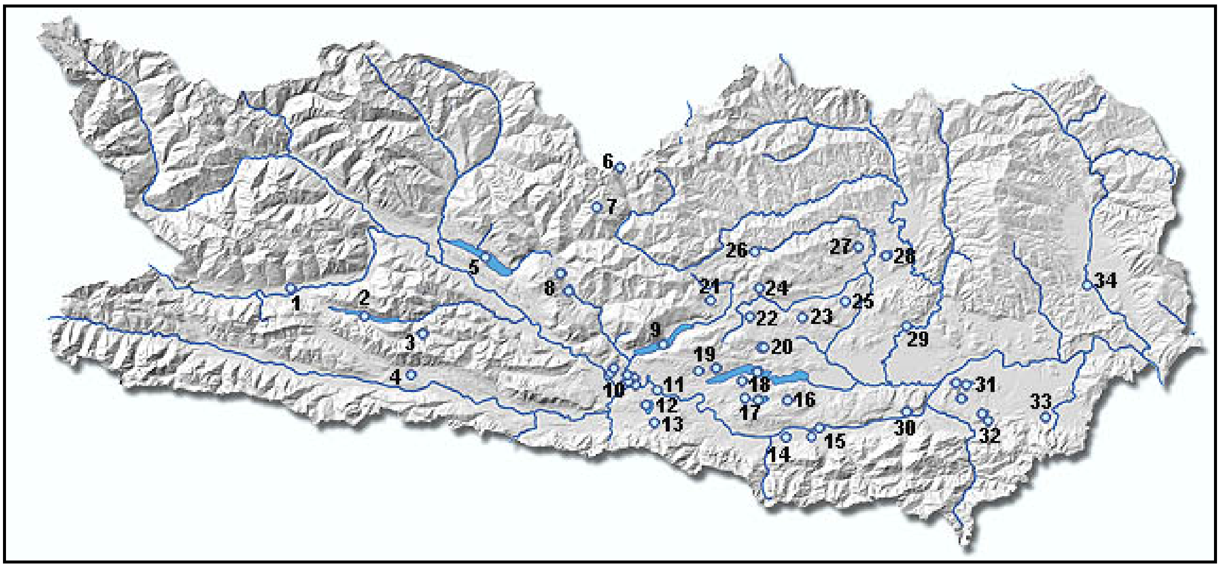

Figure 8: Locations of the Carinthian lakes see Table 5 (compiled from data published on KIS's internet site (KIS, 2003))
Slika 8: Lokacije koroških jezer, glej Preglednico 5 (zbrano iz podatkov objavljenih na spletni strani KIS-a (KIS, 2003))

3.2 Management approach in the Carinthian lakes

3.2.1 Province

In Carinthia, the management of lakes is of the provincial domain, indeed, in cooperation with the state and municipalities. Regional administration has twenty departments, and four of them are connected with the lake management. They are engaged with environmental protection, water management, agriculture, spatial planning and legislation. Department 15, one of the most important, is responsible for environmental protection and technology and includes Carinthian Institute of Limnology (KIS – Kärntner Institut für Seenforschung). Provincial administration is governing organization that controls most of environmental projects. Because of its effectiveness and public respect, private sector is involved only in the minority of projects. Of course, designing and building of infrastructures are outsourced or tendered on the market. Other stakeholders are united in a few associations, which represent their interests.

3.2.2 Municipalities and water associations

Building, operation and management of the infrastructures (sewage systems, wastewater treatment plants, lakes remedial infrastructure, etc.) are in municipality or in (waste) water association domain. An answer who exactly will operate it is in the hands of provincial administration and municipalities. In the case of building and managing of sewage system which spreads across more municipalities, establishing of a water association is usually the best solution (example Faaker See). Otherwise, for sole projects, everything could be managed by the municipality. Common lake management scheme is shown in Figure 9.

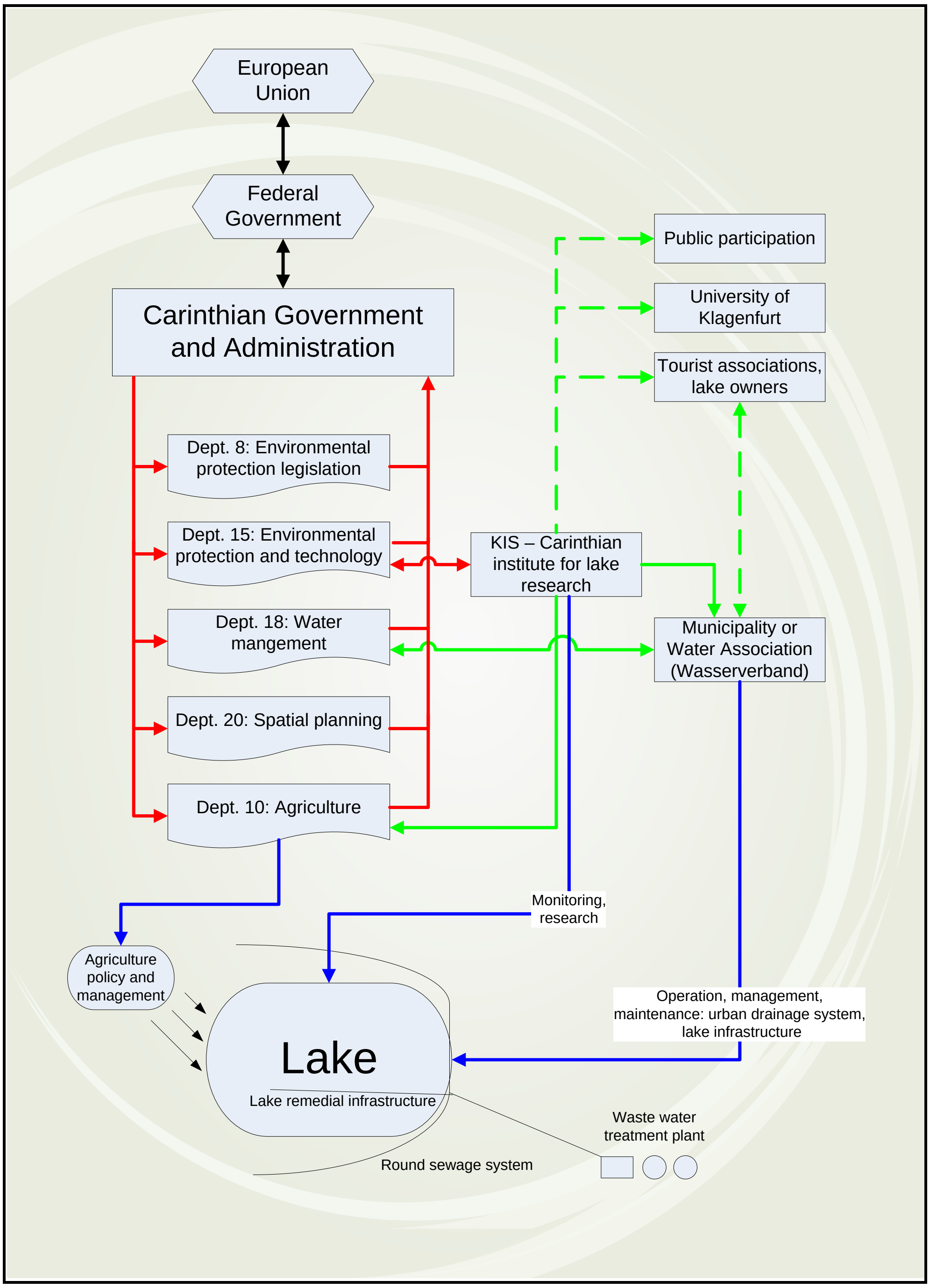

Figure 9: Carinthian lakes – management structure
Slika 9: Koroška jezera – upravljavska struktura

When something goes wrong, for example leaking of sewage water into the lake, KIS perceives higher amounts of nutrients in lake by measurements and informs the sewage system operator about that. In the case of bigger damages, it is necessary to communicate with the regional administration, first with environmental protection and water management department. When a solution and financial sources are found, everything must be accepted by the regional government. After that communication goes top-to-down, finally to the municipality or water association, which built new system or make necessary repairs.

3.2.3 Carinthian Institute of Limnology (KIS)

Carinthian Institute of Limnology (KIS) was established by the Province Carinthia and Nature Science Association. Beside lake and river measurements, it also makes researches and assessments in other projects connected with water and environment. It is mainly financed by a regional budget, it earns a small portion from projects made on the market and from the European projects. Management board is composed of three people, one from Nature Science Association and two from the Carinthian administration, department 15. Organizational structure is shown in Figure 10.

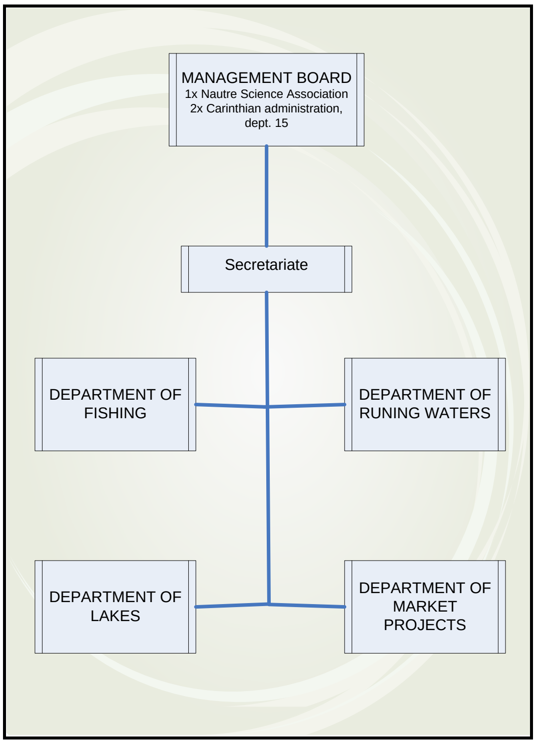

Figure 10: KIS – Organizational structure (compiled from data published on KIS's internet site (KIS, 2003))
Slika 10: Organigram KIS-a (zbrano iz podatkov objavljenih na spletni strani KIS-a (KIS, 2003))

3.2.3.1 Measurements

KIS makes researches and monitoring in all Carinthian lakes and rivers. In smaller lakes only two measurements per year are made, namely before and after a tourist season. In bigger lakes monitoring is made three to four times per year, once in every state of lakes (summer and winter stagnation, spring and autumn mixing). Monitoring includes the following parameters (Schulz, 2006):

- Physical: light penetration (Secchi depth), temperature, pH, conductivity;
- Chemical: total phosphorous, orthophosphate, nitrate, oxygen, chlorophyll-a;
- Biological: phytoplankton biomass, zooplankton.

In lakes used for bathing, monitoring also includes sanitation (microbiological) testing.

Every year one lake is subjected to an extensive analysis, which includes one monitoring per month. In the past, before and after establishing of sanitation and remedial measurements, monitoring was made once per month in all bigger lakes to control successfulness of implemented solutions. Today, when lake ecosystems are stable, it is enough to control lake quality once in four months, what is also prescribed as a minimum in OECD recommendation Eutrophication of Waters (Vollenweider et al, 1986).

3.2.3.2 Database about watershed

KIS collects and manages all important data about lakes and watershed areas. All data are collected in ESRI® base, with a parcel as an elementary unit. Like that, watershed area is defined for every lake using parcel borders, which causes easier implementation of measurements and spatial policy. Furthermore, the following land characteristics are defined inside each watershed area:

- Lake influents and effluents;
- Exact definition of belonging areas;
- Contour lines;
- Soil characteristics;
- Vegetation;
- Intensive agriculture areas;
- Land use.

Characteristics are presented in tables and graphical maps (one example is shown in Fig. 11, detailed introduction is shown in appendices), and everything is accessible over the internet (www.kis.ktn.gv.at). With so exact watershed definition is then much easier to manage the lakes. Moreover, together with municipalities and province, future spatial policy and development are proposed on foundations of this database. Furthermore, intensive agriculture areas are a potential danger for lakes. From the graphical maps it is easy to recognize such areas and then treat and control them more precisely. All that is one very important step towards the prevention of future annoying events and successful management of agriculture influences. Provincial administration and geodetic services also use the same database, which results in easier data exchange and better communication. Usage of online services makes data exchange even faster and more user friendly. Cutting off the costs is also one very important advantage.

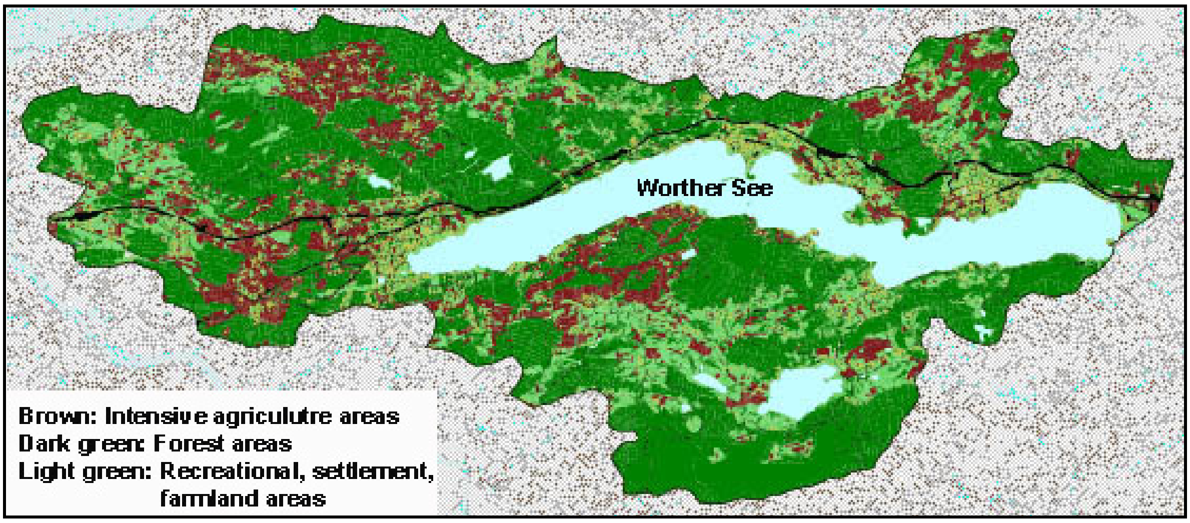

Figure 11: Watershed area of Wörthersee – land use (KIS, 2003)
Slika 11: Pojezerje Vrbskega jezera – raba tal (KIS, 2003)

For the conclusion, two parts compose the Carinthian lake management system. KIS is responsible for monitoring and research, and municipalities or water associations for doing management and operation of infrastructures. Above all, the Carinthian administration stays as a connection and supervision subject.

3.3 Sanitation measurements

3.3.1 Development of tourism in previous century

Increasing urban load in the middle of the former century caused eutrophication problem in the majority of the Carinthian lakes. Specially fast developing tourism was the main inducer (Fig. 12). Algae blooming occurred in Wörthersee, the symbol of Carinthian beauty and purity (Fig. 13). Awareness that something must be done in the way of sanitation and remediation was becoming obvious.

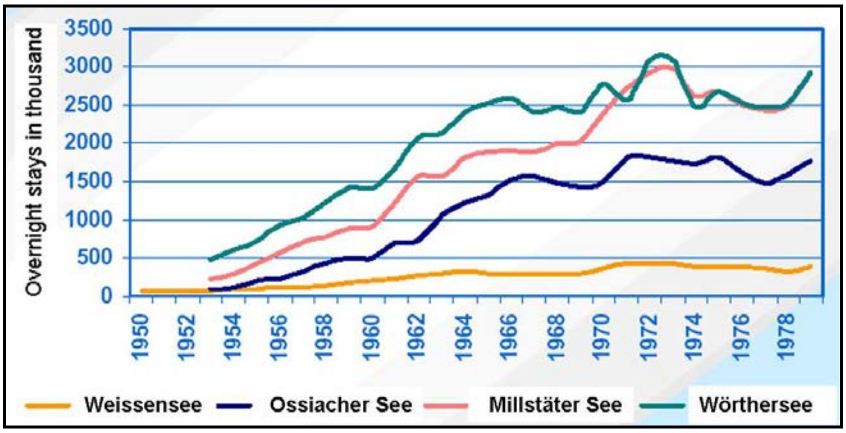

Figure 12: Development of the Carinthian tourism – annual overnight stays (Schulz, 2003)
Slika 12: Razvoj turizma na Koroškem – število letnih nočitev (Schulz, 2003)

Unsettled urban drainage system and wastewater respectively, was a main problem. In the year 1964, the Carinthian government proposed lake sanitation program, with the building of sewage systems around all bigger lakes as main goal (Sampl, 2005). Federal government decided to help the project with financial support (favorable loans).

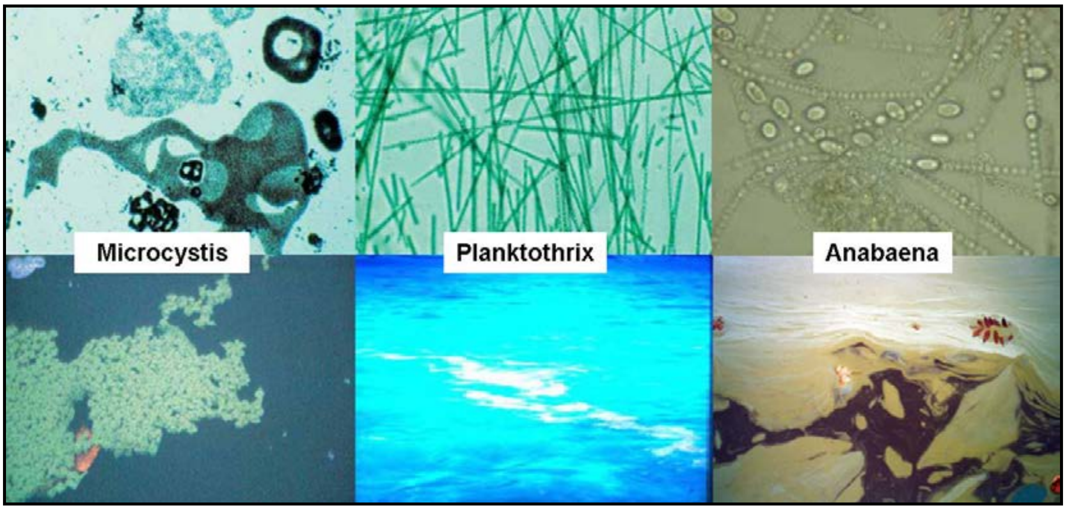

Figure 13: Algae blooming in Carinthian lakes (Schulz, 2003)
Slika 13: Cvetenje koroških jezer (Schulz, 2003)

3.3.2 Organization

Proposed lakes sanitation program anticipated building of circular sewage systems as the first priority. Furthermore, organizational solutions and establishment of water associations were also included in the program. Foundation of water associations were laid in the following steps:

- Planning;
- Organization;
- Management.

Consequently, the first step of established water associations was planning of urban drainage systems and searching for the best variants. Furthermore, when everything was accepted by the regional government and financial sources were assured, associations led and managed all building processes (selection of executors, legal affairs, construction supervision). Later, when all infrastructures were built, they started with operating and managing. Because operational, managerial and maintenance costs are high, it is necessary that prices for services are high enough to cover all costs and assure good long-term operation.

Seven water associations have been established for lake sanitation projects (Tab. 6). The biggest, Wasserverband Wörthersee-Ost, has in operation 155 km of transport sewage pipes and 129 pumping stations. In addition, in the eastern part of Wörthersee (Krumpendorf) pumping station with capacity 350 l/sec is located (WW Wörthersee – Ost, 2003). Big central wastewater treatment plants are located in Klagenfurt (300.000 PE), Villach (200.000 PE), Mettersdorf (180.000 PE) and Spittal (110.000 PE), while others, smaller, are scattered all around the region.

Table 6: Water associations in the Carinthian region – lake areas (Schulz, 2003)
Preglednica 6: Vodna združenja na Koroškem – območja jezer (Schulz, 2003)

Name	Headquarters	Year of establishment
WV Wörthersee-Ost	Klagenfurt	1965
WV Ossiacher See	Feldkirchen	1965
WV Millstätter See	Seeboden	1965
Abwasserverband Faaker See	Drobollach	1969
Reinhalteverband für das Gebiet St. Veit/Glan	St. Veit/Glan	1976
Abwasserverband Völkermarkt-Jaunfeld	Völkermarkt	1985
WV Wörthersee-West	Velden	1991

3.3.3 Urban drainage system

3.3.3.1 Circular sewage systems

Urban drainage systems were built around all bigger lakes, beginning with an erection in the year 1964. For that reason, all wastewater in lake-watershed areas is collected in sewers and led away from lakes. Wastewater systems are mostly separate, they are mixed only in very urbanized regions. Rainwater is usually infiltrated to the underground on place or lead to the nearest flowing creeks or rivers, following pre-cleaning in grit and grease chambers. Systems are gravitational (pipes in the ground) and pressure with belonging pumping stations (pipes inside lakes, in some places also in the land).

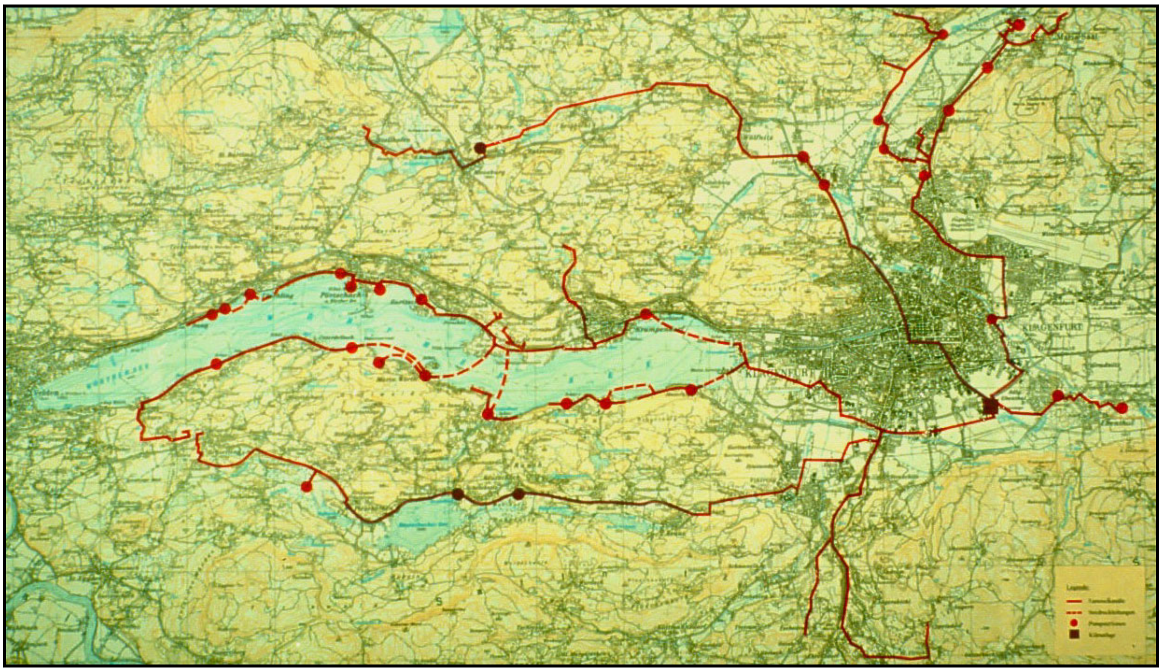

Figure 14: Example of circular drainage system: Klagenfurt, Wörthersee and Keutschacher See (WW Wörthersee – Ost, 2003)
Slika 14: Primer krožnega kanalizacijskega sistema: Celovec, Vrbsko in Hodiško jezero (WW Wörthersee – Ost, 2003)

3.3.3.2 Used technology of building

Circular sewage systems were built mostly by asbestos-cement pipes, only for pressure collectors inside lakes polyethylene (PE) pipes were used. Technology of building under water systems was the following: endless pipe was fabricated on place, charged with concrete weights in every meter and then pulled with boat into the lake. When the pipe was filled with the water, it sank to the bottom of the lake (Fig. 15, 16). In the case of maintenance works or damages, water is only pumped out and pipe swim up. Very cost-effective and technologically easy approach which represents only 5% in total sum of costs (Sampl, 2005). Another 95% belongs to the investment and operation of pumping stations. Usually, affected people are unsatisfied with pressure systems (operation risk), but in lake areas this technology is the most appropriate or the only possible one. With the stable electric supply and remote controlling of pumping stations, pressure systems can assure permanent operation and high enough security.

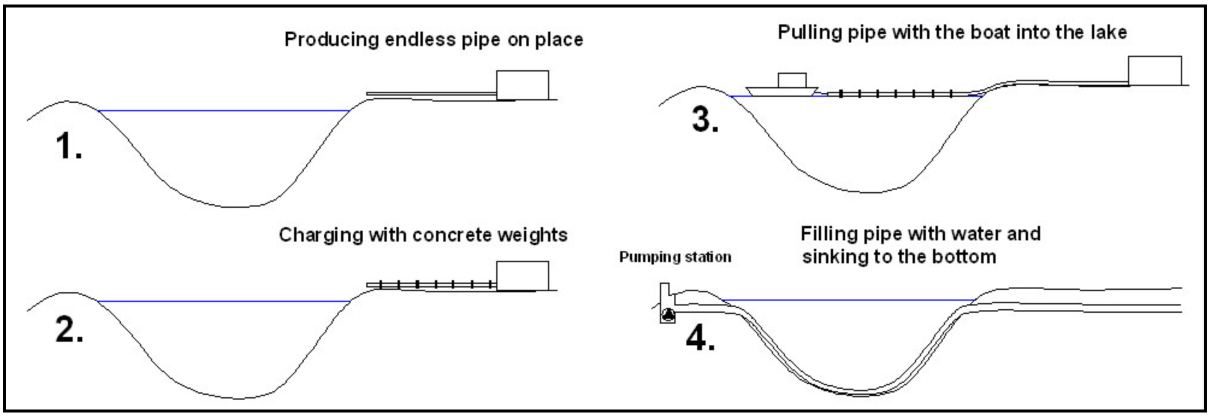

Figure 15: Pressure pipes inside lake – technology of building
Slika 15: Tlačni vodi po dnu jezera – tehnologija gradnje

Figure 16: Pressure pipes inside lake during construction (Schulz, 2003)
Slika 16: Tlačni vodi po dnu jezera med gradnjo (Schulz, 2003)

3.3.4 Constructed wetlands

The main motorway from Villach to Vienna (A2) is located near the Wörthersee. In the case of precipitation a lot of rainwater comes from motorway, furthermore, polluted water endangers lake system and increases load with nutrients. For that reason, more then 15 constructed wetlands have been built along the motorway (Fig. 17). Rainwater from the first minutes of storm is collecting in retention basins and then, when storm or rain stops, it is let to the constructed wetland (planted soil filters). Controlled infiltration to the underground, through planted soil filter, biologically purifies the water and consequently reduces amounts of nutrients in the lake. Mechanical cleaning is located in front of the inlet to the retention basin, where rainwater flows through special nets and later in the retentions basins, where most of the rough parts sink to the bottom. Therefore, cleaning of retentions basins is obligatory in defined periods. When it rains for a longer time, excess rainwater is overflowed from retention basins directly to the drainage creek or river. Because this water is not polluted so much, it does not endanger the surrounding environment.

Figure 17: Constructed wetland along A2 motorway – Wörthersee region (Sampl, 2005)
Slika 17: Rastlinska čistilna naprava vzdolž avtoceste A2 – območje Vrbskega jezera (Sampl, 2005)

The amount of rainwater from the whole motorway is very high. Consequently, leading this water to the wastewater treatment plants will represent enormous transportation and cleaning costs. Because we know that precipitations are happening stochastically, and specially in winter and in summer time not so frequently, building of aforementioned infrastructure is even more unacceptable. The second thing is also that rainwater is not so much polluted as wastewater and therefore constructed wetlands represent a very cost effective solution, also with good purifying results. The same technology can be used for purification of rainwater from urbanized areas or purification of wastewater from small settlements or lonesome houses. A research project, cold SWAMP (Sustainable water management and wastewater purification in tourism facilities), supported by the European Commission under the Fifth Framework Programme and contributing to the implementation of the Key Action "Sustainable Management and Quality of Water" within the Energy, Environment and Sustainable Development, was made in the previous years. The project aimed at developing economically feasible and technically satisfying wastewater treatment for tourism facilities with seasonal fluctuation using an integrated approach comprising sustainable water management, constructed wetlands for wastewater treatment and reclamation of the treated effluent (The European Commission Community Research, 2002). Therefore, results from this project can help and support future decisions considering solutions about waste- and rainwater treatment in urbanized and even more in rural areas.

3.3.5 Financial construction

1.785.000 meters of sewage systems were built from the year 1964 to 2003, the whole project amounted to the total sum of 430.665.000 EUR (Schulz, 2003). Moreover, the structure of financial sources was the following:

- State loans (environmental and water funds): 20 – 50% till 50 – 80%;
- Regional non-return sources: 15 – 20%;
- Connection fees: 10% (max. 2.534 EUR/100m^2), paid by local inhabitants who were connecting to the infrastructure, price depended on the largeness of the housing surface (e.g. for house with 150 m^2 of housing surface this means max. 3.801 EUR, i.e. 950,25 EUR/PE for the family with four members).

The whole money was obliged directly to the known projects and was not transferring through the unnecessary programs and local budgets. For that reason, the financial constructions were surveyable and easily controlled by all partners. State loans were given through the private bank. Furthermore, all projects were supported and controlled from that bank, which also employs people for the consulting of projects implementation. Because the private sector is always interested that project is occurring in proposed way and consequently, it can realize its profit, suchlike establishment of public-private partnership was a win-win combination.

3.4 Remedial measurements

When sanitation measurements are not enough, which means nutrients load is too high and danger for algae blooming still exist, it is necessary to implement one of the remedial measurements. Two approaches are possible here, i.e. in-lake and in watershed area.

Table 7: Remedial measurements in the Carinthian lakes (summarized from the Carinthian lakes report 2004 (KIS, 2004))
Preglednica 7: Zdravstveni ukrepi na Koroških jezerih (povzeto po Poročilu o stanju jezer na Koroškem v letu 2004 (KIS, 2004))

Siphoning	Harvesting	Dredging	Aeration	Artificial Flushing	Biomanipulation
Klopeiner See	Feldsee	Ossiacher See	Feldsee		Ossiacher See
Kraiger See	St. Andräer Badesee	Moosburger Mitterteich			Wörther See
Vassacher See	St. Urbaner See	St. Urbaner See		Vassacher See	
Leonhardersee	Afritzer See	Afritzer See		Leonhardersee	
Hörzendorfer See	Pressegger See	Pressegger See			
	Maltschacher See				

List of all feasible measures is shown in Appendix A. In-lake remedial measurements usually do not abolish problems on source, therefore they treat only consequences. On the other side, measurements in watershed areas reduce nutrient load and improve conditions directly on source. One evidence more how watershed area is important for the lake quality and how a successful management of it is necessary. E.g. urban drainage system is also a part of measurements in watershed. Established in-lake remedial measurements in the Carinthian region are shown in Table 7, with explanations in the following chapters.

3.4.1 Dilution, flushing and siphoning

Dilution or flushing introduces nutrient-poor water and flushes out nutrient-rich water, decreasing the concentration of pollutants and thus the potential for algal growth. Siphoning is an example of flushing of the hypolimniom water (Fig. 18), where nutrient-rich water from the bottom is flushed out through the siphon pipe. Technology is very simple, with very low operation, management and maintenance costs (no movable and electrical devices, in some cases only a small vacuum pump). Erection costs vary from project to project, depending on the pipe diameter, its length and other necessary infrastructure (aeration devices). Problem in most cases is that it is necessary to find new influent water which substitutes flushed water through the siphon pipe. Because siphoning is useful mostly in lakes with a small amount of influent water, it is not always easy to find new influents.

3.4.1.1 Siphoning in Klopeiner See

Siphon pipe in Klopeiner See (Fig. 18) distincts of two specialties. First, there is a movable inlet to the siphon pipe, which can displace for 15 meters. Because Klopeiner See is a meromictic lake where lower meromictic level varies from 10 to 20 meters, the inlet of siphon pipe can fit-up to this movement. In the last decade, lake conditions have been stable, therefore, inlet to the siphon pipe has been in the same position, in depth of 35 m, for almost 10 years (Municipality St. Kanzian, 2005). The second specialty is dosing of hydrogen peroxide (H_2O_2) into the flushed water before the siphon pipe outlet. The outlet is located in the urbanized area (houses and hotels). Flushed water from the bottom is without oxygen and it stinks, therefore, it causes a lot of dissatisfaction by inhabitants and tourists. There with the dosing of hydrogen peroxide, which is a strong oxidant, conditions in flushed water are improved, furthermore, outlet water does not stink anymore. Which oxidant is used in suchlike processes depends on price, accessibility on the market and supplier references. The other solution to avoid such problematic is extending of siphon pipe to the end of urbanized area. This claims new investment and cancels operation costs for dosing station. To decide which solution is better, it is necessary to make a calculation, usually cost-benefit analyses (CBA), which also considers unmeasured costs and benefits.

Klopeiner See is without influents, it is supplied only by well water from the ground in the total amount of approximately 35 l/s. Therefore, flushing through the siphon pipe can also operate in such amounts. Diameter of siphon pipe is 400 mm, what is appropriate for much higher flow (KIS, 2004). For that reason, like in Lake Bled, it is in the case of higher flows necessary to connect Klopeiner See with new influents. Such solution will decrease hydraulic residence time from today's record 11,5 years to lower values. Because, according to the OECD criteria, Klopeiner See is in oligotrophic state, suchlike expensive measurement is unnecessary.

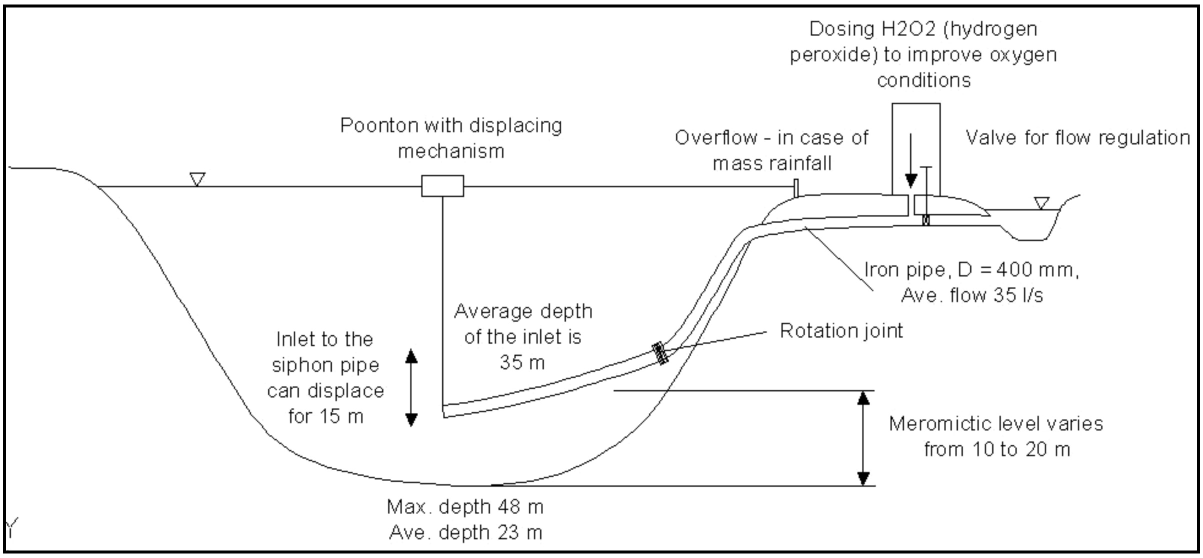

Figure 18: Siphoning of hypolimniom water in Klopeiner See
Slika 18: Natega za odvod hipolimnijskih vod na Klopinjskem jezeru

3.4.1.2 Siphoning and flushing in small lakes

Kraiger See, Vassacher See, Leonharder See and Hörzendorfer See are very small. Therefore, it is hard to compare them with Lake Bled. The technology of building of siphon pipe in Kraiger See is interesting. It was built in winter time, when the lake was frozen. Only 60 cm belt of ice was cut-off and pipe sank to the bottom (Sampl, 2005). For the artificial flushing in Vassacher See and Leonharder See overflowed water from drinking water tanks is used, which means the system is not operating continuously.

The depth structure of the lake inlet water varies through the year (Fig. 19). The problems have already been explained in *Chapter 1.2.3*. Construction costs for establishing the artificial flushing system are high and depends on project characteristics. First, it is essential to find new water sources, then to build belonging infrastructure (inlet, basins, connection pipe or new riverbed) and in cases where new water source lies in the lower level than the lake, it is necessary to build pumping station. The last mentioned claims high operation and maintenance costs and it is for that reason useful only for smaller amounts of water. For flushing water is appropriate only clean, nutrient-poor water, with higher amounts of oxygen.

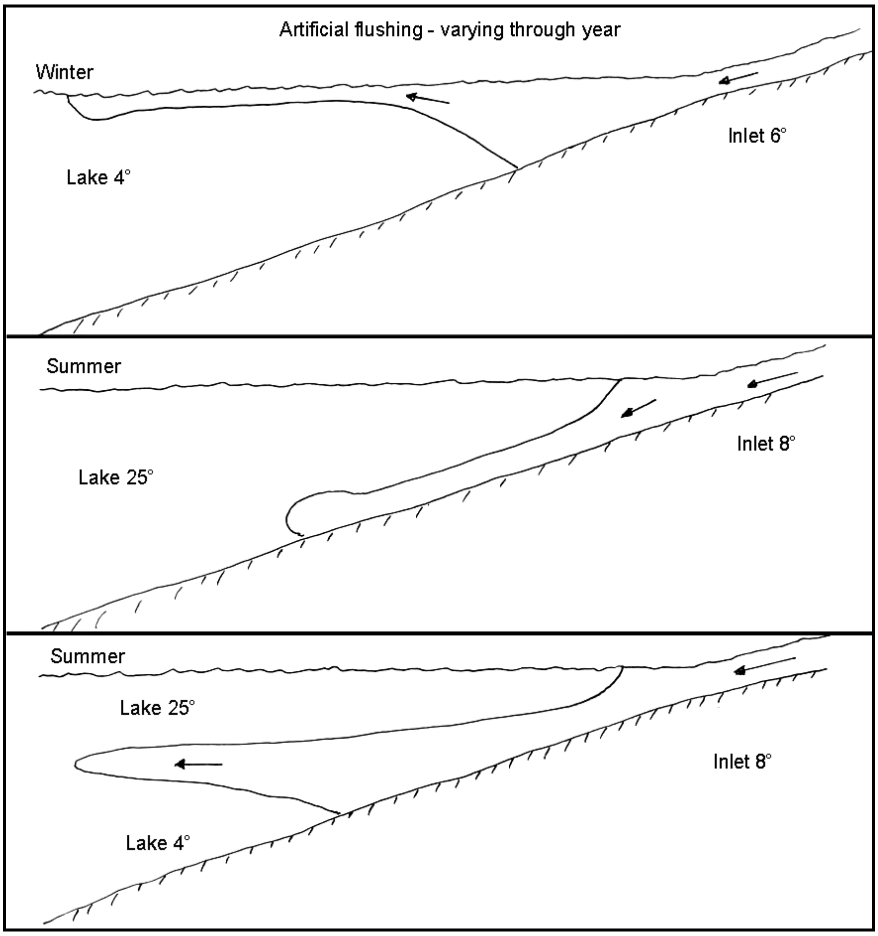

Figure 19: Inlet to the lake – varying through the year (Sampl, 2005)
Slika 19: Dotok v jezero – spreminjanje tekom leta (Sampl, 2005)

3.4.2 Harvesting

3.4.2.1 Harvesting of bottom vegetation

Harvesting removes nutrients from the system by eliminating algae, plants, and fish. In eutrophic lakes, however, only relatively small amounts of nutrients are removed by mechanical harvesting. It is primarily considered as a cosmetic improvement, like mowing a lawn and it is used mostly in bathing zones (enabling bathing usage). A special boat with a knife cuts-off the bottom vegetation (macrophytes), which then swims up to the surface. Then, the boat collects all cut vegetation and pulls it to the shore (Fig. 20, 21). Harvesting procedure is performed once a year, usually before the summer (bathing) season in April or May (Tab.8). Harvester costs approximately 150.000 EUR (DWA – Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall, 2005). The other costs belong to the operation (persons, fuel, transport) and depositing of the vegetation. According to DWA Guideline, the amount of costs for harvesting per ton of cut vegetation is 115 EUR (AWWR & Ruhrverband, 2001). In the Carinthian lakes, the structure of costs is the following (Schulz, 2006):

- Harvester per hour (depreciation, fuel, etc.): 21,70 EUR;
- Operator of harvester per hour: 25,00 EUR;
- Transport costs, lorry per hour: 27,00 EUR;
- Lorry driver per hour: 25,00 EUR.

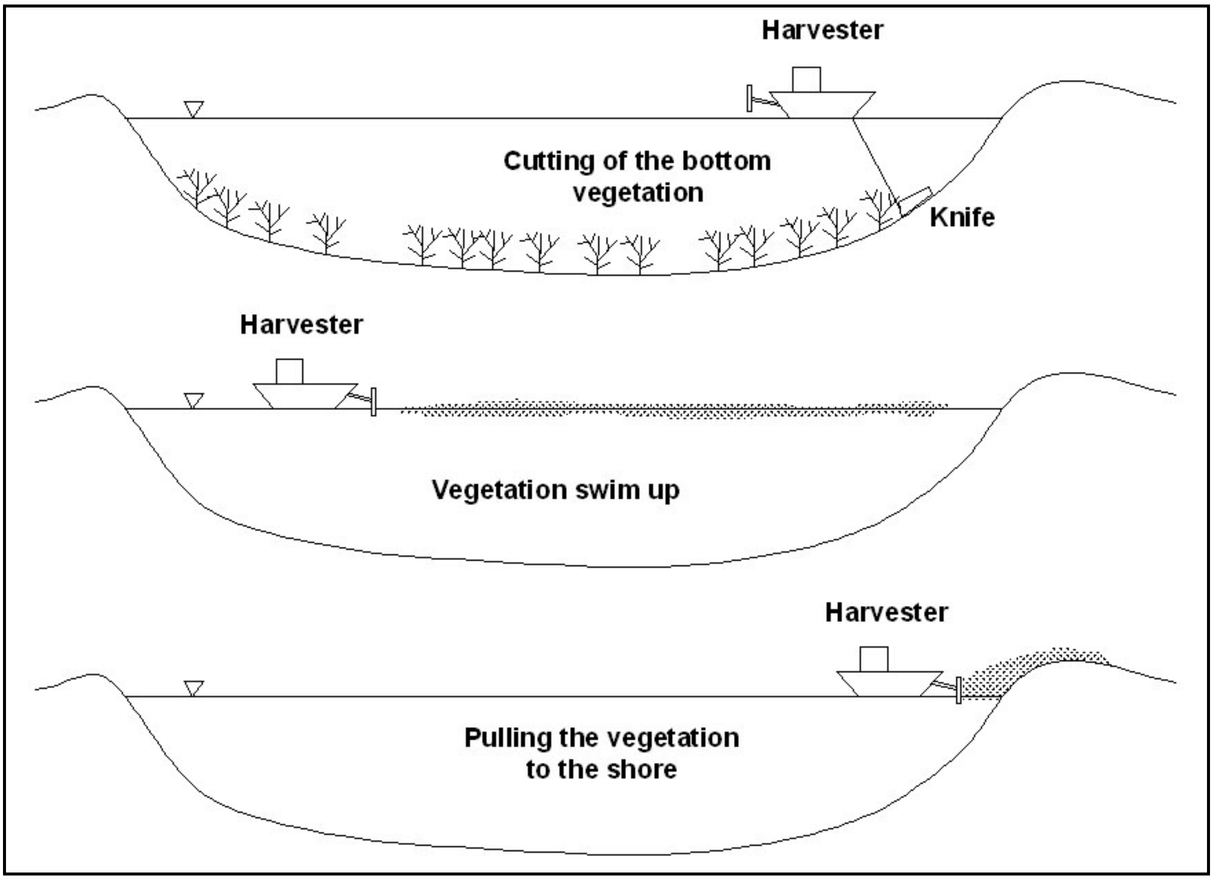

Figure 20: Procedure of harvesting of the bottom vegetation
Slika 20: Postopek odstranjevanja makrofitov iz dna jezera

Macrophytes exist only in littoral zone, down to the depth of light penetration. Therefore, harvesting is occurring only in these areas. In deep lakes, with high bottom inclination, harvesting is useless. It was already mentioned that harvesting was used mostly for improving bathing conditions and therefore occurs only in bath zones in the depth from 0 to 5 meters. In the case of harvesting of bottom vegetation in the whole lake, procedure will take a lot of time and, consequently, claim high operation costs. Specially in bigger lakes suchlike measurement is impossible. Depositing of cut vegetation can be problematic too, especially in the case of higher amounts. Good thing is that vegetation is a biological waste and it can be reused for fertilization. In the right part of Figure 21 is shown how great the volume of cut vegetation is when it is pulled to the shore. In the left part, harvester with plough, and special cutting knife are shown.

Figure 21: Harvesting of bottom vegetation in the Carinthian lakes (Schulz, 2003)
Slika 21: Odstranjevanje makrofitov na koroških jezerih (Schulz, 2003)

Table 8: Harvesting in the Carinthian lakes in the year 2004 (KIS, 2005)
Preglednica 8: Odstranjevanje makrofitov na koroških jezerih v letu 2004 (KIS, 2005)

Lake	**Person placing an order**	**Number**	**Total hours**	**Costs[3] (EUR)**
St. Urbaner See	Municipality St. Urban	2	70	3.477
Afritzer See	Municipality Afritz	3	46	2.460
Afritzer See	Municipality Feld am See	1	8	478
Maltschacher See	Sotour GmbH	3	90	4.515
Feldsee	Municipality Feld am See	1	18	945

3.4.2.2 Harvesting of algae

A few times in the past, algae blooming emerged in Ossiacher See before the summer season and disabled its tourist usage. Because the lake represents one of the main tourist attractions,

[3] Calculation made by A. Urevc. Based on data published above. Assumption: two hours of transport are considered for every procedure.

its useless can also hinder tourist development in the whole region. All other tourist offer mostly bases on the wellness lakes program. The same problems can happen now, with discovering of avian flu in a few countries inside the European Union. In Ossiacher See, algae harvesting was used as "quick-fix" management, to solve the summer tourist season. In algae harvesting procedure, special boat floats the lake, pumps the lake water together with algae to filter device and let the clean water back to the lake. Algae stay in filter and they are removed in certain periods.

It depends on the depth of algae blooming from which depth level water is pumped to the filter. Algae blooming can also occur inside the water body (in the depth of few meters) and not only on the lake surface. In many cases bloomed algae swim up to the surface. Because Ossiacher See is very big, algae filtration procedure lasts a pretty long time and costs a lot. But to enable tourist season and consequently assure future economic development of the area suchlike "quick-fix" measurement is requisite.

Figure 22: Harvesting of algae (water filtration) in Ossiacher See (Schulz, 2003)
Slika 22: Odstranjevanja alg na Osojskem jezeru (Schulz, 2003)

3.4.3 Dredging

Dredging removes sediments, which can be a major source of phosphorus in the water and they can hinder recreational use of the lake (Fig. 23, 24). In the Carinthian lakes approximately 50 cm of sediment is excavated, usually in the spring time (April, May). Sediment removal, however, is costly. According to DWA Guideline, dredging costs 7,50 EUR/m^3 of the dredged sediment (DWA, 2005). Disposal of the dredged sediment is often a problem. First, it is hard to find the appropriate areas and then there are problems with the land purchase, which takes a lot of organization and legal work. The cost for deposing depends mostly on the prices of the land. It is usually privately owned, so the price for the land purchase depends on market conditions and negotiations. Public interests and regional administration power can help a lot in negotiating procedure.

Companies for Germany and Netherlands, which deal with the same procedures in harbors along Northern sea coast, perform dredging in the Carinthian lakes. For better separation of water and sludge, flucculant is dosed before sludge depositing. When the sludge ultimately dries up, the volume is much smaller than at the beginning when water represents the majority of excavation. Finally, a landfill is planted with the grass and it is appropriate for the agriculture use again.

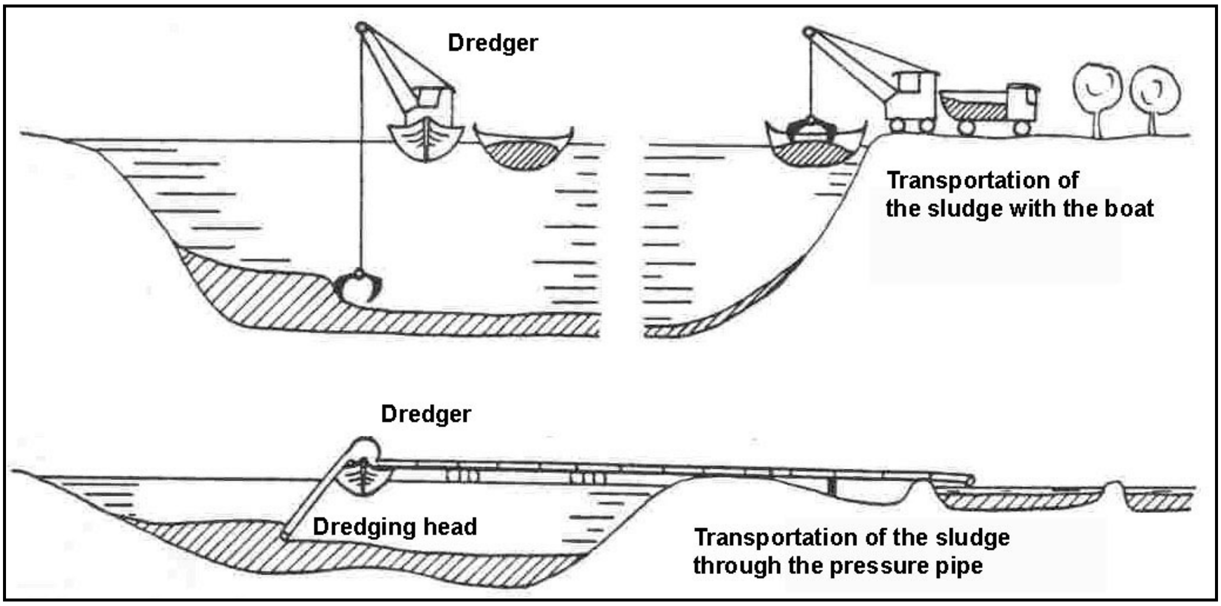

Figure 23: Dredging procedures in the Carinthian lakes (Sampl, 2005)
Slika 23: Odstranjevanje sedimenta na koroških jezerih (Sampl, 2005)

Because the amounts of dredged sludge from bigger lakes are too high, dredging is useful mostly in smaller lakes. Structure of the bottom has to be taken into the consideration, too. When a bedrock constructs the bottom or when it is covered with rocks or other solid matters, the use of dredging is problematic.

Figure 24: Dredger in one of the Carinthian lakes (Carinthian environmental report, 1999)
Slika 24: Bager za odstranjevanje sedimenta na enem izmed koroških jezer (Poročilo o stanju okolja na Koroškem, 1999)

3.4.4 Aeration

Aeration and circulation are techniques that involve moving the water and adding oxygen which increases dissolved oxygen levels. This may prevent fish kills and create a larger habitat for fish and microscopic animal communities. Aeration can also slow down the tapping of phosphorus from the bottom sediments. Results, however, are not always predictable.

Two technologies are possible for the aeration. The first one is blowing the air or even pure oxygen directly to the bottom of the lake, like in aeration basin in wastewater treatment plant. The second technology is pumping the hypolimnium water to the surface where it mixes with air, and then it is lead back to the bottom (Fig. 25). In this technology it is important that the outlet of aerated water does not allow mixing with inlet water (see water separator in Fig. 25) and with epi- and metalimnium water. The last thing is important, because hypolimnium water contains a lot of nutrients and will therefore accelerate the biomass production in limnetic zone. The second technology is used in Feldsee in Carinthia. The aerator before put into place is shown in Figure 26. It was transported with the helicopter from the shore to the middle of the lake. The other possibility is also transport with the ship. The aerator includes pumps and other electric devices, and for that reason electric supply is necessary. Electric connection with the shore is, of course, the easiest and the cheapest solution.

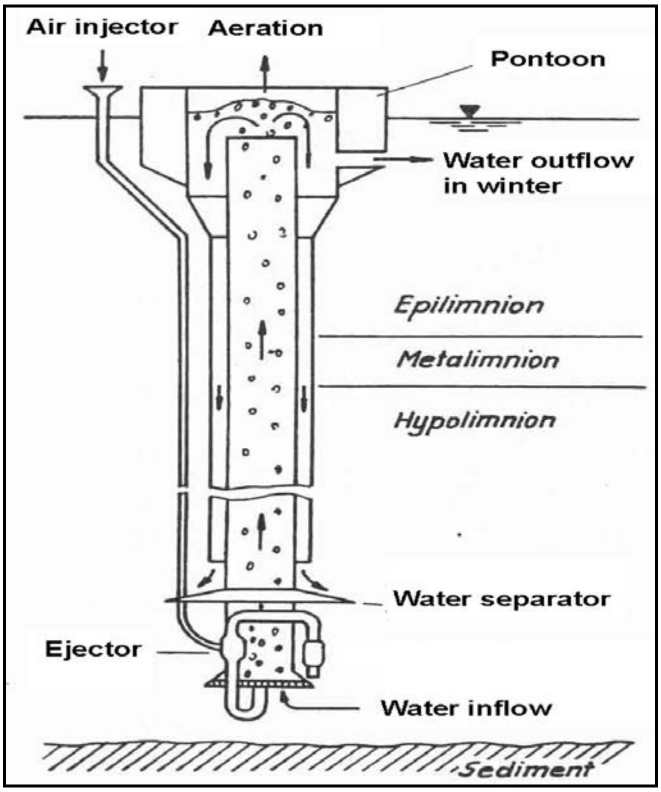

Figure 25: Aeration of the hypolimnium water in Feldsee (Sampl, 2005)
Slika 25: Prezračevanje hipolimnijske vode na Feldsee-ju (Sampl, 2005)

In Feldsee, aerator is in operation continuously in the summer time, usually from the end of June to the middle of October, when oxygen conditions at the bottom are the most critical ones (Carinthian lakes Report, 2004). Investment costs for implementing of aeration device are high. In Sempacher See in Switzerland, the whole investment amounts to 1, 5 Mio EUR. Sempacher See is a very big lake with the surface of 1440 ha and with 639 Mio m^3 of whole water volume, and therefore costs were so high (Gemeindeverband Sempachersee, 2001). For smaller lakes, e.g. Feldsee, investment costs varies from 15.000 to 250.000 EUR (DWA, 2005). Moreover, according to the electric and movable devices which compose the aeration system, operation, management and maintenance costs are also high. In aforementioned Sempacher See annual costs for operation reaches 250.000 EUR per year which is certainly much more than in the case of siphoning. Advantage against siphoning is that in aeration it is not necessary to substitute sucked water through the siphon pipe with new influents. Furthermore, searching for the new inlet water and building new connection pipe or riverbed are not necessary. Of course, in the areas where there are enough influents, siphoning is a much better, safer and cheaper solution.

Figure 26: Aerator in Feldsee before put into place (Sampl, 2005)
Slika 26: Naprava za prezračevanje na Feldsee-ju pred vgradnjo (Sampl, 2005)

3.4.5 Bio manipulation

Bio manipulation includes variety of chances and represents a relatively new effort to control the growth of algae and weeds through manipulation of the lake's ecological inter-connections. In Wörthersee and Ossiacher See two techniques for decreasing the algae growth have been used. The first problem emerged with special algae species which are growing at the bottom in the littoral zone, and later, when they grow enough, swim-up to the lake surface. Because this usually happened in the beginning of the summer time, it was always a threat and unintelligibility for the main authorities and tourist developers from both regions. Planting the littoral zone with vegetation was the solution (Fig. 27, 28). Such measurement decreases light penetration and shade algae, respectively. Moreover, algae need enough light for their growth, and with the decreasing of it, photosynthesis process is slowed down. Consequently, algae do not grow so fast and therefore there is no danger that algae will swim-up.

Sizes of Wörthersee and Ossiacher See are very big, they are the largest lakes in Carinthia, and for that reason aforementioned measurement takes a lot of work. It was implemented more as a test than as a permanent solution. The second used technique is planting the littoral zone with reeds (phragmites) which absorb nutrients from the water and slow down the algae growth. In many of the Carinthian lakes, shore and littoral zone are covered with reeds, in the majority cases naturally. Moreover, reeds biologically help to sustain good conditions in the lakes and it is obvious that these areas are protected and any removal is forbidden.

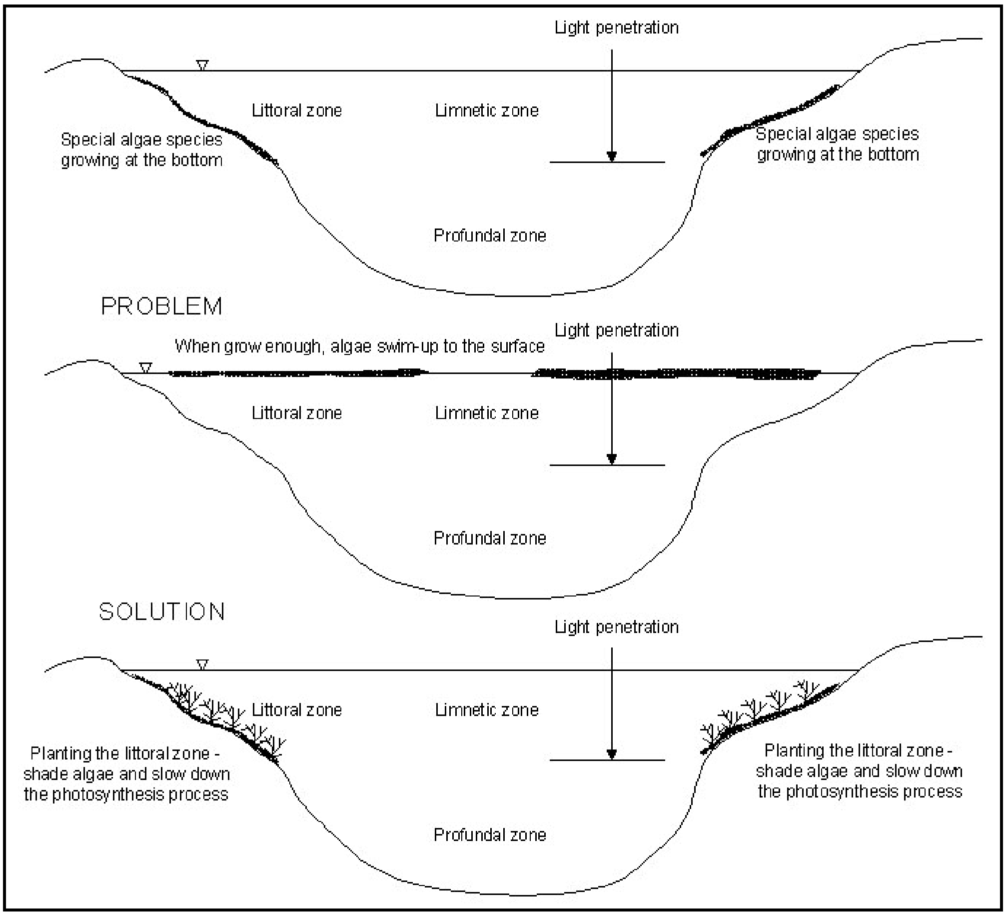

Figure 27: Bio manipulation – planting the littoral zone
Slika 27: Zasaditev litorala in preprečitev hitre rasti alg

Figure 28: Planting the bottom of the Wörthersee (Schulz, 2003)
Slika 28: Zasaditev dna na Vrbskem jezeru (Schulz, 2003)

Bio manipulation includes variety of chances for improving lake conditions with biological processes. Not only with new vegetation, but also with new fish species or other faunae which can survive in lake ecosystems. The main goal is slowing down or killing the species which are growing too fast and consequently endangering natural stability. Because nature is very unpredictable with a lot of stochastic processes, bio manipulation measurements represent risk that they will not reach the main goals or they will make conditions even worse.

3.4.6 Best management practices (BMP) in watershed areas

3.4.6.1 Off-site best management practices

Implemented best management practices (BMP) in watershed areas are mainly aforementioned circular sewage systems and constructed wetlands for treatment of rainwater from motorway. Waste- and rainwater were also the main polluters of lakes before the implementing of all expensive infrastructures. The other off-site best management practice is a wetland protection. All wetland areas near lakes are protected with the Carinthian land protection act (Landschaftschutzrecht), nature protection act (Naturschutzgesetz), sensible areas definition and areas protected by Ramsar Convention on Wetlands. In these areas building and agriculture are forbidden, only the land protection act allows controlled farming usage. Wetland areas between lakes and intensive agriculture areas are a perfect clarifier and also from that point of view entitled of a special treatment. Restoration efforts are not necessary because in the past only a minority of wetlands were drained.

Farming is not allowed in 10 – 15 m belt along the majority of influents to the lakes. Banks are covered with trees and bushes, in some cases they rise-up from the surrounding farm land. Therefore, in the case of rain storms, flushing of fertilizers directly from the farm land to the creeks or rivers is hardly possible.

In the past, the intensive agriculture endangered lake quality in Ossiacher See watershed. Therefore, the Carinhian government decided to buy this land, disabled farming use and protect the lake, consequently.

3.4.6.2 Non-structural best management practices

Non-structural best management practices are mostly led by the Carinthian Institute of Limnology (KIS). Such practices are the following: educational efforts, ordinances and regulations. Last two mentioned are accepted by the provincial government, KIS makes only drafts and suggestions. Educational efforts include newsletters, conferences, workshops and web sites. Newsletters usually educate what is not good to do in or near the lakes (urination, feeding the ducks and swans, dumping of litters, excessive use of sun creams, harming reeds, etc.) and presenting what has been done for sustaining good state of the environment (sanitation and remedial measurements). Such actions increase people consciousness about the importance of environment and about its protecting for future generations. Workshops and conferences are organized together with the tourist bidders, with the main goal to present the untouched nature and to increase the tourist demand. KIS internet site (www.kis.ktn.gv.at) is the main and an easily accessible presentation of institute's work. People can find the following things there:

- Detailed data about all lakes in the Carinthian region (shown in *Chapter 3.2.3*);
- Detailed data about all running waters in the Carinthian region;
- Details about fishes living in the Carinthian waters;
- Description of the institute (mission statement, history, plans for future, etc.);
- Description of representatives and employees with their contact addresses;
- Annual research and monitoring reports (explained in *Chapter 3.2.3*);
- Free online publications (same contents than in newsletters);
- Interesting graduation thesis, dissertations and other school projects;
- Description of best management practices;
- Useful links (Province Carinthia, universities, partners, etc.);
- Explanation of words used in limnology;
- News (future events, up-to-date explanations about lakes behavior).

KIS internet site is really wide and it offers a lot of information about lakes and other waters in the Carinthian region. This site also exists in mode for blind and sightless people which is very praising and certainly well accepted from the disabled people.

3.5 Results as a confirmation of right decisions

Proposed sanitation and remedial measurements claim an examination of success after they have been implemented. Lake systems, like a complex environment, not always react quickly, therefore, long-term and deep monitoring is necessary. The following figures show changing of three important parameters of the lake quality: total phosphorous, light penetration and ammonium – nitrogen. Representative measurements began in the year 1971, only light penetration dated back to the year 1931. Results are missing only from the second-world-war's time. It is necessary to mention that the results are not directly comparable with the results from other lakes. First, it is important which measurement procedure is used for certain parameter, then the monitoring frequency and finally the presentation of results. Consequently, for certain comparison it is necessary to check the mentioned parameters or makes measurements again in all lakes with the same procedures.

3.5.1 Phosphorous

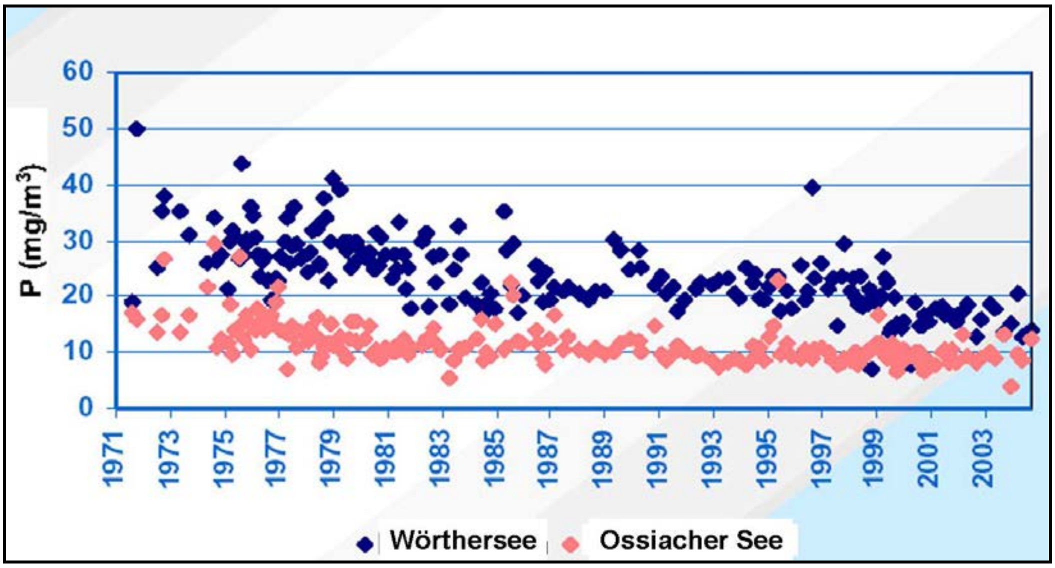

Figure 29: Total phosphorous (KIS, 2004)
Slika 29: Celokupni fosfor (KIS, 2004)

Phosphorous (Fig. 29) is a limiting eutrophication factor in most of alpine lakes. In the last three decades, after the implementation of sanitation and remedial measurements, the amounts of phosphorous in the Carinthan lakes decreased in average of 40% (e.g. in Wörthersee from 28 μg/l in the year 1975 to 15 μg/l in 2003). Although tourist development increased for 20% in the same period, the amounts of phosphorous decline what we can assign to the sanitation and remedial measurements. It is hard to imagine how high nutrients concentrations would be and how lakes would look like today without the implementation of measurements. A lake with phosphorous concentrations more than 60 μg/l is entirely useless for recreation and it represents a big break in the tourist development.

3.5.2 Light penetration – Secchi depth

Like with phosphorous, the same situation is with the light penetration (Fig. 30); e.g. in Ossiacher See increased from 3 m in 1960 to 7 m in 1995 (133% increase). In the last period, a little decrease has been perceived what we can assign to very hot summers in years around the year 2000. The success of sanitation measurements is very well noticed from the light penetration chart. Since the year 1971, when round sewage systems were finished, a really great increase has been perceivable.

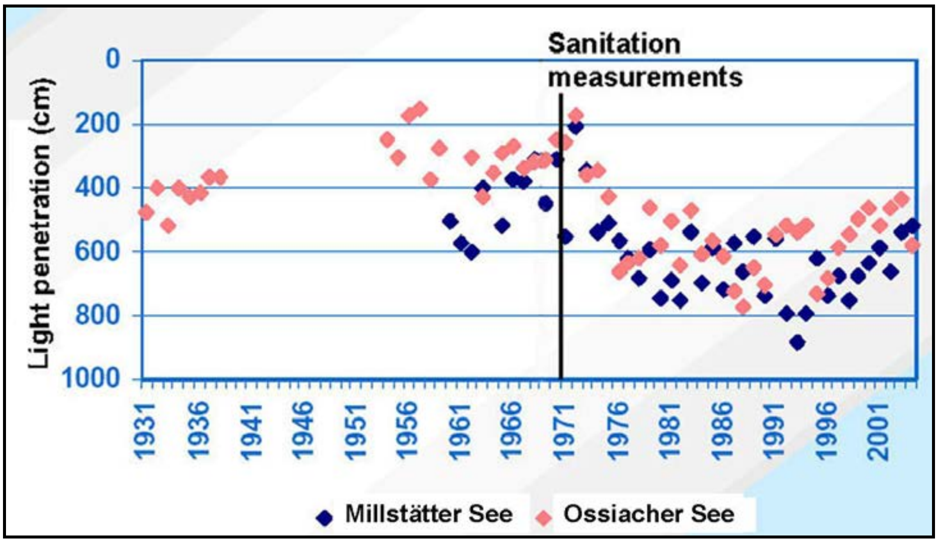

Figure 30: Light penetration – Secchi depth (KIS, 2004)
Slika 30: Prosojnost – Secchi-jeva globina (KIS, 2004)

3.5.3 Ammonium – nitrogen

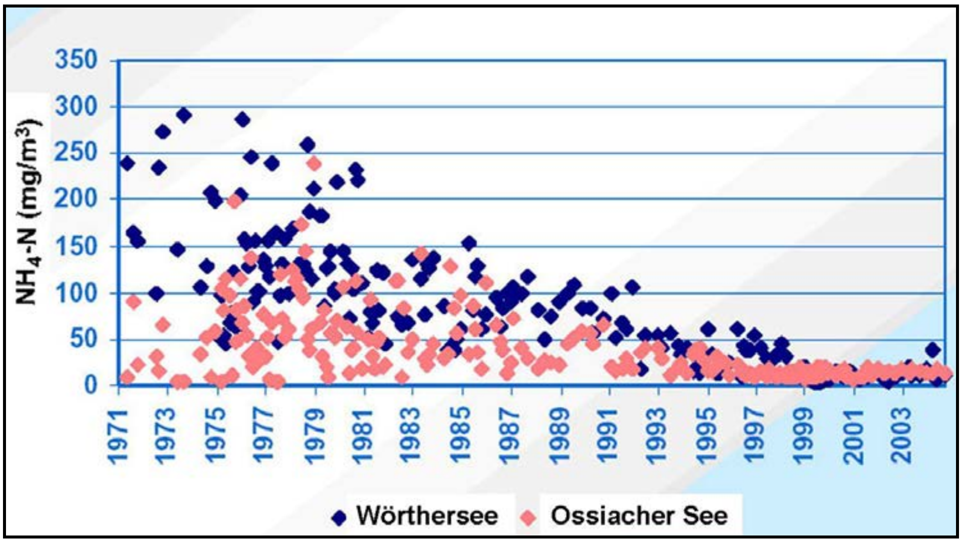

Figure 31: Ammonium – Nitrogen (KIS, 2004)
Slika 31: Amonijev dušik (KIS, 2004)

The biggest improvement is visible in ammonium – nitrogen (Fig. 31). E.g. in Wörthersee it has decreased for 84% (from 125 μg/l to 20 μg/l) in the last 30 years. Ammonium is very problematic because in the case of higher pH values it converts to the ammonia which is toxic for fishes and therefore endangering the whole lake ecosystem. Furthermore, the process of converting ammonium to nitrate, called nitrification, consumes oxygen and therefore reduces its amount in the water. Such things make conditions in the lakes even worse. Controlling and reducing of ammonium is for these reasons necessary. Wastewater contains a lot of ammonium; therefore, sewage systems and proper wastewater treatment plants help a lot in this case. Good maintenance of the whole system is also very important to prevent leaking. The second polluter with ammonium is agriculture. Farming has dropped in the last years and the usage of more environmental friendly technologies (fertilization) is present, which certainly is a very positive step for the future.

3.5.4 Oxygen conditions in Faaker See

As the last example, the depth profile of oxygen conditions through years in Faaker See is shown (Fig. 32). We have to say that Faaker See is one of the cleanest lakes in the whole Carinthia. Figure summarizes everything what is written above. At the beginning of the previous century conditions were very good, then in the 1970s, according to increasing urban load, a big worsening was visible. Later, when sanitation measurements have been implemented, oxygen conditions show an improvement.

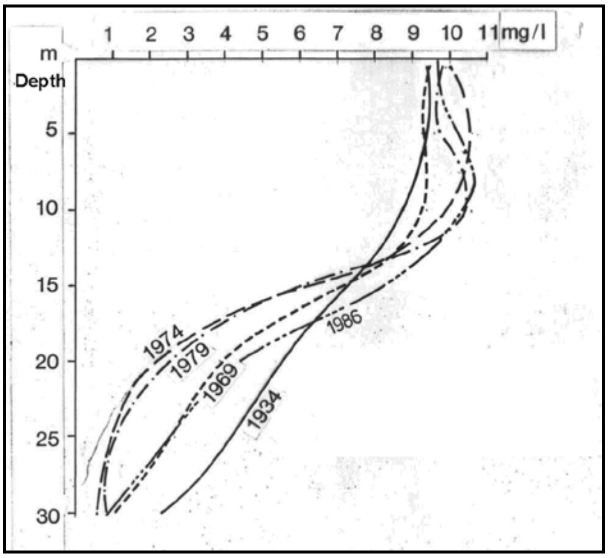

Figure 32: Development of oxygen conditions through depth in Faaker See (Sampl, 2005)
Slika 32: Koncentracije kisika po globini v Baškem jezeru – časovna slika (Sampl, 2005)

3.5.5 Stagnant water classification (ÖNORM M 6231)

According to the Austrian standard ÖNORM M 6231 (Guideline for ecological monitoring and classification of stagnant waters), stagnant waters are classified in trophic classes. Details are shown in Table 9. Classification of all lakes in Carinthia (KIS, 2004) is shown in Table 10.

Table 9: Stagnant water classification according to the Austrian standard ÖNORM M 6231
Preglednica 9: Klasifikacija stoječih voda po avstrijskem standardu ŐNORM M 6231

Class / Criteria	Oligotrophic	Weak mezotrphic	Mezotrophic	Weak eutrophic	Eutrophic
Total phosphorous (yearly ave. in epilimnium) [µg/l]	< 10	10 - 15	15 – 30	30 – 40	> 40
Total phosphorous (yearly ave. mixolimnium) [µg/l]	< 10	10 – 20	20 – 40	40 – 60	> 60
Phytoplankton biomass in epilimnium [mg/m^3]	< 1000	1000 – 1500	1500 – 3000	> 3000	> 3000
Chlorophyll-a in epilimnium [µg/l]	< 4	4 – 12	4 - 12	12 – 35	12 – 35
Presence of oxygen	Whole depth	Summer – at the bottom not	Summer – at the bottom not	At the bottom not	At the bottom not

Table 10: Classification of the Carinthian lakes (KIS, 2004)
Preglednica 10: Uvrstitev koroških jezer v trofične razrede (KIS, 2004)

Oligotrophic lakes (16/+5)	Weak mezotrophic lakes (18/-3)	Mezotrophic lakes (12/-1)	Weak eutrophic lakes (1/-3)	Eutrophic lakes (1/+1)
Badesee Kirschentheuer (+)	Afritzer See	Flatschacher See	Goggausee (-)	Grünsee (-)
Faaker See	Aichwaldsee	Flatschacher Vorteich (+)		
Farchtensee (+)	Feldsee	Hafnersee		
Falkertsee	Greifenburger Badesee	Hörzendorfer See		
Ferlacher Badesee	Keutschacher See	Leonhardersee (-)		
Forstsee (++)	Kleinsee	Moosburger Mitterteich		
Gösselsdorfer See (+)	Kopeiner See	Moosburger Mühlteich		
Längsee (+)	Kraiger See (+)	Pirkdorfer Badeteich		
Linsendorfer See	Magdalenensee (-)	Sonnegger See		
Millstätter See (+)	Ossiacher See	St. Andräer Badesee		
Pischeldorfer Badeteich	Rauschelesee (+)	Trattnigteich		
Pressegger See	Saisser See	Maltschacher See (+)		
Silbersee	St. Urbaner See			
Weißensee	Turnersee			
Wernberger Badesee (+)	Turracher See			
St. Johanner Badesee	Vassacher See			
	Wörthersee			
	Zmulner See (+)			

Classification in Table 10 shows that only two lakes are in eutrophic class, all others are better. Grünsee is not used for bathing and it is therefore not so problematic. Furthermore, all big lakes (also the most known) are classified in oligotrophic or weak mezotrophic class and indicate stable state. Pluses (+) or minuses (-) by some lakes mean improvement or worsening of lake conditions for one class in comparison to the previous year (2003). Two pluses mean an improvement for two classes. As we can see, in comparison to the year 2003, in 2004 12 lakes moved up for one or two classes and only of them 4 moved down.

Long-term data show that sanitation and management approach has been the right one and has reached the main goals which were set at the beginning. According to the stagnating tourist development in present time and reforming of agriculture, solutions are good enough for the next decades and will help the future sustainable development of the whole region.

3.6 Possibilities of financing the environmental projects

3.6.1 Basic founding possibilities

Building the environmental protection infrastructure usually claims high investment costs, especially for projects connected with wastewater disposal. Building of sewage systems and wastewater treatment plants are too expensive for small municipality budgets, therefore, state and regional aids are necessary. Whole Austria solved these problems in a very good way. Variants investigations, written in the funding regulation for urban water investments, are the foundation for decisions which projects will be co-financed by the region, which by the state and which by the European Union. Municipalities or water associations prepare various plans for newly equipped areas with the assistance of regional administration. Furthermore, all stakeholders then together decide which variants are the best and how the financial structure will look like. The following possibilities exist for the financing (Carinthian environmental report, 1998):

- European Union – mostly non-return sources (must sign-up to public competitions);
- State – favourable loans (Kommunalkredit AG, KPC);
- Region – in the past non-return sources, today mostly favourable loans;
- Municipality;
- Connection fees – paid by newly connected inhabitants (according to the Carinthian legislation max. 2.543 EUR/100 m^2 of basal housing surface);
- Private money (public – private partnership).

3.6.2 Repayment, management and operation

When infrastructure is in operation, price for service usually consists of a fix and a variable part. The fix part is calculated on the basis of a unit (one unit represent 100 m^2 of housing surface, 20 m^2 of restaurant or hotel surface, 20 bathers for camping sites, etc.), while the variable part bases on consumed water or produced wastes. Money coming from the fix part covers financial (loans) and management costs which are also fixed. The amount of loans and their redemptions are known before the project implementation and therefore, with the fix part of the price, long-term returning is assured, also before the operation. Consequently, the interests of banks to give loans for such secure environmental projects are higher.

Money coming from the variable part covers operational and maintenance costs. These costs are not fixed and depend on loading of the system. For example, in the case of higher water consumptions, sewage system and treatment plant operate on higher flows, moreover, operation (e.g. electricity for pumping stations) and maintenance costs (e.g. pumping stations damage frequently) are higher. With the variable part of the price for municipal services money for aforementioned costs is assured. Furthermore, high enough prices stimulate lower consumption from people (saving with natural resources) and protect environment, consequently. In some big municipalities (e.g. city of Villach) prices consist only of the fix part. Inclusion of the variable part claims too high investment and management costs and it is therefore not economical. Certainly, suchlike structure does not stimulate lower consumption and this is surely one disadvantage.

3.6.3 Financing of the lake sanitation infrastructures

In financing of the lake sanitation program (building of sewage systems around lakes) the Austrian Government participated with favourable loans, given by the bank Kommunalkredit AG which usually helps in environmental projects. This is totally privately owned bank (shareholders are Investkredit Bank AG and Dexia Credit Local), municipalities own only 0,22% (Kommunalkredit AG, 2005). The bank also employs special experts who help municipalities and regions to prepare and implement the proposed projects. Interest rate for regional or inter-municipalities lake sanitation projects was 1%, while for projects inside municipalities was 2%. Again, it is one advantage for projects done in cooperation and stimulation for stakeholders to cooperate. The return period was also more favourable for regional projects, furthermore, possibilities were the following (Carinthian environmental report, 1998):

- 30 years for inside municipalities projects;
- 40 years for regional projects;
- 50 for lake sanitation projects (round sewage systems).

State grants have based on special laws, Wasserbautenförderungsgesetz (WBFG) and Umweltförderugsgesetz (UFG) since the year 1992. The last one was passed in 1993. According to WBFG state gives favourable loans (details are explained in the previous paragraph) in maximum of 30% of the whole investment. According to UFG state gives non-return sources in amounts from 8 to 60 % of the whole investment. Non-return sources are not directly covering the investment; however, they are covering part of annuities. A region mostly gave non-return funds in the maximum amount of 20% of the whole investment. In the present time, a region also gives favourable loans. But this is not such a problem, because most of the necessary projects have already been done. And, with 1 or 2% interest rate, the final prices have not risen up so much (it is also necessary to include allowance costs, administration costs, etc.). One important diction from the Carinthian regulation prescribes that in the case when municipality decides not to collect connection fees from newly connected inhabitants, it is also impossible to get regional and state sources. It is a principle that when local people pay nothing, then the external funds will also not contribute to the project. One good approach to increase the awareness for the sustainable environment is that they all have to contribute also with the financial means.

3.6.4 Annual erection costs – Carinthian example

For the conclusion, in Figure 33, the annual erection costs for municipal infrastructure (drinking water supply and wastewater disposal) in the whole Carinthia are shown (Carinthian environmental report, 1999). From 1960 to 1997 all erection costs for wastewater disposal infrastructure amounted to 1.040.431.654 EUR. Furthermore, according to the *Chapter 3.3.4,* lake sanitation measurements represent 41% of the whole investment. Because Slovenia is in the beginning of suchlike investment, this is one good example how high the costs are.

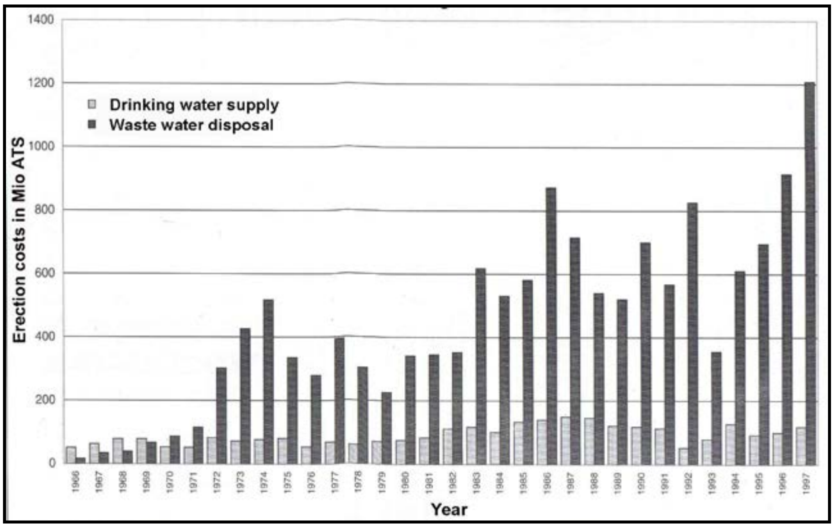

Figure 33: Annual erection costs of municipal infrastructure in Carinthia among years 1966 – 1997 (Carinthian environmental report, 1999)[4]
Slika 33: Stroški gradnje komunalne infrastrukture na Koroškem v letih 1966 – 1997 (Poročilo o stanju okolja na Koroškem, 1999)[4]

[4] To calculate Euros from Austrian Schilling use ratio 1 EUR = 13,8 ATS.

As an example of differences, in *Chapter 4.3*, a comparison of prices for municipal services (water, wastewater, wastes) between the municipalities St. Kanzian and Bled is made.

3.7 Example 1: Faaker See

3.7.1 Basic data

Faaker See (Fig. 34), the fifth largest in Carinthia, lies in the southern part of the province, just a few kilometers from the city of Villach. It is divided into two municipalities, Finkenstein and Villach. Urbanized settlements Egg and Drobollach lie in the northern part and Faak in the southern part of the lake. Along the eastern and southern shoreline a few camping places are scattered. The whole area is totally tourist oriented; a number of all overnight stays reaches 500.000 per year (Municipality Finkenstein, 2005).

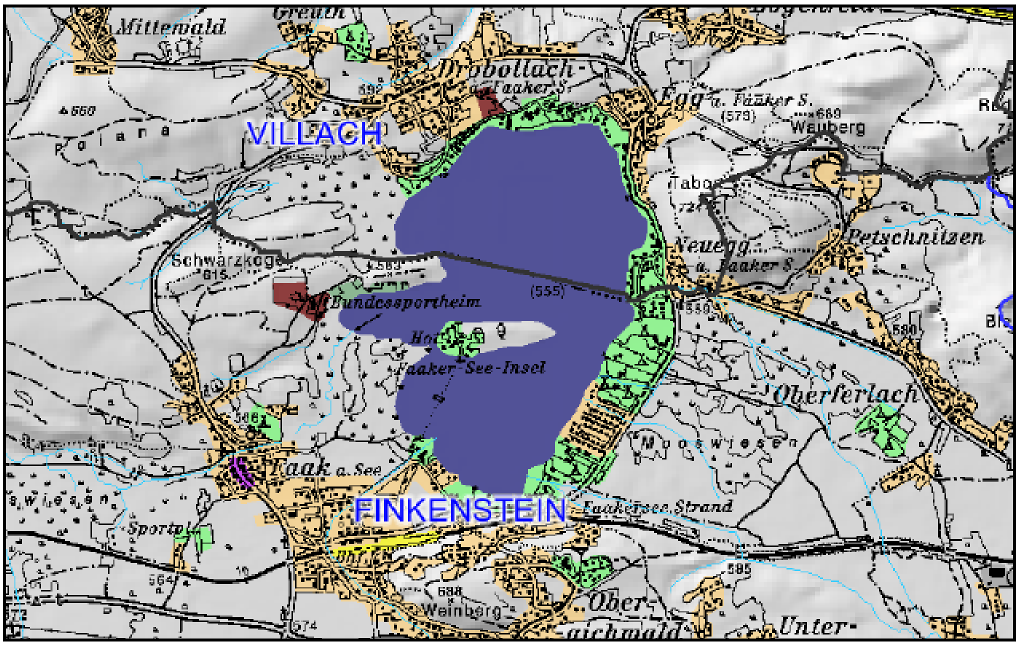

Figure 34: Faaker See area with marked urban areas (KAGIS, 2005)
Slika 34: Baško jezero z označenimi urbanimi površinami (KAGIS, 2005)

Lake is privately owned by the families Bucher and Kataster. Administration is led in Gutsvervaltung Landskron and includes fishing fees, contracts with lake users and usage fees. Faaker See represents one of the most important tourist areas in Villach region. Shoreline area is mostly privately owned which is one big disadvantage for the future tourist development. It is practically impossible to get directly to the lake.

Lake has the following characteristics (KIS, 2003):

- Surface: 220 ha;
- Depth: ave. 16,1 m, max. 29,5;
- Volume: 35,24 x 10^6 m^3;
- Hydraulic residence time: 1,8 years;
- Four influents - amount of inflow water: 619 l/s (biggest Wourounitza);
- Watershed area: 37,09 km^2.

Island in the middle divides Faaker See into two basins, the southern and the northern one. The main water current flows from the southern part (where all influents inflow) around the island to the northern part where the only effluent is located. In higher flows the biggest influent, Wourounitza, brings a lot of troubled matters into the lake. Consequently, in the summer time, Faaker See has a distinctive turquoise-blue colour and light penetration decrease from 7 to 2 meters. According to the measurements Faaker See is one of the cleanest lakes in the whole Carinthian region. Monitoring results are shown in Appendix B.

Eighteen fish species live in Faaker See, namely white fish, lake trout, rainbow trout, pike, sheatfish, ell, whiting, bitterling, bream, white beam, carp, bleak, barb, roach, red-eye fish, tench, bass and pike perch (KIS, 2003).

3.7.2 Wetlands and other protected areas

A few wetland areas which represent a very important part in the biological chain lie near the lake and they are also some kind of clarifiers for the lake influences. Moreover, agriculture areas, which lie in the eastern part of watershed area, are not so problematic, because one big wetland area lies between. All areas, especially wetlands, are protected by the Carinthian environmental protection legislation which includes the following acts:

- Land protection act (Landschaftschutzrecht): building in this areas is strictly forbidden, only controlled agriculture is allowed (Wetland Drobollach – 91 ha, Faaker See west – 456 ha, Faaker See island – 8 ha, Faaker See east – 472 ha are included);
- Nature protection act (Naturschutzgesetz): both, building and agriculture are forbidden.

The third protection act is the Carinthian spatial policy which defines sensible areas where heedful and well considered approach is necessary. Areas in Faaker See watershed area, protected by the environmental protection acts, are shown in Appendix B.

3.7.3 Urban drainage system

The sewage system around the lake was built in the year 1970. It is mostly separate, only in settlements Drobollach and Egg it is mixed. Five main pumping stations are located around the lake, one also on the island (the biggest has capacity 72 l/s). The system is connected to the central wastewater treatment plant in Villach (200.000 PE). Rainwater is led to the lake or infiltrated to the underground on place. Rainwater system inlets are not in the upper levels of the lake but in the bottom areas, like a dispersed outflow. Consequently, in the case of rain and storms, load is reduced to the minimum level. Property owners, who want to connect rainwater to the sewage system, must pay for that. The price is calculated on the basis of largeness of building land and statistic precipitation activity. Experiences show that the prices for rainwater drainage are very high and people rather build infiltration devices on place. The whole urban drainage system is managed by the wastewater association Abwassserverband Faakersee which was established in 1969 by municipalities Finkenstein and Villach. Because Faaker See lies in two municipalities, they both decided that the association was the most economical and a long-term successful solution. The decision was based on variants investigations, written in funding regulation for urban water investments. This is a very good example of across municipalities' cooperation which is in Slovenia rather an exception than the rule. Moreover, Abwasserverband Faakersee operates with the whole urban drainage system in Villach region which lies on the right side of the river Drau (Drava). In municipality Finkenstein, 95% of inhabitants are connected to the sewage system.

3.8 Example 2: Keutschacher See

3.8.1 Basic data

Keutschacher See, the sixth largest in Carinthia, lies south of Wörthersee, in Klagenfurt region. It also lies in Wörthersee watershed area. The whole lake belongs to the Municipality Keutschach and represents, together with Hafnersee, the main tourist attraction in the region. Shoreline area is urbanized in the northern part, along the main road, while the southern part is mostly covered with camping sites. Urbanized areas mostly consist of houses and some small private hotels. There is only one big hotel, located near Hafnersee. Approximately half of shoreline is covered with wetlands. Like Faaker See, Keutschacher See is privately owned, too (the owner is Mrs. Messner), with totally occupied shoreline by private owners. It has been already mentioned that suchlike arrangement is a bad point for future tourist development. The lake owner has signed the contract with all lakes users and they are paying fees for its usage. Meanwhile, the price of every contract is a secret, only an average price of 2 SCH (0,15 EUR) per bather for camping sites and baths is known (Municipality

Keutschach, 2005). Furthermore, municipality must pay for its public bath, too. Free swimming in Keutschacher See is therefore impossible, like in the majority of the Carinthian lakes.

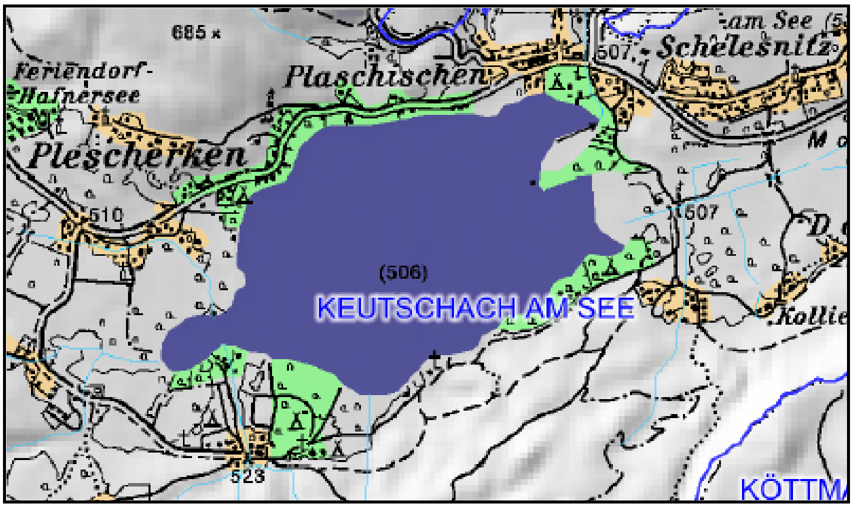

Figure 35: Keutschacher See area with marked urban areas (KAGIS, 2005)
Slika 35: Hodiško jezero z označenimi urbanimi površinami (KAGIS, 2005)

Keutschacher See has the following characteristics (KIS, 2003):

- Surface: 132,7 ha;
- Depth: ave. 10,3 m, max. 15,6;
- Volume: 13,6 x 10^6 m^3;
- Hydraulic residence time: 9 months;
- Five influents - amount of inflow water: 570 l/s;
- Watershed area: 20, 81 km^2.

The following 19 fish species live in Keutschacher See: white fish, lake trout, pike, sheatfish, ell, whiting, bream, bitterling, white bream, crucian carp, carp, bleak, roach, red-eye fish, tench, silver carp, bass, pike perch and large mouth bass (KIS, 2003).

3.8.2 Distinctions of the area, accomplished analysis and monitoring results

Well known Keutschacher See's distinction is a small peninsula which is covered with reeds. Peninsula lies in the eastern part and it is stretching like a tongue to the middle of the lake. Lake has five influents and one effluent, creek Reifnitz, which flows to the Wörthersee. The biggest influent, creek Rakouza, flows first to the Hafnersee which is very good for its purification. From the year 1982 to 1985 the average yearly amounts of nutrients in inflow and outflow creeks were the following (Honsig-Erlenburg et al., 1986):

- Inlet 1 (from Hafnersee): 4 kg of P, 72 kg of NO_3-N;
- Inlet 2: 49 kg of P, 499 kg of NO_3-N;
- Inlet East: 22 kg of P, 631 kg of NO_3-N;
- Outlet to the Wörthersee (creek Reifnitz): 133 kg of P, and 3.037 kg of N.

To protect influents against the pollution by flushing of farm land areas, special dikes around creeks have been built (Fig. 36). Dikes are covered with vegetation, bushes and tress. In certain distances, small dikes are built also in farm land to protect high flushing and erosion, consequently. Water passages are established in every dike to reduce energy and enable the water flow.

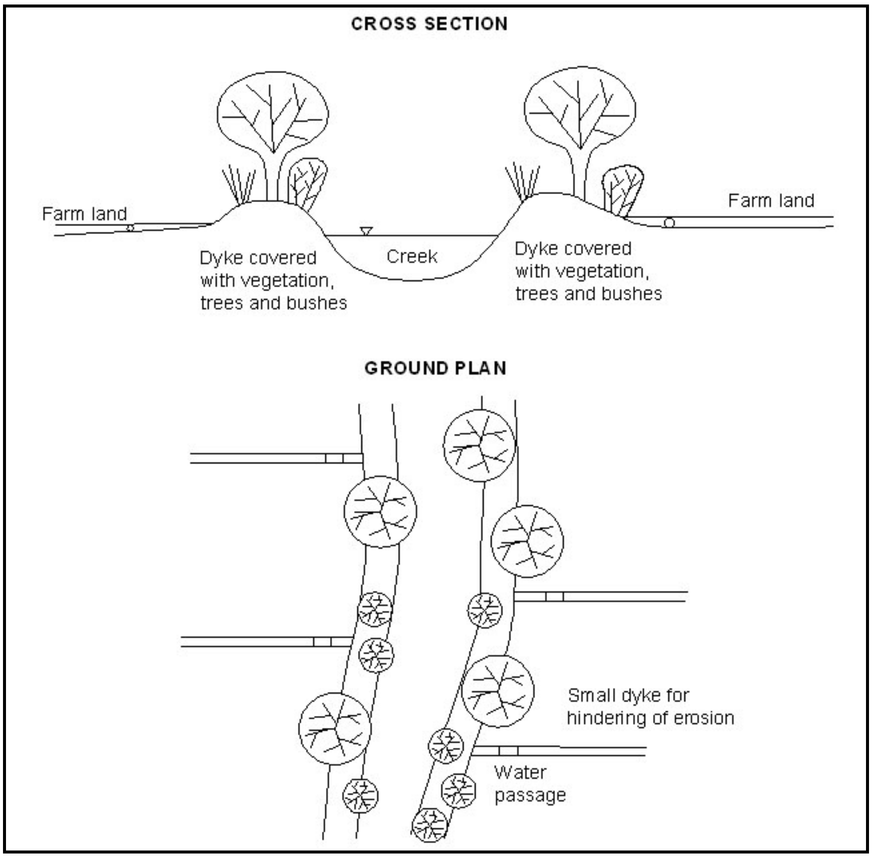

Figure 36: Protection of creeks against pollution by flushing of farm lands
Slika 36: Zaščita potokov pred vplivi izpiranja iz kmetijskih površin

In the past, a fish farm was located near Hafnersee with the annual production of 6 tones of fishes. Estimation showed that 24 kg of phosphorous per year came from the farm to the lake (Honsig-Erlenburg et al., 1986) and therefore the fish farm was closed. The estimation also showed that 10 kg of phosphorous and 310 kg of nitrogen per year come to the lake from bathers. For that reason a research, where water closets have to stay, has been made. The results showed that water closets had to stay just a few meters away from the shore and, what was also very important was that they had to be very clean if we wanted people to use them (Sampl, 2005). Dispersed impacts (erosion, ground water, feeding of ducks, precipitation, etc.) were estimated to 43 kg of phosphorous and 800 kg of nitrogen per year.

Monitoring results are a little bit better than in Lake Bled (comparison is made in *Chapter 4.2*), in the summer time there is no oxygen at the bottom, too. Sometimes at the end of the summer, blue-green algae blooming occurs and decreases light penetration, consequently. The depth profile of oxygen and phosphorous concentrations through the year 2003 is shown in Figure 37 (KIS, 2004). The lack of oxygen at the bottom is very well visible. When the concentration of oxygen is going to 0 the remobilization of phosphor is recognizable.

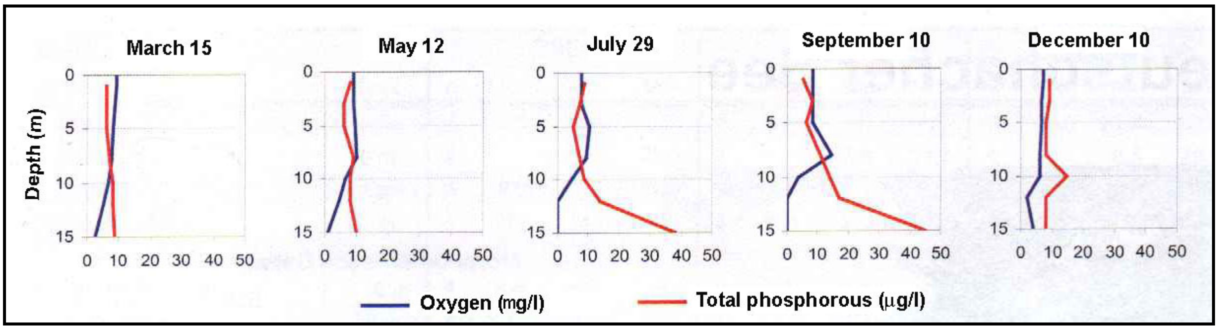

Figure 37: Depth profile of oxygen and phosphorous concentrations in 2003 (KIS, 2004)
Slika 37: Koncentracije kisika in fosforja po globini v letu 2003 (KIS, 2004)

3.8.3 Ramsar and other protected areas

Keutschacher See watershed area is great and more than half of it is covered with the forest (Fig. 38). Many of wetlands are also very distinctive, scattered from the western to the eastern part of watershed area. Because of the importance of wetlands for biological diversity, all areas are protected by Ramsar Convention on Wetlands. Convention was signed in Ramsar, Iran, in 1971, as an intergovernmental treaty which provided the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. There are presently 150 contracting parties to the convention, with 1590 wetland sites, totaling 134 million hectares, designated for inclusion in the Ramsar list of wetlands of international importance (Ramsar Convention, 2003). In Carinthia, wetlands around Turnersee are the second Ramsar protected area.

All wetlands are also protected by the Carinthian legislation (land protection act, nature protection act, sensible areas). Graphical maps are shown in Appendix C. By the land protection act (LSG) most of Keutschach valley is protected (2.532 ha).

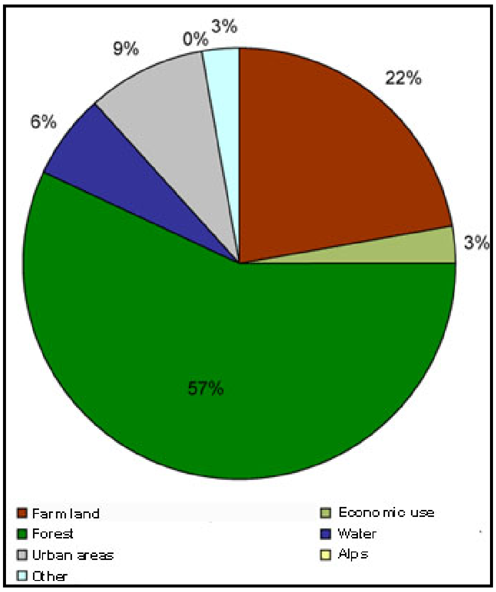

Figure 38: Land use in Keutschacher See watershed (KIS, 2005)
Slika 38: Raba tal v pojezerju Hodiškega jezera (KIS, 2005)

3.8.4 Urban drainage system

The sewage system in Keutschach was built in the year 1978 (Municipality Keutschach, 2005). The main collector is located in the northern part of the lake; built of asbestos-cement pipes with an average diameter of 500 mm. The secondary system is mostly built of 200 mm pipes. Two pumping stations consist of the main transport system which connects the whole municipality Keutschach (9.000 PE) to the central wastewater treatment plant in Klagenfurt (200.000 PE). 98% of entire population are connected to the sewage system, also Pyramidenkugel which is located more than 5 km away from the village. The connection pipe that connects camping sites in the southern part of lake to the main collector is a pressure because it lies in the wetland area, where displacements are still occurring and therefore a danger for changing the inclination of gravitational pipe exists. Rainwater is infiltrated to the ground or led to the lake, after the pre-cleaning in a grit and grease chambers.

3.9 Example 3: Klopeiner See

3.9.1 Basic data

Klopeiner See, after the Wörthersee one of the most known in the whole Carinthian region, lies in the south-eastern part of the province. Shoreline area is totally urbanized, composed of hotels, private houses and baths. Land is privately owned and it is impossible to get free access directly to the lake. As distinguished from Faaker See and Keutschacher See, Klopeiner See is not privately owned and it is therefore managed entirely by the Municipality St. Kanzian. The whole area has 4.500 inhabitants, in the summer time this number increases to 20.000. This datum shows that the municipality is totally tourist oriented. The number of night overstays per year reaches 700.000 (Municipality St. Kanzian, 2005). For comparison, this is 30% more than in Bled region, although Bled has 60% more inhabitants. Just near the Klopeiner See two other, smaller lakes, lie: Kleinsee and Turnersee. The first one is not used for bathing (bathing is forbidden), while the second one is owned by a tourist association and therefore surrounded by camps and holiday houses. Because Klopeiner See is without influents, all these lakes are not connected with creeks or rivers and they have no influence on each other. It has already been mentioned that in the eastern part of Turnersee watershed, great Ramsar protected wetland area is scattered.

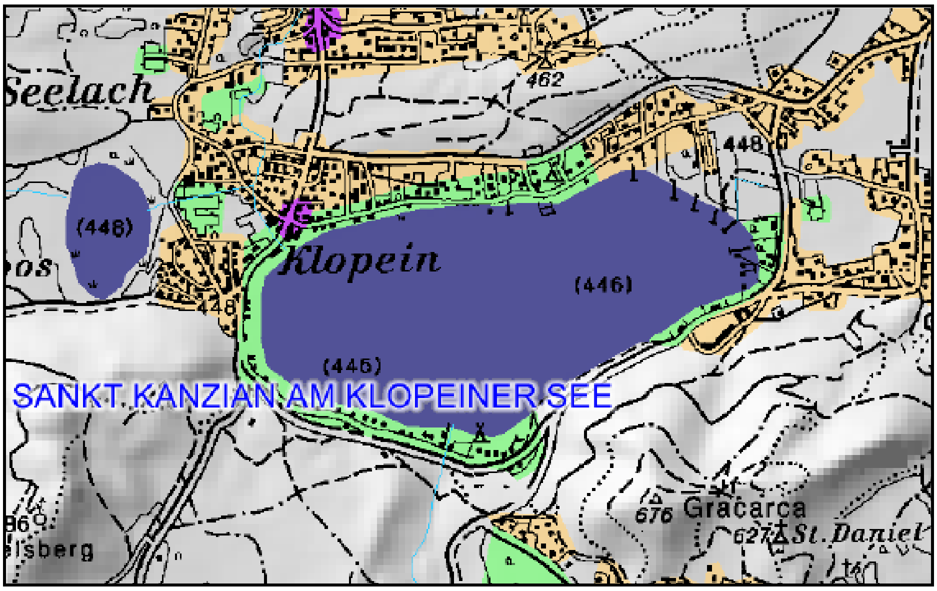

Figure 39: Klopeiner See area with marked urban areas (KAGIS, 2005)
Slika 39: Klopinjsko jezero z označenimi urbanimi površinami (KAGIS, 2005)

Klopeiner See has the following characteristics (KIS, 2003):

- Surface: 110,6 ha;
- Depth: ave. 23 m, max. 48 m;
- Volume: 25,42 x 10^6 m^3;
- Hydraulic residence time: 11,5 years;
- Five influents - amount of inflow water: 35 l/s (well water from the bottom);
- Watershed area: 4, 14 km^2.

Fish species, living in the Klopeiner See, are the following (15): white fish, lake trout, pike, sheatfish, ell, whiting, grass carp, bream, carp, bleak, roach, red-eye fish, tench, bass and pike perch (KIS, 2003).

3.9.2 Main distinctions and monitoring results

As we can see from the characteristics the hydraulic residence time in Klopeiner See is very long, which is a consequence that the lake is without any influents. The second special feature is a meromictic level at the bottom. For these reasons, in the year 1975, the siphon pipe was built. The description is already shown in *Chapter 3.2.1*. No influents also represent one advantage, i.e. Klopeiner See has a very small watershed area and it is therefore not subjected to so many influences, e.g. no flushing from farm lands, no erosion, and much easier control of the whole area, consequently. With the building of urban drainage system, lake was practically protected against all external influences.

Monitoring shows that Klopeiner See is one of the cleanest lakes in Carinthia. The results are shown in Appendix D. As an example, in Figure 40, amounts of biomass in epilimnium is shown (numbers in parenthesis near months signifies number of measurements). According to the Austrian standard ÖNORM M 6231 (Guideline for ecological monitoring and classification of stagnant waters) the upper limit for an average amount of phytoplankton for oligotrophic lakes is 1.000 mg/m^3. Figure shows that the mentioned amount was a little exceeded only in April, while in most of other months the amounts are deeply under the limit.

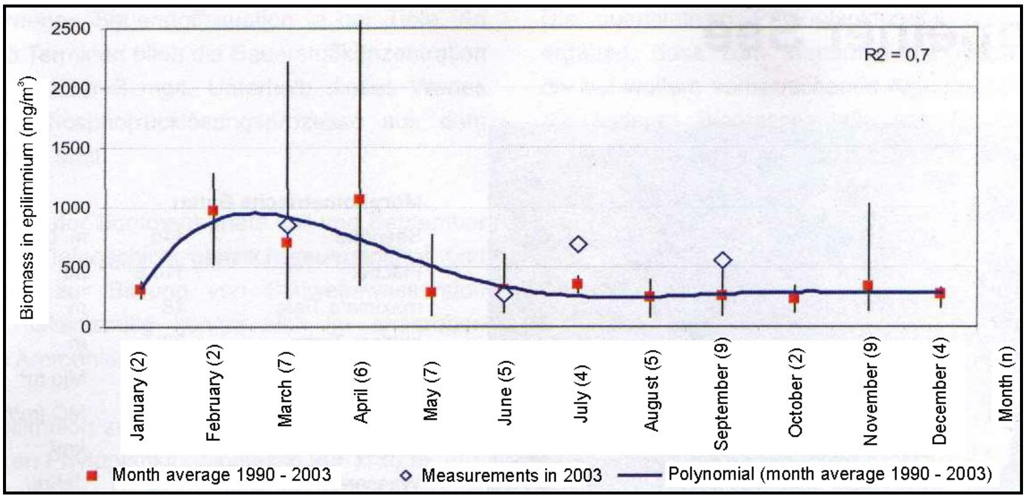

Figure 40: Klopeiner See – biomass (phytoplankton) in epilimnium (KIS, 2004)
Slika 40: Klopinjsko jezero – količina biomase (fitoplanktona) v epilimniju (KIS, 2004)

One consequence of a long hydraulic residence time are also very high temperatures in the summer time. In Klopeiner See they usually exceed 25°C, which is very good for bathing use and consequently attractive for tourism. On the other side, higher temperatures speed-up biomass production and therefore endanger the lake stability. But according to the monitoring results, such temperatures are not problematic for Klopeiner See.

3.9.3 Fees for lake usage

Klopeiner See is no man's property; therefore, every one can use it for sport, relaxation, etc. Because the shoreline is mostly privately owned and an extensive public use is not possible, Municipality St. Kanzian collects fees for lake usage. Money coming from taxes is partly used for maintaining of all infrastructures (siphon pipe, sewage system) and for projects connected with future development (marketing, advertising, new offers). Fees for lake usage are shown in Table 11.

Table 11: Fees for Klopeiner See usage (Municipality St. Kanzian, 2005)
Preglednica 11: Takse za uporabo Klopinjskega jezera (Občina Škocijan, 2005)

	Public baths, hotels, boarding houses [EUR/m² year]	**Private houses, apartments [EUR/m² year]**
Surfaces on stakes:*		
less than 100 m²	7,08	9,48
from 101 to 200 m²	8,28	10,68
more than 201 m²	9,48	11,88
Shoreline surfaces:*		
less than 1.000 m2	0,84	1,02
from 1.001 to 3.500 m²	0,60	0,78
** from 3.501 to 7.000 m²	0,48	0,66
	Amount	**Currency**
Piers:	10,68	EUR/m² year
Boats:***		
Rowing boat	42,00	EUR/boat
Pedal boat	54,00	EUR/boat
Canoe	13,20	EUR/boat
Surf board	54,00	EUR/board

* minimum fee is 420 EUR

** surfaces larger than 7.000 m² are calculated as 7.000 m²

*** one private boat is free of charge

Fees for using the shoreline surfaces have been implemented since the year 2005 and have caused many problems because property owners do not want to pay these amounts. For example, an owner of 1.000 m^2 large land on the shore has to pay 1.020 EUR per year, and at the end, together with other taxes such amounts represent a quite high expense. Therefore, municipality will prepare a new solution for the year 2006 (Municipality St. Kanzian, 2005).

3.9.4 Urban drainage system

Varying urban load, i.e. 4.500 inhabitants in winter and more than 20.000 people in summer, causes a lot of problems with municipal infrastructure. Drinking and wastewater systems have to be designed to the highest load and therefore their capacities are not fully applied in winter time. The same problems are occurring in waste management. But, here they can be solved with renting of new trucks for waste collecting and new workers. The biggest problems are happening in wastewater treatment plant, where varying load causes unstable biological part of treatment. For that reason, wastewater treatment plant in St. Kanzian can operate in three levels (Municipality St. Kanzian, 2005):

- Winter: 6.200 PE (1-line in aeration tank);
- Before and after the season: 9.800 PE (2-lines in aeration tank);
- Summer: 25.000 PE (3-lines in aeration tank).

The secondary settling tank is also divided into two parts, where one part is closed in winter time. In the past, old wastewater treatment plant had the capacity of 17.000 PE and it was in summer time overloaded. Therefore, Municipality decided in the year 2001 to build a new one with the capacity of 25.000 PE (Fig. 41). Because in winter time in St. Kanzian area there is very cold, aeration and secondary settling tanks are covered to protect biological processes against extra frost. Also, outlet from the old treatment plant was connected directly to the near flowing creek See which was for that reason burden too much, i.e. environmental quality parameters were exceeded. Outlet from new wastewater treatment plant is led to the river Drau (Drava) through a 1, 6 km long pipe. Because treatment plant in St. Kanzian is relatively new, its financing structure can be a good example of Austrian approach in financing suchlike projects. The structure is the following (Municipality St. Kanzian, 2005):

- State loan: 3.912.705, 40 EUR (77%)[5];
- Non-return regional sources: 705.071,80 EUR (14%);
- Connection fees: 458.786,60 (9%);
- Total: 5.072.563, 80 (100%).

[5] Extraordinary high state loan considering that area is socio-economically very important (tourism).

Connection fees have been collected from newly connected and also from already connected inhabitants. Already connected ones have to pay 668,70 EUR/100m^2 of a housing surface, while newly connected ones have to pay 2.542,10 EUR/100m^2 of a housing surface. The first amount is a contribution for the new wastewater treatment plant and has to be paid by all connected inhabitants. The second amount also includes costs for sewage system. In Bled, wastewater treatment plant is now in construction and therefore the same problem, how much already connected to the sewage system have to pay, is happening. The solution from St. Kanzian can be a good example for future steps and solutions.

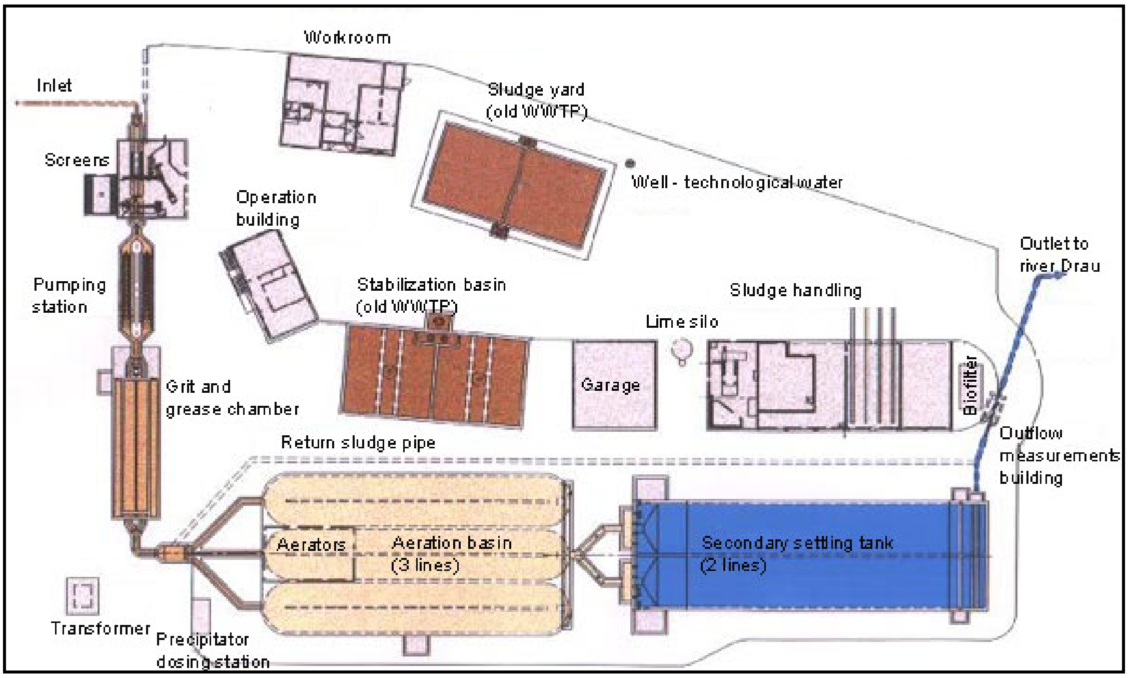

Figure 41: Wastewater treatment plant in St. Kanzian (Municipality St. Kanzian, 2005)
Slika 41: Centralna čistilna naprava Škocijan (Občina Škocijan, 2005)

Sewage system around Klopeiner See was built in the year 1968. Diameters vary from 400 to 600 mm; material is asbestos-cement, like in all other areas included in the lake sanitation program. Three pumping stations compose the main lake transport system. Today most of the inhabitants in St. Kanzian are connected to the sewage system, only out-of-the-way settlements will be connected in the future. Only two operators are employed for managing and maintaining with the whole system. They are responsible for wastewater treatment plant, sewage system, siphon pipe and public lightening. The sewage system consists of 23 pumping stations (when finished, there will be 32) which represent a high working load for operators. Therefore, the entire system is connected with “GSM” network and it is online controlled. All defects are sent to the central computer in wastewater treatment plant and to the operators’ mobile phones. Such solutions reduce operational and maintenance costs to the minimum level and they also assure continuous operation (Municipality St. Kanzian, 2005).

4 COMPARISON WITH BLED AREA

Lake Bled has many similarities with the Carinthian lakes and it is therefore possible to make a comparison. Nearness of all lakes is also one reason for that. Remedial measurements implemented in Lake Bled (siphoning, artificial flushing) are certainly good solutions and can be an example for future projects in other lakes. The same situation is with the sanitation measurement (sewage systems), where the first part of it was already built in 1930. The other thing is management of the whole infrastructure. The main transport sewage pipeline near the lake is demolished in many parts and represents one of the necessary repairs in the future. Unsettled secondary sewage systems in some areas in watershed are the second problem. Municipality Bled has signed a concession contract with the company WTE Wassertechnik Europe for building and operating the whole sewage system and wastewater treatment plant in Bled area (contract was signed for 25 years). Therefore, we can expect that problems with wastewater will be solved in the future. But it is necessary to mention that with this concession contract there are a lot of problems because communication between both stakeholders is bad and Municipality does not control the process. The consequence of all this will be still an unsettled or damaged sewage system in the most sensible areas.

Because of mentioned reasons, the comparison is made more on organizational and managerial level and not so much on technical one. The Carinthian regulation can be a good example of all, technical and managerial approaches. Specially financing of environmental projects is in Austria much better organized.

4.1 Management approaches

4.1.1 Basic management structure

In the province of Carinthia there lie more than 100 lakes and their controlling needs a very good managerial approach. Organizational structure with the Carinthian Institute of Limnology (KIS) as a part of provincial administration, and with municipalities or associations, represents a good distribution of responsibilities among the main stakeholders. KIS is a govern organization for monitoring and researching the lake quality. Suchlike work is more scientific and claims a special knowledge; therefore, its centralization is much better. Furthermore, KIS also leads communication with the public (public participation), organizes many conferences with environmental themes and issues interesting publications. KIS is a part of provincial administration (Department 15), which represents a very good communication with the main authorities of the Carinthian policy and making implementation of projects much easier.

In Lake Bled case, mentioned responsibilities are divided between the Ministry of Environment and Spatial Planning and Municipality Bled. Lake monitoring is an obligation of the Department for Limnology, which is a part of the Ministry. This department is making researches every month and it has many data about the lake quality. A different story is with a watershed area where database does not exist. We know that watershed is very important for the lake quality and its data deficiency makes management much heavier. KIS watershed database can be a good example how things have to be organized. In Bled, the public is usually not included in projects and it is hard to say who is responsible for that. In Carinthia, KIS cooperation and presentations are also included in the tourist offers with the main goal to show an importance for the environment. In Bled, there is no cooperation between Municipality, Ministry and tourist enterprises. The reason for that is because responsibilities are divided between too many stakeholders (or they are not defined) and everything is without a strong, well respected, governing organization.

4.1.2 Sanitation infrastructure

Large infrastructure systems, e.g. sewage systems, wastewater treatment plants, lake remedial infrastructure, claim high investment costs and have to be maintained well, to assure long-term operation. Systematic approach with a precise definition of the whole tasks and subjects responsible for implementation is therefore necessary. Water or wastewater associations are responsible for management with infrastructure in Austria. These strong organizations, established by municipalities or provincial administration, are well known distinction from Germanic regions. Strong support, technical and financial, from provincial administration makes work of associations more successful and cheaper for final users. Most of them are joined in two govern associations, namely Austrian Water and Waste Management Association (Österreichischer Wasser- und Abfallwirtschaftsverband, OWGW) and Austrian Association for Gas and Water (Österreichischen Vereinigung für das Gas- und Wasserfach, ÖVGW), which are representing all associations in inter- and national policies, making extensive benchmarking and implementing novelties in technological development. The organizational possibilities are almost the same in Slovenia. Associations are changed with public companies which are the most used structures for constructing and management of municipal infrastructure. Legal status of such companies is still ambiguous because they are taking out good things from the entrepreneur and public companies legislation. The second problem is financing the environmental projects where municipalities are obliged to assure all necessary infrastructures according to the legislation limits. Financial possibilities are not defined and municipalities have to find needed sources on their own. Financing from the European funds or ministry budgets are more an exception than the rule. Furthermore, money coming from taxes is usually enough only for small investments. Collecting of connection fees is not very well respected from the public and therefore represents a political question for main authorities. Austrian financing of environmental projects, shown in *Chapter 3.6*, is a perfect example how constructing of expansive municipal structure can become possible also for small municipalities. Public private partnership is implemented in higher level (bank Kommunalkredit AG) where more experts are involved and there a high danger that private interests will subject the public ones does not exist. For management, the most important are high enough prices for services which assure money for covering the costs. Prices in Slovenia are in most cases lower than in developed European countries and we can expect their growth in the future. The comparison of prices for municipal services between Municipalities St. Kanzian and Bled is shown in *Chapter 4.4*.

4.1.3 Remedial infrastructure

In Austria, lake remedial infrastructure is managed by municipalities (e.g. siphon pipe in Klopeiner See). Processes like dredging and harvesting are controlled by KIS because they are occurring in more lakes. Harvesting is made by KIS with its own equipment, while for dredging specialized companies from Germany or Netherlands are leased. In Bled, the company VGP Kranj is responsible for management of siphon pipe and artificial flushing infrastructure. This is already the third main stakeholder involved in the lake management; therefore, without a good communication it is hard to manage with all.

Again for repetition, in Lake Bled the following main stakeholders are involved:

- Monitoring: Department for limnology (Ministry of Environment and Spatial Planning);
- Management with siphon pipe and artificial flushing infrastructure: company VGP Kranj;
- Management with urban drainage system and wastewater treatment plant: company WTE Wassertechnik Essen;
- Management with drinking water systems and waste removal: public company Infrastruktura Bled;
- Shore management, legislation, spatial policy: Municipality Bled.

Schema from Carinthia is not so long. Relation: provincial administration (with the Carinthian Institute of Limnology), municipalities and associations is much easier and enables good communication. The consequences are better lake conditions, long-term maintained infrastructure and not so high prices of municipal services for the final user.

4.2 OECD lake quality criteria

To compare lake qualities it is necessary to use one of well-known criteria. OECD classification (Vollenweider et al, 1986), called Eutrophication of waters (monitoring, assessment and control), the following four criteria use for evaluation: total phosphorus, light penetration (Secchi disk), peak and average chlorophyll-a. Classification based on probability distributions, estimating how high is the probability that lake is in certain trophic category, according to measured parameter. Because it is hard to define fix limits, probability distributions are used. In comparison Lake Bled, Faaker See (Faak), Keutschacher See (Ktsch) and Klopeiner See (Klop) are used. Because these lakes have very similar characteristics, suchlike comparison is possible and it can show demanding results.

4.2.1 Total phosphorous

It has already been mentioned that phosphorous is a limiting factor in most of alpine lakes. Phosphorous exist in organic (particular) and mineral (anorganic) component. The upper limit that lake is in oligotrophic state is 10 μg/l of total phosphorus (yearly average) in the water.

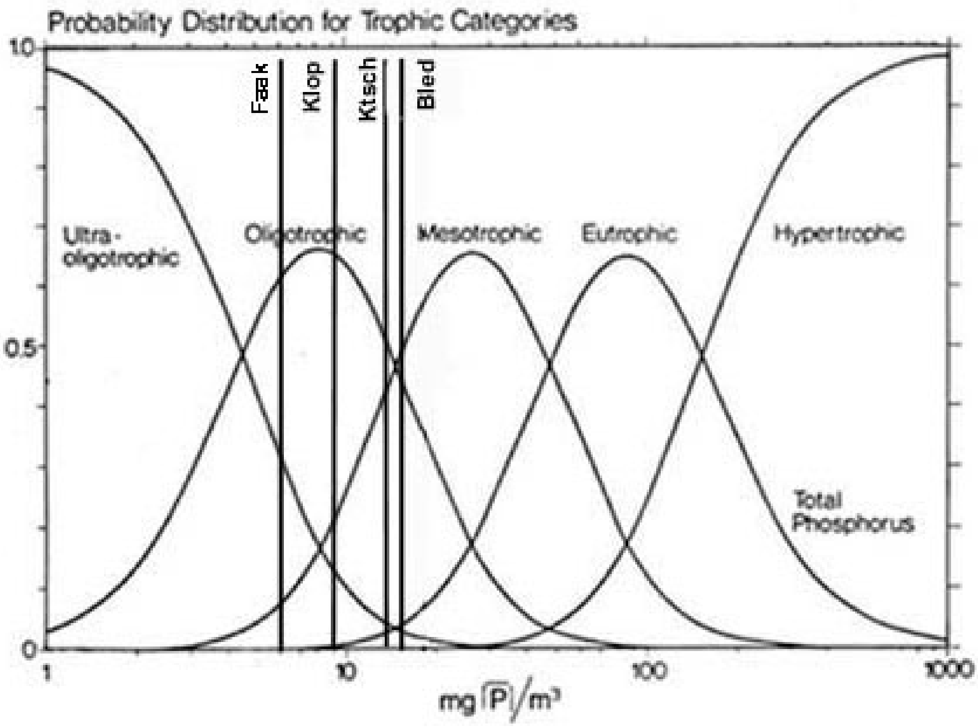

Figure 42: Total phosphorous – comparison
Slika 42: Celokupni fosfor – primerjava

From Figure 42 it is easy to comprehend that Faaker See has the lowest amount of nutrients, i.e. phosphorous concentration is deeply under 10 μg/l. It is 62% chance that Faaker See is in oligotrohopic state, 38% that it is in ultra-olgotrophic and only 5% that it is in mesotrohpic state. Furthermore, according to the phosphorous concentrations, Faaker See is the cleanest lake among all in comparison. Concentration in Klopeiner See is also under 10 μg/l and it is only 18% probability that lake is in mesotrophic state. Phosphorous concentrations in

Klopeiner See, used in comparison, are measured only in upper level, while meromictic level is excluded. Because water in meromictic level stays and it is not mixing with other, such assumption is entitled. Keutschacher See and Lake Bled have a little bit higher phosphorous concentrations and is approximately 50% probability that lakes are in mesotrophic state. Because limit 10 μg/l of phosphorous is very sensible and changes above this level are fast, we can concluded that both lakes are not in 100% stable condition and it will be good to reduce these amounts in the future.

4.2.2 Light penetration (Secchi depth)

Light penetration is the oldest measurement; they began with it in Carinthia in the year 1930. This measurement includes a special Secchi disk which is painted with alternating black in white belts. Disk is sinking to the bottom of the lake and when it is not visible anymore, sinking stops. The depth of the disk is then a light penetration measurement.

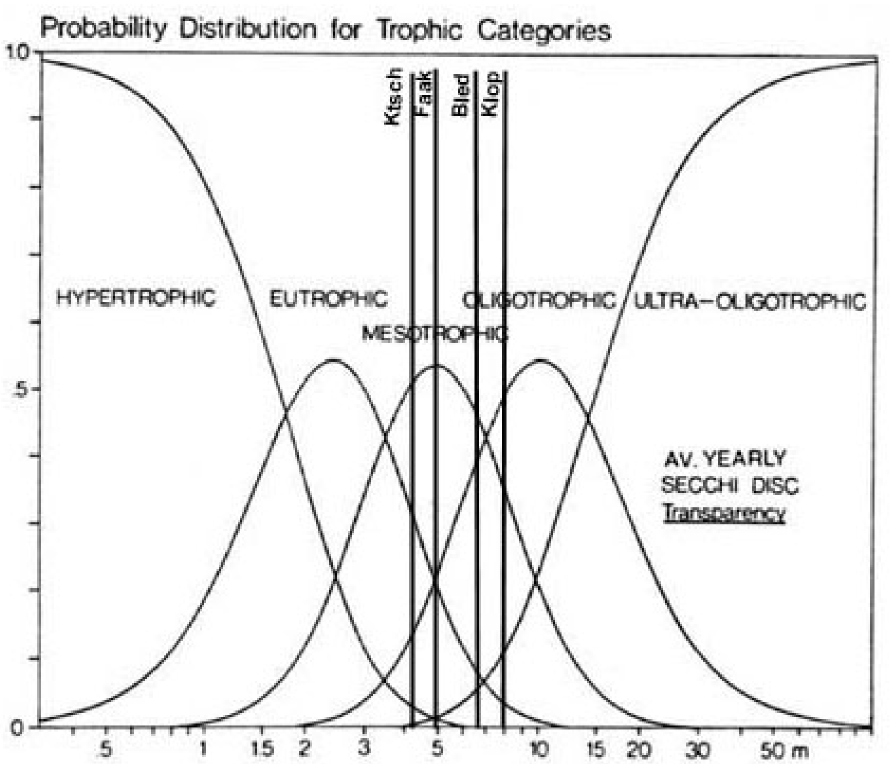

Figure 43: Light penetration – comparison
Slika 43: Prosojnost – primerjava

According to Figure 43, all lakes in comparison have almost the same transparency. Faaker See, according to the phosphorous concentrations the cleanest, has one of the lowest light penetrations and it is ranked to mesotrohpic state with 50% probability. Meanwhile, the biggest influent to the Faaker See brings, in precipitation periods, a lot of troubled matters and therefore decreases transparency of the lake. Keutschacher See shows the worst results and a 33% probability exist that the lake is in eutrophic state. Lake Bled is ranked somewhere between mesotrohpic and oligotrophic state, while Klopeiner See is in oligotrophic state with the highest probability. As we can see, the classification between phosphorous concentrations and transparency are different and we can conclude that it is very hard to rank lakes in trophic classes according to only one parameter. However, in Lake Bled Secchi disk measurements have mostly been showing good results.

4.2.3 Average chlorophyll-a

Next two criteria include chlorophyll-a measurements (average and peak). Because chlorophyll is necessary for photosynthesis processes, it shows intensity of phytoplankton (algae) production. In the case of higher chlorophyll amounts, algae are more productive, too and therefore the danger for algae blooming is higher. Nutrients (carbon, nitrogen, phosphorous, etc.) are also necessary for algae growth. But it is possible that lakes with higher amount of phosphorous could have lower amount of chlorophyll-a. There are many reasons why this is happening, e.g. short hydraulic residence time means higher flushing (dilution) rate, which means that algae cannot growth that fast (latent eutrophication), presence of high concentrations of zooplankton reduces phytoplankton, etc.

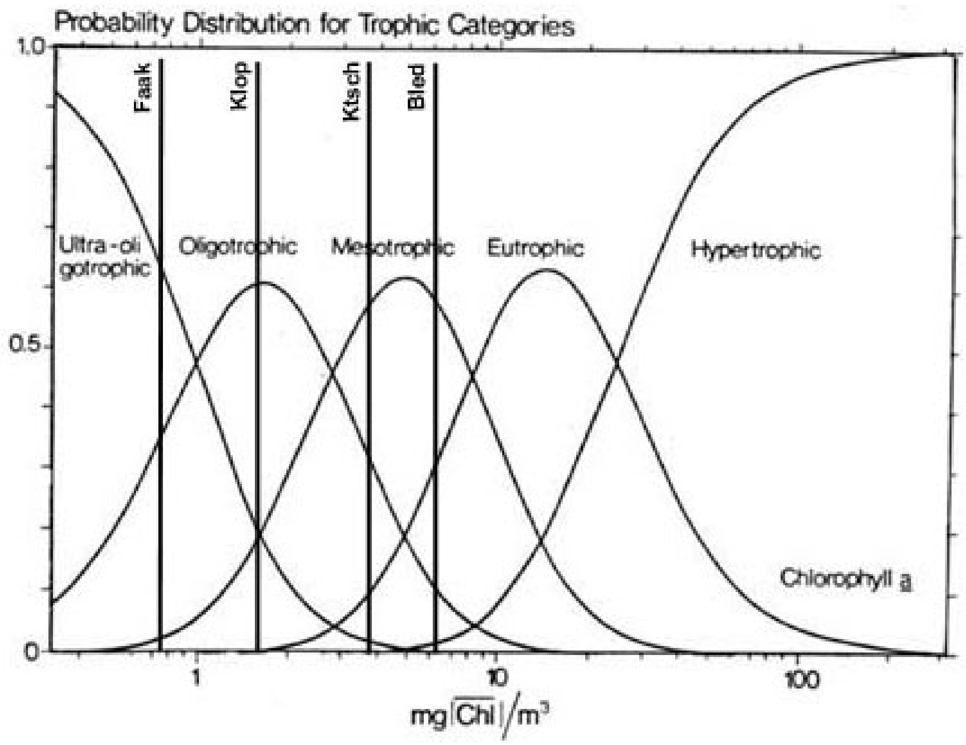

Figure 44: Average chlorophyll-a – comparison
Slika 44: Klorofil-a – primerjava

Figure 44 shows the comparison of chlorophyll-a concentrations. Here the picture is more persuasive. Especially in Faaker See concentrations are really low and it is 65% probability that the lake is in ultra-oligotrophic state. One more evidence how nutrient-poor and clean Faaker See is. Situation in Klopeiner See is also very good, a 60% probability exists that this lake is in oligotrophic state. In both lakes concentrations are low and there are therefore no dangers for algae blooming. Concentrations in Keutschacher See and Lake Bled are higher, especially in the last one. For example, it is 30% chance that Lake Bled is in eutrophic state and consequently a danger for algae blooming exists there. Meanwhile, in Keutschacher See conditions tend to mesotrophic.

4.2.4 Peak chlorophyll-a

The last criterion is the yearly peak chlorophyll-a concentration which shows maximum phytoplankton production in one year. Differences against average chlorophyll-a can be high. Algae are the most productive in summer time when temperatures are high and they accelerate the process. When average chlorophyll-a concentration is low, the possibilities for algae blooming in time of peak chlorophyll-a levels still exist. This is the reason why peak chlorophyll-a is so important.

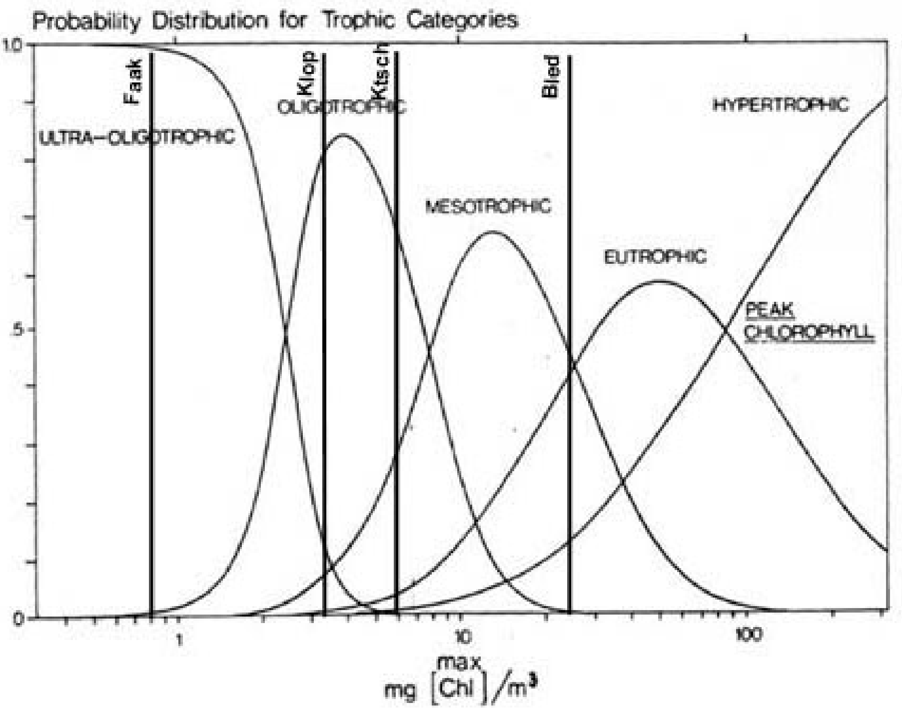

Figure 45: Peak chlorophyll-a – comparison
Slika 45: Maksimalni klorofil-a – primerjava

Figure 45 shows that peak chlorophyll-a concentration in Faaker See is almost the same as the average one what shows really stable lake conditions. According to Figure 45, there is 100% probability that Faaker See is in ultra-oligotrophic state. In Klopeiner See and Keutschacher See peak chlorophyll-a concentrations are also low and ranked both lakes to the oligotrophic state with the highest probability. The picture in Bled is opposite. High peak chlorophyll-a concentration shows high phytoplankton production in the summer time which therefore endangers the lake stability. According to the peak chlorophyll-a, it is the same probability that Lake Bled is in mesotrpohic or eutrophic state. It has already been mentioned that there are many reasons why algae are so productive and therefore it is necessary to make an extensive analysis. Other questions are connected to the measurement methods, their frequencies and result interpretations. **For example, measurements in Carinthia occur once in every three months, while in Bled every month. In three months period it is really hard to catch the peak chlorophyll-a concentrations and also average calculations are underestimated, consequently** (moreover, monthly measurements are not enough to catch the peak concentrations). Measurements method can vary too, and for extensive examination it is necessary to examine them or make new researches in all lakes with the same method. But we can conclude that for preliminary analysis suchlike comparison is enough and with the research some important results are shown. Especially high phytoplankton production and a little bit higher phosphorous concentrations in Lake Bled show that it is necessary to reduce nutrient load in the future. With building and repair of urban drainage system, good maintenance of the whole infrastructures and controlled agriculture and fisheries (farm) in watershed area, especially near influents, nutrient load can be reduced to the desirable level.

4.3 Comparison among prices for municipal services (municipality Bled vs. St. Kanzian)

Prices for municipal services (drinking water, wastewater, wastes) are also part of the lake management. Drinking water supply has no direct influence on lakes, only if lake water is used as a drinking water source, and it is therefore shown in this chapter only as an example. But consumption of drinking water is usually used for calculation of price for wastewater disposal and treatment and it has an influence on load of wastewater systems, consequently.

4.3.1 Input data and main assumptions

In comparison there are used two municipalities, Bled in Slovenia and St. Kanzian (Škocijan) in Austria. A direct comparison between them is not possible because their prices have a different structure so it is shown on an example of a family consisting of four members (two parents and two children). Furthermore, the family lives in a detached house with 150 m^2 of housing surface, on building land of 500 m^2. Monthly water consumption is estimated to 18 m^3 (150 l/day per person or 4,5 m^3/month per person), and family uses a 120 l container for wastes. A house is connected to the drinking water system and also to the wastewater system with central treatment plant. Data are collected in Table 12.

Prices in the whole Carinthian region are almost the same, especially in tourist cities, and St. Kanzian is a representative example. The highest prices are also defined in the Carinthian legislation. Prices in Municipality Bled are very interesting, especially for wastewater disposal and treatment because of concession contract which defines prices comparable to other developed European countries. All prices in comparison are shown in Euro, the exchange rate of 1 Euro for 239,64 Slovenian Tolars is used. The value added tax (VAT) is included in all prices: 8,5% in Slovenia and 10% in Austria.

Table 12: Data used in calculation
Preglednica 12: Podatki uporabljeni v računu

Datum	Quantity
Family	One family, four persons
House	Detached house, 150 m^2 of housing surface
Land	500 m^2 of building land
Location	In the center of Bled (Slo) or Klopein (Aut)
Water consumption and wastewater load	150 l/day per person, 4 persons, 18 m^3/month
Wastes	120 l container

In Bled, in the price for waste removal, one cartage per week is included (4,33 per month), while in St. Kanzain only one cartage per two weeks (2,167 per month). Because collecting centres in Austria are located in every corner and people are using them very often, two cartages per month are enough. Slovenia is at the beginning of suchlike process and it will surely reach the same standards in the future. But in the present time, one cartage per week is still necessary and therefore it is included in the comparison.

4.3.2 Municipality St. Kanzian

Prices in St. Kanzian are defined in Municipality ordinances, moreover, in accordance with the provincial legislation. Prices consist of two parts, connection fees and monthly costs. Connection fee does not exist for waste management. Connection fees and fix part of prices for services are passed in Euros per unit (Bewertungseinheit – BWE) where one unit signifies, according to the Carinthian legislation, 100 m^2 of housing surface, 20 m^2 of restaurant or hotel surface, 20 bathers for camping sites, etc.

4.3.2.1 Drinking water supply

Fee for the connection to the drinking water system amounts to 1.838,92 EUR/BWE. Therefore, family used in the example, will pay for that the following amount (150 m^2 = 1,50 BWE):

Connection fee: 1,50 BWE * 1.838,92 EUR/BWE = **2,758,38 EUR** (1)

Monthly price for service consists of a variable and a fix part. The first one is calculated with BWE and amounts to 35 EUR/BWE per year, while the second one is calculated on the base of consumed water, in the amount of 0,99 EUR/m^3. Monthly price for the family is the following:

Fix part: 1,5 BWE * 35 EUR/(BWE year) * 1/12 year = 4,38 EUR/month (2)
Variable part: 18 m^3 * 0,99 EUR/m^3 = 17,82 EUR/month (3)
Monthly price: 4,38 EUR + 17,83 EUR = **22,20 EUR/month** (4)

4.3.2.2 Wastewater disposal

Structure of price for wastewater disposal and treatment is similar to the price for drinking water supply. The basis for calculation of a variable part of the price is also the amount of consumed drinking water. Therefore, wasteful water use reflects in higher prices for both services. Fee for the connection to the sewage system and central wastewater treatment plant amounts to 2.542,10 EUR/BWE. It has already been mentioned that after the renewal of wastewater treatment plant in the year 2001, fee had to be paid also from already connected inhabitants in the amount of 668,70 EUR/BWE. Our family will pay the following connection fee:

Connection fee: 1,5 BWE * 2.542,10 EUR/BWE = **3.813,15 EUR** (5)

The fix part of monthly price amounts to 111,90 EUR/BWE per year, while the variable part is 1,40 EUR/m^3. Monthly costs for the family will be the following:

Fix part: 1,5 BWE * 111,90 EUR/(BWE year) * 1/12 year = 13,99 EUR/month (6)
Variable part: 18 m^3 * 1,40 EUR/m^3 = 25,20 EUR/month (7)
Monthly price: 13,99 EUR * 25,20 EUR = **39,19 EUR/month** (8)

4.3.2.3 Waste management

For waste management there is no connection fee, Municipality St. Kanzian charges only the monthly costs. Wastes are collected and burned in the central incineration plant in Arnoldstein (Podklošter), building of which was co-financed by the European Union, by the State of Austria, by the Province Carinthia and by the Municipalities. Monthly price also consists of a fix and a variable part. The first amounts to 36 EUR/year for 240 l container or smaller, while for larger container the fix price is 72 EUR/year. The variable part of price depends on the volume of the container and frequency of cartage. Prices are shown in Table 13.

Table 13: Prices for waste removal (Municipality St. Kanzian, 2005)
Preglednica 13: Cene za odvoz komunalnih odpadkov (Občina St. Kanzian, 2005)

Container	Price	
120 l, 2 cartages per month	5,30	EUR/cartage
120 l, 1 cartage per month	7,40	EUR/cartage
240 l	9,50	EUR/cartage
1100 l	47,40	EUR/cartage

Monthly price for the family, used in example, is the following:

Fix part: 36 EUR/year * 1/12 year = 3,00 EUR/month (9)
Variable part: 5,30 EUR/cartage * 2 cartages = 10,60 EUR/month (10)
Monthly price: 3,00 EUR + 10,60 EUR = **13, 60 EUR/month** (11)

4.3.3 Municipality Bled

In Slovenia, prices for municipal services also consist of connection fees and monthly costs. Connection fees are collected in a so-called municipal contribution which has to be paid before the public administration grants a building permission to an investor. The amount of municipal contribution, its structure and a calculation formula are defined in the Municipality ordinance. Price is given per square meter of a building land and not per housing surface. In Municipality Bled, basic price amounts to 41,80 EUR/m^2 of building land, structure is the following (Municipality Bled, 2002):

- Sewage system: 26%;
- Rainwater drainage system: 15%;
- Water supply: 14%;
- Roads: 30%;
- Open and recreational surfaces: 4%;
- Public parking places: 4%;

- Public lighting: 4%;
- Fire-extinguisher hydrant net: 3%.

Basic price has to be multiplied with two coefficients, considering the location of a building and its usage (Tab. 14). Furthermore, in comparison for certain service only belonging part from municipal contribution is used, e.g. for sewage system only 26% of whole price.

Table 14: Coefficients for calculation of municipal contribution (Municipality Bled, 2002)
Preglednica 14: Koeficienti za izračun komunalnega prispevka (Občina Bled, 2002)

Usage		**Location**	
Housing building	0,6	Bled	1,0
Business activity	0,8	Other settlements	0,8
Farm	0,4	Out-of-the-way settlements	0,6

Monthly prices consist only of a variable part which is calculated on the basis of consumed water or produced wastes. Price is divided into two parts, one part for state taxes and the other for covering the operational, management and maintenance costs. State taxes are written in legislation, Republic water contribution and Water burden tax are included.

4.3.3.1 Drinking water supply

For calculation of a fee for the connection to the drinking water supply only 17% (14% for water supply and 3% for hydrant net) of price for municipal contribution is used. In example, a house located in the city centre is used, therefore, the right coefficients are 0,6 for usage of a building and 1,0 for a location. Family will pay the following connection fee:

Connection fee: 0,17 * 41,80 EUR/m^2 * 0,6 * 1,0 * 500 m^2 = **2.131,90 EUR** (12)

Monthly price amounts to 0,32 EUR/m^3 for covering the operational, management and maintenance costs as well as 0,06 EUR/m^3 for the Republic water contribution. Family will pay the following amount of money per month for the drinking water supply:

Monthly costs: (0,32 + 0,06) EUR/m^3 * 18 m^3 = **6, 84 EUR/month** (13)

In the last amount the price for water counter is not included. Because this cost is really low, e.g. 1,37 EUR/month for a detached house, the final price is not greatly different.

4.3.3.2 Wastewater disposal

To compare prices for wastewater disposal and treatment with Municipality St. Kanzian, it is necessary to supplement the price for wastewater disposal in Muncipality Bled with the price for treatment. Wastewater treatment plant has not been built yet and the connection fee has still not been settled by the Municipality Council, therefore, the connection fee from Municipality Kranjska Gora is used where wastewater treatment plant was built in the year 2003 by the same concession contractor. Connection fee for the whole newly connected inhabitants to the central wastewater treatment plant amounts to 625 EUR per house or apartment (Municipality Kranjska Gora, 2002). This price is added to the part of municipal contribution earmarked for sewage system (26%). Family, used in the example, will pay the following amount for connection to the sewage system and wastewater treatment plant:

Connection fee: 625 EUR + 0,26 * 41,80 EUR/m^2 * 0,6 * 1 * 500 m^2 = **3.885,40 EUR** (14)

Monthly prices have the same structure as the prices for drinking water supply, only the State's water contribution is changed by Water burden tax. In present time, price includes only wastewater disposal costs, while treatment costs do not exist. According to the ordinance of water burden tax (Uredba o taksi za obremenjevanje vode), without wastewater treatment, the tax is higher (tax is calculated by COD load). Furthermore, price has the following structure:

- Wastewater disposal (urban drainage system): 0,20 EUR/m^3.
- Water burden tax: 0,52 EUR/m^3.

Because this price does not include wastewater treatment costs, it is impossible to compare it with Municipality St. Kanzian. But in the concession contract for wastewater disposal and treatment between Municipality Bled and company WTE Wassertechnik Essen the highest price for service is defined in the amount of 1,32 EUR/m^3 (Municipality Bled, 2002). By the Ministry of Environment and Spatial Planning is also settled the amount of Water burden tax after the beginning of wastewater treatment plant operation, viz. in the amount of 0, 04 EUR/m^3. Furthermore, the maximum monthly price for a family is the following (but in the case of new outer investment, lower price can be defined, in agreement between Municipality and company WTE Wassertechnik):

Monthly price: (0,04 + 1,32) EUR/m^3 * 18 m^3 = **24,48 EUR/month** (15)

In present time, the price amounts to 12, 96 EUR/month ((0,20 + 0,52) EUR/m^3 * 18 m^3), but it does not include the price for wastewater treatment. From the example, the difference between the Water burden tax with or without treatment is evident (0,52 / 0,04 = 13).

4.3.3.3 Waste management

Waste management is not included in the municipal contribution and it is therefore not obligatory to pay the connection fee for it. In Municipality Bled wastes are collected and deposited in a landfill in Logatec, following assorting in collecting centre (many sorts of wastes are also reused). Monthly price consists of two parts: the part of collecting and cartage in the amount of 11,08 EUR/m^3 and the part of depositing which amounts to 12,84 EUR/m^3. The price is not calculated directly on the basis of produced wastes, but in dependence on volume of containers which are used by inhabitants. Volumes are also prescribed in Municipality ordinances, regarding to the number of persons living in a certain family, e.g. for ordinary families 120 l container, for individuals half of it (60 l). Consequently, monthly price for the family, used in example, is the following:

Monthly price: (11,08 + 12,84) EUR/m^3 * 0,120 m^3 * 4,33 cartages = **12,43 EUR/month** (16)

4.3.4 Comparison

In Tables 15 and 16 comparison among fees for connection to the municipal infrastructure and among monthly prices for municipal services are shown. Note that Austrian gross domestic product per capita (GDP) is 50% higher than Slovenian one. In the year 2004 Austrian GDP per capita, calculated with purchasing power parity (PPP), was 31.254 EUR (International Monetary Fund, 2005) and ranged Austria in the 11th place among all countries joined in the United Nations. Slovenian GDP per capita was 20.306 EUR and it was ranged in the position number 35. Secondly, note also that drinking water supply in both municipalities does not include treatment of water because water is already clean enough.

4.3.4.1 Connection fees

From Table 15, it is evident that the fee for the connection to the sewage system and wastewater treatment plant is more expensive in municipality Bled than in St. Kanzian. They both have almost new treatment plants (St. Kanzian 2001, Bled 2006), therefore, Austrian financing system is more effective (in St. Kanzian case note very high founding from the state, too). The second problem in Slovenia is the municipal contribution, which collecting is not very transparent and it is in many cases used for other projects managed by the Municipality. From the comparison it is also evident how important good financing of projects is as well as help of all main stakeholders (state, province, and municipality). Moreover, the benefit of public investment can be seen in a quality of a built system, especially if all involved partners do their jobs well. Private sector can be very competitive too, but in most cases too strong leaning towards the profit can reduce the quality. Fees for connection to the drinking water system are comparable because labour force and most of assets in Austria are more expensive than in Slovenia, therefore, ratio 1,29 is appreciable.

Table 15: Comparison among fees for connection to the municipal infrastructure (example)
Preglednica 15: Primerjava višine priključnin na objekte komunalne infrastrukture (primer)

	Bled	**St. Kanzian**	**Ratio[6]**
Fee for connection to the drinking water system [EUR]	2.131,80	2.758,38	1,29
Calculated with GDP ratio[7]	3.281,16	2.758,38	0,84
Fee for connection to the sewage system and wastewater treatment plant [EUR]	3.886,00	3.813,15	0,98
Calculated with GDP ratio[7]	5.981,14	3.813,15	0,64
Sum [EUR]	**6.017,80**	**6.571,53**	**1,09**
Calculated with GDP ratio[7]	**9.262,30**	**6.571,53**	**0,71**

4.3.4.2 Monthly costs

Table 16: Comparison among monthly costs for municipal services (example)
Preglednica 16: Primerjave mesečnih stroškov komunalnih storitev (primer)

	Bled	**St. Kanzian**	**Ratio[6]**
Drinking water supply [EUR/month]	8,21	22,20	2,70
Calculated with GDP ratio[7]	12,64	22,20	1,76
Wastewater disposal and treatment [EUR/month]	24,48	39,19	1,60
Calculated with GDP ratio[7]	37,68	39,19	1,04
Waste management [EUR/month]	12,43	13,60	1,09
Calculated with GDP ratio[7]	19,13	13,60	0,71
Sum [EUR/month]	**45,12**	**74,99**	**1,66**
Calculated with GDP ratio[7]	**69,45**	**74,99**	**1,08**

Monthly costs show very variable picture among all three services. Prices for wastewater disposal and treatment are comparable what we can assign to the concession contract with a private partner which will built the new and renew the old system. Prices for drinking water are very different which results in higher and wasteful consumption of water in Slovenia. Furthermore, lower prices also do not cover the maintenance costs, and high investments for repair will be therefore necessary in the future. Waste management is, in comparison to St. Kanzian, more expensive in Bled. Reason for that lies in an endless discussion among Upper Carniola municipalities about the location of a landfill or an incineration plant, and wastes

[6] Ratio = Prices in St. Kanzian / Prices in Bled
[7] GDP ratio = GDP AUT / GDP SLO = 31.254 / 20.306 = 1,539

from Bled are still depositing in other regions. Consequently, costs for such work are higher. Carinthia has solved, and also made cheaper, the waste problems by building the central incineration plant in Arnoldstein (Podklošter). In the future, a lot in the field of waste management in Slovenia will have to be done if we want to fulfill European directives.

4.4 Suggestions for improving the Lake Bled management

From the previous chapters it is evident that the Carinthian lake management approach is effective and successful, therefore, it can be an example for future steps in Bled. Sanitation and remedial measurements are implemented in both regions, however, monitoring results still show better picture in the Carinthian lakes (see *Chapter 4.2*). For that reason, future management steps towards sustainable development are a necessity in Bled region. In addition to that, it is also a great opportunity for future cooperation with Carinthia and a chance to prepare common development plan in the field of environment and tourism. Regional cooperation is written in European developing perspectives, too.

According to the previous chapters, the following solutions for improvement of the Lake Bled management are suggested:

- Establishing an organization, like the Carinthian Institute of Limnology. In supervision board of such organization there have to be joined all stakeholders mentioned in *Chapter 1.3.2* with their representatives. Ministry of Environment and Spatial Planning and Municipality Bled have to play the main role. Executive board has to include highly skilled labour force, i.e. the experts from all fields of environmental science, e.g. biologists, technicians, economists, lawyers, etc. A good cooperation with tourist companies is also necessary. Existent Department for Limnology has headquarters in Bled and it makes researches in all Slovenian lakes. Therefore, it has to incorporate in newly established organization. All tasks and responsibilities to avoid future disharmonies between state, municipality and organization have to be defined in the statute of this organization.

- Newly established organization has to setup a database about the lake watershed. This base has to include all important data, shown in *Chapter 3.2.3.2*. Definition of a land use, locations of influents, and intensive agriculture areas are the most important things. A parcel land, e.g. ESRI® database which is prepared by the Geodetic service, has to be a basis of all. In the future, it is necessary to maintain and to up-to-date the database. Spatial policy in watershed area has to be prepared in accordance to such database, moreover, with a good cooperation with municipality representatives. With such approach, if all other conditions are considered, future spatial mistakes will be dismissed. In present time, spatial policy in Bled is too much subjected to the private interests which reflects in wrong and unfair decisions.

- Creek Mišca is the main polluter of the Lake Bled. Therefore, something it has to be done for its future revitalizing. One possibility is to transfer creek Mišca back to its ancient riverbed. This solution is more theoretical than real because it will cause many problems, especially in today's watershed area. Fish farm near the lake is officially not in operation anymore, but it operates illegally. Ultimate closing and, if it is economically so important, transferring it to the other location (e.g. near the river Sava Bohinjka) is one of the most necessary steps. Near creek Mišca there lie also a few intensive agriculture areas from which, in precipitation periods, come a lot of nutrients. To protect the creek against flushing, we are proposing to built small dikes around it, e.g. like in Keutschacher See area (shown in *Chapter 3.8.2*).

- A sewage system around the lake and in its watershed area has to be built or renewed to prevent infiltration of wastewater water to the lake and to its influents. Especially the old system in the centre of Bled and the connection pipeline to the wastewater treatment plant are the most urgent. The system can stay mixed; it has to be only supplemented with overflows and retention basins with enough capacity. Moreover, the main pipeline from Mlino to the wastewater treatment plant ("M" pipeline) is also leaking in many parts and therefore the area near creek Jezernica is impregnated with sewage water. Another problem in this area is a small hydro power plant which is using water from the sewage system and siphon pipe for its operation. Nobody knows exactly how this system works and how is with the permissions. System checkout and definition of responsibilities is therefore necessary. Furthermore, areas with unsettled sewage system near creek Mišca, shown in Figure 5, have to be equipped in the next years. In addition, public in Bled has to know that the sewage system is more important for the lake protection than wastewater treatment plant and it deserves the same dealing.

- In the previous bullet the necessary steps referring to the sewage system are shown. Because the municipality has signed the concession contract with the private partner for solving the mentioned problems, it has to supervise the project more strictly and cooperate in decisions making processes. It is also the final time for both partners to solve the misunderstanding about rainwater system which is not included in the contract. The concession partner has to establish a good cooperation with the proposed organization from the first bullet. All future inlets to the lake, e.g. from the sewage system overflows, have to be examined on the lake mathematical models. Universities and institutes dealing with the ecological modeling are appropriate addresses for such work.

- In Klopeiner See, Municipality collects fees for lake usage. In Bled, the same approach can be used. It is not necessary to collect fees from land owners of lake shoreline, it will be enough to collect fees from lake users, especially those who are making profit from that (e.g. pletna leaders, renters of small boats, baths). Legal statuses about mentioned subjects and contracts with them, consequently, have not been settled yet. In addition, it is the final time to forbid free bathing wherever around the lake and only allow it in the organized bathing zones. Consequently, urine load will be controlled and reduced. In the case of 20.000 bathers per year, approximately 20 kg of phosphorous and 200 kg of nitrogen come to the lake (1 PE = 1g of P and 10 g of N).

- The last proposal does not concern only Bled region but the whole Slovenia. The Austrian example of financing of environmental project shows such problems can be solved without a high private investment and consequently more secure. Conditions for that are only good cooperation, decision schema, involvements of private banks and, when system is built, high enough prices of services for final user. Payback of loan and good maintenance of system are for that reason assured. From the comparison to the municipality St. Kanzian, shown in *Chapter 4.3*, it is evident that Austrian approach is a competitive one, and even more, it assures a long-term operation and better quality of the whole environment.

The most necessary proposals which have to be established in Bled region in the future are listed. Most of proposals are the organizational ones; therefore, their implementation does not claim high investment costs and makes them achievable in a very short time. Meanwhile, we know that foundation for every good institution is organization. It is the same with the environment.

5 CONCLUSION

The variety of the Carinthian lakes and their eutrophication problem in the middle of previous century constrained Carinthian authorities to establish and implement a successful lake management in the whole region. Systematic approach, beginning with organizational and financial solutions, and then followed by technical measurements, represents a good sequence of long-term and sustainable solutions. Bled region, with its lake, is also a good example of successfully implemented lake sanitation and remedial measurements, the problem is their maintenance. Moreover, too dispersed management structure is also a break in achieving the main goals. Bad communication between the main stakeholders makes situation even worse.

The Carinthian approach shows the basic principles of successful lake management which enables stable conditions in lakes despite the high urban load. Furthermore, everything is evaluated economically with the main goal to enable the future tourist development which represents a very important part in a socio-economic chain. The same goal has to be reached in Bled region to ensure sustainable development which is also one of the main European goals. Bled has a perfect opportunity to become one of the main tourist attractions in the whole mid-European region, especially with its unique nature and perfect environment. Furthermore, to enable such tourist development, it is first necessary to protect environment against higher urban or human load with the implementation of the whole needed infrastructures. To assure long-term operation, infrastructures have to be maintained well so they do not represent a danger for higher investment in the future, consequently. Austria is much better than Slovenia in organizational approach and solutions and it can be a good example for our future policy. In addition, in many cases the whole European Union set the solutions on Austrian ideas, especially in the field of environmental protection. Therefore, if Austrian solutions are good enough for the most of the countries from the old continent, they will most probably be good for Slovenia, too. Especially if taken into account the similarities between Austria and Slovenia.

The following topics are suggested for the future work:

- To examine more precisely the results of lake water quality and quantity monitoring in both regions. First it is necessary to check the measurement procedures, their frequency and evaluation, and then prepare the exact comparison. The explanation why changes exist can also be included in suchlike comparison;
- To prepare the precise definition of Lake Bled watershed area, including all important data shown in the present thesis. The most problematic zones have to be marked specially with proposed solution for their revitalization;
- To prepare the exact plant for revitalizing the creek Mišca with the possibility of transferring the creek back to its ancient riverbed. Plan has to include a solution for the

problem with the existing fish farm, too. Finally, socio-economic consequences have to be evaluated for all solutions;

- To make an evaluation of the existing urban drainage system in Bled municipality. In the past, many projects concerning urban drainage system were made, but no one has been implemented yet. Therefore, checking all this projects and proposing the final solution is necessary. The research can include newly built wastewater treatment plant, too (used technology, capacity, etc.);
- To prepare a tax model for lake usage (tax payers, structure, amounts, etc.) and the exact plan for spending money coming from such taxes.

Slovenia is developing very fast and it is becoming a successful county inside Europe. But it is small and it will never be an industrial superpower. Therefore it has to find branches where smaller countries can be successful too. Technology and tourism are suchlike examples. The last one usually depends on environment and it is possible only in regions with perfect surroundings, without very high investment. Slovenia, with Bled region as the first representative, has such surroundings and has chances to become a successful tourist country. However, to ensure a long-term tourist and sustainable development, it is first necessary to implement all infrastructures and establish successful managerial models. In the present thesis, one example of suchlike work is shown.

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7 EXECUTIVE SUMMARY IN SLOVENIAN LANGUAGE / IZVRŠNI POVZETEK V SLOVENSKEM JEZIKU

7.1 Uvod

Ohranjanje naravnih vrednot, biotske raznovrstnosti in zagotavljanje zdravega življenjskega okolja so eni izmed glavnih okoljskih ciljev skupne evropske politike. Turistični kraji, katerih razvoj in promocija v večini temelji na neokrnjeni naravi, obenem z velikim številom turistov predstavljajo za naravo tudi veliko obremenitev. Še posebej občutljiva okolja na zunanje obremenitve so kraji z jezeri, ki tako zahtevajo še podrobnejšo obravnavo in dobro delujoče upravljalske modele. Blejsko jezero, kot fenomen slovenskega prostora, predstavlja za našo državo pomembno narodno-gospodarsko vrednoto in temu primerno je bilo v preteklosti tudi obravnavano. Za njegovo sanacijo sta bila vzpostavljena dva tehnična ukrepa, ki sta prinesla dobre rezultate in zaščitila jezero pred najhujšim. Kljub vsemu trudu pa stanje jezera še danes ni stabilno, kar gre pripisati nepravemu pristopu pri upravljanju celotnega pojezerja, ki ima na samo jezero tudi največji vpliv. Veliko število različnih interesov, večinoma nasprotujočih, in kar je še huje, celoten sistem deluje brez pravega vodje, povzročajo zmedo in nejasnosti pri samem upravljanju. V pričujočem diplomskem delu je, kot možnost bodočih rešitev in nadaljnega delovanja, prikazan model upravljanja z jezeri v sosednji Avstriji, točneje v deželi Koroški. Deželo odlikuje množica različno velikih jezer, katerih okoliški kraji so turistično znani po vsem svetu in v sezonah temu primerno tudi oblegani. Vse skupaj zahteva dobro delujoč upravljalski model, v katerega so vključeni vsi deležniki, njihove funkcije in delovanje pa točno določene. Ker so bili na koroških jezerih izvedeni številni sanacijski ukrepi, tako uspešni kot tudi tisti malo manj, so v diplomskem delu prikazane tudi te rešitve. V zadnjem delu je izvedena še primerjava med posameznimi kraji ter navedeni predlogi za izboljšanje upravljanja z našim najbolj znanim jezerom.

7.2 Značilnosti Bleda in Blejskega jezera

Blejska kotlina leži v severozahodnem delu Slovenije, ujeta med planoti Jelovico in Pokljuko ter na drugi strani odprta proti radovljiško-žirovniški ravnini. Glavna posebnost celotnega območja je seveda Blejsko jezero, z idiličnim otokom ter cerkvijo na sredini. Od uveljavitve zakona o lokalni samoupravi, t.j. leta 1995, območje pokriva občina Bled, ki ima 11.305 prebivalcev in 4.000 turističnih kapacitet (STAT, 2005). Ravno turizem, kot glavna gospodarska panoga kraja, predstavlja tudi dokaj veliko obremenitev komunalnih sistemov, saj so ti v sezonah velikokrat preobremenjeni, v vmesnem obdobju pa ne v celoti izkoriščeni. Višina in pravilna struktura cen za omenjene storitve sta še kako pomembna za kritje vseh stroškov ter posledično nemotenem delovanju sistemov.

Blejsko jezero je tektonsko-ledeniškega izvora, nastalo je pred približno 15.000 leti, uvrščamo pa ga med alpska jezera (Urbanc-Berčič, 1993). Jezero je po najdaljših točkah dolgo 2.120 m ter široko 1.080 m, največja globina znaša 32 m. Celotni volumen vode v jezeru znaša 25,7 x 10^6 m^3, z zadrževalnim časom vode 2,5 let (Kompare, 2005). V Tabeli 1 so osnovne morfološke karakteristike natančno navedene. Velikost pojezerja se je skozi zgodovino dvakrat močno spremenila, z začetnih 487 ha na današnjih 10.703 ha (Rismal, 1993). Prvo povečanje gre pripisati povezavi potoka Mišce z jezerom, drugo pa vzpostavitvi umetnega sistema površinskega izpiranja in povezavi z reko Radovno. Blejsko jezero napaja 12 pritokov ter nekaj manjših izvorov iz dna (Tabela 2).

Monitoring Blejskega jezera je pod okriljem Agencije Republike Slovenije za okolje (ARSO), Oddelka za limnologijo, in se izvaja vsak mesec. Meritve vključujejo fizikalne (prosojnost, temperatura, prevodnost, pH, itd.), kemijske (kisik, fosfor, ortofosfat, amonij, nitrit, nitrat, itd.), biološke (fitoplankton, zooplankton, klorofil, itd.) in mikrobiološke parametre. Vzorčenje se izvaja v vzhodni in zahodni jezerski kotanji ter večjih pritokih in iztokih iz jezera (Slika 2). V zadnjih dveh letih se izvaja tudi analiza sedimenta v pritoku Mišca (ARSO, 2003).

7.2.1 Sanacijski ukrepi na Blejskem jezeru

7.2.1.1 Površinsko izpiranje

Zaradi naraščajoče urbanizacije ter vedno večjih vplivov na jezero, se je v sredini prejšnjega stoletja pojavil problem evtrofikacije, t.i. cvetenje jezera. Ker evtrofna jezera za turizem alpskega tipa niso zanimiva, je bil takoj ustanovljen strokovni odbor z nalogo sanacije jezera. Po vročih polemikah so kot prvo rešitev predlagali sistem površinskega izpiranja jezera z dodatnim dotokom vode bogate z kisikom. Tako je bil leta 1964 zgrajen 2,4 km dolg cevovod, ki je jezero povezal z reko Radovno. Zaradi obstoječe hidroelektrarne na reki Radovni, ki ne dovoljuje večjega odvzema vode, sistem površinskega izpiranja ni nikoli deloval s polno kapaciteto (2 m^3/s), pač pa so maksimalni dotok omejili na cca 300 l/s. Zadrževalni čas vode v jezeru se je tako zmanjšal z 2,7 na 1,4 leta (Remec-Rekar, Bat, 2005). Ker je hitrost rasti alg povprečno 14 dni (Kompare, 2005), sistem površinskega izpiranja pri takih pretokih ni mogel prinesti zadovoljivih rezultatov, kar se je pokazalo v cvetenju jezera tudi v letih po začetku delovanja sistema. Poleg tega bi večji dotok Radovne znižal temperaturo jezera in na ta način zmanjšal privlačnost jezera za vodne športe, kar bi imelo posledice tudi v turističnem gospodarstvu. Prav tako se iz Slike 3 vidi, da je zadrževalni čas vode pri pretoku 3 m^3/s še vedno 90 dni, kar pomeni, da je hitrost rasti alg 6,4-krat hitrejša.

7.2.1.2 Globinsko izpiranje - natega

Ker površinsko izpiranje ni prineslo želenih rezultatov so se raziskave možnih rešitev za sanacijo jezera nadaljevale. Na Inštitutu za zdravstveno hidrotehniko pri Univerzi v Ljubljani so na podlagi poznanih rešitev iz drugih jezer in bilance hraniv v jezeru (glej Tabela 3) predlagali sledeče rešitve (Rismal, Kompare, 1992):

- Zmanjšanje dotoka hraniv v jezero s pritoki;
- Površinsko izpiranje (že delujoč sistem povezave z reko Radovno);
- Globinsko izpiranje hipolimnjiskih voda;
- Prezračevanje hipolimnijskih voda;
- Kemijski ukrepi.

Zadnja dva so zaradi visokih stroškov obratovanja in vzdrževanja opustili ter kot glavno rešitev predlagali globinsko izpiranje s pomočjo natege. Tak sistem je bil prvič vzpostavljen na Krotowskem jezeru na Poljskem. V letih 1980 – 1981 je bil tako v vsako izmed kotanj zgrajen krak natege, ki iz hipolimnija v povprečju odvaja 300 litrov vode na sekundo. Rešitev globinskega izpiranja je pokazala dobre rezultate, saj se je jezero vrnilo v dokaj stabilno mezotrofno stanje. Cvetenje se je pojavilo še enkrat edino le v letih 1999 – 2000, ko so upravljalci zaradi nepravilnega pristopa poškodovali odzračevalni ventil na zahodnem kraku natege ter tako onemogočili učinkovito delovanje sistema. Po odpravi omenjene napake oba sanacijska sistema delujeta dokaj dobro.

7.2.1.3 Kanalizacijski sistem

Že prva komisija pristojna za sanacijo jezera je kot najnujnejšo rešitev predlagala dokončno ureditev kanalizacijskega sistema in odvod vseh odpadnih voda v ožji jezerski skledi stran od jezera. »M« kanal, kot glavni odvodnik odpadnih voda iz centra Bleda, je bil zgrajen že v tridesetih letih prejšnjega stoletja in je še vedno v uporabi. Kljub sanaciji je kanal netesen in na določenih mestih odpadna voda uhaja v jezero in obratno, kar pomeni, da je odpadna voda na iztoku že precej razredčena. Zaradi tega lahko v bioloških procesih na centralni čistilni napravi, ki bo začela s poskusnim obratovanjem v letošnjem letu, pričakujemo težave v njenem obratovanju. Občina Bled je v letu 2002, z mednarodnim podjetjem WTE Wassertechnik iz Essna, podpisala koncesijsko pogodbo za izgradnjo in upravljanje sistema odvajanja in čiščenja odpadnih voda v občini Bled. Koncesijska pogodba je podpisana za dobo 25 let in kot glavni cilj predvideva 95% priključenost objektov v občini na čistilno napravo (Občina Bled, 2002). Zaradi tega lahko upravičeno pričakujemo, da se bo problem odpadnih voda, vsaj v območjih z vplivi na jezero, ustrezno rešil v prihodnjih 3 letih.

7.2.2 Upravljanje z Blejskim jezerom in glavni problemi

Ker sta bila za sanacijo jezera vzpostavljena že dva dokaj draga ukrepa, so glavni problemi v zvezi z Blejskim jezerom organizacijske in ne tehnične narave. Kot probleme tehnične narave velja omeniti, poleg netesne kanalizacije v centru Bleda, še neurejen odvod odpadnih voda ob potoku Mišca, ki je glavnik pritok v jezero (glej Sliko 5) in nerazjasnjeno stanje glede ribogojnice, ki se nahaja le nekaj metrov pred izlivom Mišce v jezero, ki skoznjo tudi teče. Uradno naj ribogojnica ne bi bila več v uporabi, a očitno obratuje nelegalno. Dokončno zaprtje in, če je njena ekonomska vrednost tolikšna, selitev na drugo lokacijo (npr. na Savo Bohinjko) sta tako nujna koraka za prihodnost.

Probleme organizacijske narave lahko strnemo v tri glavne točke:

- Zapletena zakonodaja;
- Sodelovanje deležnikov;
- Program upravljanja z okoljem.

V prvem primeru gre za zapleteno stanje v zvezi z zakonodajo, ki vsako vodno telo definira kot javno dobro, njegov upravljalec pa je Ministrstvo za okolje in prostor oziroma pooblaščena organizacija ali podjetje. Na drugi strani je kot upravljalec obale postavljena Občina Bled. Ker med obema stranema še vedno ni prišlo do podpisa sporazuma o celotnem upravljanju, se pojavlja precej problemov, ki se v primeru enega generalnega upravljalca sploh ne bi dogodili. Poleg tega imata na priobalnih zemljiščih tako Ministrstvo kot občina predkupno pravico, s prvo upravičenim Ministrstvom. Na ta način je občina zakonsko povsem destimulirana za kakršnokoli bolj natančno upravljanje obale jezera.

Drugi problem upravljanja je nesodelovanje deležnikov, ki so z jezerom neposredno ali posredno povezani. Tudi sama javnost je v procese odločanja ponavadi vključena prepozno, kar se odraža v velikem negodovanju lokalnega prebivalstva tik pred začetkom implementacije načrtovanih projektov. Glavni deležniki v zvezi z upravljanjem z jezerom so, poleg omenjenih Ministrstva za okolje in prostor (Oddelek za limnologijo) ter Občine Bled (skupno z občinskimi podjetji), še VGP Kranj, kot upravljalec z vodami na področju zgornje Gorenjske, vsa turistična podjetja in ponudniki, zlasti Sava Kranj d.d., kmetje in Kmetijska zbornica, zasebna podjetja ali gospodarske družbe, ki so v okviru koncesij pripravljene sodelovati pri določenih projektih upravljanja, ter univerze in inštituti, ki se ukvarjajo z za jezero pomembnimi področji. Vsa ta množica deležnikov bi se morala združiti v posebni organizaciji, ki bi s primernimi strokovnjaki in dovolj visokimi finančnimi sredstvi z jezerom tudi upravljala.

Ker gre v primeru jezera za kompleksen naravni sistem, na katerega vplivajo številni vplivi, v prvi vrsti urbani, upravljanje ne more potekati stihijsko, pač pa po točno določenem programu, kjer so vsi koraki dobro preučeni in načrtovani. Tako je za Blejsko jezero potrebno pripraviti program upravljanja z jezerom ali celotnim okoljem in na ta način začrtati poteze v prejšnjem odstavku omenjeni organizaciji.

7.3 Upravljanje z jezeri v Avstriji – primer avstrijske Koroške

Republika Avstrija velja za eno izmed okoljsko najbolj zavednih držav na svetu. Za okoljske rešitve namenja v povprečju 3,4 % bruto družbenega produkta (BDP), kar je skupaj s Švedsko in Finsko tudi največ v celotni Evropski uniji (Preslmayr Rechtsanwälte, 2005).

7.3.1 Osnove avstrijske okoljske zakonodaje

Avstrijo odlikuje zelo dovršena in dobro strukturirana zakonodaja na vseh področjih. Kljub nekoliko bolj zapleteni strukturi je sistem pregleden ter s strani stroke in uporabnikov dobro upoštevan. Okoljsko zakonodajo pripravljajo na dveh različnih nivojih, na državnem in na regijskem. Vodni zakon, zakon o gozdovih, zakon in večina podzakonskih aktov na področju ravnanja z odpadki so sprejeti in pripravljeni na državnem nivoju, medtem ko se zakoni o varovanju okolja, graditvi objektov in urejanju prostora pripravljajo na regijskem nivoju, torej so od dežele do dežele različni. Struktura avstrijske okoljske zakonodaje je prikazana na Sliki 5.

Glavni zakon s področja voda je državni vodni zakon, ki je bil prvič sprejet že leta 1953, zadnjo spremembo pa doživel leta 2003, zaradi zahtev evropske vodne direktive (WFD). Zakon definira sledeča področja (Kainz, 2000):

- Razvoj vodnih teles;
- Uporaba vode;
- Trajnostna kvaliteta in zaščita voda;
- Čiščenje voda in sanacije.

V zvezi z vodnim zakonom velja omeniti njegovo določbo o t.i. stanju tehnike (state-of-the-art), ki vsem deležnikom nalaga, da morajo spremljati tehnološki razvoj ter svoje objekte in naprave temu primerno tudi izboljševati. Ministrstvo za kmetijstvo, gozdove, okolje in upravljanje z vodami na podlagi te dikcije v določenih periodah objavlja pravilnike s predpisanimi največjimi dovoljenimi emisijami in imisijami v vodna telesa. Vodnemu zakonu tako pripada 53 uredb, od katerih 3 urejajo področje komunalnih odpadnih voda, ostalih 50 pa ureja industrijske odpadne vode. Obremenitev okolja s strani kmetijstva, kot enega izmed največjih onesnaževalcev, je v vodnem zakonu definirana z največjimi dovoljenimi obremenitvami tal z gnojili. Za poljske površine je meja postavljena na 175 kg N/(leto•ha), za travnate površine na 210 N/(leto•ha) ter za vodno občutljiva območja na 110 N/(leto•ha).

Poleg določbe o stanju tehnike je potrebno omeniti še posebno določbo, ki jo definira zakonodaja s področja financiranja vodnogospodarskih projektov, in govori o pripravi projektov v več variantah. To pomeni, da morajo občine ali posamezna združenja projektne rešitev vedno pripraviti v več variantah, na podlagi katerih se potem posebna komisija na regijskem nivoju odloči za najboljšega. S tem je povezano tudi financiranje, saj imajo le najboljše rešitve možnost pridobiti nepovratna sredstva Evropske unije ali ugodne kredite s strani državne uprave. Prav tako iskanje najboljših rešitev ponavadi privede do sodelovanja med posameznimi občinami, saj je upravljanje in vzdrževanje velikih sistemov v večini cenejše kot več manjših (izračunano na uporabnika).

Na področju vodnega gospodarstva in varovanja okolja avstrijska zakonodaja pozna sledeče organizacijske strukture za gradnjo, upravljanje in vzdrževanje s sistemi (Kainz, 2000):
- Zadruge (Genossenschaften);
- Združenja (Verbände);
- Občine;
- Javno – zasebno partnerstvo;
- Privatna podjetja.

Prvi dve sta v celotni Evropi prepoznavni kot izredno dobri rešitvi. V primeru zadrug gre za majhne organizacije, ki jih ustanovijo tisti prebivalci, ki so priključeni na zaključen sistem. To pomeni, da je v zadrugo lahko vključena le majhna vas ali celotno mesto, odvisno od zmožnosti sodelovanja lokalnega prebivalstva. V večini so zadruge ustanovljene za upravljanje z vodovodnimi sistemi, le v redkih tudi za upravljanje s kanalizacijskimi sistemi. Na drugi strani so združenja že lahko ogromna podjetja, ki upravljajo s sistemi, ki se razprostirajo v več občin ali celo v celotni regiji. Združenja bi lahko primerjali z našimi javnimi komunalnimi podjetji, saj gre za zelo podobno strukturo. Ko gre za sisteme znotraj posamezne občine, v večini primerov občine z njimi upravljajo kar same. Ustanovitev in vodenje združenj bi namreč predstavljalo večji strošek in posledično višjo ceno za končnega uporabnika. Primeri privatnih podjetij ali javno – zasebnega partnerstva so v Avstriji redki, saj dober sistem financiranja omogoča izgradnjo in upravljanje sistemov brez zasebnega kapitala.

7.3.2 Pregled koroških jezer in upravljalska struktura

V deželi Koroški leži kar 1.270 stoječih voda in jezer, v skupni površini 60 km^2, kar Koroško uvršča med zelo vodnate pokrajine (Schulz, 2006). Vsa večja jezera in njihove karakteristike so navedeni v Preglednici 5, lokacije pa prikazane na Sliki 8. Večina od naštetih je namenjena kopanju, kar pomeni, da se na njih izvajajo meritve s skladu z Evropsko direktivo o kopalnih vodah. Meritve za leto 2003 kažejo, da je kar 95,4% meritev uvrstilo jezera v razred »zelo dobro«. Ker gre za turistično oblegana območja, so to zelo dobri rezultati.

Veliko število jezer zahteva celovit in dobro strukturiran pristop pri upravljanju. Glavne pristojnosti so v rokah deželne vlade oz. uprave, kjer se tudi sprejemajo in potrjujejo vsi večji projekti. 15. enoti deželne uprave, ki je zadolžena za varstvo okolja in tehnologijo, pripada Koroški inštitut za preučevanje jezer (KIS) kot poseben organ v sestavi. Njegova naloga je izvajati monitoring na vseh večjih jezerih, vzdrževati bazo podatkov za vsa vodna telesa v deželi (vodna telesa + prispevna območja), izdelovati študije v primeru novih posegov ali težav, voditi odnose z javnostjo (PR), privabiti k sodelovanju vse pomembne deležnike ter izvajati dejavnosti tudi na trgu. Glavni del sredstev za delovanje inštituta zagotovi deželna vlada, manjšinski delež prispevajo razne organizacije in gospodarske družbe, nekaj sredstev pa inštitut pridobi na trgu.

Glavni dejavnosti Inštituta za preučevanje jezer sta torej izvajanje meritev in vzdrževanje baze podatkov o okolju oz. vodnih telesih. Na manjših jezerih se meritve izvajajo dvakrat letno, medtem ko pri večjih štirikrat. Vsako leto se na enem jezeru izvajajo bolj pogoste meritve, t.j. enkrat mesečno. Omenjeno število meritev je v OECD-jevih priporočilih o evtrofikaciji voda predpisano kot minimalno (Vollenweider s sod., 1986). Meritve obsegajo večino fizikalnih, kemijskih in bioloških parametrov, v kopalnih jezerih pa tudi mikrobiološke analize. KIS vodi in vzdržuje bazo podatkov o rezultatih meritev v samih jezerih in kar je še pomembnejše, tudi podatke o pojezerjih. Slednji so obdelani na podlagi baz geodetskih služb, z zemljiško parcelo kot osnovno enoto. Podatki so zapisani v tekstovnih datotekah in za boljšo preglednost prikazani na načrtih in kartah. O pojezerjih se vodijo naslednji podatki:

- Pritoki in iztoki jezera;
- Prikaz območij pripadajočih posamezni upravni enoti;
- Višinske točke in linije;
- Karakteristike tal;
- Vegetacija;
- Območja namenjena intenzivni kmetijski rabi;
- Raba tal.

Iz omenjenih kart je nato enostavno razbrati potencialno nevarna območja, katerim je potrebno posvetiti posebno pozornosti. To pomeni zbirati še več podatkov o teh območjih, deželni vladi pripraviti in poslati v sprejem dodatne ukrepe in odloke ter pripraviti študije o možnih izboljšavah ali sanacijah.

S komunalnimi sistemi in sistemi za sanacijo jezer upravljajo vodna združenja ali občine. Prva upravljajo večinoma z večjimi sistemi (medobčinskimi), medtem ko so manjši pod okriljem občin. Kvaliteta storitve in cena za končnega uporabnika sta glavno vodilo za izbor. Pred izvedbo posameznega projekta se vedno izdela finančni plan, v katerem je definirana struktura financiranja, kapitalski stroški ter stroški upravljanja, obratovanja in vzdrževanja, in sicer tako, da je finančna konstrukcija zaprta. To pomeni, da upravljalec deluje samo v okviru projekta, iz katerega se krijejo vsi stroški. Na ta način so projekti pregledni in ne prihaja do dodatnega financiranja med samim obratovanjem, sistemi pa so zaradi primerno visokih cen dobro vzdrževani. Zelo pomembna je tudi komunikacija med Koroškim inštitutom za preučevanje jezer in upravljalci komunalnih sistemov, saj je v primeru težav odzivnost še kako pomembna. Poleg tega je pred implementacijo projektov potrebno izdelati študije vplivov na jezera in pojezerja, kar je v pristojnosti Inštituta.

Generalna upravljajska struktura je prikazana na Sliki 9.

7.3.3 Sanacijski ukrepi na koroških jezerih

Po drugi svetovni vojni so urbanizacija, hitro rastoči turizem ter moderno kmetijstvo privedli do točke, ko so bili vplivi na jezerske ekosisteme preveliki, sanacije v smislu zaščite le teh pa nujne. Zaščita jezer pred odpadnimi vodami je bila predstavljena kot prvi in najnujnejši ukrep. Koroška deželna vlada je k reševanju problema pristopila celovito in leta 1964 sprejela program izgradnje sistemov odvajanja in čiščenja odpadnih voda v jezerskih območjih. Program je v prvi vrsti predvidel organizacijske rešitev, to so že prej omenjeni sistemi upravljanja, in kot drugo navedel tehnične rešitve za posamezna območja. Zvezna vlada se je odločila projektu pomagati s finančnimi sredstvi, v smislu ugodnejših kreditov in daljših odplačilnih dob. Te je bilo za projekte sanacije jezer možno dobiti s pol nižjimi obrestnimi merami kot pri ostalih. Tako so bili v sedemdesetih in osemdesetih letih prejšnjega stoletja, okoli vseh večjih jezer, zgrajeni krožni kanalizacijski sistemi, ki so se priključevali na čistilne naprave. Na ta način je bil vpliv odpadnih voda na jezera povsem izničen. Sistemi so se gradili v klasični izvedbi v zemljini (gravitacijski ali tlačni) in kjer je bilo to ekonomsko opravičljivo, tudi po dnu jezer. V tem primeru je šlo za tehnologijo neskončne cevi, ki so jo izdelovali na mestu, t.j. na obali jezera. Cev so v določenih razmakih obteževali z betonskimi utežmi ter s posebnimi čolni povlekli na drugo stran jezera. Ko so cev napolnili z vodo, je potonila na dno. V primeru vzdrževanja ali sanacij se v cev zopet načrpa zrak, cev se dvigne na gladino in popravila se lahko izvedejo. Gre za povsem preprost pristop, ki je predstavljal samo 5% celotnih stroškov tlačne izvedbe. Ostalih 95% predstavljajo stroški gradnje in vzdrževanja črpališča (Sampl, 2005).

Drugi pomemben projekt je bil zaščita jezer pred meteornimi vodami s cest in urbanih središč. Sploh je bilo območje Vrbskega jezera zaradi bližine avtoceste A2, ki povezuje Beljak z Dunajem, zelo obremenjeno. Ker meteorne vode nastopajo v večjih količinah, njihova onesnaženost pa ni tolikšna kot v primeru fekalnih odpadnih voda, je priključitev teh na komunalne čistilne naprave ponavadi ekonomsko neupravičena. Rastlinska čistilna naprava predstavlja tako boljšo in predvsem cenovno ugodnejšo rešitev. Vzdolž omenjene avtoceste je bilo zgrajenih 15 takšnih čistilnih naprav in posledično zmanjšan vnos hraniv in onesnažil z odpadnimi vodami z avtoceste. Isto rešitev je možno uporabiti tudi v primeru meteornih voda iz urbanih središč ali fekalnih odpadnih voda iz manjših odročnih krajev, kjer gradnja male čistilne naprave ali povezovalnega kanalizacijskega voda zahteva večja finančna vlaganja.

Celotna izvedba programa odvajanja in čiščenja odpadnih voda v jezerskih območjih je od leta 1963 do 2003 stala 430.665.000 evrov. Struktura financiranja je bila sledeča (Schulz, 2005):

- Krediti zvezne vlade: 20 – 80% celotne investicije;
- Nepovratna sredstva deželne vlade: 15 – 20% celotne investicije;
- Priključnine: 10% celotne investicije.

Krediti zvezne vlade so se bili na voljo po 1 ali 2% obrestni meri (niso vključeni stroški odobritve, zavarovanja, itd.). Nižja obrestna mera je bila namenjena medobčinskim projektom, v smislu vzpodbude za povezovanje in sodelovanje. Kot dodatna ugodnost za projekte na območjih jezer je bila tudi odplačilna doba podaljšana na 50 let, ki v ostalih primerih znaša od 30 do 40 let (Poročilo o stanju okolja na Koroškem, 1999). Zvezna vlada je pri kreditih sodelovala z banko Kommunalkredit AG, ki je povsem v zasebni lasti. V tem primeru gre torej za vzpostavitev javno-zasebnega partnerstva na višjem nivoju, kjer je zaradi vpletenosti večjega števila strokovnjakov možnost napak in izsiljevanja toliko manjša.
Lastniki objektov, ki so se na novo priključevali na sisteme odvajanja in čiščenja odpadnih voda, so za to morali plačati t.i. priključnino. Znesek se je obračunal na podlagi kvadrature stanovanjske površine in je lahko znašal največ 2.534 EUR/100m^2 (Koroška deželna vlada, 2005). Poleg tega koroška deželna zakonodaja še danes določa, da v primeru, ko se občine ne odločajo za pobiranje priključnin, tudi nimajo možnosti pridobiti nepovratna sredstva ali ugodne kredite s strani državne ali deželne vlade. Na ta način je zagotovljeno vzdrževanje načela, da morajo povzročitelji prispevati sredstva za zaščito oz. sanacijo okolja (PPP). Priključnina ima v Republiki Avstriji enak pomen kot komunalni prispevek pri nas, le da se njeno zbiranje izvaja na pregleden način, t.j. že prej omenjena zaprta finančna konstrukcija, in se ne prerazporeja po občinskih blagajnah.

7.3.4 Tehnični – neposredni ukrepi

V primerih, ko sanacijski ukrepi odvajanja in čiščenja odpadnih voda še vedno niso zagotovili stabilnega stanja jezer oz. v primerih, ko so bili ostali zunanji vplivi preveliki, je bilo potrebno izvesti dodatne ukrepe v samih jezerih. Slabost teh ukrepov je ta, da vzrokov na odpravljajo, pač pa samo zmanjšujejo njihove posledice. Stroka danes pozna ogromno tehničnih rešitev (večina jih je predstavljenih v Prilogi A), na koroških jezerih so bile izvedene slednje:

- Površinsko in globinsko izpiranje – natega (Sliki 18 in 19);
- Odstranjevanje talne vegetacije (Sliki 20 in 21);
- Odstranjevanje alg (Slika 22);
- Odstranjevanje sedimenta iz dna (Sliki 23 in 24);
- Ozračevanje hipolimnijske vode (Sliki 25 in 26);
- Biološki postopki (Sliki 27 in 28).

V Preglednici 7 so navedena jezera, v katerih so bili našteti ukrepi izvedeni.

Postopka površinskega in globinskega izpiranja sta predstavljena že v okviru sanacijskih ukrepov na Blejskem jezeru. Posebej velja omeniti le sistem globinskega izpiranja na Klopinjskem jezeru, ki je poznano po svojem dolgem zadrževalnem času vode (11,5 let), saj je brez površinskih pritokov in ga napaja le nekaj izvirov iz dna (v povprečju 35 l/s). Poleg tega je Klopinjsko jezero meromiktično, kar pomeni, da je na dnu poseben sloj vode, ki se zaradi svojih karakteristik z ostalo vodo ne meša. Višina meromiktičnega sloja je pred gradnjo natege varirala od 10 do 20 m, zato so načrtovalci natege predvideli premični vtok natege, ki se lahko prilagaja spremembam meromiktičnega sloja. V zadnjem času je jezero v zelo stabilnem stanju, zato je vtok zadnjih 15 let vseskozi na enaki globini, t.j. 35 m (Občina Škocijan, 2005). Zaradi majhne količine dotekajoče vode tudi natega obratuje pri enakih pretokih (35 l/s), kljub temu, da premer 400 mm omogoča veliko večje pretoke. V primeru polnih pretokov po nategi bi bilo potrebno v jezero speljati nove pritoke, ki bi nadomestili izgube zaradi natege (primer povezave Radovne z Blejskim jezerom). Ker je Klopinjsko jezero po OECD klasifikaciji uvrščeno v razred oligotrofnih jezer, omenjena dopolnitev sistema zaenkrat ni potrebna. Druga posebnost natege na Klopinjskem jezeru je iztok, ki je lociran v povsem urbanem okolju. Ker se v hipolimnjiskih vodah nahaja le neznatna količina kisika, te ponavadi smrdijo in povzročajo neprijetnosti okoliškim prebivalcem ter turistom. Zato na Klopinjskem jezeru hipolimnijski vodi pred iztokom iz natege dodajajo vodikov pereoksid (H_2O_2), ki kot močan oksidant izboljša kisikove razmere in prepreči nastajanje smradu. Druga možnost za rešitev problema bi bila podaljšanje natege in lociranje njenega iztoka izven urbanih območij, kot je to izvedeno v primeru Blejskega jezera (podaljšan cevovod mimo vasi Mlino in iztok v Savo Bohinjko).

Odstranjevanje talne vegetacije je poznano bolj kot kozmetični popravek in ne toliko kot sanacijskih ukrep. V večini se uporablja na območjih namenjenih za kopanje, kjer je pred kopalno sezono potrebno odstraniti vegetacijo z dna, saj bi le ta ovirala in odvračala kopalce. Delno se z odstranitvijo vegetacije zmanjša tudi količina hraniv. Postopek se izvaja s posebnim čolnom, ki po dnu vleče rezilo in odstranjuje vegetacijo. Ko ta priplava na površino, jo čoln s plugom potisne na obalo, kjer se odstrani. Postopek se izvaja na šestih jezerih avstrijske Koroške in je pod okriljem Koroškega inštituta za preučevanje jezer, ki ima v lasti tudi vse potrebne stroje in opremo. Stroški za 8 ur dela znašajo približno 500 evrov (Schulz, 2006).

Postopek odstranjevanja alg se uporabi v primerih, ko že nastopi cvetenje in ogroža stabilno stanje jezera in posledično tudi celotno turistično gospodarstvo pripadajočega območja. Gre za enostaven postopek, kjer plovilo s posebno filtrsko mrežo pluje po jezeru in pobira alge iz vode. Na Koroškem je bil uporabljen na Osojskem jezeru, kjer se je cvetenje alg pojavilo tik pred poletno turistično sezono. Kljub razsežnostim Osojskega jezera (površina meri 1078,7 ha) je bil, zaradi njegove pomembnosti za celotno turistično privlačnost Koroške, omenjeni ukrep še vedno ekonomsko upravičen.

Sedimenti na dnu jezera so pomemben vir hraniv in predstavljajo t.i. notranjo obremenitev jezera. Z njihovo delno odstranitvijo lahko znatno zmanjšamo vnos hraniv in zaščitimo jezero. Kakorkoli že, postopek odstranjevanja sedimentov je dokaj zapleten in predvsem izredno drag. Po standardih Nemškega združenja za vode, cena za kubičnim meter odstranjenega sedimenta znaša približno 7,5 evra (DWA, 2005). Ker gre za velike količine sedimentov, predstavlja problem tudi njihovo odlaganje. Odlagalne površine so za nekaj časa neuporabne, kar še dodatno dviguje ceno najema ali odkupa zemljišč. Pred odlaganjem se za boljšo ločevanje vode od trdnih delcev dodaja flokulant. Za odstranjevanje sedimetov na koroških jezerih KIS sklepa pogodbe z nemškimi in nizozemskimi podjetji, ki podobne postopke izvajajo v velikih pristaniščih vzdolž obale severnega morja.

Ozračevanje hipolimnijskih voda predstavlja alternativo globinskemu izpiranju s pomočjo natege. Z ozračevanjem se izboljšajo kisikove razmere na dnu in zmanjša notranja obremenitev s hranivi. Prednost tega sistema je, da jezera ni potrebno povezovati z dodatnimi pritoki, kar precej zmanjša investicijske stroške in je uporabno predvsem v jezerih, kjer povezave z dodatnimi pritoki niso možne. Po drugi strani pa so stroški obratovanja in vzdrževanja znatno večji, saj sistem sestavljajo velike črpalke za ozračevanje ali črpanje vode. Po standardih DWA, investicijski stroški za povprečno velike sisteme znašajo od 15.000 do 150.000 evrov. Poznana sta dva sistema, kjer se pri prvem zrak dodaja direktno v hipolimnijskih del, pri drugem pa se voda iz tega dela črpa na površje, kjer se obogati s kisikom, nato pa vrne nazaj v hipolimnij. Pri tem je potrebno paziti, da se vtekajoča in iztekajoča voda ne mešata ter da ne pride do razpršitve vode po površini. Slednje bi namreč precej povečalo vnos hraniv v epilimnij, kjer je razvoj fitoplanktona najbolj intenziven. Na koroškem jezeru Feldsee je uporabljen drugi postopek. Sistem je v obratovanju samo v času poletne sezone, od konca junija do sredine oktobra (Poročilo o stanju jezer na Koroškem, 2004), ko je v hipolimniju tudi najmanj kisika. Poleg tega se s prenehanjem v zimskem obdobju zmanjšajo stroški obratovanja in vzdrževanja.

Biološki postopki so razmeroma nove in še dokaj neraziskane metode za sanacijo jezer. Gre za postopke, kjer z vzpostavitvijo novih ali dodatnih rastlinskih oziroma živalskih vrst dosežemo ravnovesje v jezerskem ekosistemu. Ker je narava zelo nepredvidljiva in procesi v njej večinoma potekajo stihijsko, je uspeh bioloških postopkov sila težko napovedati ter obstaja tudi možnost nepričakovanih ali celo nezaželenih rezultatov. Na Vrbskem in Osojskem jezeru sta bila, sicer bolj za test kot trajna rešitev (Sampl, 2005), uporabljena dva biološka postopka. Prvi ukrep je bil namenjen zmanjšanju hitrosti rasti alg, ki na začetku rastejo pri dnu, nato pa se z večanjem njihove plovne površine zaradi vzgona dvignejo na gladino. Ker alge za svojo rast potrebujejo zadostne količine svetlobe (proces fotosinteze), lahko s senčenjem hitrost rasti uspešno zmanjšamo ter tako preprečimo njihov dvig na površje. Senčenje dosežemo z vegetacijo, ki jo zasadimo po dnu jezera. Drugi uporabljeni biološki postopek je zasajevanje litoralne cone s trsjem. Trsje iz vode črpa hranljive snovi in na ta način zmanjšuje obremenitev jezera. Na splošno so obale koroških jezer na veliko delih porasle s trsjem, kar tudi pripomore k stabilnejšemu stanju. Seveda so vsa ta območja zaščitena in je vsako uničevanje vegetacije strogo prepovedano.

7.3.5 Posredni ukrepi

Pod posredne ukrepe štejemo tiste, ki se izvajajo izven jezerskih kotanj, t.j. v pojezerju. Gre za ukrepe, ki v večini vzroke odpravljajo in so lahko tehnične, strukturne in nestrukturne narave. Pod prve štejemo že omenjene kanalizacijske sisteme in rastlinske čistilne naprave, pod druge vse zakonske prepovedi in omejitve, pod tretje pa razne predstavitvene brošure, konference, delavnice, internetne strani, skratka osveščanje in vključevanje javnosti o zaščiti jezerskih območij.

Koroška zakonodaja pozna tri možnosti zakonske zaščite za naravo pomembnih območij. Prva je zakon o varovanju prostora, ki prepoveduje kakršnokoli gradnjo ali spreminjanje zaščitenih območij, dovoljuje pa uporabo za namene kmetijstva. Druga možnost je zakon o varstvu narave, s katerim so zaščiteni pomembni habitati. V jezerskih območjih so to največkrat nasadi trsja ter močvirja. Na teh območjih je poleg vseh ostalih posegov prepovedana tudi uporaba v kmetijske namene. Tretja možnost je prostorska politika, ki definira občutljiva območja, v katerih je pred posegi potrebno izdelati študije o vplivih na okolje in z njimi dokazati upravičenost posega. Poleg naštetih možnosti so tu še vse mednarodne konvencije in pogodbe, ki vsaka za svoje področje ščitijo mednarodno pomembna naravna območja (npr. močvirja v pojezerju Hodiškega jezera so pod zaščito Ramsarske konvencije za zaščito močvirij).

V smislu nestrukturnih ukrepov Koroški inštitut za preučevanje jezer (KIS) izdaja razne brošure s podatki o samih jezerih, predstavitvijo izvedenih sanacijskih ukrepov ter nasveti za trajnostno uporabo jezer (npr. uporaba stranišč na kopališčih, ne hranjenje vodnih ptic, pametna uporaba zaščitnih krem, zaščita trsja, odlaganje odpadkov v za to namenjena mesta). S takimi ukrepi se pripomore k izboljšanju okoljske osveščenosti lokalnih prebivalcev in turistov ter tudi k turistični promociji regije. Prav tako KIS vse omenjene podatke objavlja na svoji spletni strani (www.kis.ktn.gv.at), vključno s podatki o aktualnem stanju jezer. Stran obstaja tudi v obliki prirejeni za slepe in slabovidne.

7.3.6 Rezultati kot potrditev pravih odločitev

Da so sanacijski in ostali ukrepi dosegli zastavljene cilje, kažejo rezultati analiz jezerskih voda, ki so se izvajale v vseh letih od začetka sanacij. Rezultati meritev glavnih pokazateljev kvalitete jezerske vode, kot so fosfor, prosojnost in amonijev dušik, so prikazani na Slikah 29 do 32. Koncentracije fosforja so se od leta 1975 v povprečju zmanjšale za 40% (KIS, 2004), kar je ob zavedanju, da je v alpskih jezerih fosfor glavni omejitveni faktor evtrofikacije, zelo pomembno zmanjšanje. Najboljši pokazatelj uspešnosti sanacijskih ukrepov so rezultati meritev prosojnosti, saj se meritve le te izvajajo že od leta 1931, z daljšo prekinitvijo le v obdobju druge svetovne vojne. Iz Slike 30 je lepo razvidno drastično večanje prosojnosti po letu 1970. Največje zmanjšanje je vidno pri amonijevem dušiku, v primeru Vrbskega jezera kar za 84% (KIS, 2004). Amonij ob višjih pH vrednostih prehaja v amoniak, ki je strupen za ribe. Poleg tega se za nitrifikacijo (prehajanje amonija v nitrit in naprej v nitrat) porablja kisik, kar zmanjšuje koncentracije kisika v vodi in posledično poslabšuje pogoje za življenje. Zmanjšanje amonija gre večinoma pripisati sistemom za odvajanje in čiščenje odpadnih voda, saj ga sveža odpadna voda vsebuje zelo veliko. Nadalje, upadanje intenzivnega kmetijstva ter uporaba okolju prijaznejših gnojil sta prav tako pripomogla k zmanjšanju vnosa amonija v stoječe vode.

Po avstrijskem standardu ŐNORM M 6231 so jezera uvrščena v trofične razrede (v Preglednici 9 so prikazani kriteriji za uvrstitev v posamezen razred). Razvrstitev za leto 2003 kaže, da je velika večina jezer uvrščenih med oligotrofna ali šibko mezotrofna. Vsa večja in najbolj znana spadajo med te. V razred evtrofnih jezer sta uvrščeni samo dve manjši jezeri, ki nista namenjeni kopanju (KIS, 2004). Razvrstitev je prikazana v Preglednici 10.

7.3.7 Posebnosti Baškega, Hodiškega in Klopinjskega jezera

Baško, Hodiško in Klopinjsko jezero so po karakteristikah najbolj podobna Blejskemu jezeru. Tudi območja, ki so s temi jezeri in od njih v veliki meri odvisna (turistična privlačnost kraja), so približno enaka Bledu, s podobnim številom prebivalcev. V nadaljevanju podajamo nekaj rešitev na teh območij, ki bi se lahko uporabile tudi kot dobre rešitve na območju Bleda.

Baško jezero leži v južnem delu dežele Koroške in je razdeljeno med občini Bekštanj in Beljak. Jezero je v zasebni lasti, zato imajo vsi uporabniki z lastniki sklenjeno dolgoročno najemno pogodbo o uporabi. Seveda, zaščita jezera, spremljanje njegovega stanja in zbiranje podatkov je še vedno v pristojnosti obeh občin in deželne uprave, predvsem Koroškega inštituta za preučevanje jezer. Ker je vpletenih subjektov kar nekaj in bi proces odločanja trajal predlogo, so za zaščito jezera pred vplivi odpadnih voda (krožni kanalizacijski sistem) ustanovili Vodno združenje Baško jezero, ki je bilo zadolženo za gradnjo sistema, danes pa z njim tudi upravlja. Na ta način so se ponavadi prevladujoči občinski interesi podredili zavedanju o pomembnosti jezera za celotno območje in njegovi zaščiti. S krovnim združenjem se je problem rešil v celoti, na dolgi rok pa zagotovila stabilna in kvalitetna storitev.

Hodiško jezero leži v pojezerju Vrbskega jezera, v bližini mesta Celovec. Podobno kot Baško je tudi Hodiško jezero v zasebni lasti. V območju okoli jezera leži kar nekaj močvirij, ki so zaščitena z Ramsarsko konvencijo za zaščito močvirij iz leta 2003. Močvirja so idealna zaščita jezera pred zunanjimi vplivi, sploh vplivi vtočnih voda, saj se le te v močvirjih delno prečistijo. Nadalje, pritoki v jezera so zaščiteni pred izpiranjem s kmetijskih površin s posebnimi nasipi, ki so zasajeni z bujno vegetacijo (Slika 36). Na ta način direktno izpiranje v potoke ni možno, intenzivna vegetacija pa poskrbi za še dodatno zmanjšanje posrednih vplivov. V preteklosti je v bližini Hodiškega jezera obratovala ribogojnica, z letno produkcijo okoli 6 ton rib. Študije so pokazale, da je iz ribogojnice v jezero prišlo približno 24 kg fosforja letno, zaradi česar so ribogojnico zaprli (Honsig-Erlenburg et al., 1986).

Klopinjsko jezero, ki je skupaj z Vrbskim v svetu najbolj poznano, leži v severovzhodnem delu dežele, v bližini kraja Velikovec. Za razliko od prejšnji dveh ni v zasebni lasti in ima status javnega dobra. Ker je obala skoraj v celoti v zasebni lasti in zaradi tega do jezera prosto ni mogoče priti, Občina Škocijan lastnikom nepremičnin na obali (zemljišča, pomoli) obračunava dodatne takse. Prav tako se takse obračunavajo za uporabo plovil na jezeru. Sistem zaračunavanja in višine taks so prikazane v Preglednici 11. Kot sanacijska rešitev je na Klopinjskem jezeru uporabljen sistem globinskega izpiranja (natega), ki je podrobno predstavljen že v enem izmed prejšnjih poglavij. Ker na celotnem območju zabeležijo letno okoli 700.000 nočitev (Občina Škocijan, 2005), od tega večji del v poletnih mesecih, je prisotno precejšnjo nihanje v količinah odpadnih voda tekom leta. Zaradi tega so v letu 2001 zgradili novo centralno čistilno napravo, s kapaciteto 25.000 PE, ki lahko obratuje pri treh različnih obremenitvah:

- Zimska: 6.200 PE (ena linija v prezračevalnem bazenu);
- Med sezonski čas: 9.800 PE (dve liniji v prezračevalnem bazenu);
- Poletna: 25.000 PE (tri linije v prezračevalnem bazenu).

Prav tako je naknadni usedalnik razdeljen na dve liniji, od katerih druga deluje samo v poletnem obdobju. Z omenjenimi rešitvam je možno, kljub spreminjajoči količini odpadnih voda, še vedno vzdrževati stabilne procese na biološkem delu čistilne naprave ter zagotavljati stalno kvaliteto čiščenja, v skladu s predmetno zakonodajo. Ker je centralna čistilna naprava razmeroma nova, je zanimiva struktura financiranja njene izgradnje (Občina Škocijan, 2005):

- Kredit zvezne vlade: 3.912.705,40 EUR (77%);
- Nepovratna sredstva deželne vlade: 705.071,80 EUR (14%);
- Priključnine: 458.786,60 (9%);

- Skupaj: 5.072.563,80 (100%).

Zaradi pomembnosti območja za turistični razvoj celotne države, je kredit zvezne vlade dokaj visok. V ostalih primerih ta sredstva dosegajo v povprečju 50% celotne investicije (Poročilo o stanju okolja na Koroškem,1999). Priključinino so morali plačati lastniki vseh objektov, tudi tistih, ki so bili priključeni že na staro čistilno napravo. Znesek je bil različen, in sicer so že priključeni morali plačati 668,70 EUR/100m^2 stanovanjske površine, medtem ko so lastniki na novo priključenih objektov plačali 2.542,10 EUR/100m^2 stanovanjske površine (Občina Škocijan 2005).

Glavna negativna posebnost večine koroških jezer je popolna uzurpacija obale s strani zasebnih lastnikov. To pomeni, da je neposreden dostop do jezer za obiskovalce mogoč le v organiziranih kopališčih ali za to namenjenih parkih. Sprehoda povsem okoli obale si ni mogoče privoščiti skoraj nikjer. Vse to je ena izmed velikih prednosti in obenem tudi priložnosti Bleda v njegovem nadaljnjem razvoju.

7.4 Primerjava koroških rešitev z blejskimi

V začetnih poglavjih je bilo omenjeno, da so blejske sanacijske rešitve povsem primerljive z rešitvami v svetu. Še več, v mnogih primerih bi Blejsko jezero, zaradi svoje majhnosti in dokaj hitrih procesov v njem, lahko služilo kot naravni laboratorij za preizkušanje novih dognanj ter potrditev rezultatov dobljenih na matematičnih modelih. Glavni problem jezera so, kot že navedeno, vplivi s pojezerja in upravljanje z njim. Da so avstrijski pristopi bolj učinkoviti, priča tudi uvrstitev jezer v trofične razrede v skladu z OECD-jevo klasifikacijo (Vollenweider s sod., 1986) in je izvedena v nadaljevanju.

7.4.1 OECD klasifikacija

OECD klasifikacija uvršča jezera v pet trofičnih razredov na podlagi štirih parametrov, ki so pomembni pokazatelji stanja v jezerih. To so fosfor, prosojnost, povprečni in maksimalni klorofil-a (t.j. tisti klorofil, ki sveti v UV svetlobi). Ker je v primeru naravnih ekosistemov težko določiti točne meje med posameznimi razredi, so meje predstavljene v obliki verjetnostnih diagramov, s pomočjo katerih jezera uvrstimo v trofične razrede z določeno verjetnostjo. Verjetnostne krivulje so dobljene na podlagi opazovanj velikega števila jezer in primerjave s koncentracijami posameznih parametrov. Trofični razredi so slednji: ultra oligotrofni, oligotrofni, mesotrofni, evtrofni in hiperevtrofni. V prvi razred se uvrščajo s hranivi najbolj revna in zato najbolj stabilna jezera, medtem ko je pri zadnjih slika ravno obratna. V primerjavi je potrebno upoštevati, da v meritvah na Blejskem jezeru in koroških jezerih prihaja do določenih razlik, bodisi v številu meritev, uporabljenem postopku ali interpretaciji rezultatov. Za grobo analizo je to sprejemljivo, medtem ko bi bilo v primeru podrobnejših analiz potrebno preveriti omenjene razlike ali ponovno izvesti meritve na vseh jezerih po enaki proceduri.

Na Sliki 42 je prikazana uvrstitev jezer glede na meritve fosforja. Baško jezero izmed vseh vsebuje najmanjše koncentracije fosforja in je torej s hranivi najbolj revno. Po OECD klasifikaciji ga lahko z 62% verjetnostjo uvrstimo v razred oligotrofnih jezer, z 38% v razred ultra oligotrofnih in le s 5% verjetnostjo med mesotrofna jezera. Povprečna letna koncentracija fosforja pod 10 μg/l je izmerjena tudi v Klopinjskem jezeru, katerega lahko uvrstimo v oligotrofni razred s 65% verjetnostjo. Meja 10 μg/l je namreč zelo občutljiva, saj so pri večjih koncentracijah spremembe zelo hitre in poslabšujejo stanje v jezerih (Sampl, 2005). Temu primerna je tudi uvrstitev Hodiškega in Blejskega jezera, ki vsebujeta nekoliko večje koncentracije fosforja, v razred mesotrofnih jezer s približno 50% verjetnostjo.

Prosojnost kaže nekoliko drugačno sliko (Slika 43). S fosforjem revno Baško jezero ima skoraj najmanjšo prosojnost, kar ga uvršča med mesotrofna jezera s 50% verjetnostjo. To gre pripisati glavnemu pritoku v jezero, potoku Borovnica, ki s seboj prinaša veliko kalnih snovi, kar daje Baškemu jezeru značilno turkizno zeleno barvo ter zmanjšuje njegovo prosojnost (KIS, 2004). Hodiško jezero ima še manjšo prosojnost, medtem ko je le ta v Blejskem in Klopinjskem jezeru precej večja. Slednjega lahko z največjo verjetnostjo uvrstimo v oligotrofni razred. Primerjava s klasifikacijo glede na fosfor kaže, da se rezultati precej razlikujejo. To potrjuje dejstvo, da uvrščanje v določene razrede na podlagi le enega kriterija ponavadi ne kaže najbolj realnega stanja.

Na Slikah 44 in 45 je prikazana klasifikacija glede na povprečni in maksimalni klorofil-a. Klorofil je potreben za proces fotosinteze, njegove meritve pa povedo o produktivnosti fitoplanktona oz. o hitrosti rasti alg. Na slikah je vidna dokaj velika razlika med vsemi tremi koroškimi jezeri in Blejskim, sploh pri meritvah maksimalnega klorofila. Omenjeno kaže na visoko produktivnost fitoplanktona v Blejskem jezeru, kar lahko pripišemo različnim dejavnikom, npr. daljši zadrževalni čas vode daje algam več časa za rast, majhne koncentracije zooplanktona omogočajo hitrejši razvoj fitoplanktona. Točen razlog bi bilo potrebno poiskati s posebno analizo. Pri klasifikaciji glede na klorofil je potrebno še enkrat omeniti, da se meritve na koroških jezerih izvajajo 4-krat letno, medtem ko na Blejskem 12-krat. Z redkejšimi meritvami je skoraj nemogoče ujeti maksimalne koncentracije, kar posledično znižuje tudi povprečne. Še mesečne meritve so za detajlno analizo premalo (Kompare, 2005).

7.4.2 Cene komunalnih storitev

Cene za komunalne storitve so pomemben del okoljskega managementa. Z njimi omogočamo gradnjo in vzdrževanje komunalnih sistemov ter obenem kontroliramo porabo oziroma obremenitve. Nadalje je tako prikazana primerjava cen za komunalne storitve med dvema izrazito turističnima občinama, Bled v Sloveniji ter Škocijan v Avstriji. Vodovodni sistemi sicer nimajo direktnega vpliva na jezerske ekosisteme, a ker se v večini občin stroški za odvajanje in čiščenje odpadnih voda računajo na podlagi porabe pitne vode, je njihov vpliv posreden.

Kot prvo si oglejmo stroške za sam priklop na vodovodni in kanalizacijski sistem s čistilno napravo. V Avstriji se priklop plača direktno preko priključnine, medtem ko so pri nas ti stroški vključeni v komunalni prispevek. Ker je sama struktura cene drugačna, neposredna primerjava ni mogoča in zato je za prikaz uporabljen primer štiričlanske družine, ki živi v samostojni hiši s 150 m^2 stanovanjske površine in pripadajoči gradbeni parceli v velikost 500 m^2. Družina v St. Kanzianu bi tako za priklop na vodovodni sistem odštela 2.758,38 EUR ter še dodatnih 3.813,15 EUR za priklop na sistem odvajanja in čiščenja odpadnih voda. Na Bledu je slika dokaj podobna. Če iz komunalnega prispevka vzamemo samo del za kritje stroškov gradnje vodovodnega sistema (17%), bi naša družina za to plačala 2.135,21 EUR. Pri odpadni vodi je stvar nekoliko bolj komplicirana. Tu je treba delu komunalnega prispevka, ki je vezan na kanalizacijski sistem (26%), dodati še stroške priklopa na čistilno napravo. Le to bo dokončana v septembru letošnjega leta, a ker se blejski občinski možje še vedno niso dogovorili o višini priključnine, je v primerjavo vzeta kar cena iz bližnje občine Kranjska Gora (625 EUR), kjer je sistem zgradil isti koncesionar (WTE Wassertechnik). Stroški priklopa enodružinske hiše na sistem odvajanja in čiščenja odpadnih voda bi tako na Bledu znašali 3.890,62 EUR. Zneski so zbrani tudi v Preglednici 15.

Nadalje si oglejmo še višino mesečnih stroškov za omenjene storitve. Ker je tudi v tem primeru struktura cene precej drugačna, je za ponazoritev zopet uporabljen primer štiričlanske družine, ki na mesec porabi 18 m^3 vode ter uporablja 120 litrski zabojnik za odpadke. Cene komunalnih storitev v St. Kanzianu so namreč sestavljene iz fiksnega in variabilnega dela. Prvi se računa na osnovi stanovanjske površine in je namenjen za pokrivanje fiksnih stroškov (financiranje, upravljanje), medtem ko je podlaga za obračun drugega količina porabljene vode ali oddanih odpadkov, le ta pa pokriva variabilne stroške (obratovanje, vzdrževanje). Cena za komunalne storitve na Bledu je sestavljena samo iz variabilnega dela, namenjena pa je kritju stroškov ter državnih taks (vodni prispevek, taksa za obremenjevanje voda). Iz Preglednice 16 je razvidno, da so cene oskrbe s pitno vodo na Bledu znatno nižje, odvajanja in čiščenja odpadnih voda nekako primerljive, medtem ko gospodarjenje z odpadki stane Blejce skoraj enako kot prebivalce Škocijana. Tu velja opomniti, da je v ceno za odvajanje in čiščenje odpadnih voda vključena najvišja cena iz koncesijske pogodbe, ki bo obveljala šele po začetku obratovanja čistilne naprave. Trenutno je cena skoraj za 50% nižja, a ne vključuje stroškov čiščenja.

Iz prikazane primerjave je razvidno, da pri nas pijemo zelo poceni vodo, kar se odraža v prekomerni in neracionalni porabi ter obenem tudi neprimerni vzdrževanosti sistemov, zaradi česar lahko v prihodnje pričakujemo primerno večje investicije v obnovo. Blejski primer odvajanja in čiščenja odpadnih voda kaže že na evropsko naravnanost, saj se bodo cene s prihodom koncesionarja primerno dvignile, s tem pa bo zagotovljeno tudi primerno vzdrževanje in stabilno obratovanje. Drago ravnanje z odpadki je plod stalnih razprtij gorenjskih občin o lokaciji deponij ali sežigalnice. Avstrijska Koroška je problem rešila in, iz pričujoče primerjave razvidno, tudi pocenila s centralno sežigalnico v Podkloštru.

7.5 Predlogi za izboljšanje upravljanja z Blejskim jezerom

Na podlagi opisanih problemov pri upravljanju Blejskega jezera in predstavitvi dobrih rešitev v sosednji avstrijski Koroški, so v nadaljevanju našteti predlogi za izboljšanje upravljanja z našim najbolj znanim jezerom. Ker je večina teh organizacijske narave, ki v večini ne zahtevajo znatnih finančnih vlaganj, bi bila implementacija predlaganih rešitev izvedljiva že v prihodnjih letih. Prav tako se odpira dobra možnost sodelovanja z organizacijami na Koroškem, tako v smislu okoljskih rešitev kot tudi turizma. Podobnost krajine, neposredna bližina in velika možnost podpore s strani Evropske Unije pričajo v prid temu.

Predlogi za izboljšanje upravljanja z Blejskim jezerom so sledeči:

- Ustanovitev podobne organizacije kot je Koroški inštitut za preučevanje jezer (KIS). V svetu te organizacije je potrebno združiti vse deležnike omenjene v prvem poglavju, kot glavna subjekta pa imenovati Ministrstvo za okolje in prostor ter Občino Bled.

Strokovno telo organizacije mora vsebovati strokovnjake iz vseh področij povezanih z okoljskim upravljanjem, npr. biologi, tehniki, ekonomisti, pravniki. Obstoječi Oddelek za limnologijo, ki deluje pri Agencije Republike Slovenije za okolja (ARSO), je potrebno pridružiti predlagani organizaciji. Da se preprečijo bodoča nesoglasja med glavnima deležnikoma (MOP in Občina Bled), je v statutu organizaciji potrebno te pristojnosti točno definirati.

- Novoustanovljena organizacija mora kot prvo vzpostaviti bazo podatkov o pojezerju, kot je predstavljena v poglavju 7.3.2. Danes Oddelek za limologijo zbira ogromno podatkov o stanju jezera, nima pa podatkov o pojezerju. Ker so vplivi iz pojezerja za jezero najpomembnejši, je nujno voditi bazo podatkov o njem. Nadalje, občinska prostorska politika mora biti pripravljena v skladu z omenjeno bazo. Z uporabo informacijske tehnologije je izmenjava podatkov povsem enostavna, seveda ob predpostavki, da vsi subjekti uporabljajo iste aplikacije, npr. ESRI®-jeva bazo.

- Potok Mišca je glavni onesnaževalec jezera, saj vanj prinaša največ hranljivih snovi. Ker je bila Mišca umetno preusmerjena v jezero, je potrebno izdelati študijo o vzpostavitvi prejšnjega stanja, t.j. povezava Mišce s potokom Rečico, ki se kasneje izliva v Savo Dolinko. Ker bo omenjeni projekt verjetno težko realizirati, je nujno potrebno dokončno zapreti ribogojnico ter jo, če je ekonomsko opravičljivo, preseliti na drugo lokacijo, stran od jezera. Nadalje, potok Mišca na določenih delih teče po kmetijskih površinah, s katerih se ob deževjih intenzivno izpirajo gnojila. Na teh delih je ob potoku potrebno zgraditi nasipe ter tako preprečiti izpiranje direktno v Mišco in preko nje v jezero. Omenjena rešitev je predstavljena v posebnostih Hodiškega jezera. Prav tako je na območjih ob Mišci, ki še nimajo urejene kanalizacije (Slika 5), potrebno to čimprej zgraditi in povezati s centralno čistilno napravo.

- Kanalizacijski sistem v centru Bleda je na mnogih delih dotrajan, kar povzroča uhajanje odpadnih voda v jezero ter na določenih mestih tudi vdor jezerske vode v kanal. Zato je celoten sistem potrebno pregledati s TV kamero ter odpraviti napake ali zgraditi nove cevovode. Najbolj problematičen je glavni povezovalni vod do bodoče čistile naprave, t.i. »M« kanal, katerega sanacija v osemdesetih letih prejšnjega stoletja ni bila uspešna. Tla ob potoku Jezernica so zaradi tega prepojena s fekalnimi vodami, kar je to območje v vseh letih pripeljalo do popolne ekološke degradacije. Ker je Občina Bled s podjetjem WTE Wassertechnik iz Essna podpisala koncesijsko pogodbo o odvajanju in čiščenju odpadnih voda ter v njej predvidela izgradnjo kanalizacijske sistema v občini do leta 2007, se torej upravičeno pričakuje rešitev omenjenih problemov. Med obema pogodbenima partnerjema zaenkrat še ni prišlo do pravega sodelovanja, sploh pri reševanju odvajanja meteornih voda, saj je vse skupaj preveč podrejeno ozkim interesom tako javnega kot tudi zasebnega sektorja. Da bo pravo javno – zasebno partnerstvo res zaživelo, bo v procese odločanja potrebno vključiti še ostale deležnike, npr. vse rešitve odvajanja odpadnih voda, ki imajo ali bodo imela vpliv na jezero, je potrebno preveriti na matematičnih modelih in s tem preprečiti neprave rešitve.

- Podobno kot v primeru Klopinjskega jezera je tudi na Bledu potrebno pripravit taksni model za uporabo jezera, v prvi vrsti za tiste subjekte, ki jim uporaba jezera prinaša dobiček (pletnarji, izposojevalci čolnov, kopališča). Prav tako je potrebno striktno prepovedati kopanje kjerkoli ob jezeru ter ga omogočiti le v zato urejenih kopališčih. Seveda je najprej potrebno povečati njihovo število. Na ta način bo vzpostavljen sistem nadzora in kontrole zunanje obremenitve jezera s strani kopalcev (npr. obremenitev z urinom).

- Slednji predlog velja za državni sistem financiranja okoljskih projektov. Avstrijski model je primer dobro delujočega modela, kjer je z vzpostavitvijo javno – zasebnega partnerstva na višjem nivoju (država in banka Kommunalkredit AG) preprečena situacija močnega zasebnega sektorja proti malim občinam. Poleg tega struktura in višina cen za komunalne storitve omogočata odplačevanje kreditov ter obenem zagotavljata stabilno in varno obratovanje. Sistemi, ki so sicer zgrajeni na novo, a kasneje zaradi prenizkih cen niso primerno vzdrževani in se za njihovo obnovo namenja sredstva iz državnega ali lokalnega proračuna, povzročajo t.i. prerazdeljevanje v javnem financiranju in ustvarjanje mrtvih izgub.

7.6 Zaključek

Množica jezer na avstrijskem Koroškem, urbanizacija in rastoči turizem so Koroško zvezno vlado v šestdesetih letih prejšnjega stoletja pripeljali do spoznanja, da je k upravljanju z vodami potrebno pristopi načrtno, celostno in dolgoročno. Tako so prvo postavili organizacijske temelje in nato vsakemu od deležnikov naložili izvrševanje določenih nalog. Organizacijska struktura s centralizirano organizacijo, ki zahteva bolj specifična znanja (Koroški inštitut za preučevanja jezer) ter množico lokalnih operativcev (občine, združenja), ki z vso infrastrukturo upravljajo, vse skupaj pod močno kontrolo regije, zagotavljajo učinkovito upravljanje z jezeri in pripadajočimi pojezerji, celotni regiji pa omogočajo trajnostni razvoj.

Situacija na Bledu je nekoliko bolj zapletena in manj uspešna. Vzpostavljeni sanacijski ukrepi, ki so zahtevali velika finančna sredstva, so ubranili jezero pred najhujšim. A za povsem stabilno stanje jezera je potrebno dokončno definirati upravljalsko strukturo, vanjo vključiti vse pomembne deležnike in predvsem zagotoviti učinkovito in vzdržno upravljanje s pojezerjem. Le to ima na jezero največji vpliv, a je bilo v preteklosti na žalost povsem na stranskem tiru. V pričujoči diplomski nalogi so tako na podlagi avstrijskih rešitev prikazani glavni in najnujnejši koraki za prihodnje.

Nadaljnje delo bi moralo biti usmerjeno v izdelavo detajlnih analiz primerjav in rešitev, ki so navedene v diplomski nalogi ter na ta način točno dokazati njihovo upravičenost. Kot prioritetno predlagamo predvsem sledeče:

- Natančna primerjava rezultatov monitoringa in uvrstitev jezer v trofične razrede v skladu z OECD klasifikacijo. Pred tem je potrebno preveriti postopke, po katerih so se meritve izvajale, njihovo pogostnost ter interpretacijo rezultatov. V primeru, da so odstopanja prevelika, predlagamo ponovno izvedbo meritev na vseh jezerih;
- Po vzoru Koroškega inštituta za preučevanje jezer točno definirati pojezerje Blejskega jezera in pripraviti bazo podatkov o njem. Poleg tega definirati potencialno nevarna oz. problematična območja ter predlagati ukrepe za njihovo sanacijo;
- Pripraviti načrt revitalizacije potoka Mišce, vključno z možnostjo prevezave nazaj na potok Rečica. Načrt naj poleg tehničnih rešitev vsebuje tudi socio-ekonomsko analizo;
- Pripraviti analizo obstoječega stanja kanalizacijskega sistema ter na podlagi množice že predlaganih rešitev izdelati dokončen predlog sanacije;
- Izdelati taksni model za uporabo jezera.

APPENDIX A: LIST OF REMEDIAL MEASUREMENTS AND BEST MANAGEMENT PRACTICES

(collected from Guide to Lake Protection and Management, Minnesota Freshwater Society, Minnesota 2004)

Table 1: In-lake remedial techniques

Physical Measures	**Chemical Measures**	**Biological Measures**
Aeration and circulation	Algal toxins	Biomanipulation
Dredging	Direct nutrient control	
Dilution and flushing	Plant control	
On-shore treatment techniques	Fish control	
Drawdown		
Harvesting		
Bottom sealing		
Shading		

Aeration and circulation are techniques that involve moving the water and adding oxygen, which increases dissolved oxygen levels. This may prevent fish kills and create a larger habitat for fish and microscopic communities. Aeration can also slow the tapping of phosphorous from the bottom sediments. Results, however, are not always predictable.

Dredging removes sediment, which can be a major source of phosphorus in the water and can hinder recreational use of the lake. Sediment removal, however, is costly. Disposal of the dredged sediment is often a problem.

Dilution and flushing introduces nutrient-poor water and flushes out nutrient-rich water, decreasing the concentration of pollutants and thus the potential for algal growth.

On-shore treatment techniques involve pumping water on-shore, water treatment, and then allowing the treated water to re-enter the lake. Options for such treatment include artificial waterfalls for aeration and using the water to irrigate and fertilize field crops or wetlands, which removes nutrients from the water before it drains back into the lake.

Drawdown lowers water an impoundment and can sometimes control weeds by exposing them to drying or freezing. Exposing the littoral zone may also result in shrinkage of soft muck, thus deepening the lake without expensive dredging. This process may also cause erosion of the shoreline. Drawdown can be useful in encouraging growth of plants beneficial to waterfowl.

Harvesting removes nutrients from the system by eliminating algae, plants, and fish. In eutrophic lakes, however, only relatively small amounts of nutrients are removed by mechanical harvesting. It is primarily considered as a cosmetic improvement, like mowing a lawn.

Bottom sealing cuts off sediment as a potential source of nutrients through the application of such chemicals as alum (aluminium sulfate) or calcium nitrate.

Shading uses a dye to colour the water and prevent penetration of light into the water column. The light limitation may inhibit the growth of plants and algae. Dye must be replaced periodically. This method is used mainly in ponds or very small lakes.

Algal toxins (algaecides and barely straw) are means of quickly and briefly controlling severe nuisances, such as algal blooms, that interfere with recreation. The treatment does not remove nutrients from the lake, and repeated treatment may be necessary in the same season. After repeated treatments, chemicals and metals as cooper may build up in the sediments and fish. Algaecides, pesticides that are effective on algae, are usually broad-spectrum, killing many of plants and animals in the lake as well as the algae. Use of the water by humans is restricted for a time following the application of such chemicals. Barely straw has been used to treat small lakes and ponds. Natural toxins in the straw inhibit the growth of algae in the water. The straw is placed in netting bags and staked in multiple locations around the lake. Application of algal toxins, treats the symptoms inadequately, does little to solve the problem, and may lead to buildup of undesirable chemicals and metals in the lake. These techniques are seldom incorporated into a comprehensive lake restoration plan and should be considered only for short-term treatment of symptoms. However, in some cases these producers may be the only feasible approach.

Direct nutrient control reduces internal loading of phosphorous by binding the phosphorous in the sediment. Chemicals used for this procedure include ferric chloride or, more commonly, alum or calcium nitrate. These chemicals are expensive to apply and their effects is limited in duration.

Plant control uses herbicides (plant-killing chemicals) toxic either to a broad group of plants or to specific plants, but not to other non-targeted plants of animals. This is a temporary treatment that must be repeated annually or more frequently.

Fish control uses pesticides such as rotenone that are toxic to fish. These toxins are usually specific for fish. This may be conducted by the MDNR when a lake has become dominated by undesirable fish. Restocking with game fish generally follows.

Biological controls represent relatively new effort to control the growth of algae and weeds through manipulation of the lake's inter-connections. Although great potential exist in this area, the ecology of lakes is not yet sufficient understood for such approach to be used routinely. Biomanipulation is the term used for a restoration technique that attempts are made to adjust the fish species composition of the lake in order to encourage the growth of the zooplankton population. If successful, these tiny animals are able to reduce algae by eating them. This technique is often coupled with aeration, which creates a larger zone for the zooplankton, and the destruction of the existing fish population with a subsequent restocking of fish species that do not generally feed on zooplankton, such as largemouth bass.

Table 2: Best management practices (BMP) in watershed

On-site BMP's	**Off-site BMP's**	**Non-structural BMP's**
Agricultural pollutants: Manure management, contour framing, rotational grazing, live stock exclusion, etc.	Wetland protection: Wetlands not be altered or drained	Educational efforts Storm drain marking, newsletters, workshops, conferences, web sites, etc.
Urban pollutants: Yard waste clean up, rain gardens, lawn aeration, collect runoff from paved areas, storm sewer, low impact development, etc.	Wetland restoration: It may be valuable to re-establish wetlands that have been drained in the past	Ordinances and regulations: Priority of state government or local municipality
Erosion and sedimentation: Erosion control, area stabilization, directing runoff, inspection and reporting program, etc.	Storm water treatment ponds: Catch storm water and suspend load of fine particles	
	Alum injection: Remove phosphorous from the water before it enters to lake	

APPENDIX B: FAAKER SEE – MAPS

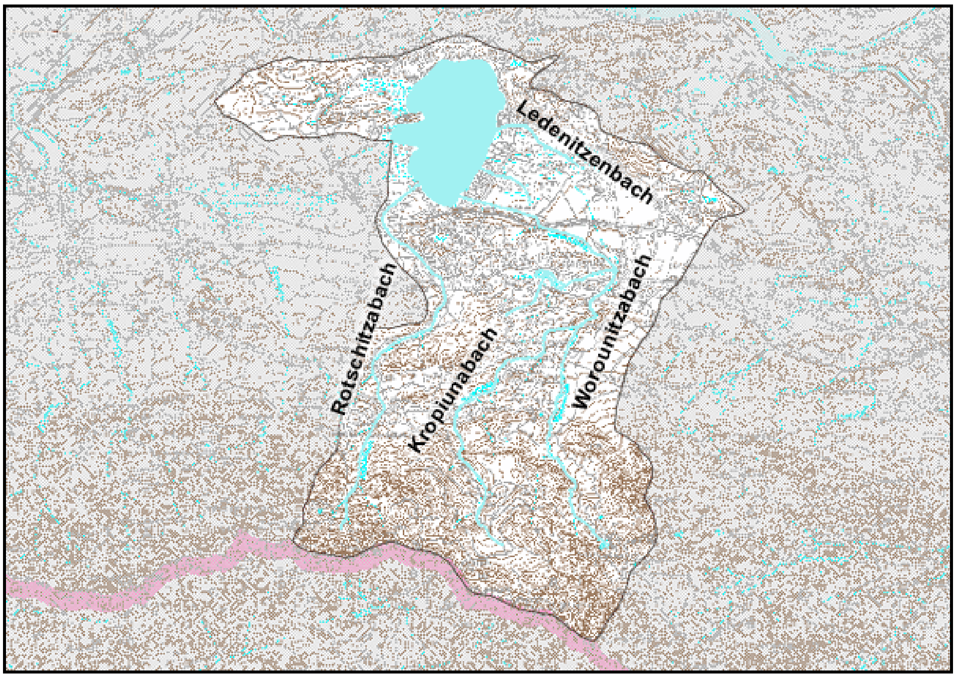

Figure 1: Influents (KIS, 2005)

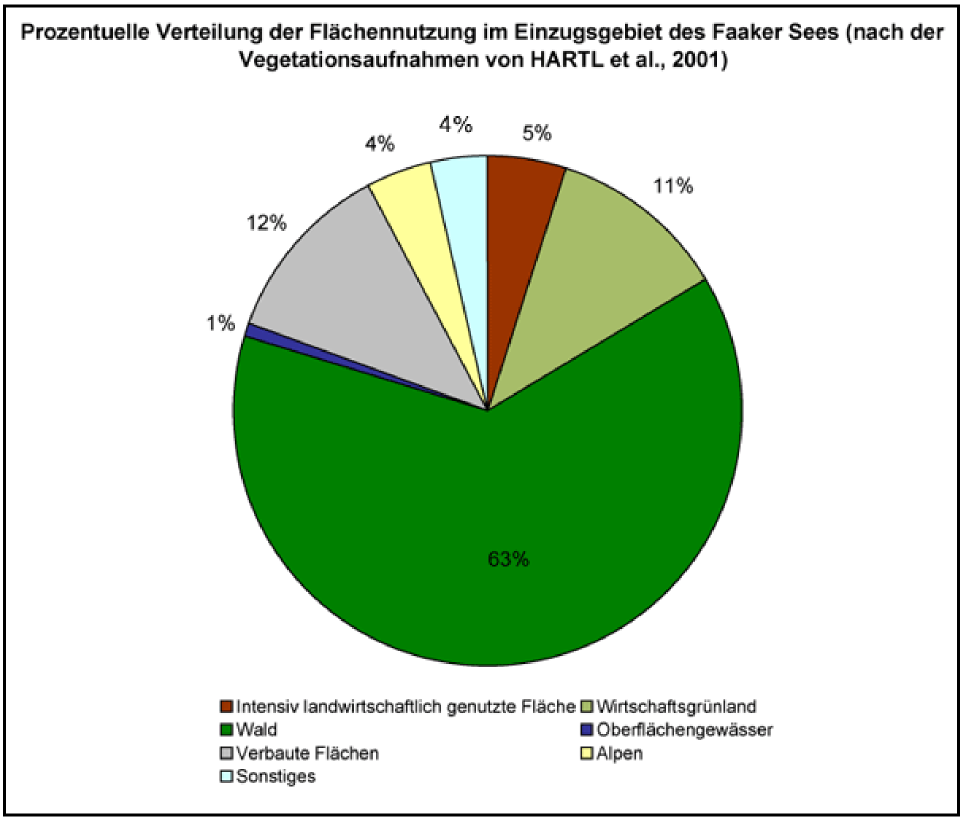

Figure 2: Land use in the watershed (Hartl et al, 2001)

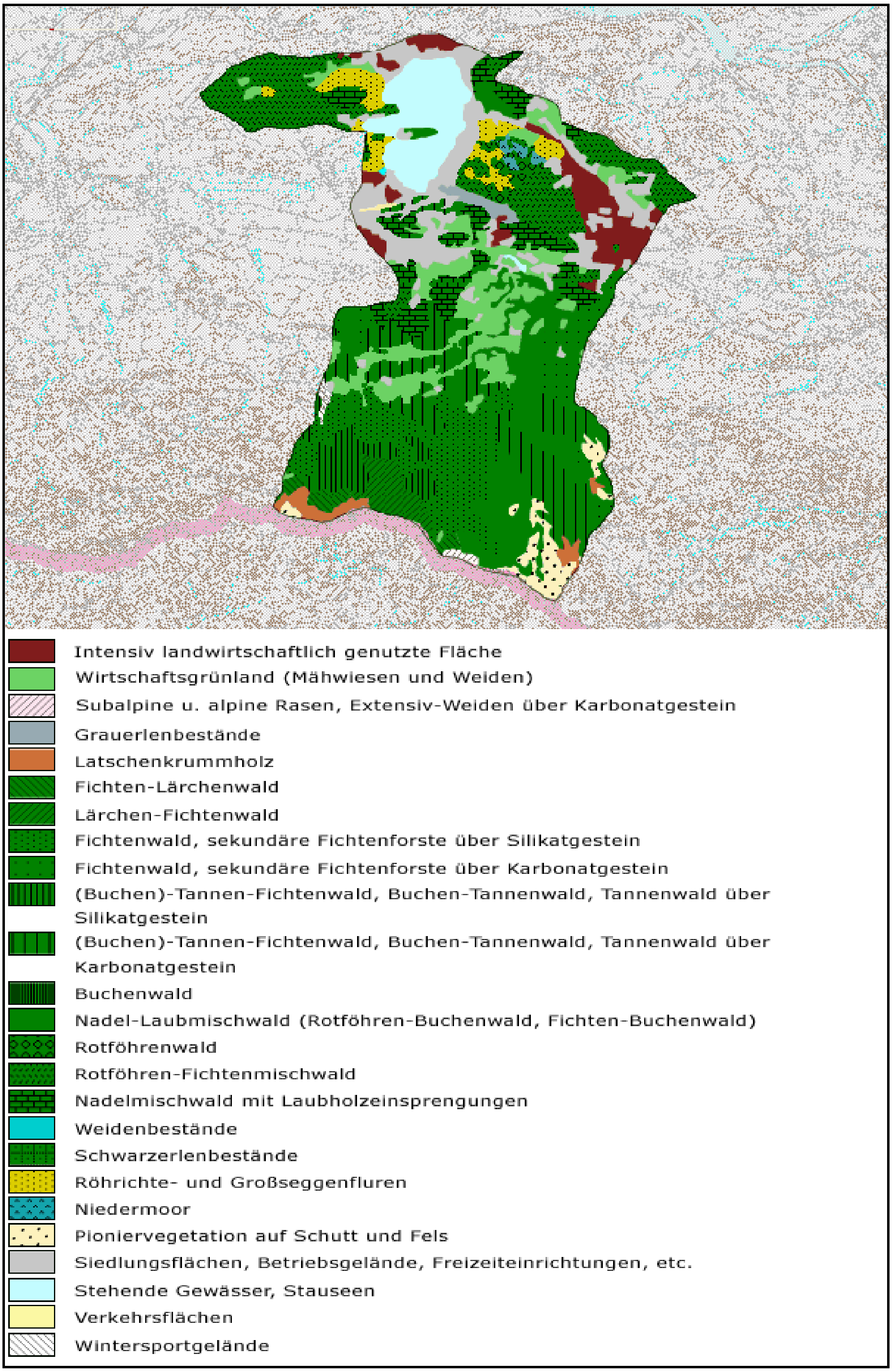

Figure 3: Vegetation in the watershed (Hartl et al, 2001)

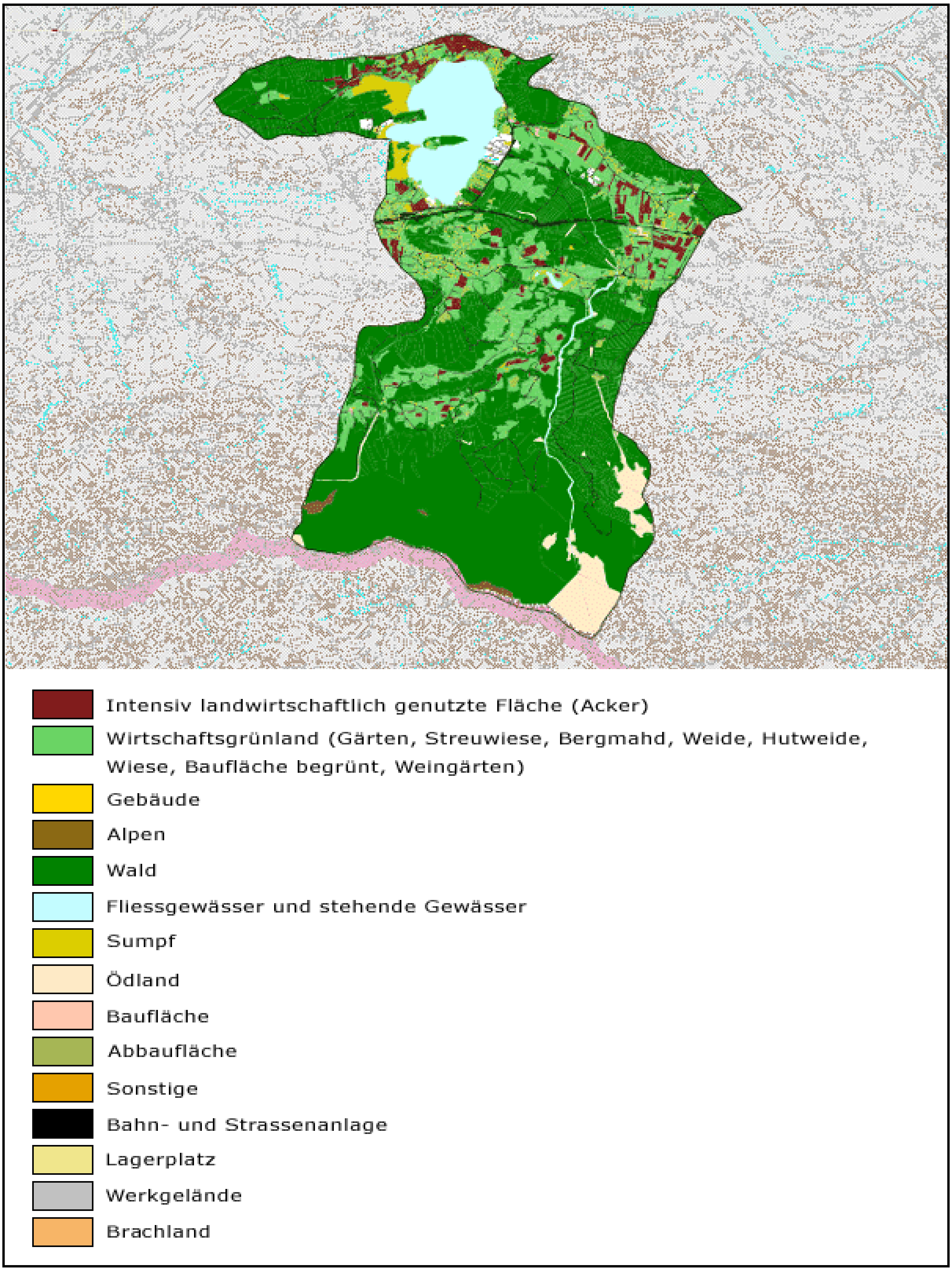

Figure 4: Land use in the watershed according to the digital cadastre (KIS, 2005)

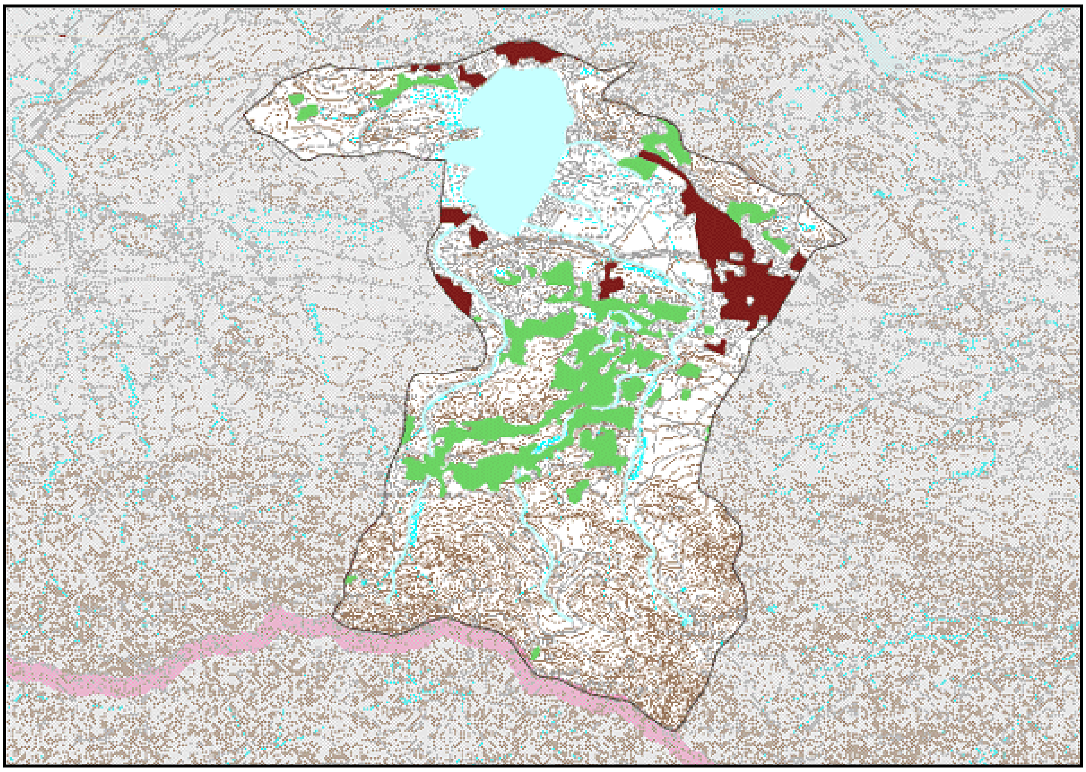

Figure 5: Intensive agriculture areas (red) and economic use (green) (Hartl et al, 2001)

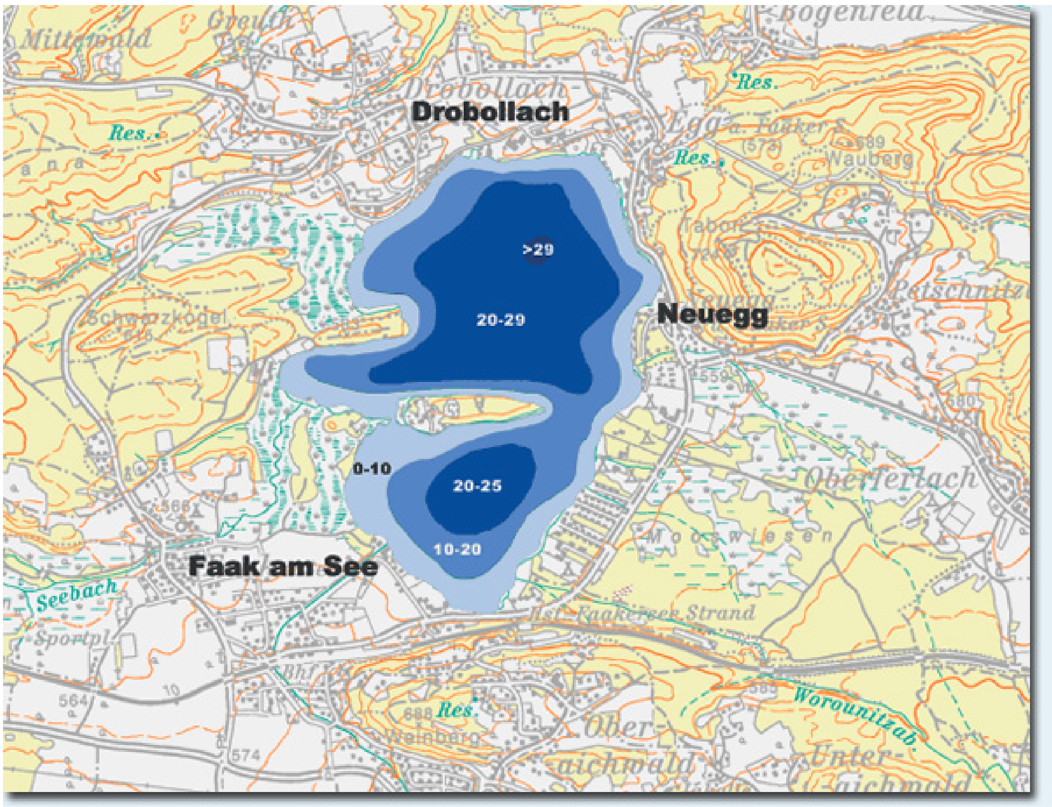

Figure 6: Morphology – the depth structure (KIS, 2005)

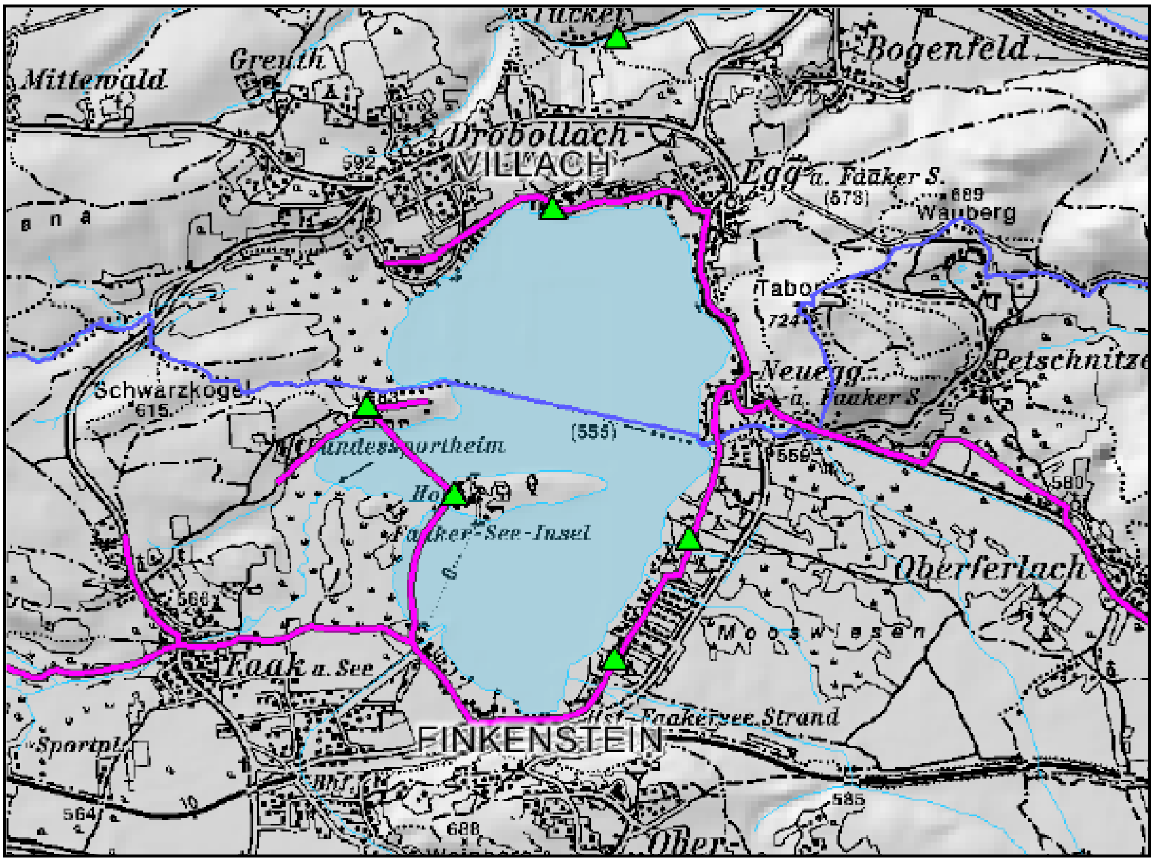

Figure 7: Urban drainage system with pumping stations (KAGIS, 2005)

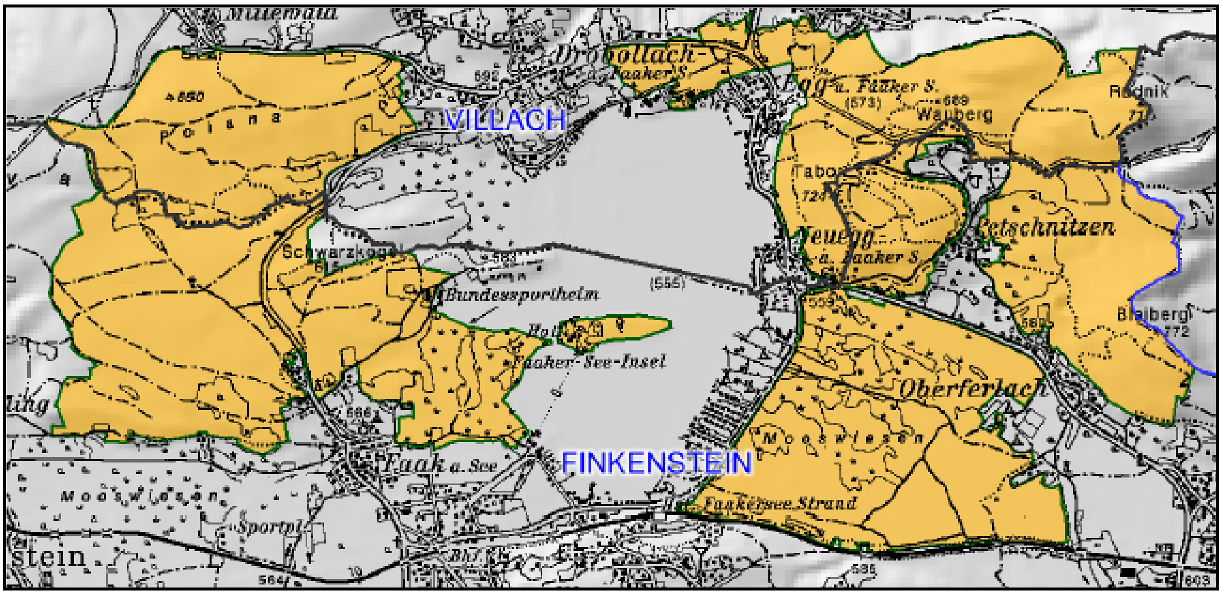

Figure 8: Areas protected with the land protection act (KAGIS, 2005)

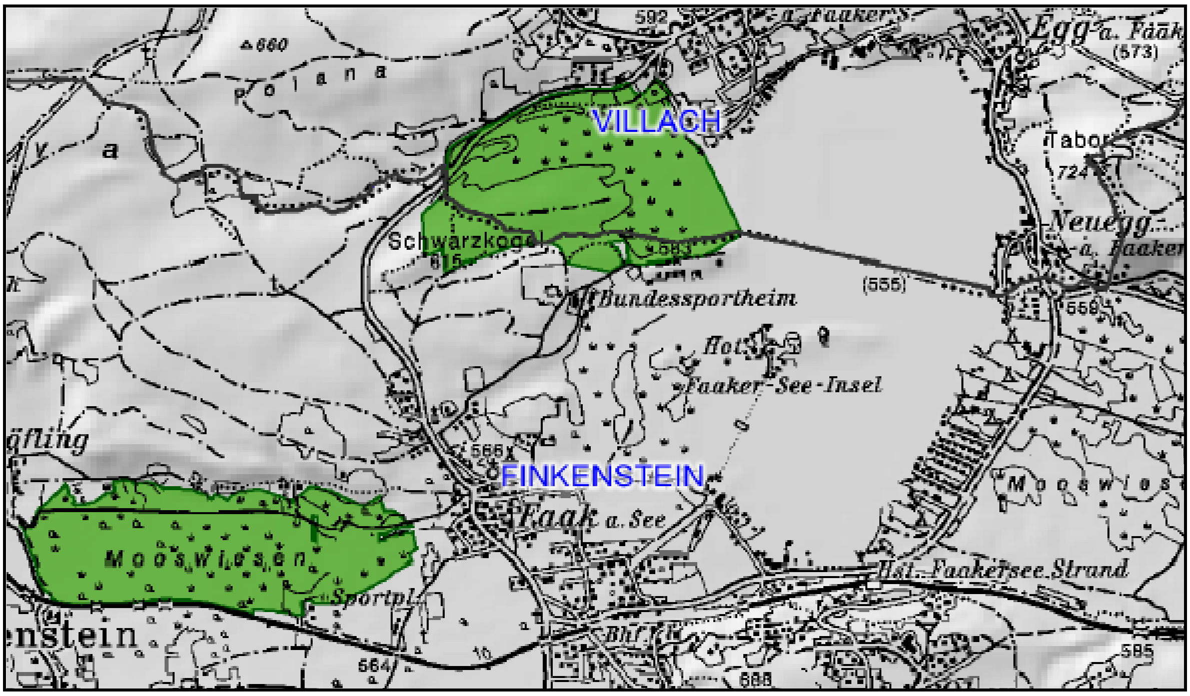

Figure 9: Areas protected with the nature protection act (KAGIS, 2005)

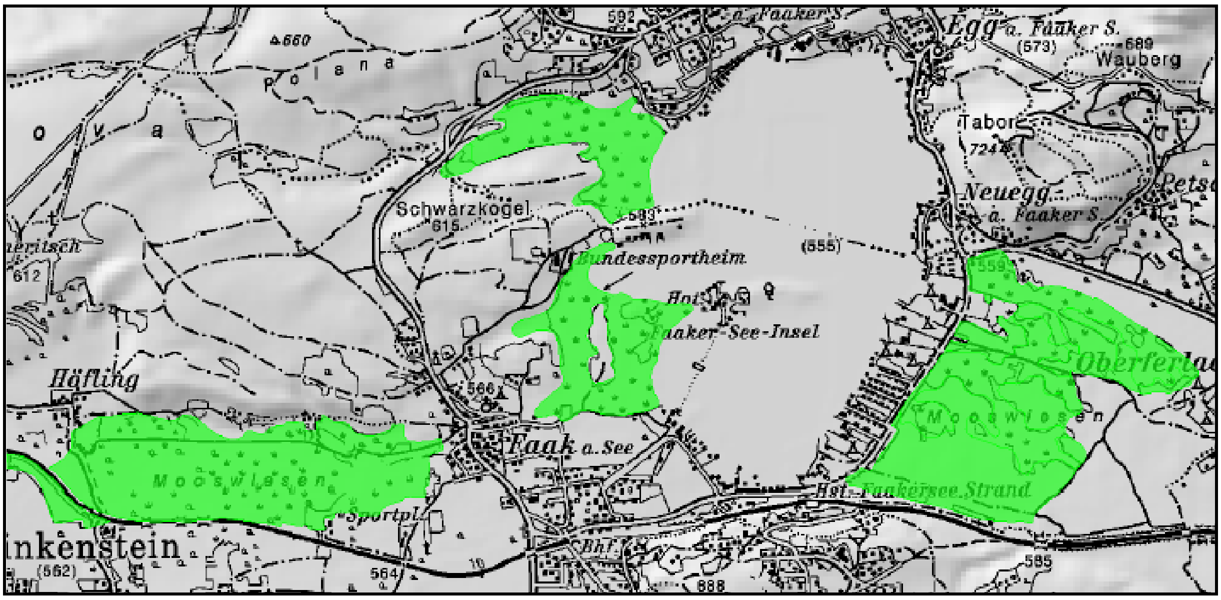

Figure 10: Sensible areas (KAGIS, 2005)

APPENDIX C: KEUTSCHACHER SEE – MAPS

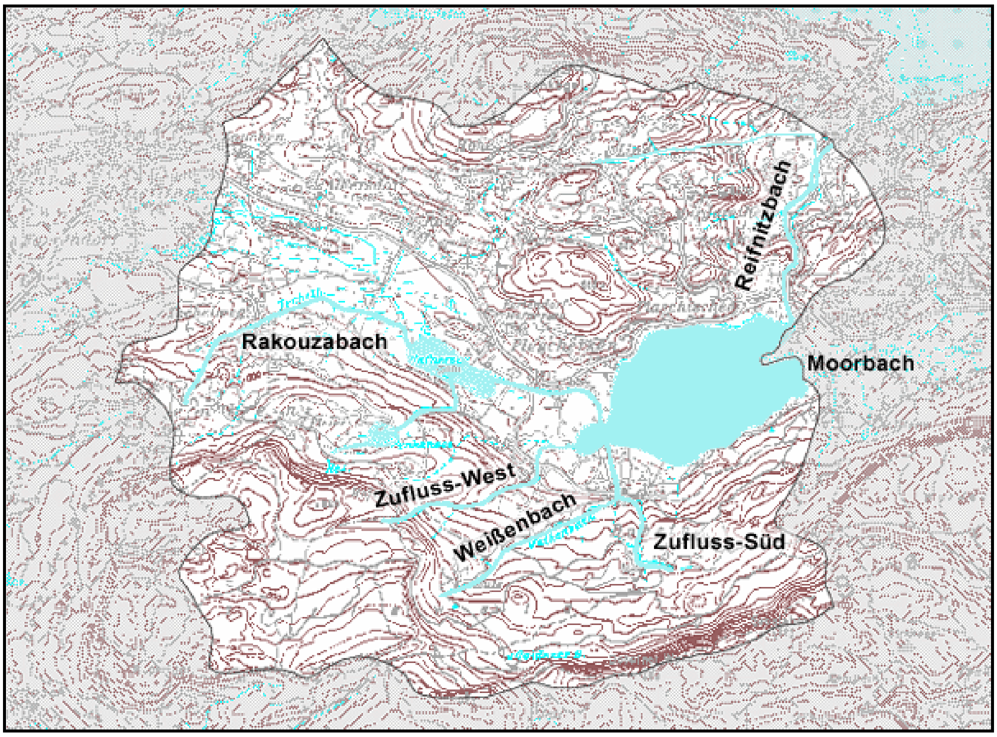

Figure 1: Influents and effluent (KIS, 2005)

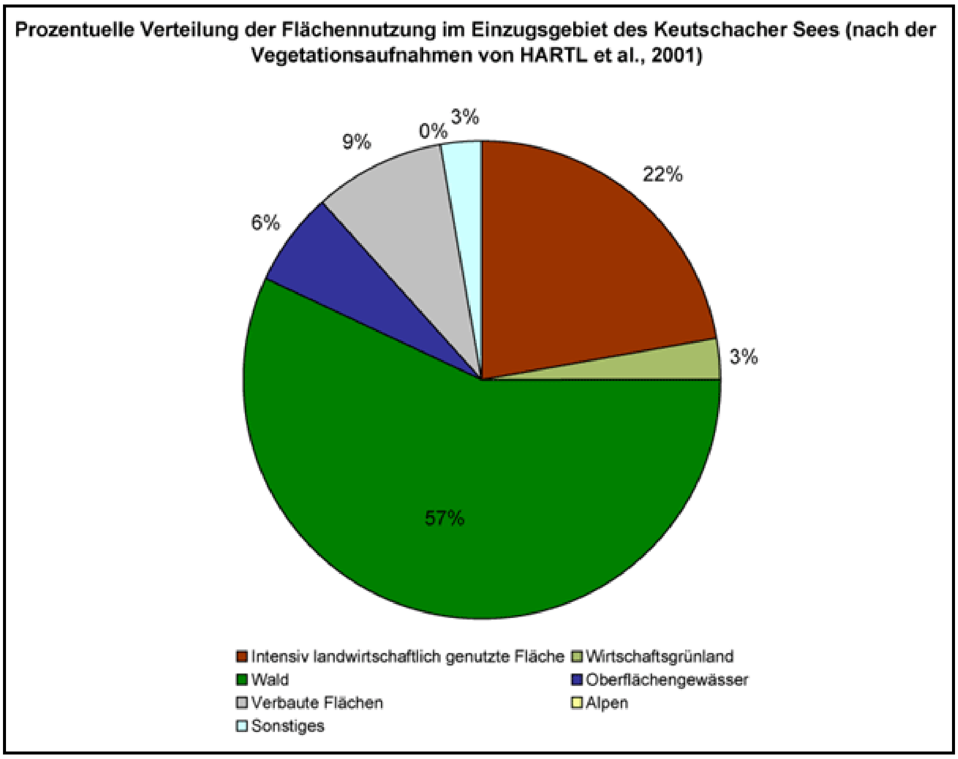

Figure 2: Land use in the watershed (Hartl et al, 2001)

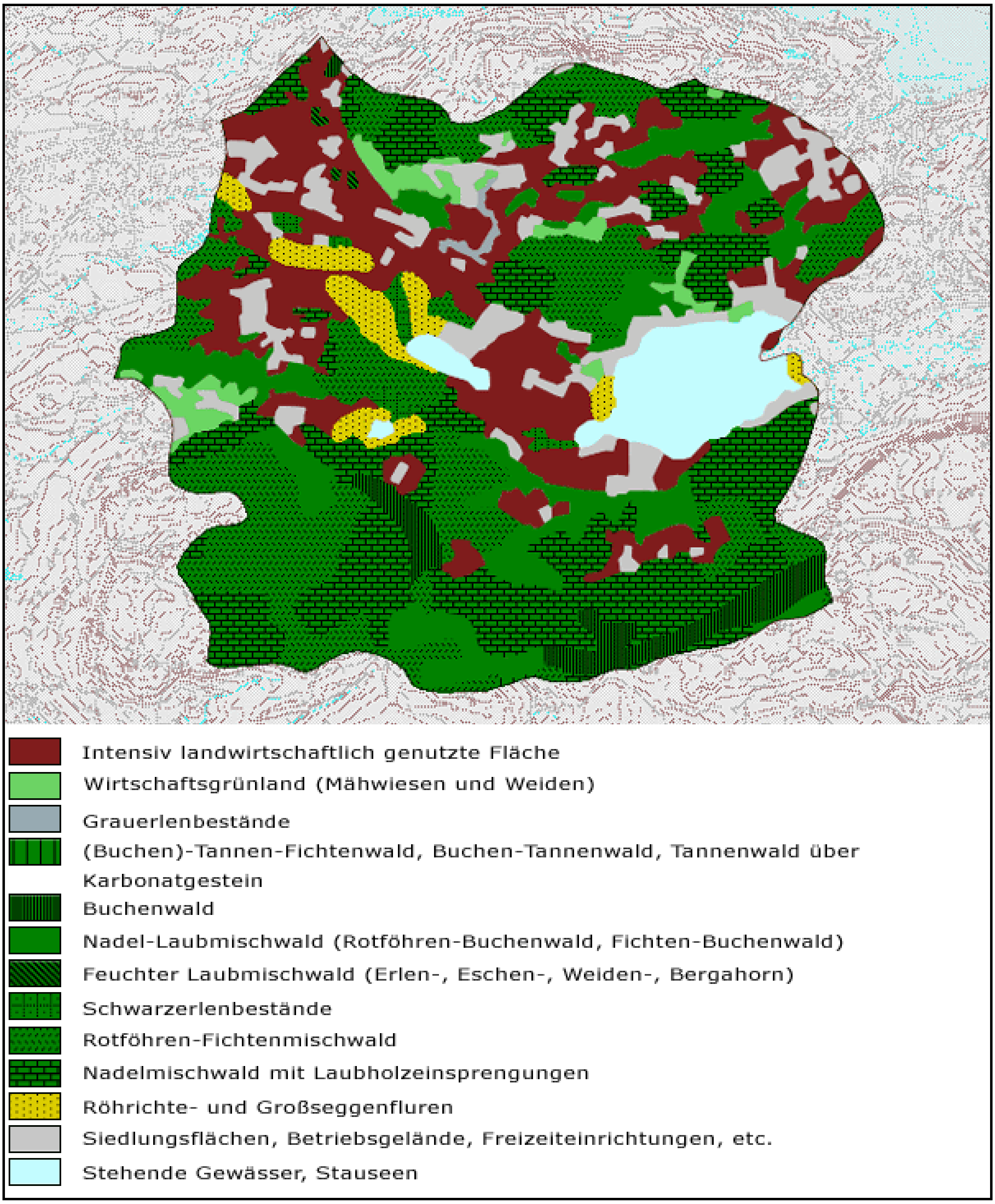

Figure 3: Vegetation in the watershed (Hartl et al, 2001)

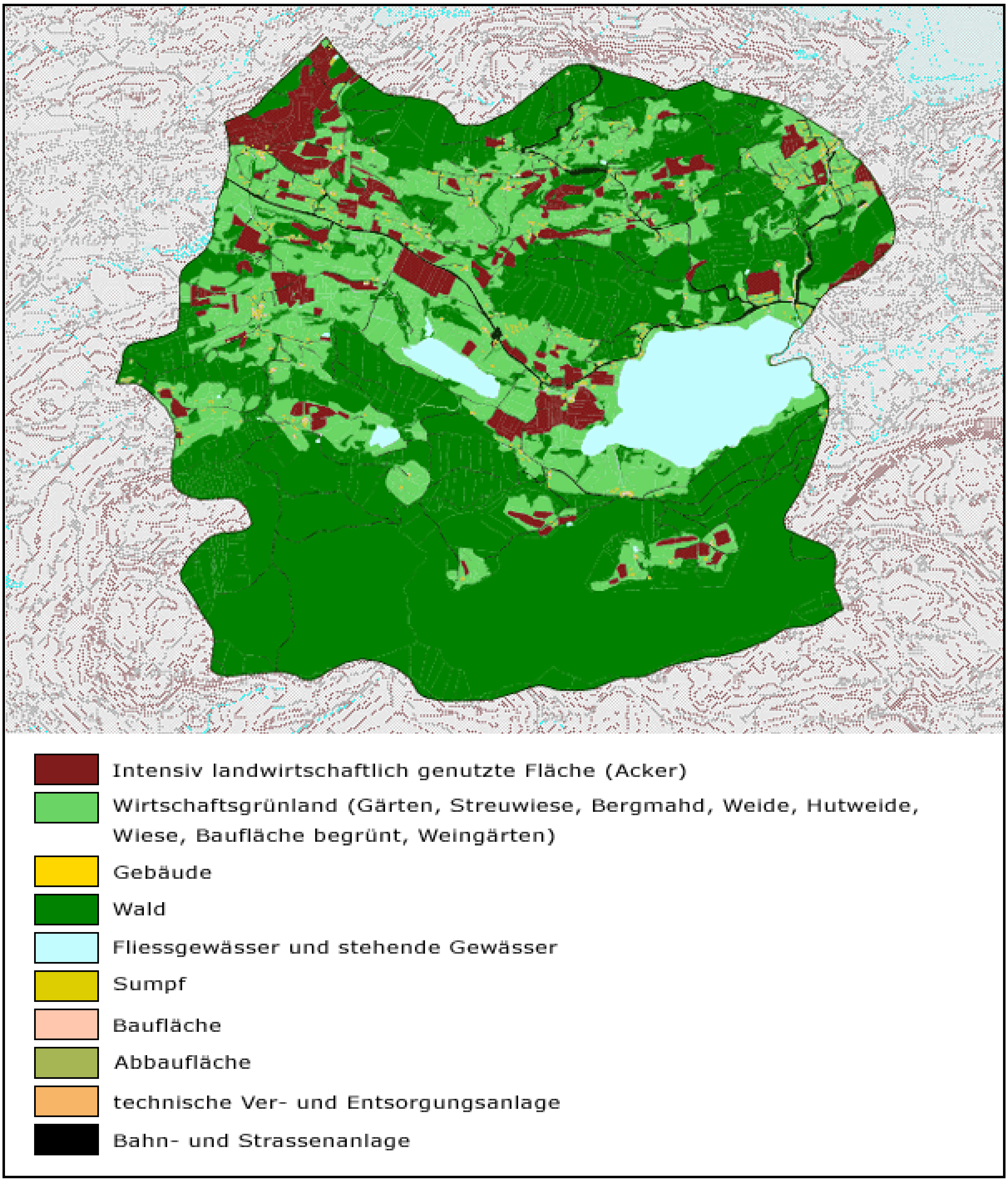

Figure 4: Land use in the watershed according to the digital cadastre (KIS, 2005)

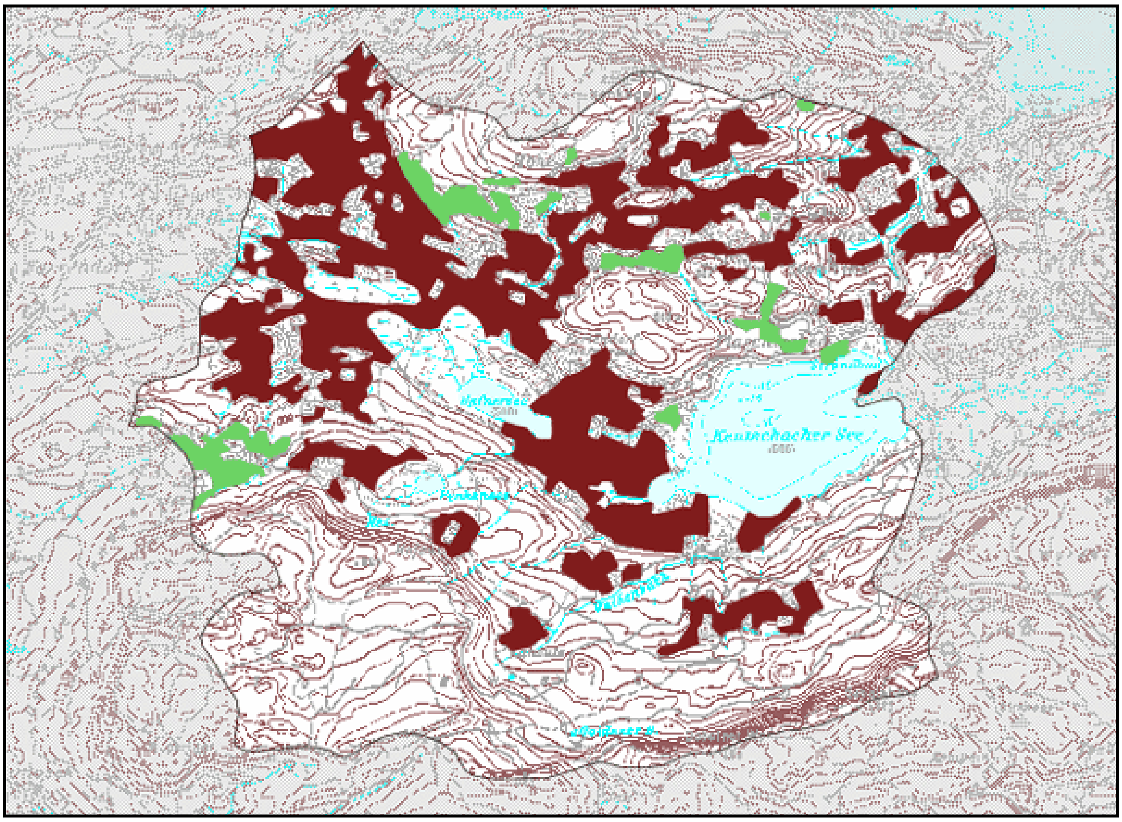

Figure 5: Intensive agriculture areas (red) and economic use (green) (Hartl et al, 2001)

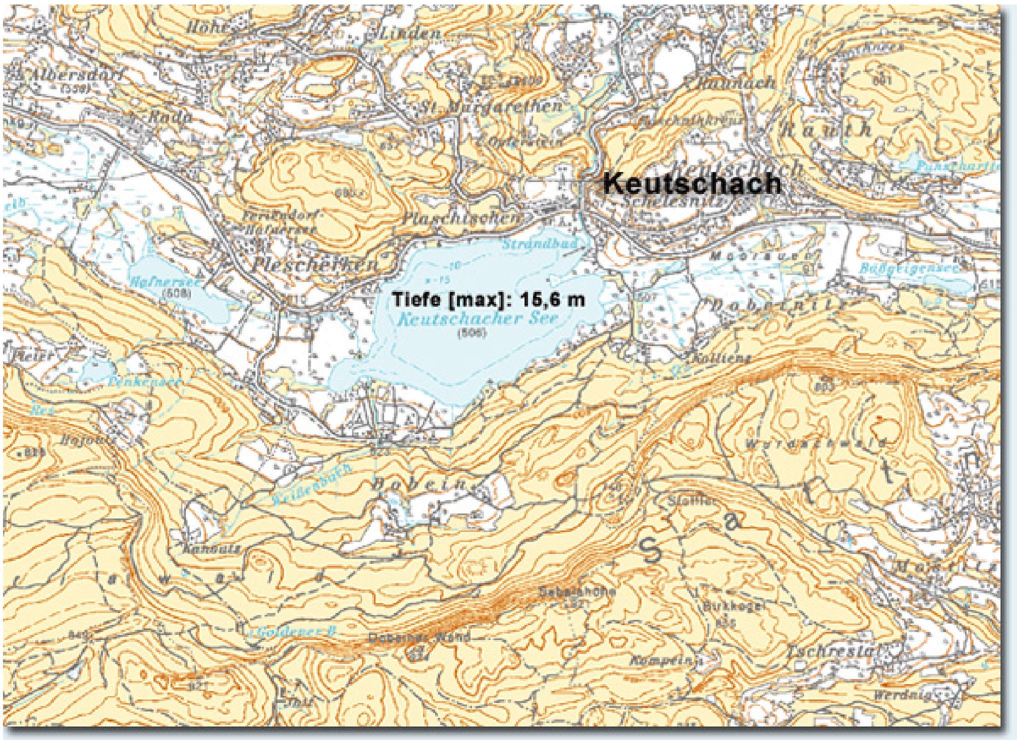

Figure 6: Morphology – the depth structure (KIS, 2005)

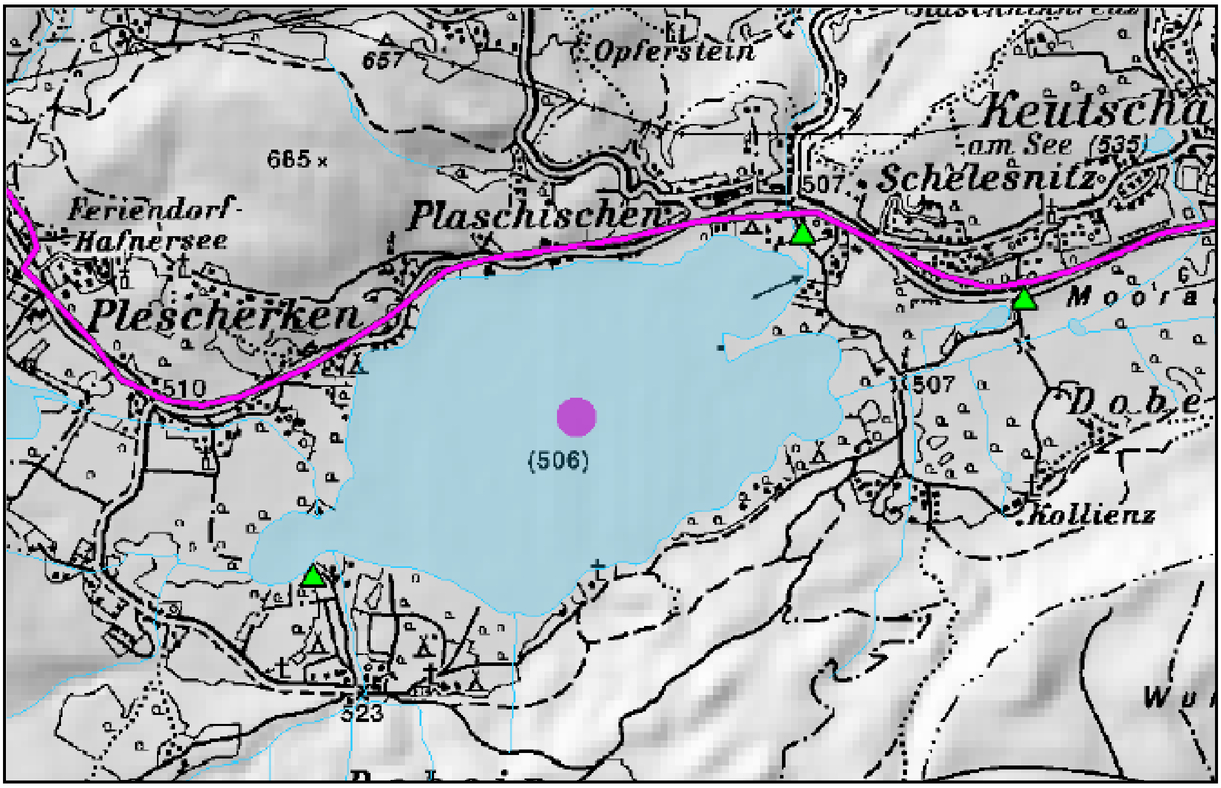

Figure 7: Urban drainage system with pumping stations (KAGIS, 2005)

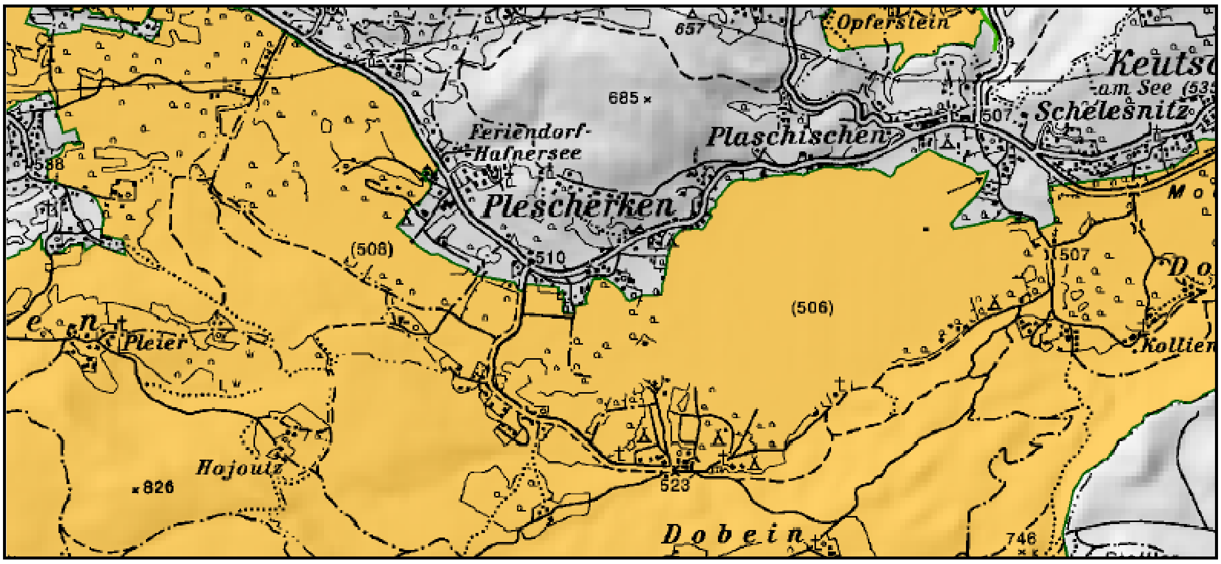

Figure 8: Areas protected with the land protection act (KAGIS, 2005)

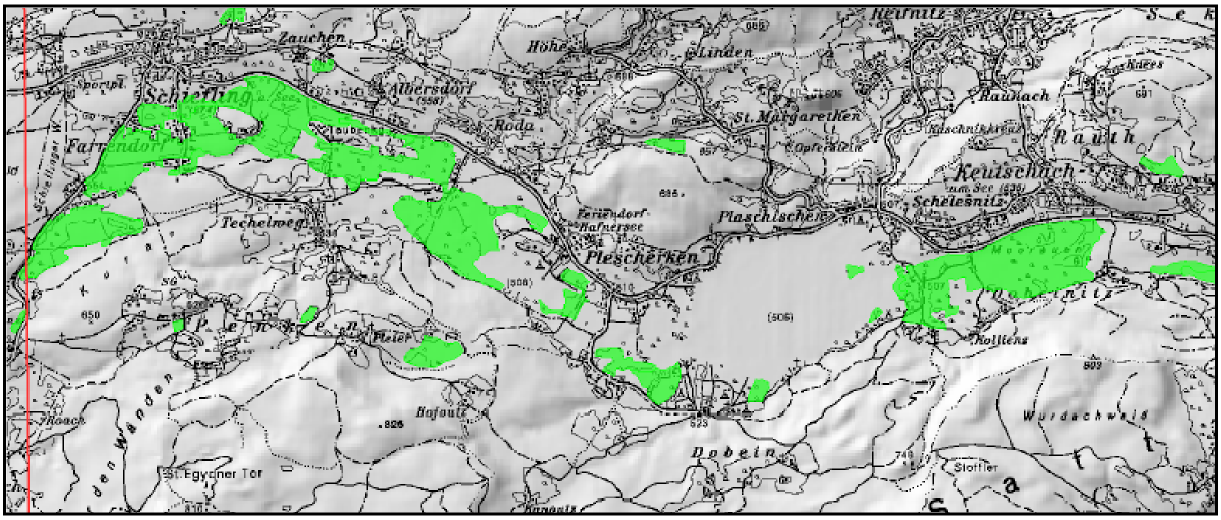

Figure 9: Sensible areas (KAGIS, 2005)

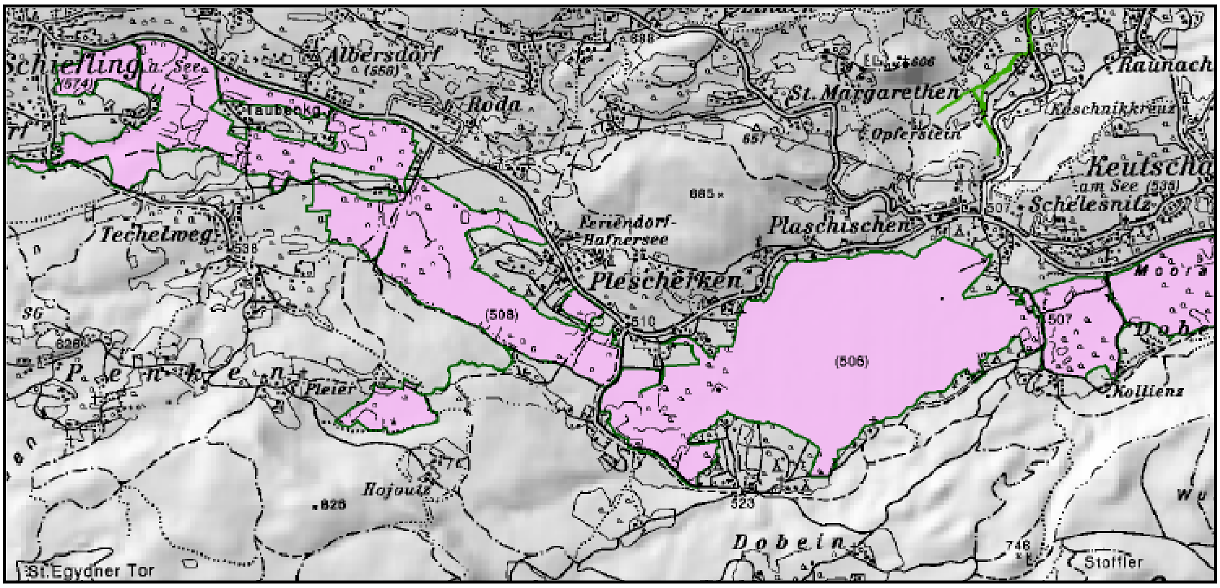

Figure 10: Areas protected with Ramsar Convention on wetlands (KAGIS, 2005)

APPENDIX D: KLOPEINER SEE – MAPS

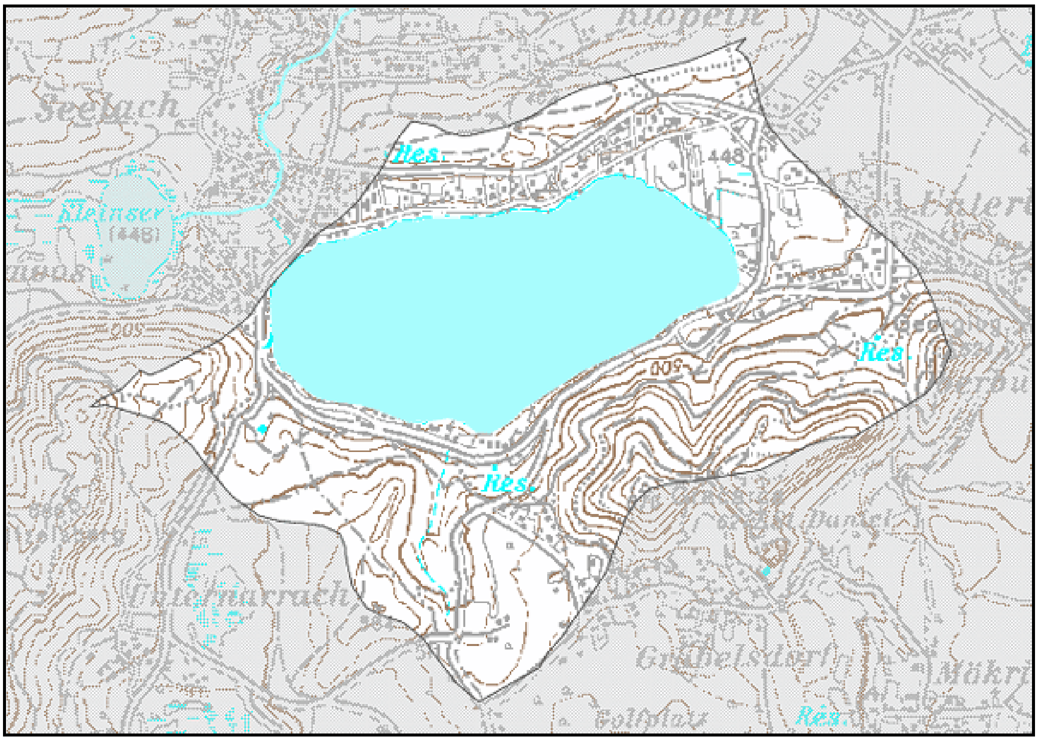

Figure 1: Influents and effluents (KIS, 2005)

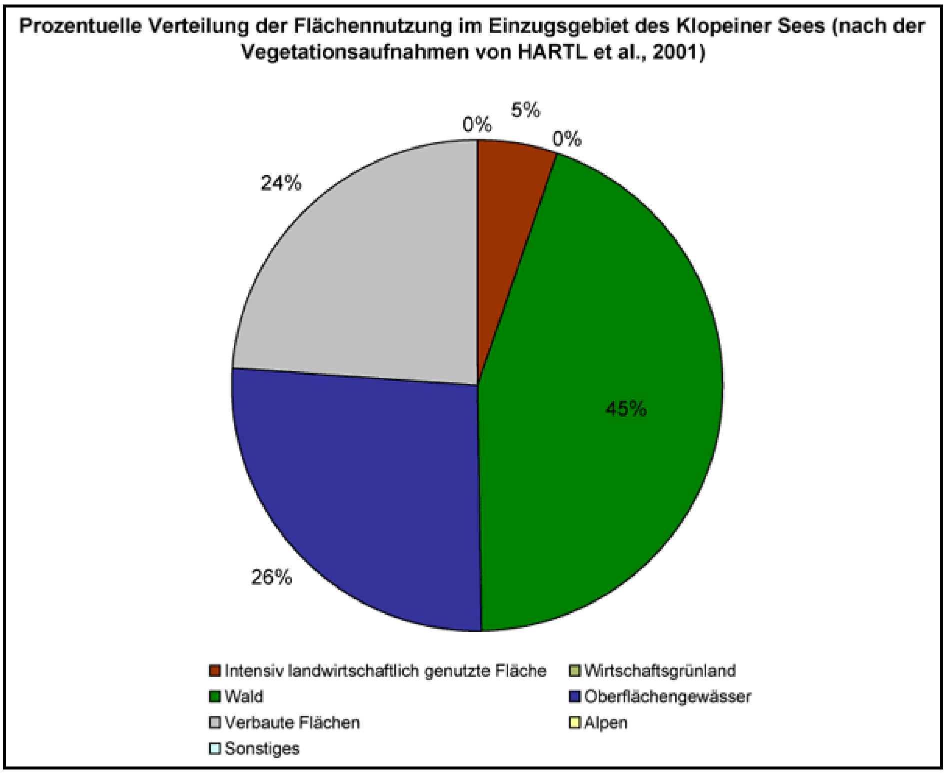

Figure 2: Land use in the watershed (Hartl et al, 2001)

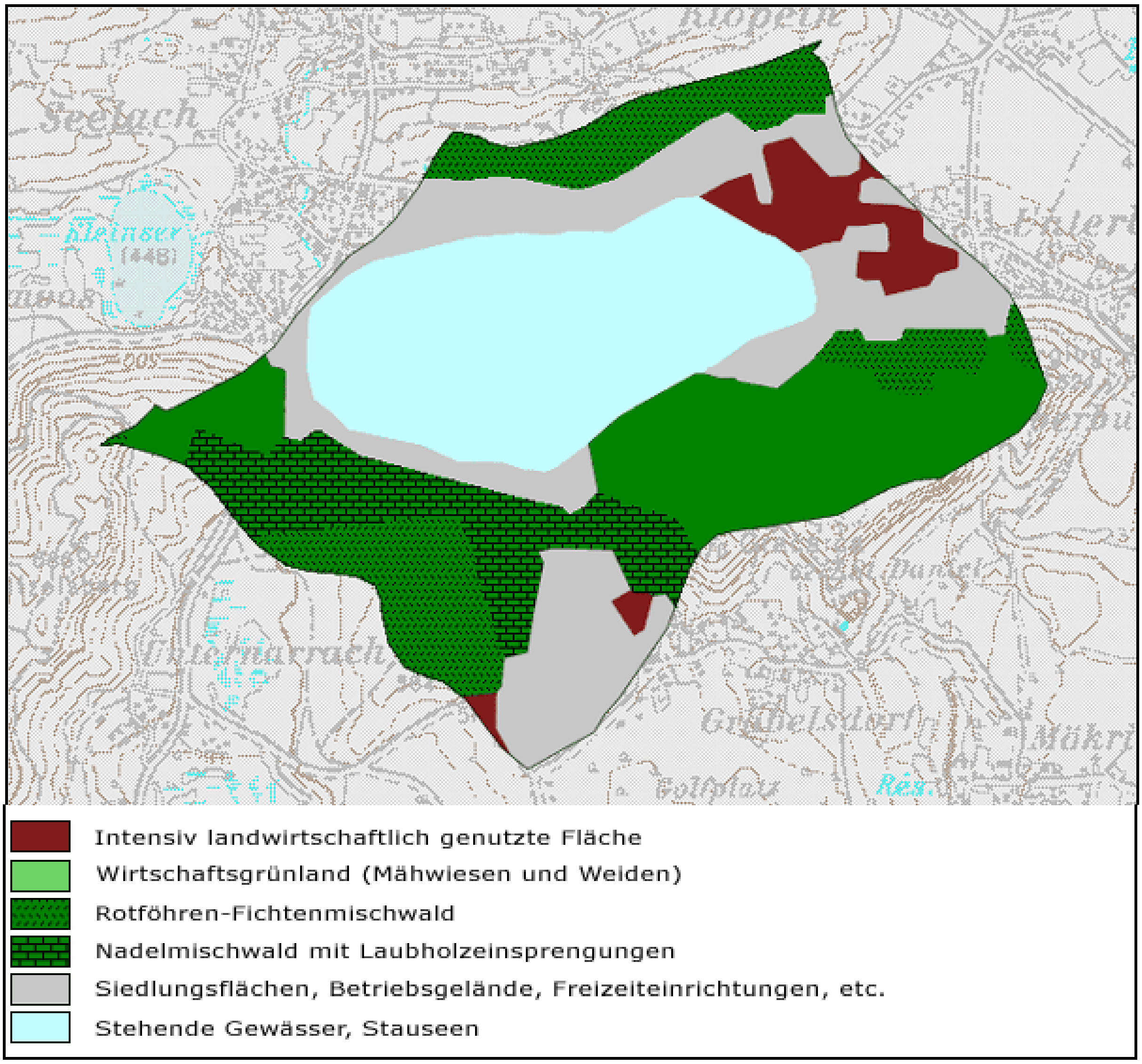

Figure 3: Vegetation in the watershed (Hartl et al, 2001)

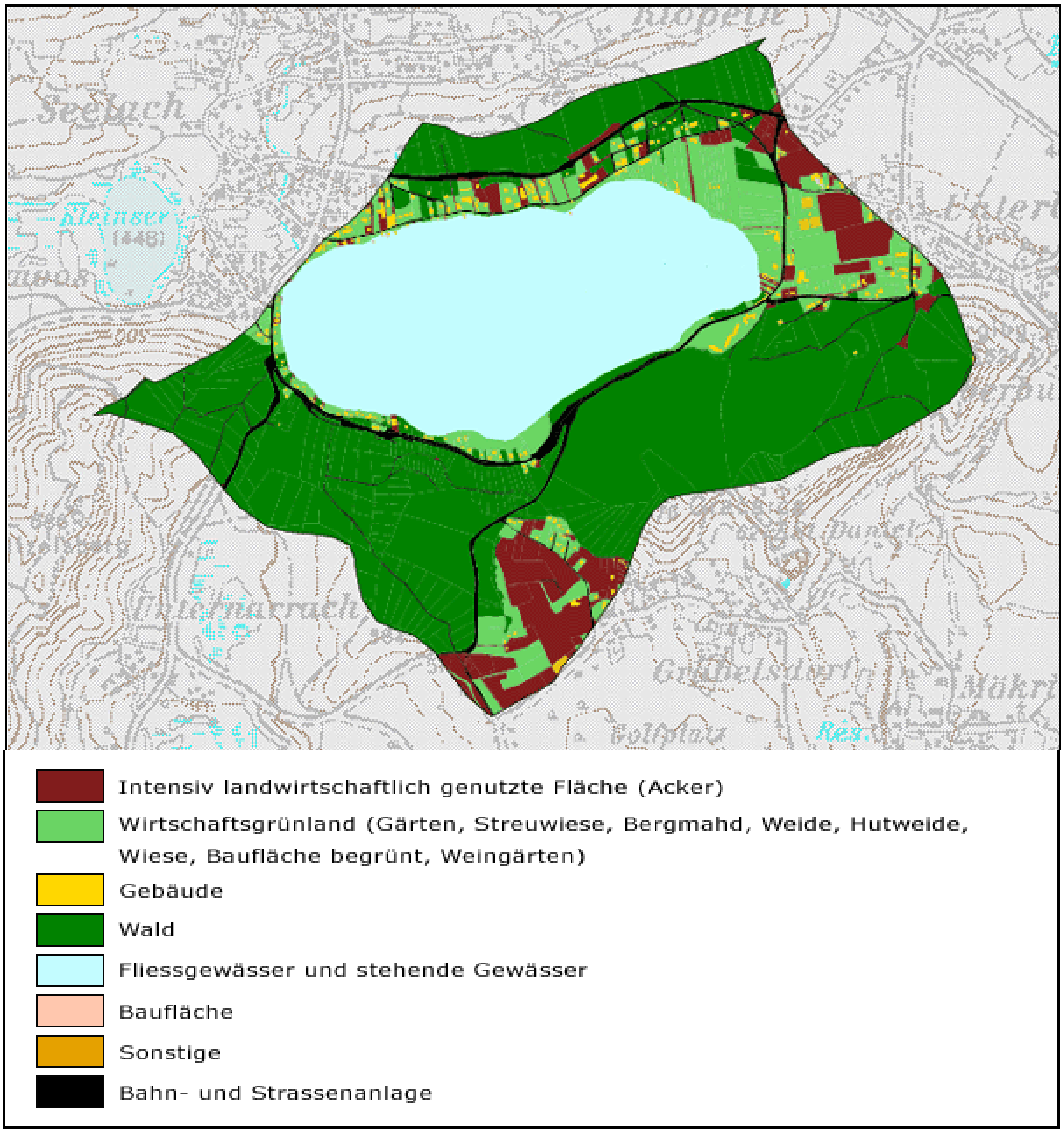

Figure 4: Land use in the watershed according to the digital cadastre (KIS, 2005)

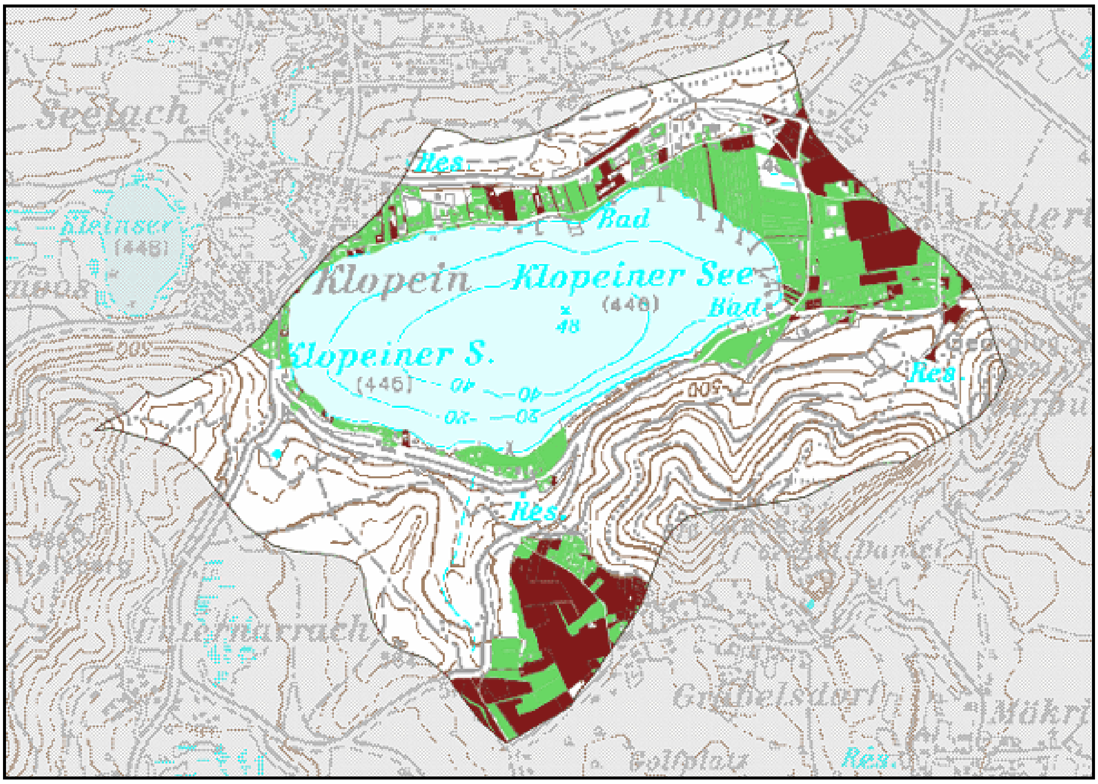

Figure 5: Intensive agriculture areas (red) and economic use (green) (Hartl et al, 2001)

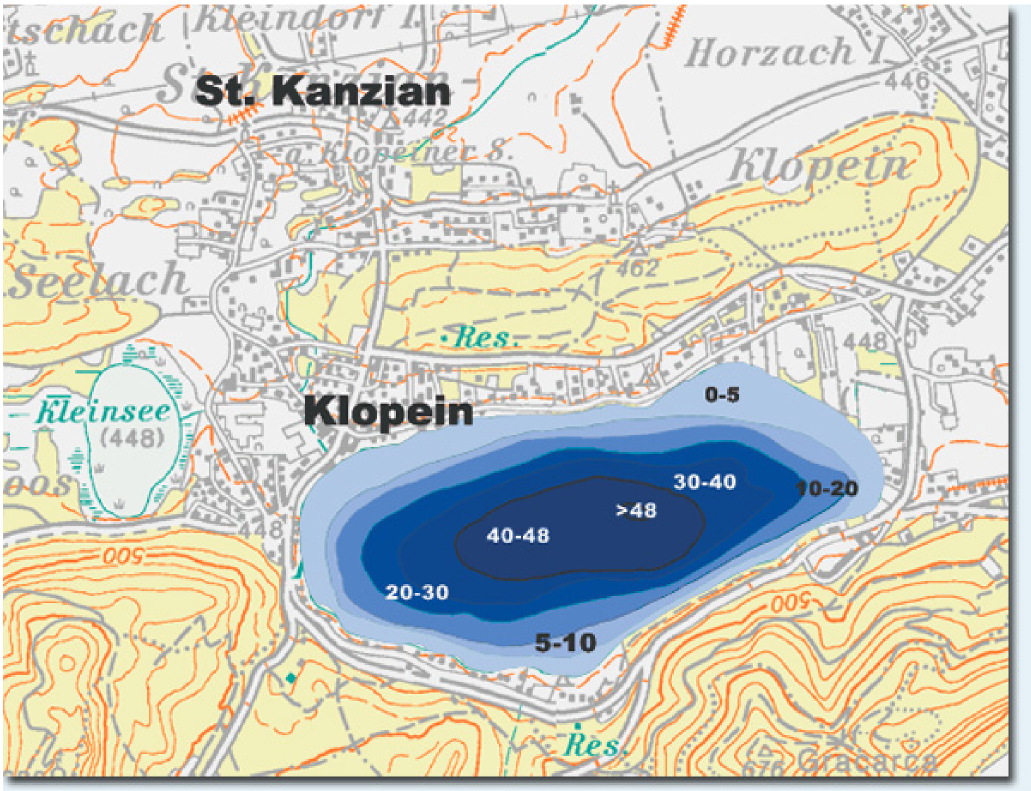

Figure 6: Morphology – depth structure (KIS, 2005)

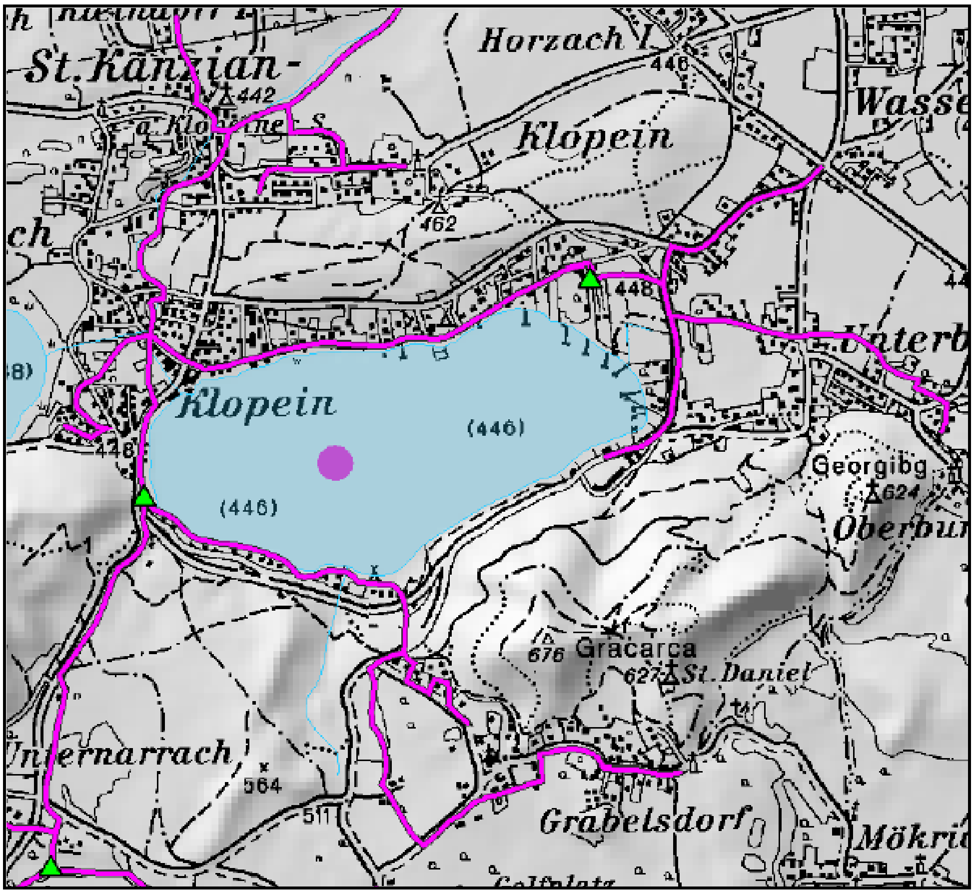

Figure 7: Urban drainage system with pumping stations (KAGIS, 2005)

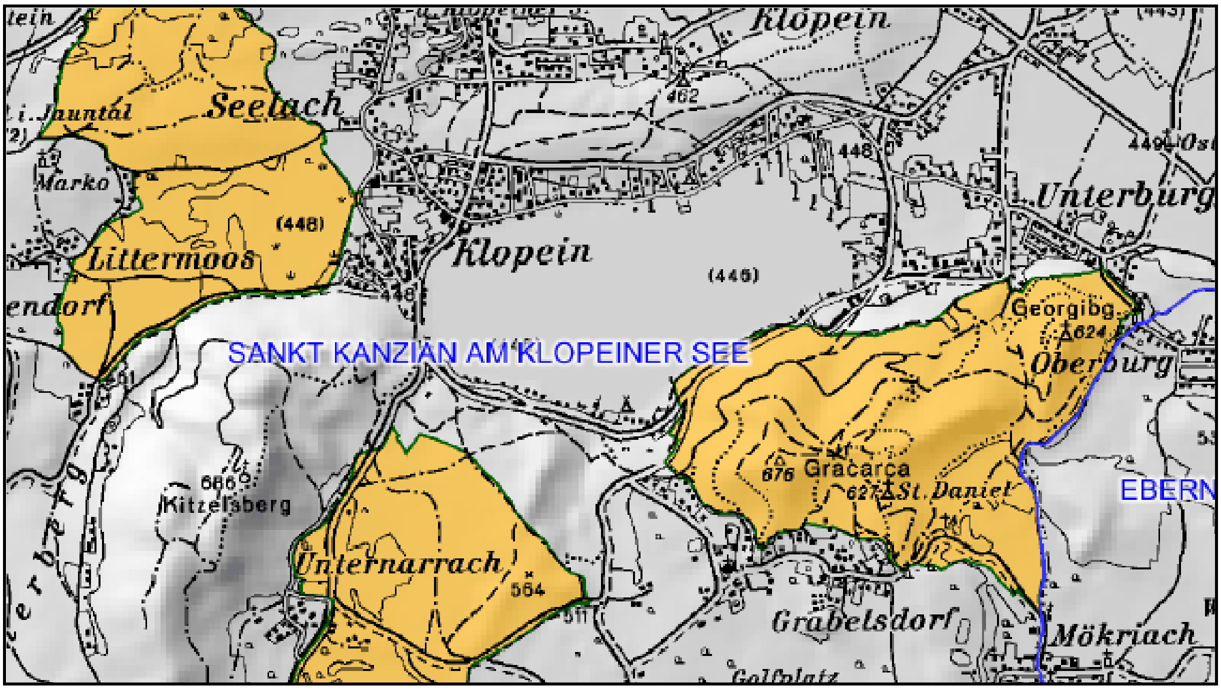

Figure 8: Areas protected with the land protection act (KAGIS, 2005)

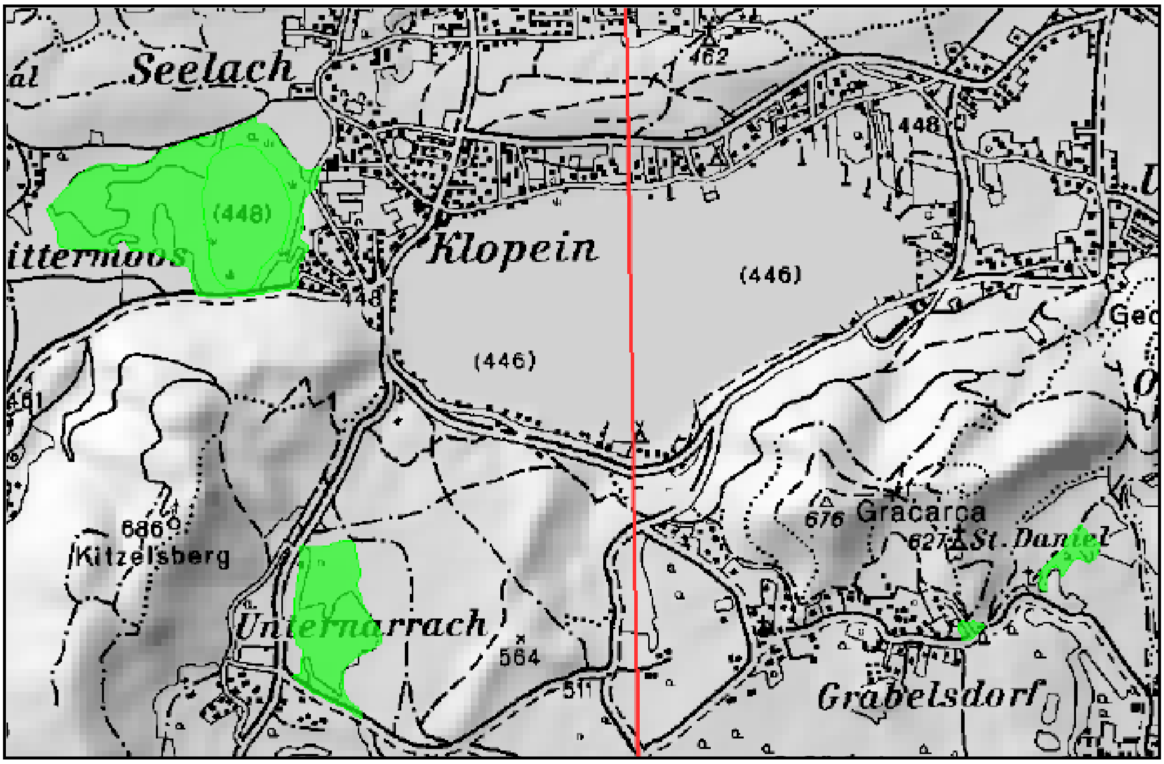

Figure 9: Sensible areas (KAGIS, 2005)

APPENDIX E: RESULTS OF MONITORING IN FAAKER SEE, KEUTSCHACHER SEE AND KLOPEINER SEE

Table 1: Faaker See (KIS, 2004)

FAAKER SEE		2001				2002				2003			
Parameter	Tiefe	n	Mittel	Min	Max	n	Mittel	Min	Max	3	Mittel	Min	Max
Sichttiefe (m)		4	5,5	4,0	6,3	3	4,9	3,5	7,0	4	5,0	1,2	9,2
Temperatur (°C)	0 m	4		5,0	23,3	4		6,9	21,7	4		6,5	20,0
pH-Wert	1 m	4	8,0	7,5	8,3	4	8,3	8,1	8,4	4	8,2	8,0	8,4
Leitfähigkeit (µS/cm)	1 m	4	372	344	400	4	354	323	379	4	351	327	366
Gesamtphosphor (µg/l)	0 - 6 m	4	< 5	< 5	9	4	< 5	< 5	5	4	6	< 5	8
Gesamtphosphor (µg/l)	29 m	4	7	< 5	12	4	7	< 5	15	4	9	< 5	13
Gesamtphosphor (µg/l) gewichtet	0 - 29 m	4	6	< 5	8	4	6	< 5	7	4	6	< 5	8
Orthophosphat-Phosphor (µg/l)	0 - 6 m	4	< 2	< 2	< 2	4	< 2	< 2	< 2	4	< 2	< 2	< 2
Nitrat-Stickstoff (µg/l)	0 - 6 m	4	244	189	301	4	151	105	184	4	188	125	230
Ammonium-Stickstoff (µg/l)	29 m	4	83	25	235	4	131	33	244	4	96	43	164
Sauerstoff (mg/l)	29 m	4		2,4	14,6	4		0,0	11,0	4		0,6	8,7
Phytoplankton (mg/m³)	0 - 6 m	4	359	232	608	4	409	357	462	4	382	77	826
Chlorophyll a (µg/l)	0 - 6 m					4	1,1	0,2	2,0	3	0,4*	0,1*	0,6*
Phytoplankton (g/m²)	0 - 29 m	4	9,5	6,1	12,6	4	10,9	7,1	14,7	4	14,8	1,2	21,9
Chlorophyll a (µg/l)	0 - 29 m					4	1,2	0,8	1,4	3	0,7*	0,6*	0,8*

Die mit * gekennzeichneten Chlorophyll-a-Werte wurden mittels Fluoreszenzsonde ermittelt.

Table 2: Keutschacher See (KIS, 2004)

KEUTSCHACHER SEE		2001				2002				2003			
Parameter	Tiefe	n	Mittel	Min	Max	n	Mittel	Min	Max	n	Mittel	Min	Max
Sichttiefe (m)		4	4,0	2,8	6,4	4	3,7	1,6	5,0	5	4,1	1,8	5,8
Temperatur (°C)	0 m	4		5,4	25,3	4		8,0	23,1	5		6,4	25,4
pH-Wert	1 m	4	8,0	7,8	8,3	4	8,2	8,0	8,6	5	8,1	7,7	8,3
Leitfähigkeit (µS/cm)	1 m	4	314	293	335	4	314	291	330	5	299	282	321
Gesamtphosphor (µg/l)	0 - 6 m	4	7	5	9	4	8	7	8	5	7	6	9
Gesamtphosphor (µg/l)	15 m	4	15	6	28	4	22	16	33	5	22	8	45
Orthophosphat-Phosphor (µg/l)	0 - 6 m	4	< 2	< 2	< 2	4	< 2	< 2	< 2	5	< 2	< 2	< 2
Nitrat-Stickstoff (µg/l)	0 - 6 m	4	175	42	273	4	53	21	98	5	137	106	153
Ammonium-Stickstoff (µg/l)	15 m	4	421	196	970	4	793	350	1240	5	536	221	1090
Sauerstoff (mg/l)	15 m	4		0,0	10,0	4		0,0	3,9	5		0,0	4,0
Phytoplankton (mg/m³)	0 - 6 m	4	363	239	506	4	634	322	963	4	439	183	1060
Chlorophyll a (µg/l)	0 - 6 m					4	3,2	< 1,71	7,9	3	1,4*	0,6*	2,1*
Phytoplankton (g/m²)	0 - 15 m	4	10,5	3,2	20,6	4	17,5	3,9	39,3	4	8,4	2,5	11,6
Chlorophyll a (µg/l)	0 - 15 m					4	3,1	1,1	4,4	3	3,8*	1,7*	5,9*

Die mit * gekennzeichneten Chlorophyll-a-Werte wurden mittels Fluoreszenzsonde ermittelt.

Table 3: Klopeiner See (KIS, 2004)

KLOPEINER SEE		2001				2002				2003			
Parameter	Tiefe	n	Mittel	Min	Max	n	Mittel	Min	Max	n	Mittel	Min	Max
Sichttiefe (m)		13	6,1	3,5	11,5	4	9,2	5,0	15,0	3	7,9	6,0	11,5
Temperatur (°C)	0 m	14		3,7	24,6	4		4,6	23,0	4		6,1	25,1
pH-Wert	1 m	14	8,3	7,7	8,6	4	8,3	8,0	8,4	4	8,2	7,7	8,4
Leitfähigkeit (µS/cm)	1 m	14	256	242	275	4	255	235	284	4	240	226	252
Gesamtphosphor (µg/l)	0 - 6 m	12	9	6	11	4	7	6	9	4	8	6	10
Gesamtphosphor (µg/l)	30 m	12	55	20	71	4	47	31	71	4	59	42	76
Gesamtphosphor (µg/l) gewichtet	0 - 30 m	12	17	8	27	4	15	10	22	4	17	13	22
Orthophosphat-Phosphor (µg/l)	0 - 6 m	13	< 2	< 2	< 2	4	< 2	< 2	< 2	4	< 2	< 2	< 2
Nitrat-Stickstoff (µg/l)	0 - 6 m	12	28	< 10	68	4	20	< 11	52	8	31	< 11	81
Ammonium-Stickstoff (µg/l)	30 m	13	969	109	1210	4	1050	720	1260	4	948	690	1150
Sauerstoff (mg/l)	30 m	14		0,0	1,0	4		0,0	0,0	4		0,0	0,0
Phytoplankton (mg/m^3)	0 - 6 m	4	396	195	797	4	224	85	316	4	585	273	841
Chlorophyll a (µg/l)	0 - 6 m	8	1,8	0,9	2,7	4	1,8	1,0	2,5	4	0,5*	0,1*	0,9*
Phytoplankton (g/m^2)	0 - 20 m	4	12,9	9,1	20,7	4	6,8	2,0	10,7	4	19,5	11,0	28,0
Chlorophyll a (µg/l)	0 - 20 m	8	2,5	1,1	4,5	4	2,8	2,4	3,4	4	1,6*	0,4*	3,1*

Die mit * gekennzeichneten Chlorophyll-a-Werte wurden mittels Fluoreszenzsonde ermittelt.

APPENDIX F: TRANSLATION OF WORDS USED IN APPENDICES B, C, D and E

German	English	Slovenian
Intensiv landwirtschaftlich genutzte Fläche	Intensive agriculture areas	Kmetijske površine v intenzivni rabi
Wald	Forest	Gozd
Wirtschaftsgrünland	Open spaces - economic use	Zelene površine - ekonomska raba
Verbaute Flächen	Building areas	Pozidane površine
Alpen	Alps	Alpe
Oberflächengewässer	Surface waters	Površinske vode
Sonstiges	Various	Razno

Subalpine u. alpine Rasen	Sub-alpine and alpine pastures	Subalpski in alpski travniki
Extensiv Weiden	Extensive pastures	Ekstenzivni travniki
Weidenbestände	Pastures	Travniki
Karbonatgestein	Carbonate stone	Karbonatne kamnine
Silikatgestein	Silicate stone	Silikatne kamnine
Grauerlenbestände	Grey alder areas	Območja sive jelše
Schwarzerlenbestande	Black alder areas	Območja črne jelše
Latschenkrummholz	Dwarf pine	Ruševje
Fichtenwald	Pine forest	Smrekov gozd
Lärchenwald	Larch forest	Macesnov gozd
Buchenwald	Beech forest	Bukov gozd
Tannenwald	Fir forest	Gozd jelke
Rotföhrenwald	Red pine forest	Borov gozd
Mischwald	Mixed forest	Mešan gozd
Nadelwald	Conifer forest	Iglasti gozd
Laubwald	Deciduous forest	Listnati gozd
Röhrichte	Reeds	Trsje
Neidermoor, sumpf	Wetlands, shallow lakes	Močvirja
Groβseggenfluren	Bent grass	Šaš
Pioniervegetation auf Schutt und Fels	Gravel and cliff	Grušč in skala
Siedlungsflachen	Settlements	Naselja
Stehende Gewässer, Stauseen	Stagnant waters, lakes	Stoječe vode, jezera
Fliessgewässer	Running waters	Tekoče vode
Verkehrsflächen	Transport, traffic areas	Prometne površine
Wintersportgelände	Winter sports areas	Površine za zimske športe
Feucht	Moisture	Vlaga

Acker	Field	Njiva
Gebäude	Building	Zgradba
Baufläche	Building land	Gradbeno zemljišče

Abbauflache	Mining area	Kop
Bahn	Railroad	Železnica
Strassen Anlage	Road body	Cestno telo
Lagerplatz	Warehouse	Skladišče
Werkgelände	Manufacturing areas	Tovarniške površine
Brach land, Ödland	Uncultivated land, follow	Neobdelana zemlja, ledina
Ver- und Entsorgungsanlage	Supply and disposal areas	Oskrbne in odlagalne površine

Sichttiefe	Light penetration, transparency	Prosojnost
Temperatur	Temperature	Temperatura
pH-Wert	pH-Value	pH vrednost
Leitfähigkeit	Conductivity	Prevodnost
Gesamtphosphor	Total phosphorous	Celokupni fosfor (P)
Orthophosphat - Phosphor	Orthophosphate - Phosphorous	Ortofosfat – fosfor (PO_3-P)
Nitrat - Stickstoff	Nitrate - Nitrogen	Nitratni dušik (NO_3-N)
Ammonium - Stickstoff	Ammonium - Nitrogen	Amonijev dušik (NH_4-N)
Sauerstoff	Oxygen	Kisik
Phytoplankton	Phytoplankton	Fitoplankton
Chlorophyll	Chlorophyll	Klorofil