WP 7.2 Pilot Case Study Monograph

HP Kirchbichl River Inn

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Summary

SHORT DESCRIPTION
This document intends to describe the basin characteristic of the river Inn and especial the pilot study area.

Document Control

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1. Table of contents

2. Introduction

The Inn is the largest alpine river in the international river basin district of the Danube River. In Tyrol, Austria, it is a mountain river with glacial impact, which typically shows low discharge during winter and a distinct flow peak in summer. However, the natural flowing regime is disturbed due to the impact of several hydropower plants (HP) all along its range.

The significant meander (app. 3.5 km length) between Wörgl and Oberlangkampfen is the SHARE pilot study area of PP7, where heavy effects of the diversion-type HP plant Kirchbichl on the ecological integrity are obvious. The HP plant near Kirchbichl is one of the biggest diversion-type HP in Tyrol. The total water discharge between October and May is used for the operation of the hydropower plant. Because there´s no water dotation set up for the meander it is subjected to draught from autumn till spring and to a high variability in the discharge in the summer months due to hydro-peaking or floods. The lack of water discharge has several negative ecological impacts. For the implementation of the WFD and in order to reach (maintain) the status of a “good ecological potential” for heavily modified water bodies, several pilot investigations are planned.

3. Basin characteristics

The river Inn originates from Lake Lunghino (2.484 m) at the Maloja pass located in the Swiss Bergell region and flows through Switzerland, Austria and Germany where it enters the Danube after 510 km at Passau. The Inn’s whole catchment area accounts for 26.000 km² and is influenced by many glaciers. The highest point of its drainage is Piz Bernina at 4049 m. It is the third largest tributary of the whole Danube by water discharge and the largest within Central Europe´s tributaries. Occasionally it carries even more water than the river Danube. The Inn on his part collects the rivers Ötztaler Ache, Sill, Ziller, Alz and Salzach, its largest tributary, coming from right, and the rivers Sanna, Mangfall, Attel and Rott coming from left.

From its source in upper and lower Engadin it crosses north-eastwards the Austrian border through the canyon at Finstermünz. In Tyrol the Inn river basin is embedded between the Tyrolese ´Limestone Alps´ in the north and the Central Alps in the south. From Innsbruck on the lower Inn valley runs more diagonal to the main chain of the Alps until Kufstein (figure 1). The next kilometers the Inn forms the natural border to Germany while crossing the Kaisergebirge northwards and entering the Bavarian plateau. It runs northwards through Rosenheim and Wasserburg and makes a curve east again, passing Mühldorf, until the Salzach enters. From here it forms again the German-Austrian border and finally has its end into the Danube further north.

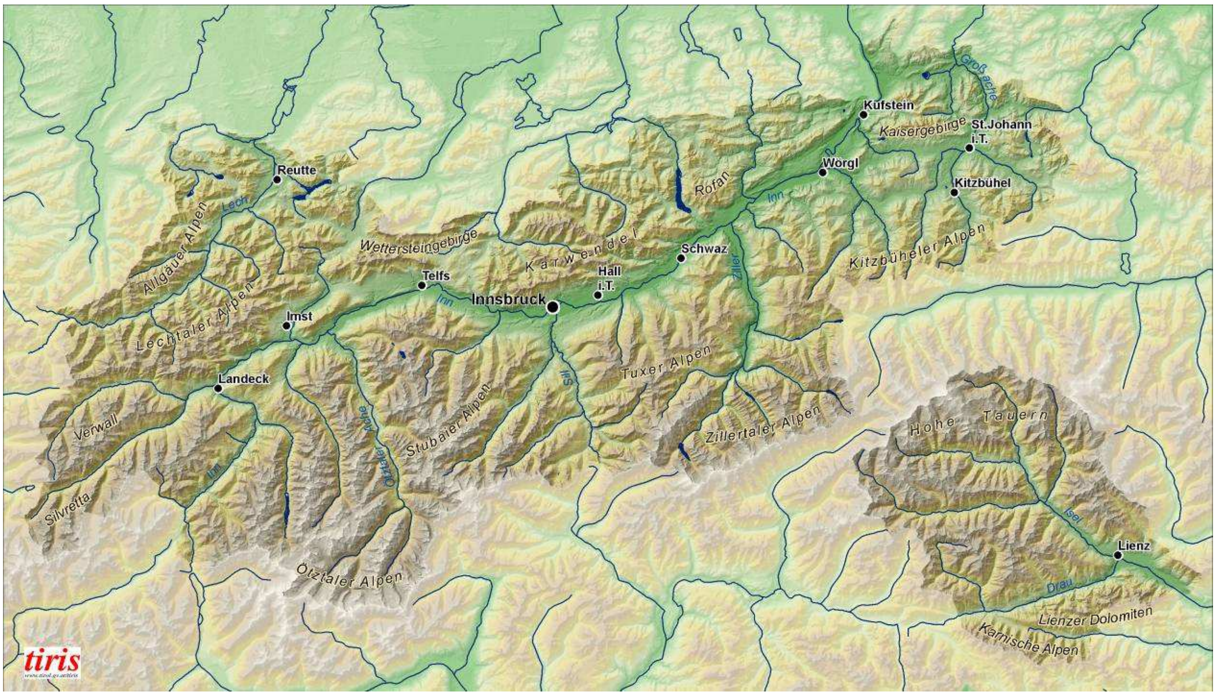

Figure 1: Map of Tyrol (North Tyrol and East Tyrol).

The slope of the river shows only variations in the upper Inn valley reaching from 11 ‰ to 2 ‰ due to the narrow and canyon like courses till Landeck. Downstream Telfs the slope decreases moderately from 2 ‰ to 1 ‰ at Kufstein (SPINDLER et al. 2002). The river morphology is characterized by heavy regulation measures. In urban areas the Inn is canalized and sheeted. Except of small courses in the upper Inn valley the river banks are far away from a natural status. Only a few remaining bands of alluvial forests and flood plains exist today on the river's shoreline, while most of the valley is covered by agricultural areas and urban settlements. Erosion from the Brixen valley into the Inn valley due to the retreat of the glacier created the significant meander at Kirchbichl (SPINDLER et al. 2002), which will be regarded in the pilot study.

4. Geolithological and land cover characterization

4.1Geolithological characterization

The geology of the project area is characterized by quaternary alluvial deposits in the lower part of the valley. The sedimentary rocks were built up by limestone and dolomite in the north and marl and sandstone in the southern part of the surrounding hills (SCHÖNLAUB & TENTSCHERT 1996). Figure 2 show the general map and an overview of the Tyrolean geological formations.

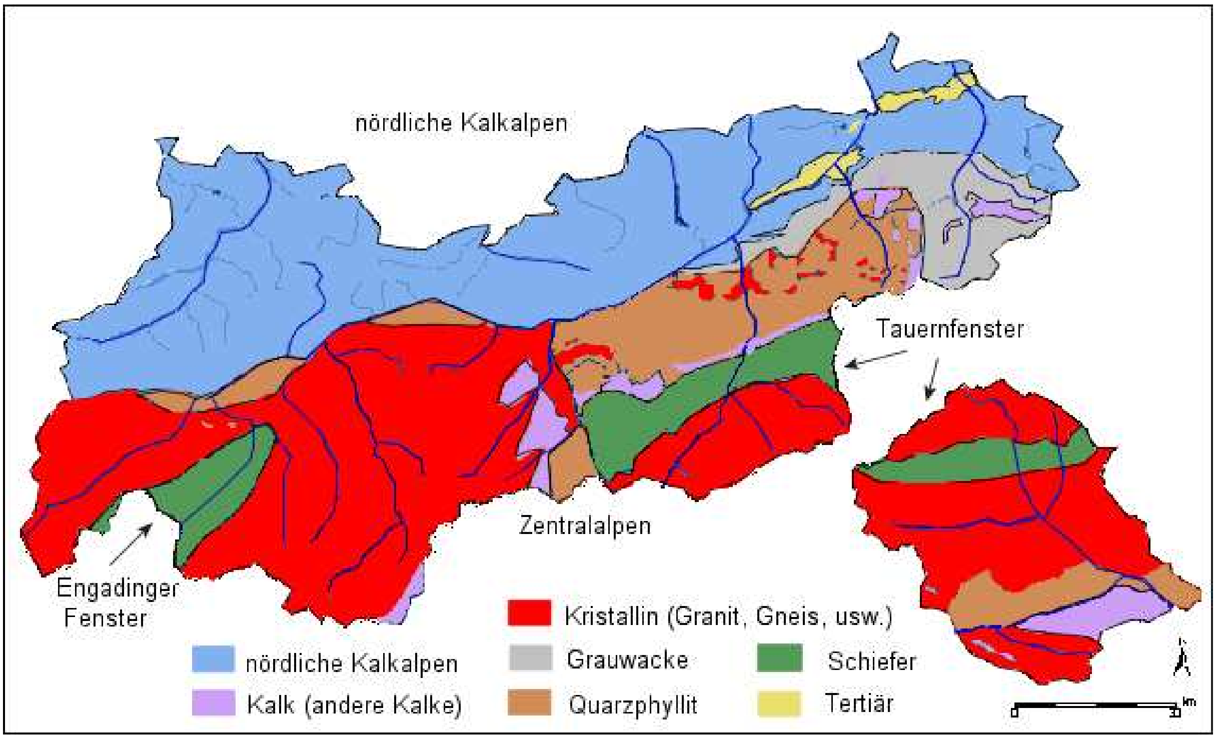

Figure 2: Map of the geology of the Tyrolean Alps. Description of the map: blue - northern limestone; violent - other limestone; red - crystalline (granite, gneiss); gray - greywacke; brown - quartz phyllite; green - schist; olive-green - tertiary sediment. Source: Tiris and wep page (www.tirolmultimedial.at/tmm/themen/0102.html).

Land cover characterization

Figure 3 and the table 1 show the land cover characteristic of North Tyrol. This map includes the river basin of the Inn River. The lower and middle altitudinal belts of North Tyrol are predominantly characterized by coniferous forest (4416 km², dark green) and mixed forest (1682 km², bright green). The high alpine areas are mainly characterized by natural grassland (2031 km²) and sparsely vegetated (1385 km²) areas together with bare rocks (1988 km²) and glaciated areas (335 km²).

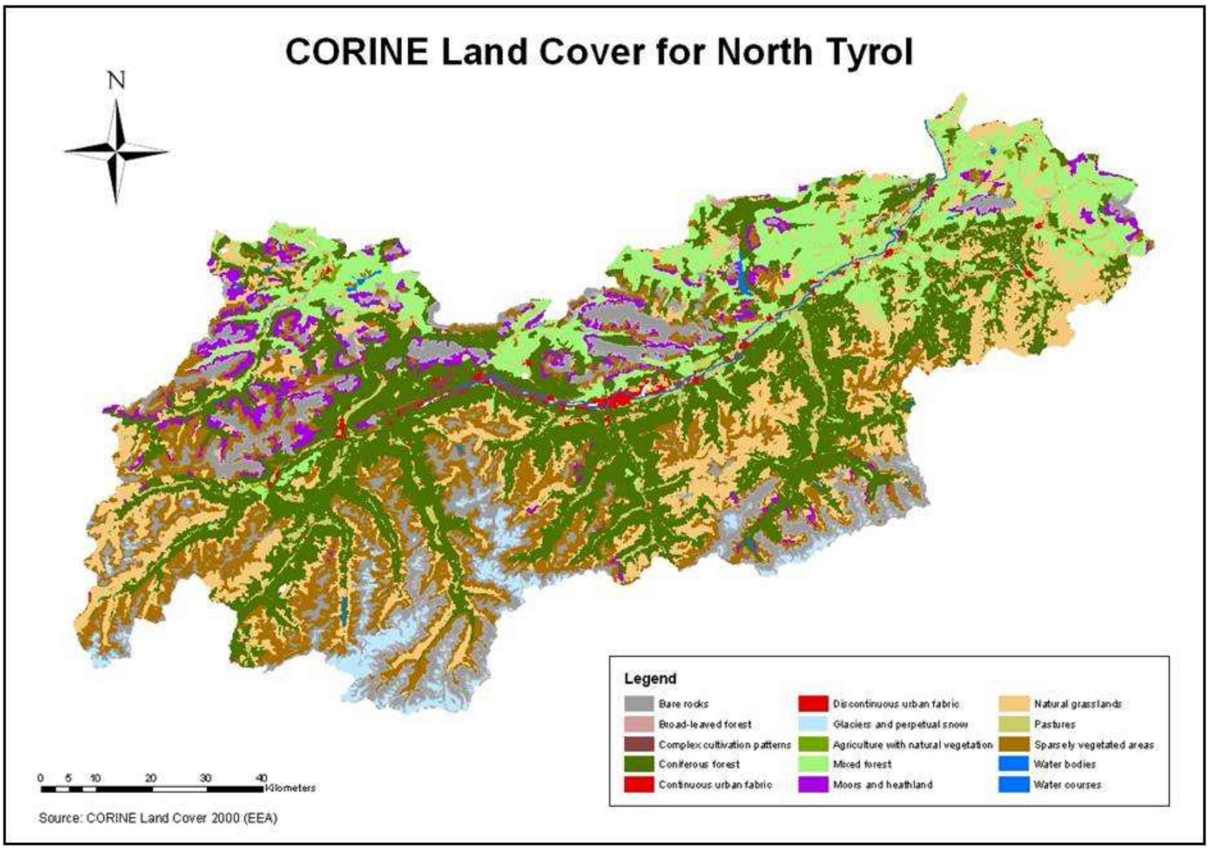

Figure 3: Land cover characteristic of North Tyrol (CORINE land cover 2000).

Table 1: The cumulative areas of the land cover categories in North Tyrol.

Land cover categories	Area (km^2)
Bare rocks	1988
Broad-leaved forest	35
Complex cultivation patterns	47
Coniferous forest	4416
Continuous urban fabric	4
Discontinuous urban fabric	199
Glaciers and perpetual snow	335
Agriculture with natural vegetation	24
Mixed forest	1682
Moors and heathland	508
Natural grasslands	2031
Pastures	925
Sparsely vegetated areas	1385
Water bodies	25
Water courses	22

5. Hydrological characterization

Until Kufstein the river Inn drainages 9.500 km² that completely lie in the mountains with a share of 5 % glaciated area. The catchment area is asymmetric in its distribution with only 20 % in the precipitation-rich northern ´Limestone Alps and´ 80 % in the dry southern Central Alps (Spindler et al. 2002). The flowing condition is deeply influenced by this high alpine catchment area. The river can be described a mountain river with glacial impact, showing low discharges during winter and a distinct flow peak in summer. However, the flowing regime is heavily influenced by the operation of reservoir power stations in the upper Inn region and severely changed from natural conditions. In the whole more than 20 power plants are installed from its source to its estuary in river Danube.

The discharge at the gauge Innsbruck counts 50 m³/s in the mean from December to March and can increase up to 400 m³/s in June. Additionally the daily water level fluctuates to 140 cm because of hydro-peaking. At Finstermünz the catchment area counts 1.943 km² and a mean discharge of 50 m³/s per annum were calculated from 1951 to 2000 (BMLFUW, Ist-Bestandsanalyse 2004). At Innsbruck and Schärding the mean values of the annual discharges on a 10 year basis (1991 – 2000) are 172 m³/s and 742 m³/s, respectively (BMLFUW, 2007). Near the border behind Kufstein the catchment area already increased to 9.750 km² and the mean annual discharge values 300 m³/s (BMLFUW, Ist-Bestandsanalyse 2004).

6. Short description of the pilot study area, Inn meander at Kirchbichl

The meander can be divided into four sections. The first section reaches from down the weir to the first groin (figure 4 and 5). Significant is a large plain of gravel fallen dry (especially in winter). Only just at the weir water can be found. The dominating substrate is microlithal. The left bank is a natural stone wall jointed with concrete with bushy stocks of *Salix sp.* and *Rubus sp*. The opposite bank is a loose riprap with herbaceous vegetation.

The second section (figure 6) has four groins on the right side to lead the flow. On the left side just at the beginning a discharge for run-of water is installed, which normally doesn't have water at low water levels. On both sides the shore line is secured with riprap with the continued vegetation type on each side. A large plain of sand and substrate is fallen dry on the left side of the riverbed. As river substrate grain sizes from psammal to mesolithal can be found.

The Section three (figure 7) starts with the water gauge control-point from the TIWAG (Tyrolean Hydropower Corporation). The control point is an artificial vertical drop which slope is flattened with a loose block ramp. The bank is completely sheeted with riprap on the left side and partially sheeted on the right side. The banks are mainly inhabited by shrubs as riparian vegetation. The predominant grain sizes are akal, microlithal, and mesolithal. The soil is pointly sheeted.

The last section (figure 8) of the meander is already influenced from the backwater of the HP-plant Langkampfen. Shrubs are the predominant both-sided riparian vegetation. The left bank is secured with riprap. The right side of the river bed forms an expended gravel plain.

Figure 4: The weir at the upper side of the meander

Figure 5: The first section of the meander.

Figure 6: The second section of the Inn Meander.

Figure 7: The third section of the meander with the gauging station.

Figure 8: The last section of the meander

7. River quality

WFD quality elements

In 2005 the record of the assessed present status of surface waters according to the WFD was published (BMLFUW 2005). While in Austria several measures undertaken in the last decade to purify the water quality of surface waters show good results, the main risks for not achieving the WFD objective of the good ecological status of Austrian surface water bodies are mainly caused by hydro-morphological disturbances.

Biological elements

Aquatic flora

In the year 2007 the Federal Ministry of Agriculture, Forestry, Environment and Water Management investigate the phytobenthos and the ecological status of the Inn River in the course of the assessment and monitoring of surface waters (GZÜV 2007). They investigate two sections between Innsbruck and the boarder to germany. The first investigation area at Mils is approximately 10 km eastern Innsbruck and the second investigation area is in Erl near to the border to Germany. The River Inn at the investigation area near Mils belongs to the bioregion ´Limestone High Alps` and ´Non-Glacial Central Alps´ with the saprobic ground status of I-IIB. Through this process they determinate 46 phytobenthos taxa within 44 species. This water section maintains the good ecological status according to the quality objectives (QZV Ökologie OG).

The second investigation area at Erl at the border to Germany is dominated by an impoundment. This area belongs to the bioregion ´Limestone High Alps´, ´Limestone foothills` and ´Non-Glacial Central Alps´ with a saprobic ground status of I-IIB. In this assessment process they determinate 44 phytobenthos taxa with 37 species. This river section maintains the moderate ecological status according to the quality objectives (QZV Ökologie OG).

Benthic invertebrate fauna

In the year 2007 the saprobic index and the macroinvertebrates was also investigated in the impoundment near Erl and a river section at Mils (see above). The saprobic index (ZELINKA & MARVAN) in the impoundment near Erl reaches the value 2.65 (moderate). The ecological state in this section according the WFD is poor. At the investigation area near Mils reached the saprobic index (ZELINKA & MARVAN) a value of 1.71, and the ecological status according the WFD reached the moderate status.

Fish fauna

A little historical overview is given in STEINER (1994). In the early years of the 20th century the fish fauna of the middle and lower course of the River Inn was composed at least of 24 species (STEINER

1994). In the year 1922 fisherman captured more than six tons of barbell in the lower part of the In at Kufstein. Beside barbell, dense stocks of nose (*Chondrostoma nasus*), chub (*Leuciscus cephalus*), souffia (*Telestes souffia*), common bleak (Alburnus alburnus) and common dace (*Leuciscu leuciscus*) were present. Further species like huchen (*Hucho hucho*) and ide (*Leuciscus idus*) consistently captured. In the upper section brown trout (*Salmo trutta forma fario*) and grayling (*Thymallus thymallus*) are the mostly dominant species. At the river banks were found mostly european bullhead (*Cottus gobio*), common minnow (*Phoxinus phoxinus*), gudgeon (*Gobio gobio*), burbot (*Lota lota*) and lamprey (Petromyzontidae). The backwaters and tributaries inhabited typical cyprinids like common carp (*Cyprinus carpio*), common bream (*Abramis brama*), tench (*Tinca tinca*), common rudd (*Scardinius erythrophthalmus*) and common roach (Rutilus rutilus). Furthermore, northern pike (*Esox lucius*), european perch (*Perca fluviatilis*) and spined loach (*Cobitis taenia*) populated this sides.

Between 2000 and 2001 SPINDLER et al. (2002) conducted a fish survey in the Tyrolean Inn. The survey map (figure 9) shows the River Inn including the investigation areas along the river, and the fish species composition of each investigation side. According to the authors (SPINDLER et al. 2002) 17 fish species and one lamprey species was identified in the Inn River between Martina (border to Switzerland) and Kufstein (near border to Germany). Whereby, diversity and the abundance of the fish species show a high variability along the river. In the upper section of the Inn the brown trout (*Salmo trutta forma fario*) are dominant, and in the lower section of the river are the rainbow trout (*Oncorhynchus mykiss*) mostly dominant. The grayling (*Thymallus thymallus*) showed an increasing abundance along the stream with the highest abundance in the lower river sections (SPINDLER et al. 2002). The most companion fish species are present in the Inn meander at Kirchbichl. Beside the common species like brown trout, grayling and rainbow trout, several other fish species like brook trout (*Salvelinus fontinalis,* Bachsaibling), gudgeon (*Gobio gobio,* Koppe), chub (Leuciscus cephalus, Aitel), common minnow (*Phoxinus phoxinus*, Elrize), common roach (*Rutilus rutilus*, Rotauge), stone loach (*Barbatula barbatula*, Schmerle), souffia (*Telestes souffia*, Strömer), northern pike (*Esox lucius*, Hecht), european perch (*Perca fluviatilis*, Flussbarsch), burbot (*Lota lota*, Aalrutte), brook lamprey (*Lampetra planeri* , Bachneunauge) occur in this river section. The fish stock along the Tyrolean Inn shows an average biomass of 60 kg/ha and a mean abundance of 400 individuals/ha (SPINDLER et al. 2002).

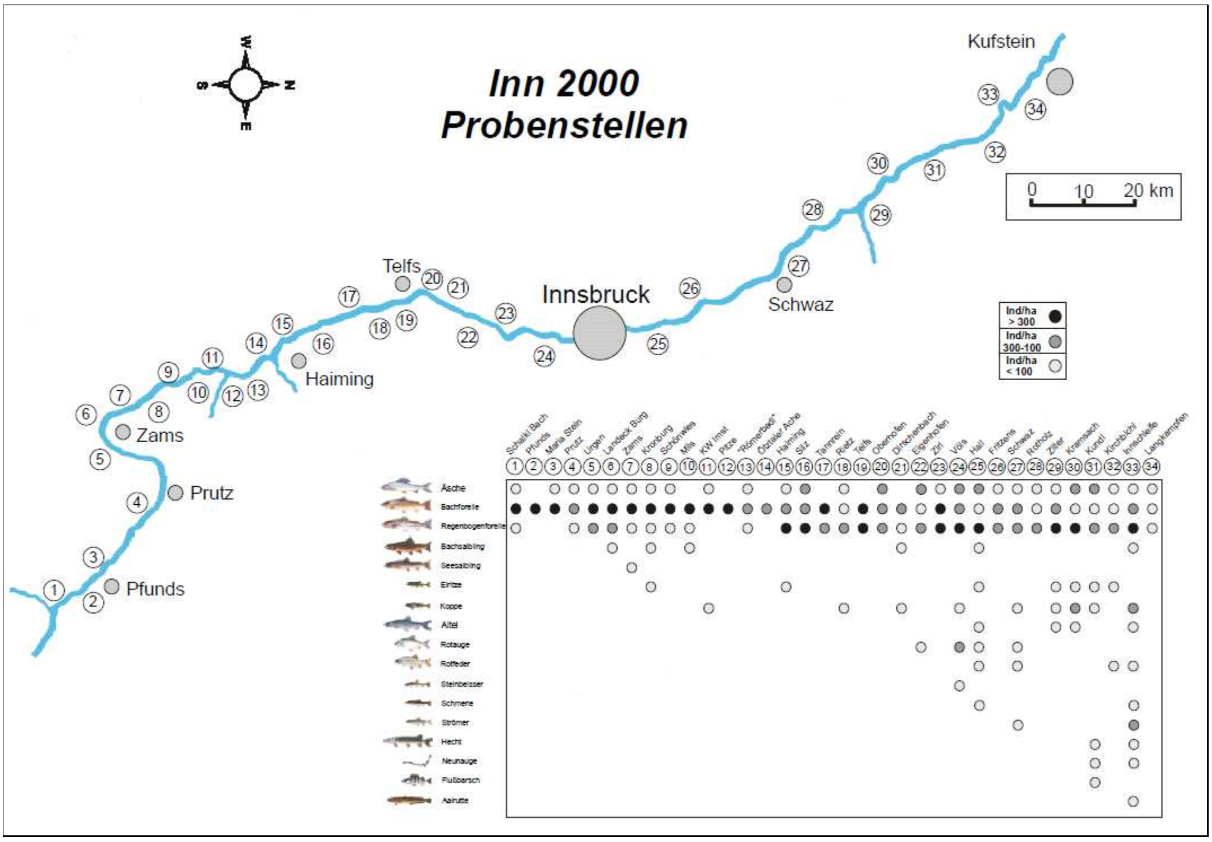

Figure 9: The 34 sample sides along the Inn River and the occurrence of fish species on each sample side (SPINDLER et al. 2002)

Hydro-morphological elements

Hydrological regime

The hydrological regime of river Inn is subjected to hydro-peaking conditions and impoundments almost for all its lengths. The ratio of sunk/swell has not been identified in the status assessment. The weir with its water diversion of HP plant Imst is located in Prutz and impounds the river upstream and causing a residual flow downstream with unknown data of discharge. Upstream the Austrian border an impoundment section reaches until the entry of the Brixenthaler Ache caused by the four HP plants Nußdorf (Germany) Oberaudorf/Ebbs (Austria/Germany), Langkampfen and Kirchbichl (BMLFUW 2005).

The average water discharge (data from 1971-2005, table 2) at the water gauge Bichlwang, not far downstream of Kirchbichl, has been calculated to be 300 m³/sec (Hydrographisches Jahrbuch 2005). The averages of the lowest daily discharge are NQ_T = 77.9 m³/sec and the highest discharge was HQ = 2454 m³/sec in the year 2005 (time period between 1971 and 2005, Hydrologisches Jahrbuch 2005).

Table 2: Average monthly means of discharges at Bichlwang, time series 1971-2005. NQ = lowest values in the observed time period, NQT = lowest daily mean in the observed time period, MNQT = mean daily low water in the observed time period, NMQ = lowest monthly mean values in the observed time period, MQ = mean values in the observed time period, HMQ = highest monthly mean values in the observed time period, MHQ = mean of the highest values in the observed time period, HQ = highest values in the observed time period (Hydrographisches Jahrbuch 2005).

Average monthly means (series 1971 – 2005)												
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
NQ	47.2	43.7	8.31	4.87	100	126	226	115	65.0	63.2	14.6	34.5
NQ_T	87.0	91.2	77.9	112	122	243	283	221	131	127	105	80.9
MNQ_T	89.2	90.2	95.0	120	212	326	340	261	182	139	115	92.6
NMQ	117	122	123	135	207	405	390	306	198	175	135	112
MQ	118	121	140	178	354	488	468	373	260	195	153	127
HMQ	180	176	236	363	758	802	885	647	388	371	303	210
MHQ	197	203	247	321	628	815	833	775	468	368	261	230
HQ	411	603	644	696	1418	1767	1855	2454	1076	862	742	701

River continuity

The river continuity of river Inn in Austria is disrupted for up- and downstream migrations of fish due to the weirs of two diversion-type HP plants at Kirchbichl and at Prutz (HP plant Imst) (BMLFUW 2005).

Morphological conditions

The morphological conditions of the river Inn remain quite equal along its range in Austria showing not many variations in depth and width. The natural structure of the riverbed is almost totally lost because of straightening and banks fixation with riprap. The predominantly substrate is gravel.

Chemical and physical-chemical elements

Thermal conditions

The thermal conditions over the period of a year were sampled and documented at Kufstein as the average monthly values (Hydrographisches Jahrbuch 2005) (Table 3). The average temperature profile shows a steady and slow increase from the lowest temperature of 2.1°C in January to the highest 12.7°C in July. The yearly average temperature was 7.8°C.

Table 3: Water temperature profiles (°C) in the course of one year (data???)

Monthly lowest, average and highest water temperatures												
Temp. [C°]	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Min.	0.4	0.8	0.8	5.8	7.4	8.3	10.2	10.3	9.3	7.0	2.3	0.0
Ø	2.1	2.7	4.7	7.9	10.2	11.8	12.7	12.0	11.7	8.9	5.8	3.0
Max.	3.4	4.3	7.8	11.4	13.4	15.0	15.5	14.7	14.1	10.8	9.0	4.8

Nutrient conditions and specific pollutants

In Tyrol the main part of water pollution relates to communal sewage water, with the highest loads in winter due to highest tourism activity and coincidentally low water levels. Because of the development of waste water disposal the saprobial status of the river Inn is rated class II (BMLFUW 2005, Biol. Gütekarte).

Figure 10 to 12 show the status of specific pollutants and the saprobial class in the river Inn near Wörgl (Tirol, Austria) between 1991 and 2004 (ASCHAUER et al. 2006, Wassergüte in Österreich - Jahresbericht 2006).

Dissolved organic carbon (DOC) and biological oxygen demand (BOD)

The dissolved organic carbon (DOC) is a measure for organic contamination of the water body and oxygen depletion caused by microbial activity. The biological oxygen demand (BOD) is the amount of dissolved oxygen needed for decomposition of organic material in a defined period of time. Both values for the measured DOC and the BOD in the river Inn at the sampling point near Wörgl were under the thresholds of 5.5 mg/l and 6 mg/l, respectively (ASCHAUER et al. 2006) (Figure 10).

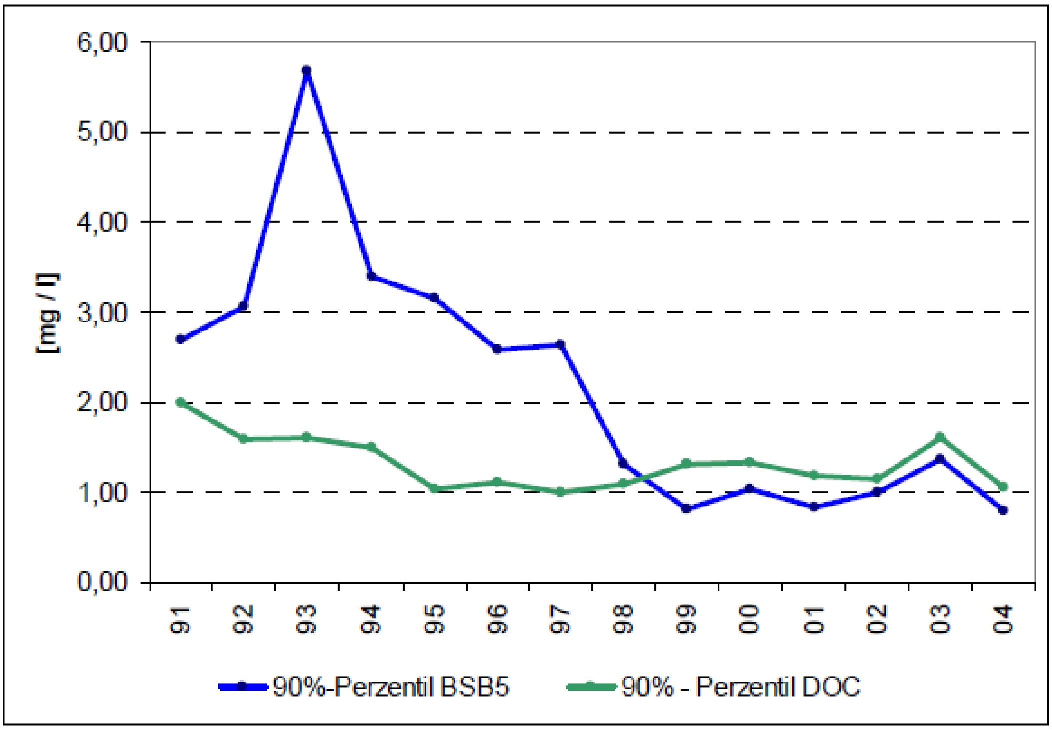

Figure 10: Dissolved organic carbon (DOC, 90%-percentile, mg/l) and biological oxygen demand (BSB=BOD, 90%-percentile, mg/l) measured over the time period between 1991 and 2004 in the river Inn near Wörgl (Tirol, Austria). (ASCHAUER et al. 2006)

Nitrate-Nitrogen (NO_3-N) and Orthophosphate-Phosphorous (PO_4-P)

Nitrogen and phosphorus are the essential nutrients in riverine ecosystems. Austrian rivers are generally limited in phosphorus, while the limitations in nitrogen load of the water are of crucial importance especially on a long-distance effect. The evaluation of the phosphorus load of a water body is based on the dissolved orthophosphate content. The evaluation is further determined by the type of water body, which is defined by the bioregion and the initial trophical status.

Figure 11 shows the profiles of Nitrate-Nitrogen (NO_3-N) and Orthophosphate-Phosphorous (PO_4-P) in the time period between 1991 and 2004 of the river Inn near Wörgl. The values for the Nitrate-Nitrogen (NO_3-N) and the Orthophosphate-Phosphorous (PO_4-P) were below the thresholds of 5.5 mg/l (PO_4-P) and 0,15mg/l (NO_3-N), respectively (Wassergüte in Österreich - Jahresbericht 2006) (ASCHAUER et al. 2006).

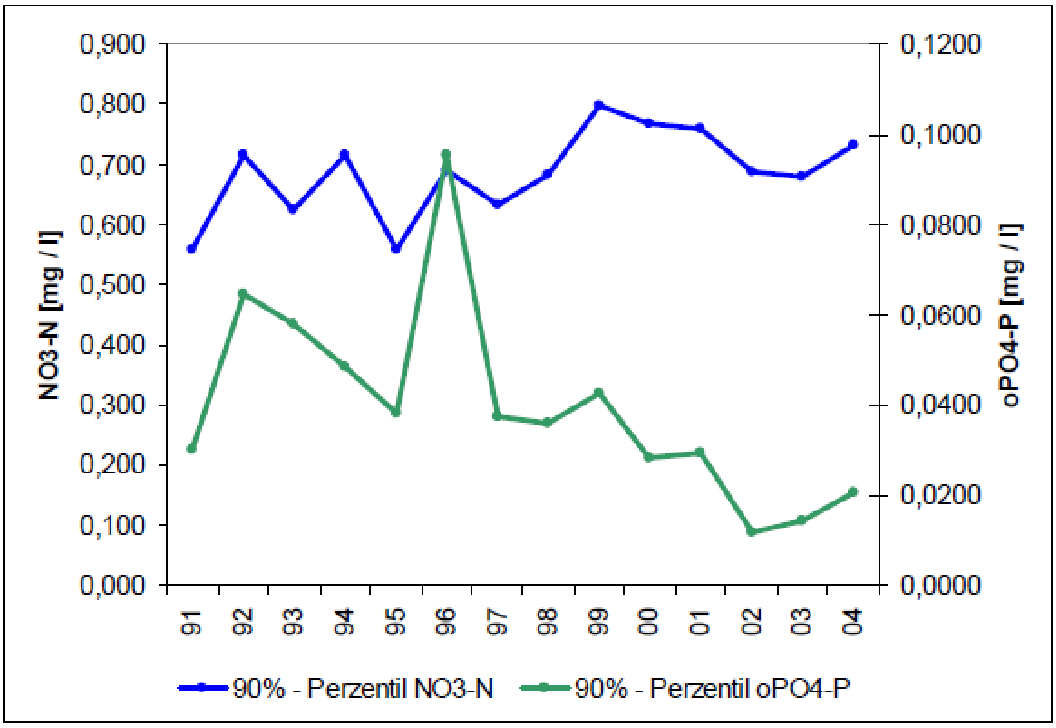

Figure 11: Nitrate-Nitrogen (NO_3-N, 90%-percentile, mg/l) and Orthophosphate-Phosphorous (PO4-P, 90%-percentile, mg/l) measured over the time period between 1991 and 2004 in the river Inn near Wörgl (Tirol, Austria). (ASCHAUER et al. 2006)

Adsorbable organic bonded Halogens (AOX) and Ammonium Nitrogen (NH_4-N)

The composite parameter of adsorbable organic bonded Halogens (AOX) is the total amount of Halogens in organic compounds. In general, all organic bonded Halogens are toxic pollutants in riverine ecosystems. The Ammonium Nitrogen (NH_4-N) is also an indicator of water quality. This pollutant comes especially from purification plants and is very toxic to aquatic organisms (ASCHAUER et al. 2006).

Figure 12 shows the pollution of absorbable organic bonded Halogen and ammonium nitrogen over a time period between 1991 and 2004 at the river in near Wörgl. The values of and adsorbable organic bonded Halogens (AOX, threshold value 50 µg/l) and Ammonium Nitrogen (NH_4-N, threshold value 0.5 mg/l) are below the thresholds values (Wassergüte in Österreich - Jahresbericht 2006).

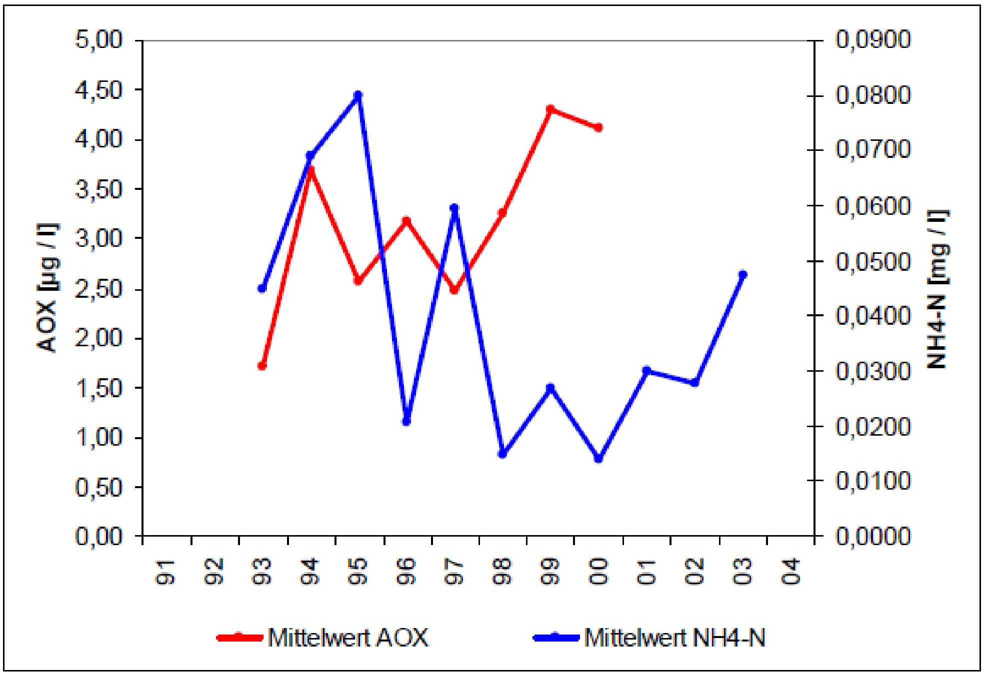

Figure 12: Adsorbable organic bonded Halogens (AOX, mean value, µg/l) and Ammonium Nitrogen (NH4-N, mean value, mg/l) measured over the time period between 1991 and 2004 in the river Inn near Wörgl (Tirol, Austria). (ASCHAUER et al. 2006)

8. River typology

Austria shares in six ecoregions according to the WFD that conform to the classification of ILLIES (1978): 4 = Alps, 5 = Dinaric Western Balkan, 10 = Carpathians, 11 = Hungarian Lowland, 9 = Central Low Mountain Range, 30 = Italy. River Inn is situated in ecoregion 4 = Alps. For a proper classification of the type specific biocoenosis the ecoregions are too large in space. Therefore the detailed structure of Austrian landscapes, water types and biocoenoses needed further classifications to river macrochore regions and river type regions which resulted in the designation of 15 bioregions (figure 13). According to WIMMER & CHOVANEC (2000) and MOOG et al. (2001) the river Inn belongs to the special category of ´Large Rivers` due to its catchment area > 2500km², stream order ≥ 7 and a average discharge > 50 m³/s.

The Inn in Austria separates the bioregions 'Limestone High-Alps' in the north from the 'Non-glacial Central Alps' in the south until it breaks thru the 'Limestone Pre-Alps' and 'Bavarian-Austrian Pre-Alps' in north-eastern Tyrol.

According to the fish zonation concept (THIENEMANN, 1925) and the biocoenotic region concept (ILLIES & BOTOSANEANU, 1963), fish regions are classified and named after the dominating key-species, which are associated with other specific species of that region. In these terms the Inn in Tyrol belongs to the barbell region or the epi-potamal.

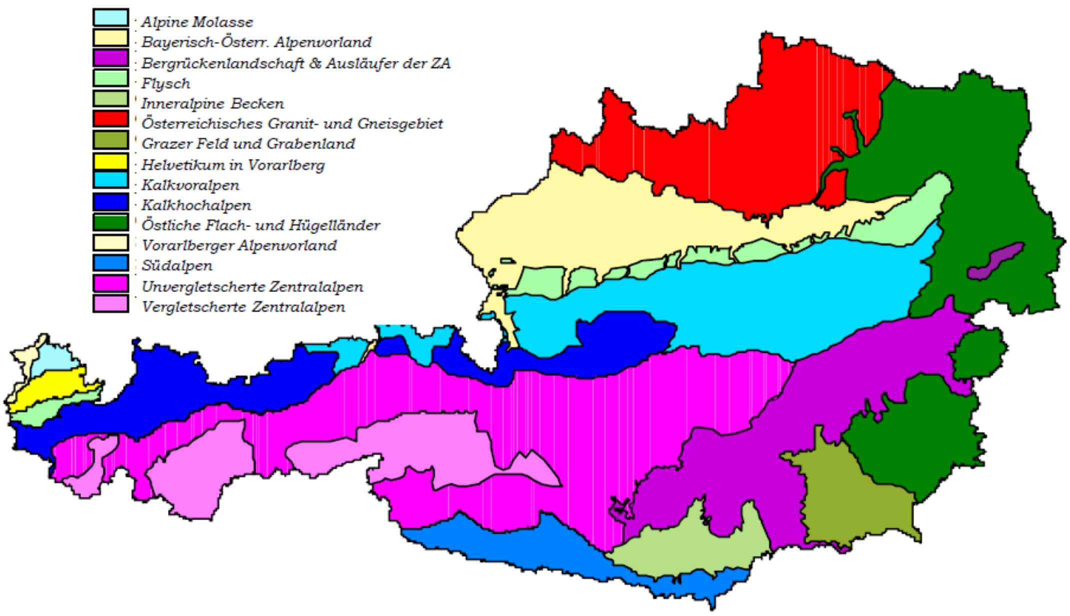

Figure 13: The 15 aquatic bioregions of Austria (MOOG et al. 2001)

9. Water uses

Hydropower exploitation in Tyrol

On the whole course of the river Inn 22 HP plants are in use from its source to end. Four of them are located in the Inn valley in Tyrol and are under operation by the TIWAG and the Grenzkraftwerke GmbH. They are located at Imst (river-km 341) with the water abstraction near Prutz, at Kirchbichl (river-km 231 km), at Langkampfen (river-km 220) and at Oberaudorf/Ebbs (river-km 211). Several more big and mid-size HP (> 10 MW) and a large number of smaller HP plants (< 10 MW) lie within the river's catchment area. Hydro power takes the major part (75 % in 2004) in the generation of electric energy in Tyrol (Tiroler Energiestrategie). The annual control power capacity of all HP plants in Tyrol sums up to be about 5900 GWh/a (± 10 %). Table 4 and table 5 provide information on the importance of hydropower in Tyrol and the operations on river Inn. The theoretical potential of hydropower in Tyrol (table 6) was assessed in studies of SCHILLER (1982), the Tyrolese government (1993) and lately PÖYRY (2008) considering precipitation, surface run-off and topography. The technical and economical potential still developable can be estimated another 5.000 GWh/a.

Table 1: Hydro power plants in Tyrol

	Big HP plants > 10MW	Smaller HP plants < 10 MW	Total
Number	22	797	819
Power [MW]	2.698	238	2.936
Control power [GWh/a]	4.651	1.258	5.909
Source: Tyrolese government, department water management and hydropower plant cadastre, state August 2006.			

Table 2: Big HP plants operated by TIWAG installed at river Inn and tributaries.

Location	Type	Control power [GWh/a]
Kaunertal	Reservoir plant	661
Imst	Run-of plant	550
Silz	Reservoir plant	718,6
Kühtai	Pump-Reservoir plant	No information
Achensee	Reservoir plant	219,5
Kirchbichl	Diversion plant	141,1
Langkampfen	Run-of plant	169
Source: Homepage TIWAG		

Table 3: Hydro power potential for the river Inn and its tributaries in Tyrol

	Schiller (1982)	Pöyry (2008)	Energy concept of the Tyrol record (1993)
Inn [GWh]	6.481	6.405	6006
Inn tributaries [GWh]	8.825	8.900	13.952
Source: Tiroler Energiebericht 2009			

Hydropower exploitation HP Kirchbichl and Langkampfen

In the study area at Kirchbichl and Langkampfen (figure 14) two HP plants with direct impact on the meander are in operation by the TIWAG. The HP plant Kirchbichl was constructed from 1938 to 1941 as a diversion-type HP plant and it uses the natural drop of the sinuosity (river-km 232) and additionally dams the river at the beginning of the meander for app. 6 m in height. Thus the effective height counts from 7.5-9.7 m respective to the water level. Located on the downstream side of the meander is the powerhouse equipped with three Kaplan-turbines, the electrical facilities and the transformation station. The three Kaplan-turbines use 250 m^3/s. The hydroelectric station has a capacity of up to 24 MW and an energy production of 141 GWh/a. The catchment area of the hydropower-plant includes 9,313 km^2 (Table 7).

The run-of HP plant Langkampfen at river-km 223 is in use since 1998. To use a vertical drop of 8.3 m the river basin had been lowered from the weir downstream to the bridge at Kufstein. It has a capacity of 31.5 MW and an energy production of 168 GWh/a (Table 7). It is located at the head of the backwater from HP Oberaudorf/Ebbs and thus the whole course from there into the meander is now influenced by backwater.

Table 4: Details on energy-management of the HP plants Kirchbichl and Langkampfen

Kirchbichl diversion-type HP plant	
Catchment area [km^2]	9.313
Discharge [m^3/sec]	250
Vertical drop [m]	9,7
Capacity [GWh/a]	141,1
Pressures on meander	Residual water scarcity, impoundment
Langkampfen run-off HP plant	
Catchment area [km^2]	9.367
Discharge [m^3/sec]	250
Vertical drop [m]	8.3/8.0
Capacity [GWh/a]	169
Pressures on meander	Impoundment
Source: Homepage TIWAG	

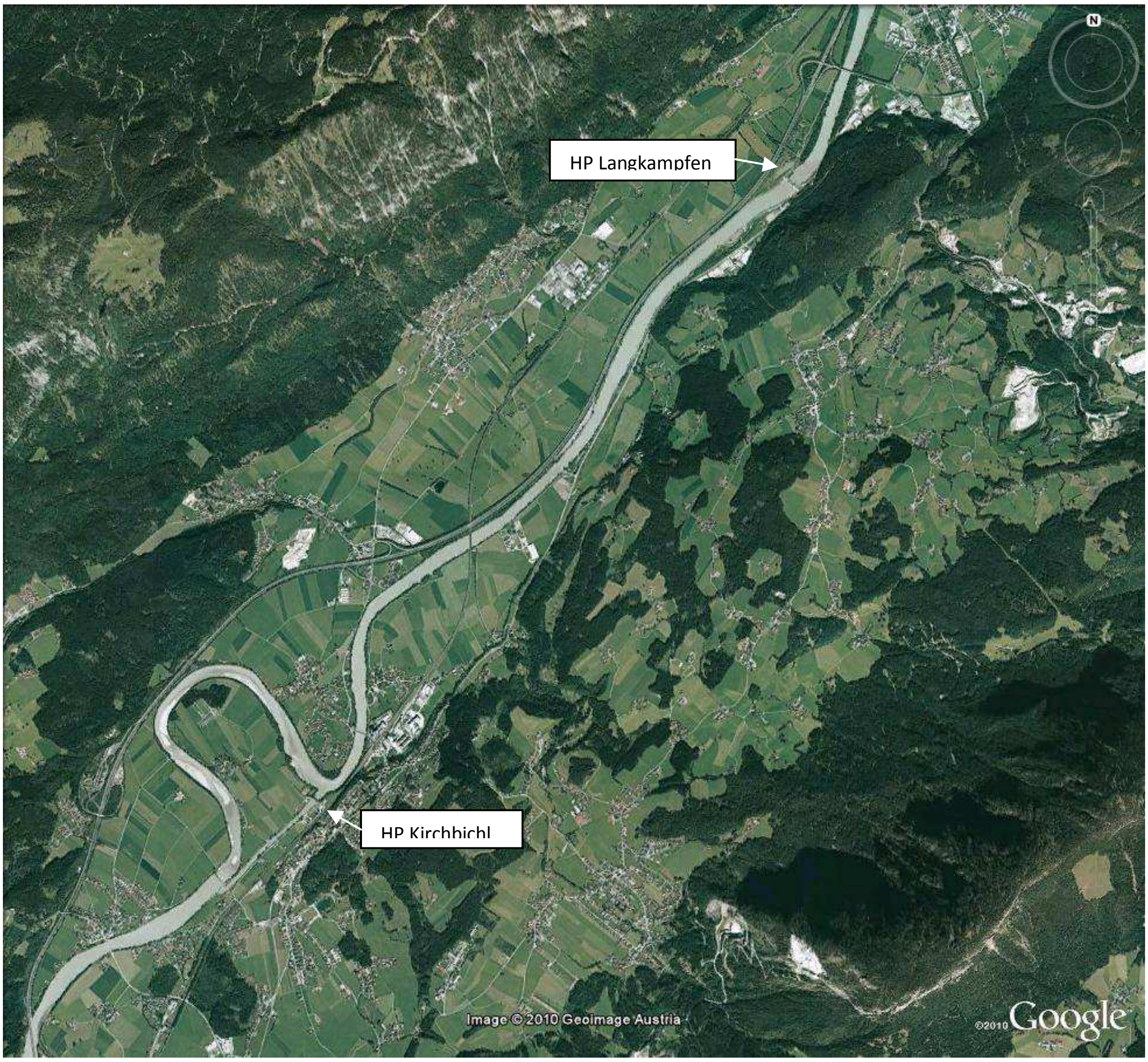

Figure 14: Aerial view of the pilot study area with the two HP plants Kirchbichl and Langkampfen (source: Google Earth).

Figure 15: The weir and the bypass channel of the HP Kirchbichl.

Figure 16: The weir seen from the downstream side of the meander (winter situation).

Figure 17: The power house of the HP Kirchbichl.

Figure 18: The power house and the weir of the HP Langkampfen seen from the downstream side.

10. Pressures and impacts related to water uses

The type of hydropower plant is characterized by a diversion of water and a lack of water downstream the plants while the headwater is dammed by a weir. The section of the residual-water is mainly characterized by:

Reduction of discharge

Equalization of water flow velocity

Reduction of water depth and a decrease of the ground-water level

Deficit of microhabitat diversity

Shift of the physico-chemical parameters

Deficits in the aquatic flora, macro invertebrate and fish fauna

These impacted hydrological conditions of the residual-water affect the macroinvertebrate communities downstream, resulting in a disappearance of the usual rheotypical variety of makroinvertebrate species. The lack of water and the low near-bed water velocity have reduced the habitat diversity of the river bed and further riverbed clogging. Furthermore dams and weirs interrupt the river connectivity and prohibit the distribution of different fish species. Particular the migration of Cyprinids and Salmonids are interrupted.

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