FIThydro

Test Case Presentation

Altheim

Isar, Germany

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1.1. Description of the water bodies related to the HPP

The river Isar is an Alpine river with its mouth being located in Austria, 1600 m above sea level. The river passes Alpine mountains, pre-alpine moor lands and also the city of Munich. After a length of 260 kilometers, the Isar enters the Danube River at 300 m above sea level below the city of Deggendorf. The catchment area including the incoming rivers Loisach and Amper is about 8960 m². The Isar is generally divided into 3 sections, the upper, the middle and the lower Isar; the test case is located in the lower Isar.

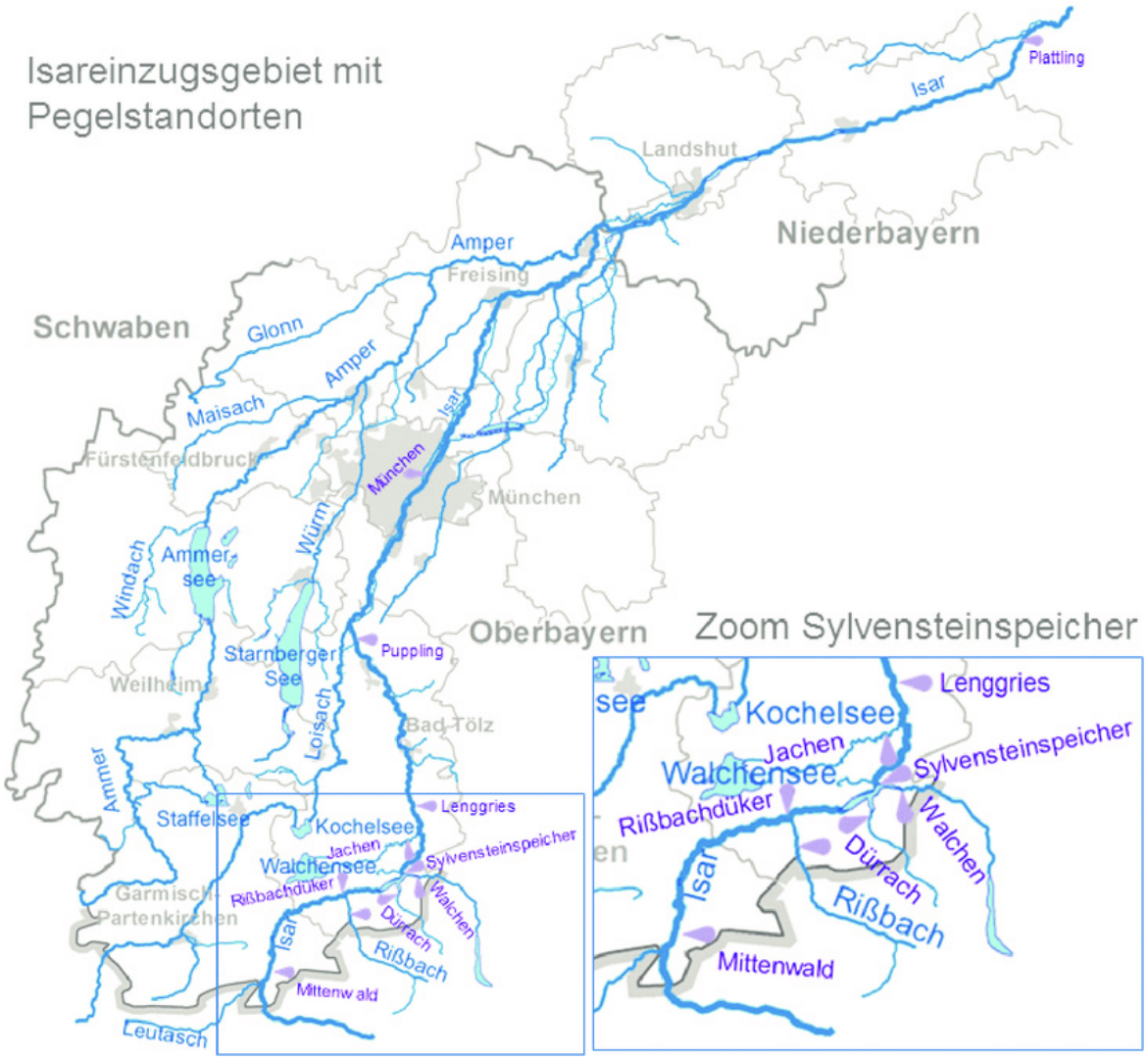

Figure 1: The water bodies related to the HPP Altheim

The water body including the case study site is named 1_F429 and includes the Isar from the entry of the Isar channel (MIK) to the city of Plattling. The water body has a catchment area of 88,2 km² and is about 73 km long. It is classified as HMWB with poor ecological potential.

- The water body upstream is 1_F405 and is classified as natural water body with good ecological status.
- The water body downstream is 1_F430 and is classified as natural water body with moderate ecological status.
- The water body entering from the right side is 1_F433 and is classified as natural water body with bad ecological status.

1.2. Main pressures on the relevant water body

The main pressures on water body 1_F429 that might according to the river base management plan 2016-2021 be causative for the status of the river stretch are:

- Nutrients
- River specific pollutants
- Soil feed
- Hydromorphological changes

1.3. Measures to be implemented at water body 1_F429 according to the river basin management plan

- Reduction of nutrients coming from agriculture
- Improvement of linear connectivity
- Improvement of dynamic habitat development
- Improvement of floodplains
- Connection of side arms

1.4. Presentation of the HPP

1.4.1. Location of the HPP

The plant is located at km 67.2 of the river Isar near Altheim. Downstream of the test case site, 7 other HPP follow in the same water body.

Figure 2: Top view of the HPP Altheim

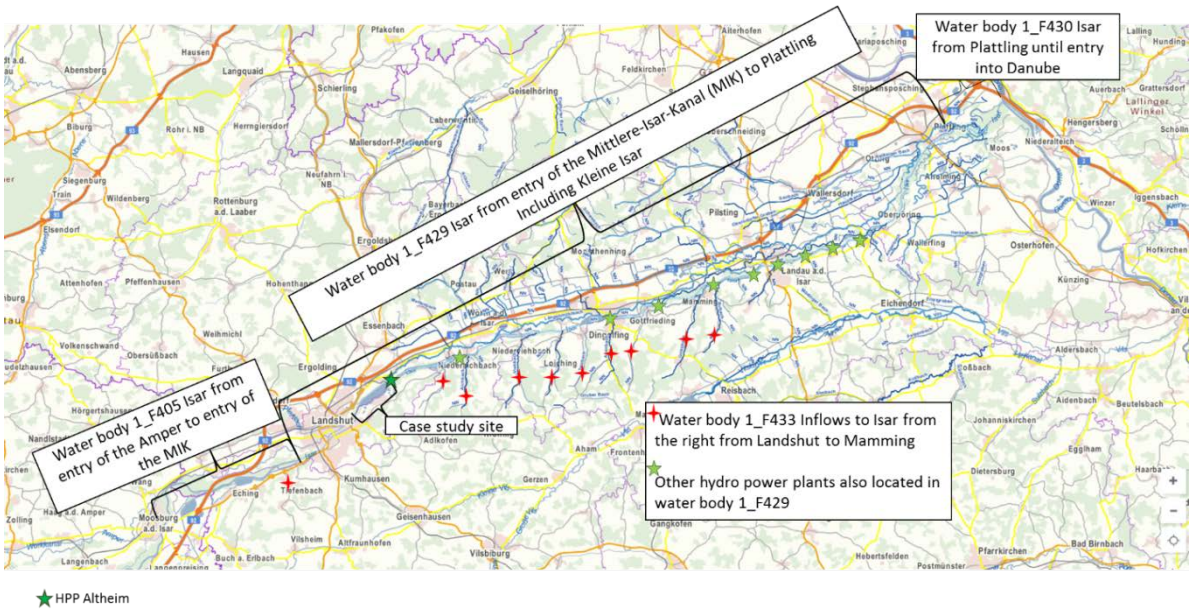

Figure 3: The location of the HPP Altheim and other HPPs on the Isar

1.4.3. Hydrology and technical data of the test case

Watercourse	Isar
Situation :	Altheim
Inter-annual discharge	163 m³/s
Low-water flow :	50.9 m³/s
Instream flow :	
Function of the dam :	Hydropower
Lenght of headrace canal :	n.a.
Length of bypassed reach :	n.a.
Maximum turbine discharge:	270 m³/s + station supply 11.7 m³/s
Species concerned :	Barbus barbus, Hucho hucho (L = 100 cm)

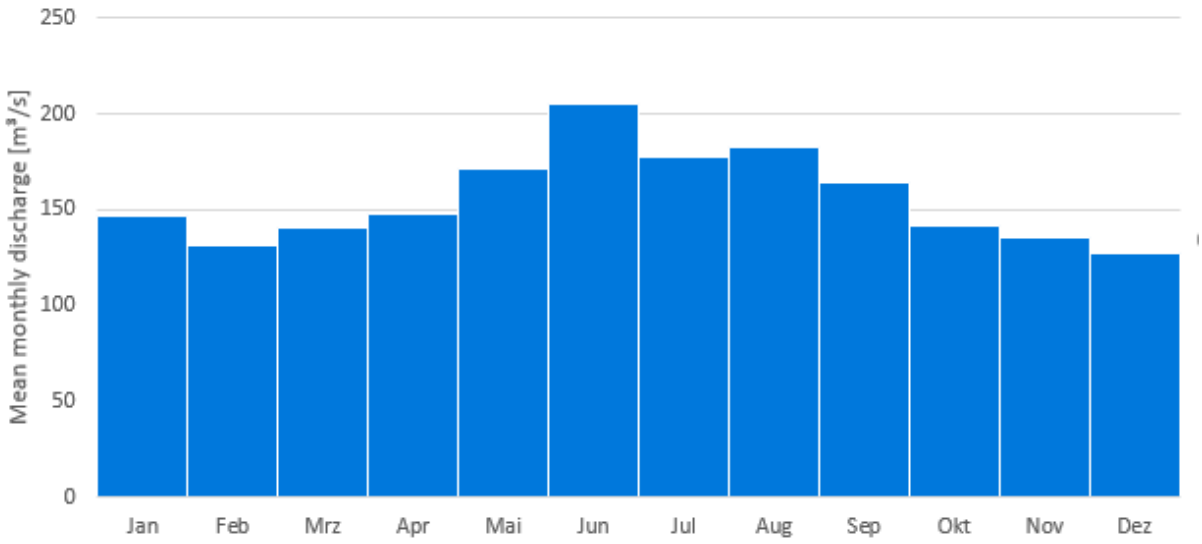

Figure 4: Mean monthly discharge at HPP Altheim average 2017 - 2019

About the HPP Altheim:

- Year of commissioning: 1951
- Installed capacity: 17.8 MW
- Mean annual output: 91.4 GWh
- Head height: 8.2 m/

The HPP consists of 5 Kaplan turbines:

	3 Kaplan turbines	1 Kaplan turbine (house machine)	1 Kaplan turbine (discharge to Längenmühlbach)
Installed capacity	8.0 MW	0.8 MW	0.1 MW
Discharge per turbine	90 ³/s	12 m³/s	3.2 m³/s
Nominal speed	107 rpm	300 rpm	775 rpm
Outer diameter of the turbine	4080 mm	1500 mm	Data not available
Hub diameter of the turbine	1800 mm	600 mm	Data not available
Number of blades	4	4	Data not available

The normal operating level is at 384,00 m above sea level, in hydropeaking mode it can be lowered by 1,00 m. On average there are 2 peaks per day, where the flow changes roughly between 50 m³/s and 170 m³/s with ramps of about 100 m³/s per hour or change of water level +45 cm/h or -30 cm/h. The plant has a head storage volume of 1980000 m³. The plant has 4 weir fields right of the power house.

1.4.4. E-flow

HPP Altheim is a block-type HPP in the river Isar and part of a chain of power plants. For the main flow in river Isar no e-flow regulations are agreed. Nevertheless, a full stop of machines is never operated. A minimum flow of 40 m³/s is always maintained voluntarily. For own purposes one machine for station supply must always be operated with 11.7 m³/s. The connected small stream Längenmühlbach has an agreed minimum e-flow of 3.2 m³/s all year, but is not in the focus of the Altheim Test Case within FIThydro.

1.4.5. Downstream migration devices

The river is dominated by potamodroumous species. No downstream migration device is installed at this plant, as downstream migration facilities for this size of river are not available and downstream migration is not a major focus of research for areas dominated by potamodroumous species.

1.4.6. Upstream migration devices

The upstream migration facility, which has been built in 2015, consists of a rough channel for the downstream connection at the entry of the fish pass. An existing drainage channel has been used to facilitate the fish passage over 4.5 km and for providing new hydromorphological structures and habitats in the fish pass. The fish pass entry is located on the right -hand side of the river Isar following the main migration route. On the upstream side a vertical slot connects the nature-like fish pass to the river. The vertical slot structure overcomes 1.45 m of height with 13 sections. The whole migration facility is always supplied with a minimum flow of 450 l/s (up to 800 l/s).

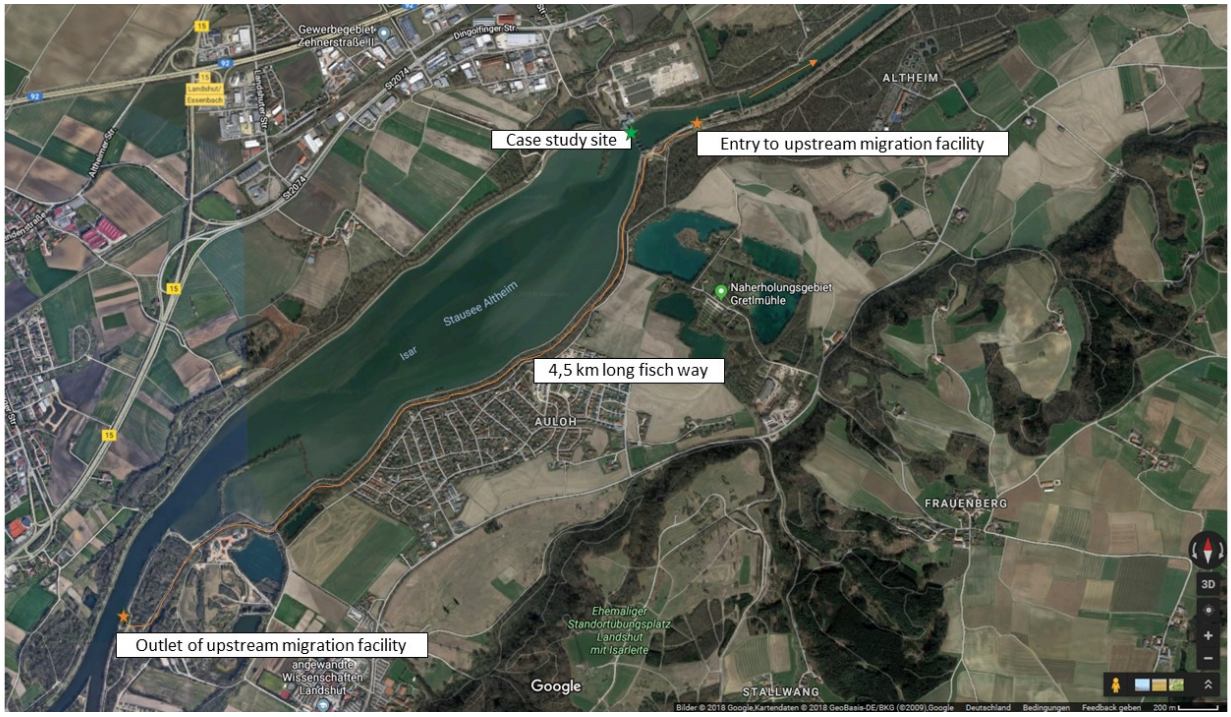

Figure 5: Location of the fishway at HPP Altheim

Geometrische Bemessungswerte

Tabelle 1: Geometrische Bemessungswerte – Schlitzpass (Vertical–Slot), Staustufe Altheim

Abmessung	Bezeich-nung	Grenz-wert	Sicherheits-beiwert	Bemessungswert	Planung
Schlitzbreite [m]	min_s	0,35	1,0	0,35	0,35
lichte Beckenbreite [m]	b_B	2,0	1,0	2,25	2,25
lichte Beckenlänge [m]	l_B	3,0	1,0	3,0	3,0

Figure 6: Entrance of the fish way downstream of the HPP Altheim

1.4.7. Sediment Management

No measures for sediment management are in place.

2. Description of the planned work

Within the project the fish pass at the plant shall be evaluated regarding the existing hydromorphological structures in the fish pass. Both the variation of the original structures to the current status as also the usage of the existing habitats by fish shall be evaluated. Upon the results a concept for improved hydromorphological measures should be developed under the aspect of usage by fish and expenses for maintenance. Moreover, the maintenance effort for the long nature-like bypass channel shall be evaluated and improved for future upstream migration facilities. This will be relevant for further decisions on the implementation of upstream migration measures.

Within the course of this assessment we expect to gain more knowledge on the design of habitat structures in nature-like fish passes, answering the questions which and how many are needed over a certain length. Moreover, we want to prove the value added by “artificially” created habitat structures. Finally, a reduced effort for maintaining these structures will support future decisions between choosing a technical fish pass or a nature-like fish pass where possible.

This evaluation will feed back into the cost effectiveness analysis within FIThydro. The development of cost efficient and effective measures is a key focus within FIThydro.

3. Presentation of results and activities in FIThydro

The waterbody 1_F429 suffers from a substantial lack of dynamic habitat development. Especially in heavily modified water bodies nature like fish ways offer the possibility to improve the ecological potential essentially. Creating connectivity can be combined with spawning grounds and habitats for juvenile fish. Often the availability of habitats is even more important for the development of the population than the mere connectivity. On the other hand, nature-like fish passes often require a significant amount of maintenance due to their length, the difficult balance between what is “nature” and what is functionality and also the maintenance of hydromorphological structures with an all year steady flow.

Along river Isar the existing drainage stitches have been used for long nature-like fish passes. The assessment within FIThydro is designed to evaluate the benefit of artificial habitat structures within nature-like fish passes for fish and macroinvertebrates.

3.1. Evaluation of the existing structural quality of the 4.5 km long fish pass

After the construction of the fish pass, it`s functionality had been evaluated according to the hydraulic conditions, but the quality of the fish pass in providing habitat structures for the relevant fish fauna and macroinvertebrates had never been evaluated. During the original design some structures had been implemented to enable the development of habitats, but the availability of these structures is not given anymore. Therefore in a first step six representative sections of the fish pass were mapped and evaluated. The methodology contained the measurement of the profile, the structure of the ground via under water photography in order to determine the grain size of the sediment and the flow velocities using a anemometer. The flow velocities were measured both in the main stream as well as in flow reduced sections. Also the existing habitat structures in those sections were mapped.

Exemplarily the results of section 2 can be described as follows:

The section is 37 m long and shows a high variety of water depths and profile widths, which results in a good variation of deep areas with high flow velocities and flat zones with low flow velocities. Some curves in this section allow the development of flat gravel banks, which is being supported by two inserted rocks to vary the dynamics of the flow. The ground shows different gravel sizes both in flat as in deep waters. The full section is under constant influence of sun rays over the whole day.

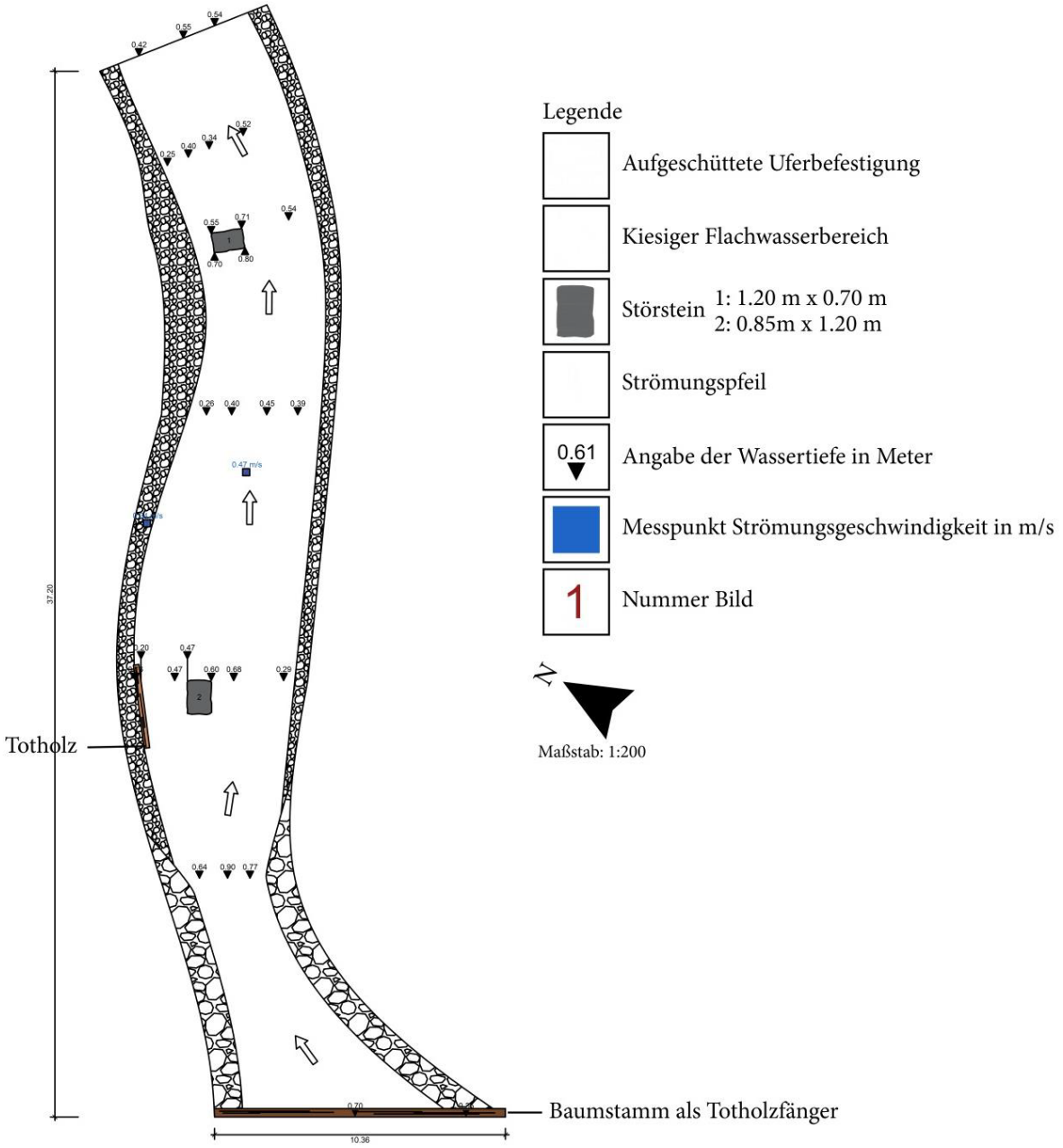

Figure 7: Section 2 from "Cross-taxonomische Bewertung der Fischaufstiegshilfe Landshut-Altheim an der Isar"

In order to gain a better understanding of the influence of water temperature five temperature loggers were inserted. They show the typical variation within days and seasons, although those do also highly vary between the different points of measurement.

3.1.1. Macroinvertebrates

The benefit of habitat structures for macroinvertebrates was evaluated along 13 habitat structures in three sections (entrance, drainage stitch and outage) according to the evaluation system PERLODES that is also being used for the WFD monitoring.

The entrance section shows two different morphologies, where one is channel-like whereas the other one is rather flat with gravel banks with two additional rocks for more flow variety. Generally both parts show medium to poor fauna index, but especially the spaces between the rocks show the availability of many species with high habitat demands. Especially the gravel bank did not show as good results as expected, which might be due to its location in a bay-like section with lower flow velocities.

The drainage stitch section showed three different morphology types representing the general structure of the fish pass but also two special habitats – a stone groyne and a structure of dead wood. The general morphology without habitats show poor results due to entry of fine sediments from the main river Isar. Also the very straight water course contributes to the lack of structural variability. The dead wood structures showed significantly better results than the stone structure and is due to higher flow velocities the better habitat structure for the desired rheophile species. The stone structures generate still water areas and do therefore provide room for ubiquitous species.

The vertical slot pass at the outage was also evaluated at two measurement points with different flow conditions. One is rather low flowing, where fine sediments can deposit from the main river, the other one is at the opposite bank. The fine sediments turned out to have a major influence on the results, that were rather poor in this section.

Overall the results show the organic pressures and a lack of habitat structures.

3.1.2. Fish fauna

The suitability of the fish pass for the fish fauna was focused on juvenile fish, as the structural variability of the main river Isar is especially poor in the bank areas, where juvenile fish are usually looking for habitats. To get information of the fish species in the fish pass, six measurement points were evaluated via under water video monitoring. Additionally further observations of the fish pass helped to interpret the results. The fish species found did not cover the full spectrum of expected species, but does generally fit to the fish species that are generally found in the main river during the WFD monitorings. Especially the red listed and FFH species could be observed in the fish pass, such as Cottus gobio, schneider (Alburnoides bipunctatus) and minnow (Phoxinus phoxnius), that indicate a high water quality and variety of habitats, flow velocities and water depths. The distribution of the fish species concentrated on the sections 4 and 5 close to the outage, which indicates that especially the sections from the entrance on have a major lack of suitable habitat structures, which would improve the benefit of the fish pass beyond the mere migration route.

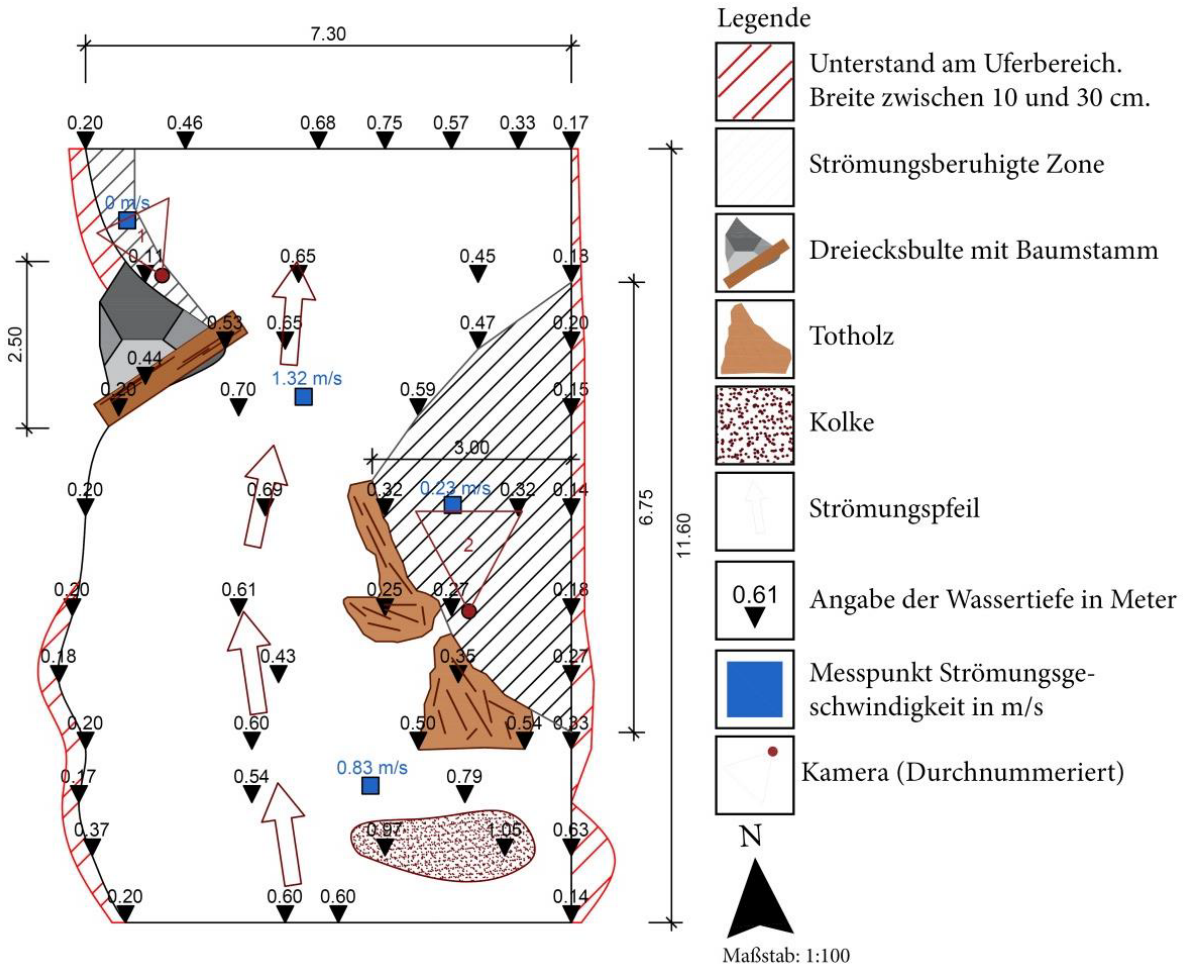

Figure 8 Example of camera position in section 3 from "..."

3.2. Development of an improved structural concept in two steps

Based on the research regarding macroinvertebrates fish fauna in the existing fish pass with the so far available habitat structures and the knowledge about the benefit of the existing structures, a concept was developed containing 5-6 standard structures and a geographical plan in which areas to implement them. The structures should be implemented within the given water course of the fish pass, regarding water depths and width and flow velocities.

General structures to provide higher variability in flow conditions and serve different habitat needs of the various species:

- Stone structures to vary the flow regimes: stone size mx. 80% of water depth, distance 50-60 cm
- Rhizomes in combination with block stones to imitate the availability of bulging and sliding slopes
- Dead wood structures to secure the banks

Structures with a certain purpose:

- Spawning area for gravel spawners
- Juvenile area separated from the main stream with lower water depth

The implementation of the new structures should concentrate on the first part of the fish pass. Especially the question of the minimum amount of structures needed and the maximum number of structures that can be implemented was posed to find the optimum. Especially for operators the amount of structures is essential, not only for the cost of implementation, but also for the maintenance effort to ensure their usability in the future. With regards to the existing results and the consultation of various experts (Fischereifachberatung Bezirk Niederbayern, Büro für Gewässerökologie und Fischbiologie Dr. Holzner), the implementation of measures was started.

3.3. Implementation of measures

In autumn 2019, 37 structures were installed in the natural fish pass. The structures mainly consist of dead wood and spawning gravel and were constructed as spawning habitats, juvenile habitats or shelter but also to generally increase the variability in flow conditions.

To evaluate the potential ecological value of the measure five habitat structures were selected and examined by using the underwater cameras „Rollei 525“. Three cameras were placed around the habitat structures and three were placed at the other, unaltered bank. This approach allowed to compare and assess the fish density between the two sides. Furthermore it was possible to compare the five habitat structures with each other on the basis of predefined parameters and to frame potential differences regarding fish density and fish species.

The results show that the habitat structures provide a significant ecological benefit. They offer habitats especially for small fish species such as schneider (Alburnoides bipunctatus) to support their population. Especially the variability between fast flowing areas and flat, flow-reduced sections support the availability of specific habitats for different species. Also it turned out that there are major differences between the habitat structures regarding fish density and the number of fish species. This is probably caused by seasonal variation and preferences, abiotic factors as well as the location and type of habitat structure.

The high velocity and cool water temperature in the fish pass support the establishment of a sustainable grayling population. This fact is especially important regarding the threatened status of the grayling and the lack of habitats in the main river Isar. It shows the high water quality and good habitat availability of the fish pass. The fish pass turned also out to be a suitable habitat for ground oriented fish species such as barbelgudgen, zingel or European bullhead.

The criteria for habitat structures adding value to the fish pass do highly vary with the species targeted at. Structures with good flow conditions and clean gravel substrate in combination with the low water temperature showed excellent results for the target species of river Isar. Also the position of the structure is important to avoid deposition of fine sediments and also over a variety of water depths.

Figure 9: Structural measures for the improvement of habitat in the fishway. Top: adding of gravel; Bottom: deadwood and gravel banks

3.4. Evaluation of the effort for maintenance of the fish pass

The maintenance efforts of any fish pass are highly site specific. It depends on the elements and construction of the fish pass, the geographical location, the river type, the hydraulic conditions and many other factors. At the Test Case Altheim the effort for maintenance should be described differentiating between regular maintenance measures and ad-hoc measures, but also pointing out which measures are related to the length of the natural fish pass in contrast to general necessary tasks. Moreover the newly built habitat structures were examined regarding additional maintenance effort.

Maintenance task	Frequency	Effort related to length	Execution
Drive through on the road along the fish pass to identify major impacts like tree trunks	Weekly	Yes	Water construction expert
Walk through along the fish pass to check for drift wood, rubbish and any type of abnormality	Monthly	Yes	Dam walker
Solving of any findings (e.g. removing drift wood, trunks, rubbish)	Ad-hoc	Yes	Landscaping specialist
Removing drift wood at the entrance	Weekly	No	Landscaping specialist
Removing drift wood at the outlet	Weekly	No	Landscaping specialist
Detailed walk along the fish pass to check for stability of the construction	Yearly	Yes	Water construction expert
Refurbishing habitat structures	Estimation: 5-yearly	Yes	Landscaping specialist

The new habitat structures do not show an increase in the regular maintenance of the fish pass. Drift wood gets stuck more frequently at those structure, but does not necessarily need to be removed, as it can support the beneficial effects of the habitat. Rubbish also gets stuck more frequently at those structures, but as the structures have been implemented at locations that are accessible, removing rubbish does not cause additional effort. As the implementation took place merely a year before the examination the mid-term effort cannot be analysed yet. It is expected that the structures will need a regular refurbishment roughly every five years.

The weekly control at the fish pass is done by a dam walker. The dam walker is not only controlling the dams of the hydropower plant, but also the whole construction of the fish pass. For this task an app has been developed which is currently in use at all Uniper HPPs at river Isar. Before developing the app, the dam walkers took pictures and sent a protocol to the internal water construction expert. The new app allows better continuity within in the dam walks. The pictures can be directly related to the exact geographical position, the walks can include fixed checkpoints that need to be controlled and the protocol is directly sent to the expert and signed both by the dam walker and the expert after control.

Each dam walker gets his specific tasks assigned within the app. The app shows the routes and the specific tasks and check points in a list and also in a map view:

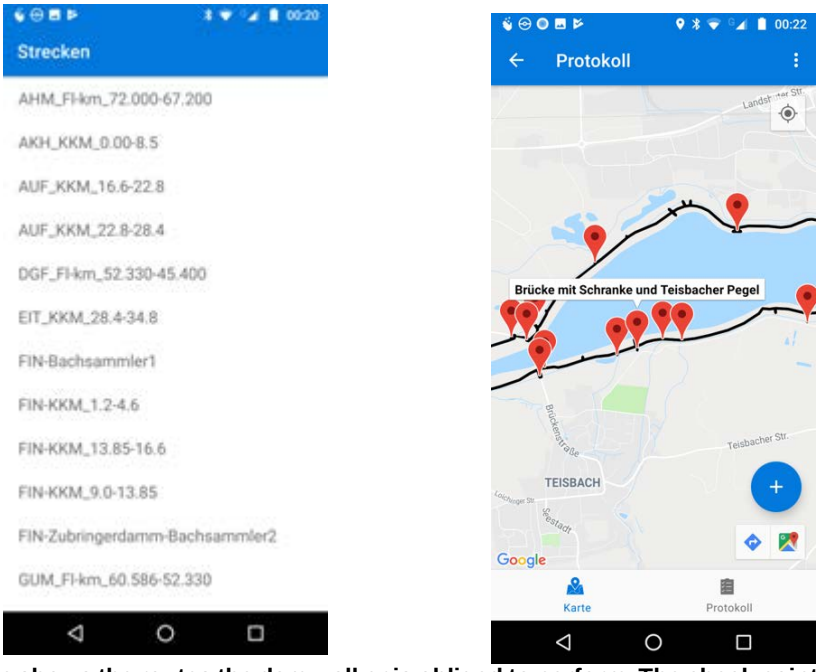

Figure 10 The app shows the routes the dam walker is obliged to perform. The check points and the protocol can be viewed on the map

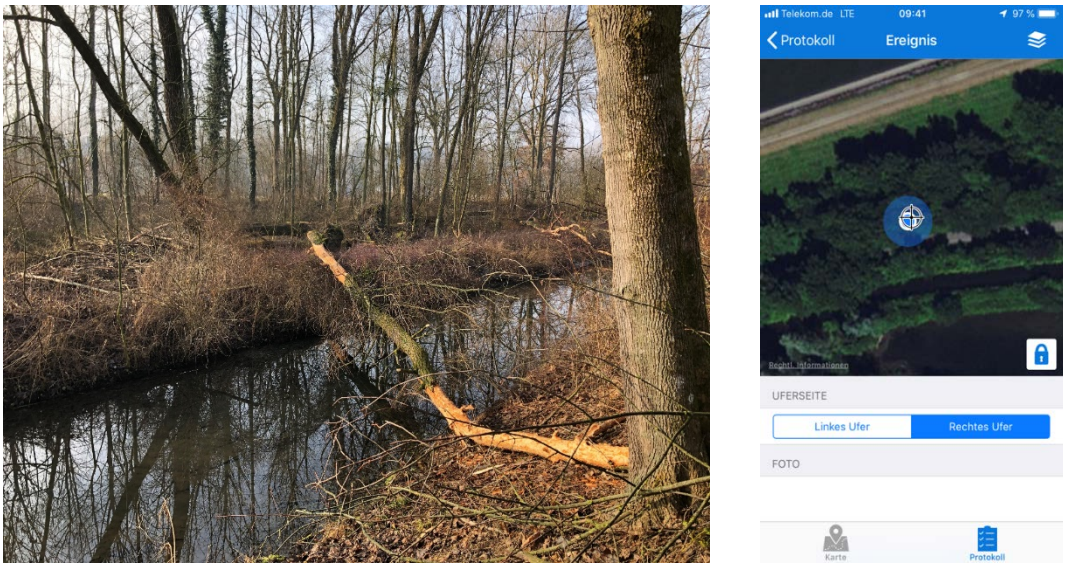

Figure 11 Upon any occasion the dam walker can create a new entry, take a picture, describe the issue and locate it on a map

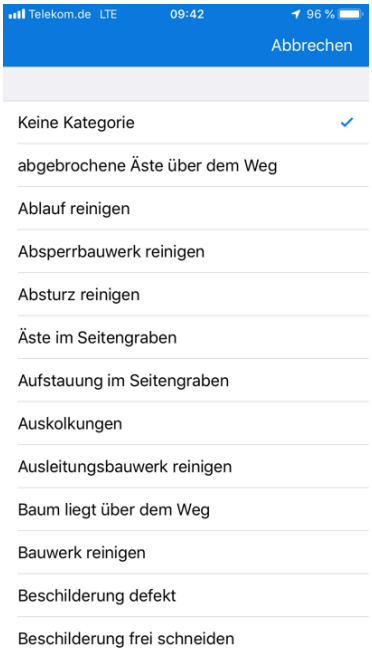

Figure 12 The dam walker can choose from a list the measures that need to be undertaken or also enter free text

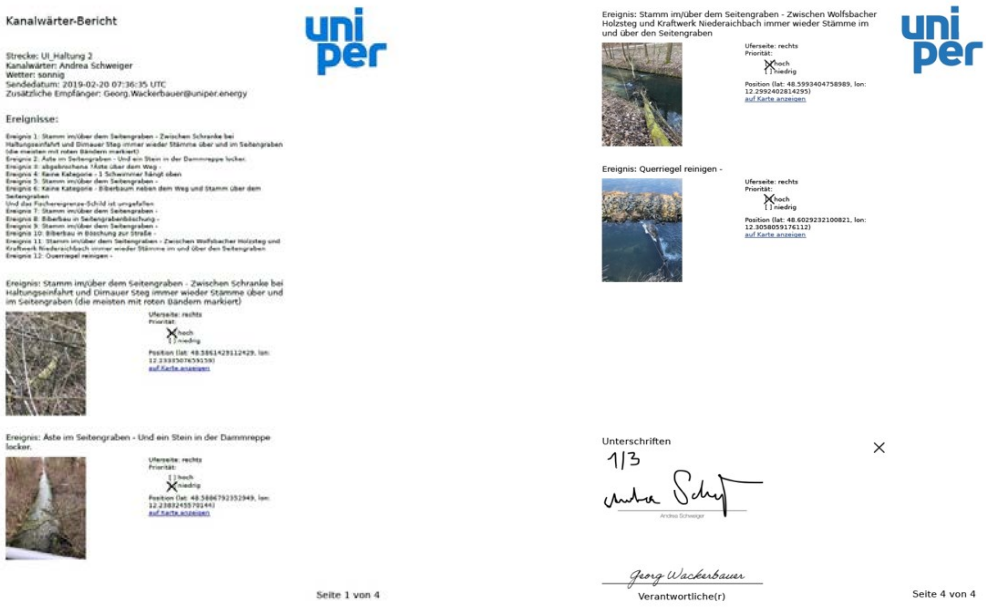

Figure 13 The protocol is sent to the expert and signed both by the dam walker and the expert.

With this protocol the water construction expert can make sure the necessary measures are taken. Either the own staff can solve the problem directly or an landscaping expert gets the order to solve the issue.

Apart from the input of the dam walkers, the fish pass is also being controlled after every flood event, but also upon hints from passengers or local fishers.

Essentially for a proper maintenance is the accessibility of the fish pass via proper roads, where also machines like excavators can pass. Trees and bushes along the fish pass are precious elements for sufficient shading of the fish pass but can also hinder the adequate maintenance and must therefore also be controlled properly.

3.5. Key findings for the planning and maintenance of natural fish ways

The works at the Test Case Altheim within the FIThydro project resulted in key findings that should be considered already in the planning phase of natural fish ways:

- Nature-like fish ways can offer the urgently needed habitats that endangered species often do not find anymore in the main river.
- In the Test Case the fish pass did already show a much higher density of the relevant fish species compared to the main river before the new habitat structures were built. The habitat structures help to support the target species The fish use the fish pass not only to migrate, but are also partly resident for a certain time within the fish pass.
- To implement habitat structures that are adapted to the different target species, it is essential that the fish pass offers a high variety of flow velocities and water depths.
- The material but also the location of the habitat structures decide over the suitability of a structure for a certain target species.
- The cost to implement habitat structures must be included already in the planning phase to get a realistic picture.
- The regular effort to maintain a nature-like fish pass increases with the length, but not with the implementation of habitat structures. Still it needs to be considered that the habitat structures are major elements that will need a refurbishment after a certain not yet defined amount of time.
- It is essential that the infrastructure for proper maintenance routines is considered in the planning phase, such as ways along the fish pass suitable for excavators, ramps at the fish pass entrance and outlet and an adequate tree cutting concept.

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