Fish passes and continuity

TYPES OF CONTINUUM INTERRUPTION

POSSIBLE SOLUTIONS

REVIEW OF FISH PASS TYPES

GENERAL CONSIDERATIONS FOR PLANNING FISHWAYS

DECISION AND CONSTRUCTION CRITERIA

MINIMUM STANDARDS

ADDITIONAL FISH WAY TYPES

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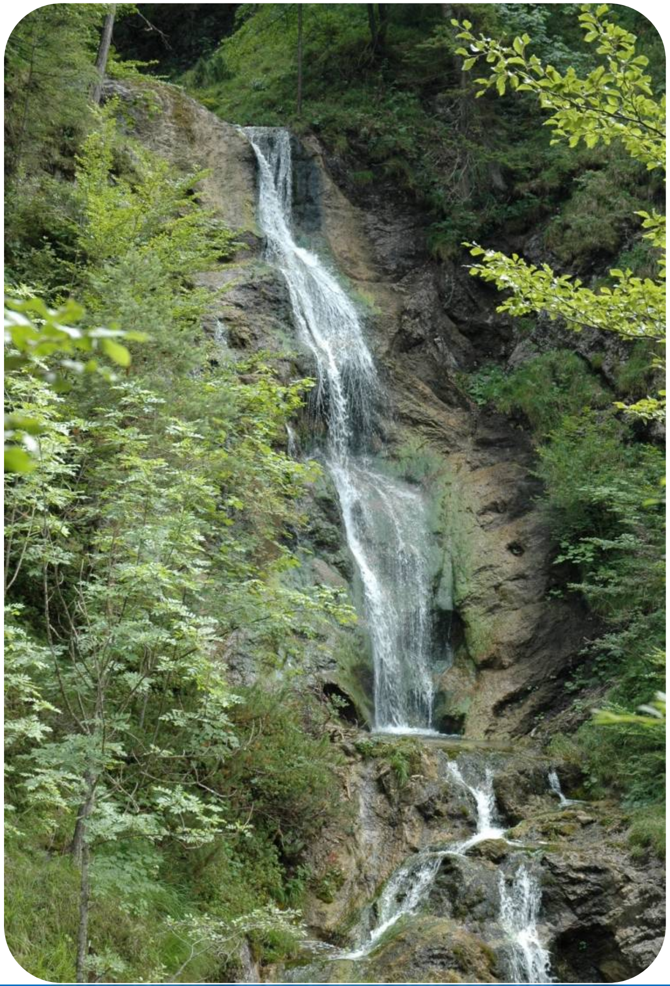
Disruption of longitudinal connectivity for fish migration:

Power plants, weirs, reservoirs

Disruption of longitudinal connectivity for fish migration:

Sills due to river regulation

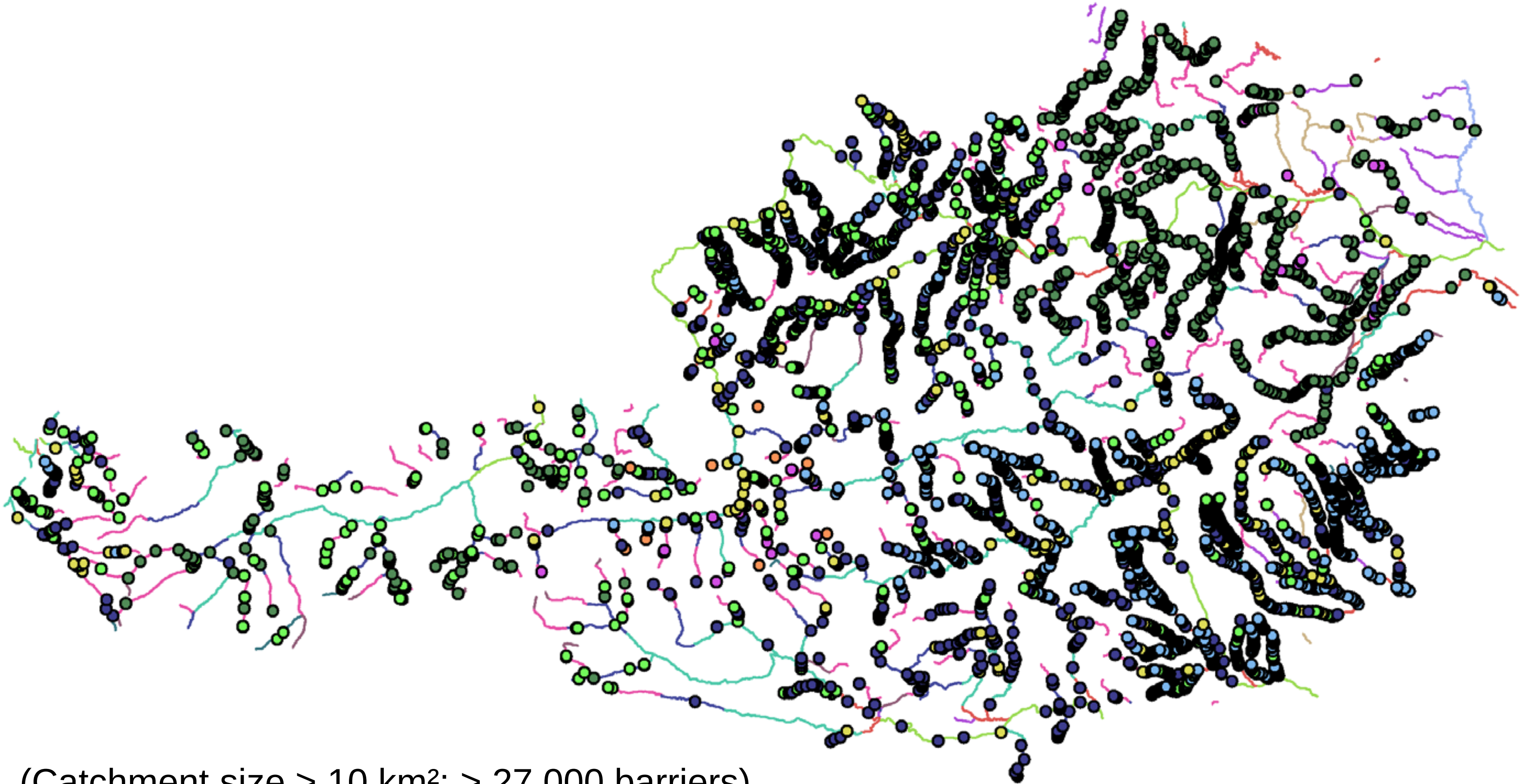
Disruption of longitudinal connectivity for fish migration:



natural sill and water falls

Migration barriers within the Austrian fluvial network >100km² catchment area:

No. of not-passable migration barriers = 3.148 (one per 3,6km)



(Catchment size > 10 km²: > 27 000 barriers)

Measures for continuity restoration:

- *Dam removal*
- *Constructions of fish passes*
  - *to enable upstream migration*
  - *and downstream migration*

To fulfill all migration needs

priority objective of a fish pass:

Highest input to obtain a good ecological status in rivers

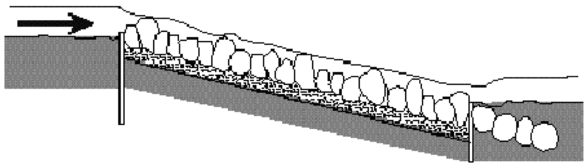
Review of types:

nature – like fishpass	technical fispass
Rock ramp *) (mainly at sills without a power plant)	Pool-type fishway
Rough channel - Fishramp *) (similar to rock ramp with pool structures, partial width rock ramp)	Vertical slot fishway *)
Nature-like bypass fishway *) or natural bypass channel *)	Denil Fishway
Nature-like pool-type fishway *)	Bristle fish pass
	Eel and elver fishways
	Trap and transport fishways
*) recommendet types	Lock Fishway

Types of rock ramps :

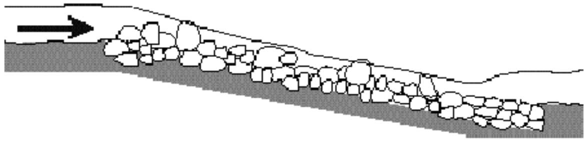
Former developed for river regulation :

- *stabalising the river bed*
- *to reduce the erosion of the river bed*
- *to increase the water level at low flow*



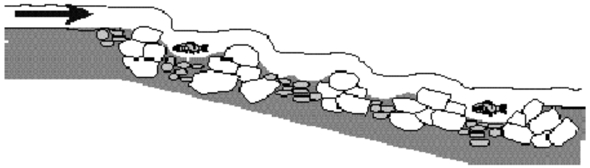
(a) Embedded-boulder construction

Single layer structure with filter layer, boulders are set clamped to each other, uniform roughness, rigid structure



(b) Rockfill construction

Loose multilayer rockfill, scour protection below necessary, elastic structure, diverse roughness, filter layer necessary



(c) Cascaded construction

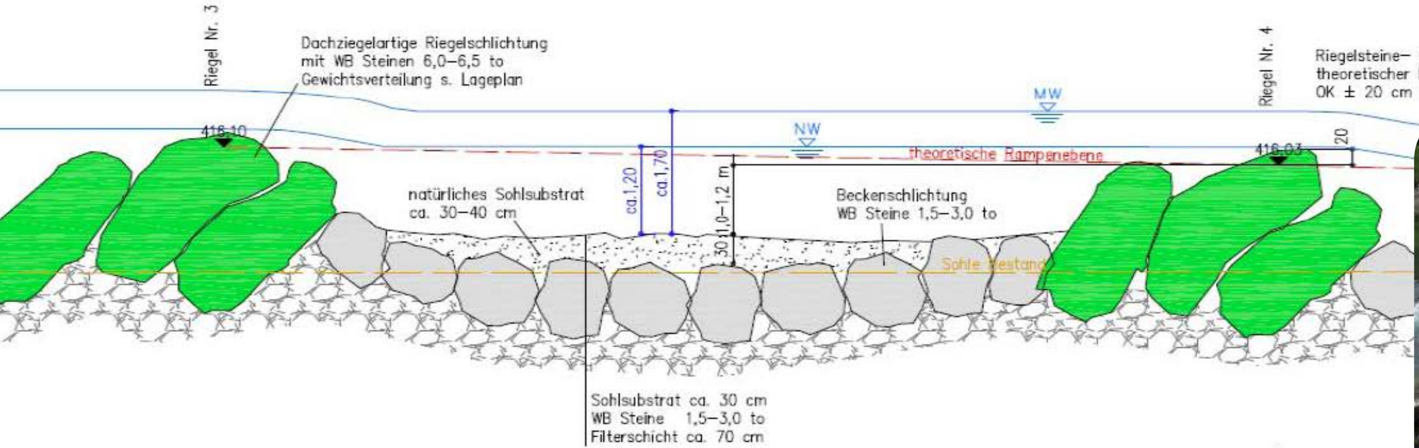
Cascaded structure forming by boulder sills, high structural variety, flow dynamics develops in basins

DVWK 232 and 118.

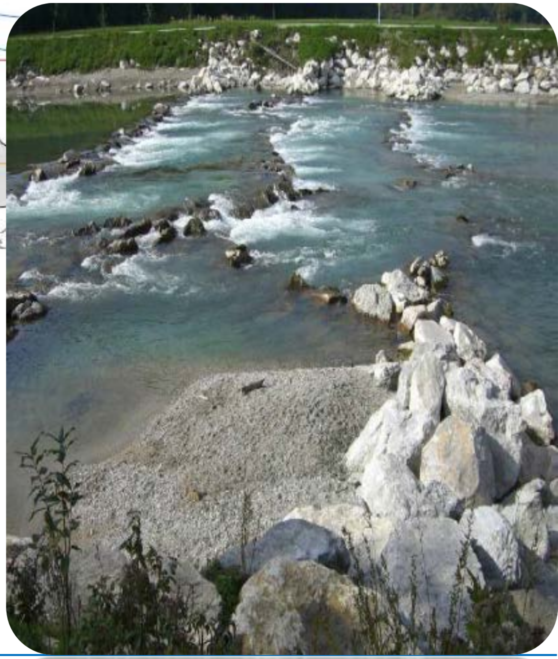
Rock ramp :

attention:

- *Large rocks and timbers are used to create pools and small falls that mimic natural structures.*

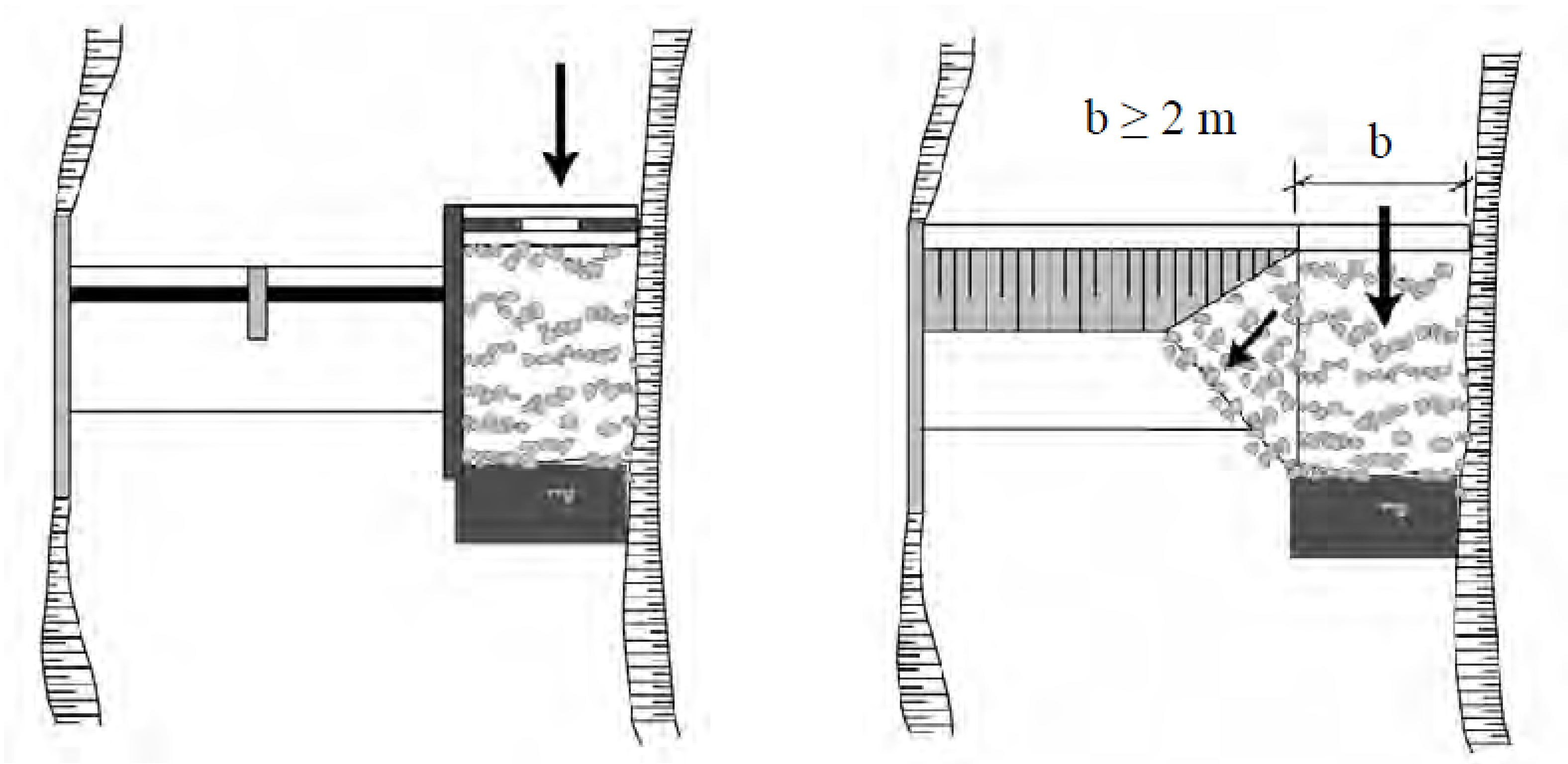


longitudinal section of a pool within the ramp (Jäger 2007)



(Foto:Jäger)

Applications of fish ramps:

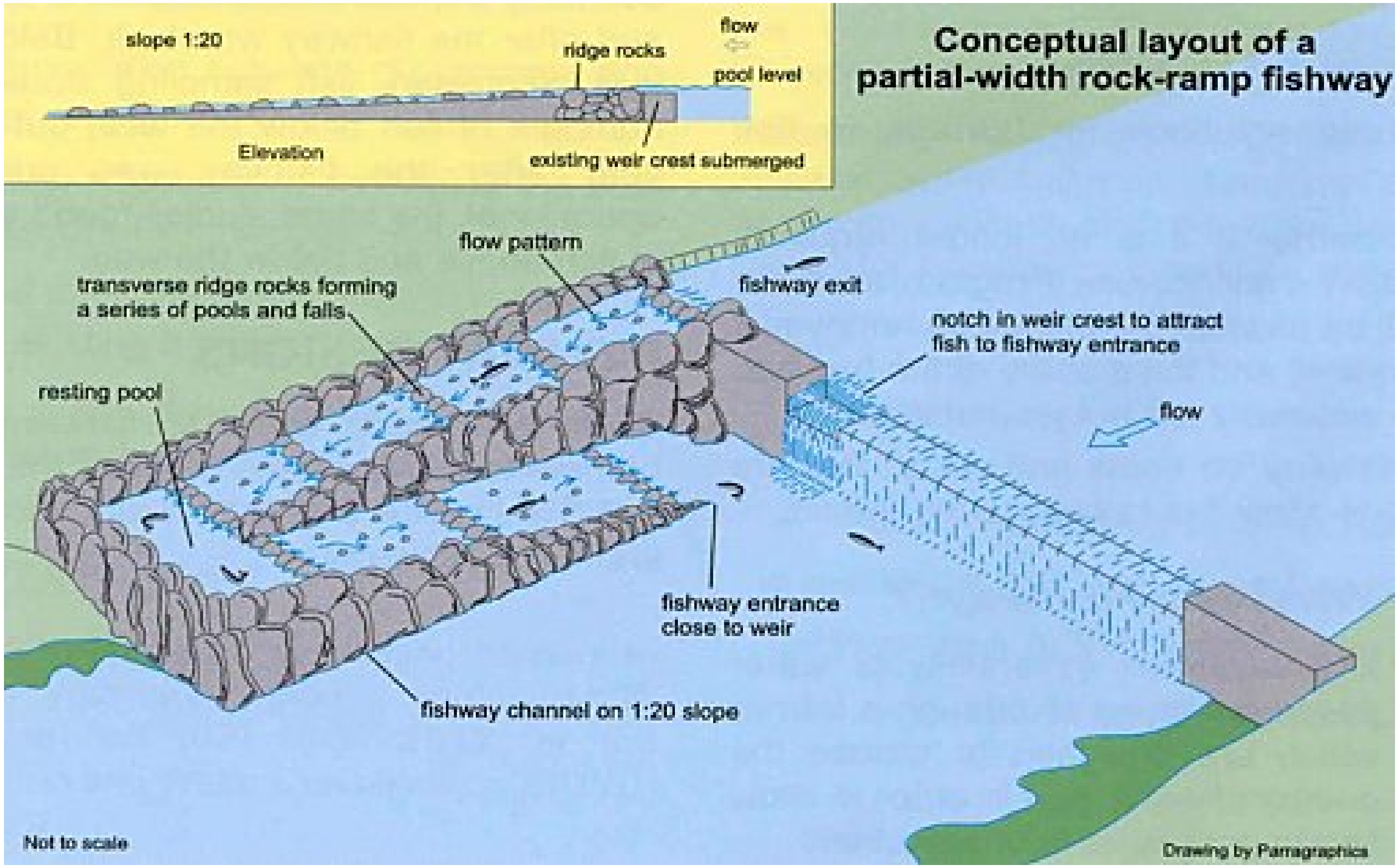


(a) at movable weir (b) at fixed weir

DVWK 232.

Rough channel (Fishramp):

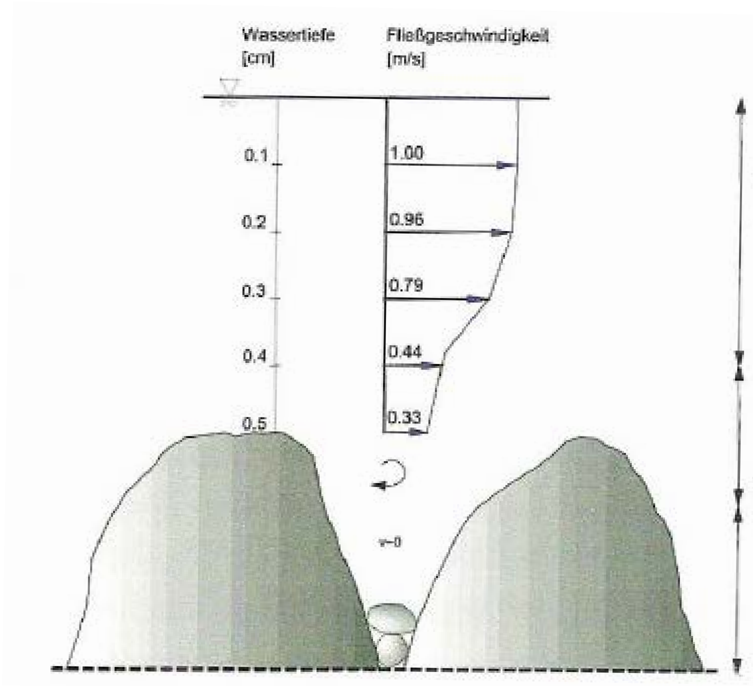
Large rocks and timbers create pools
most appropriate for relatively short barriers



NSW gov.

Rough channel (Fishramp):

Remember: different species and life stages use different patterns to migrate upstream



Corridor C
„Free water fish“

Corridor B
Small fish and juveniles

Corridor A
Small fish and juveniles
at the bottom

Velocity distribution at a rough rock sill

Gebler (2009)

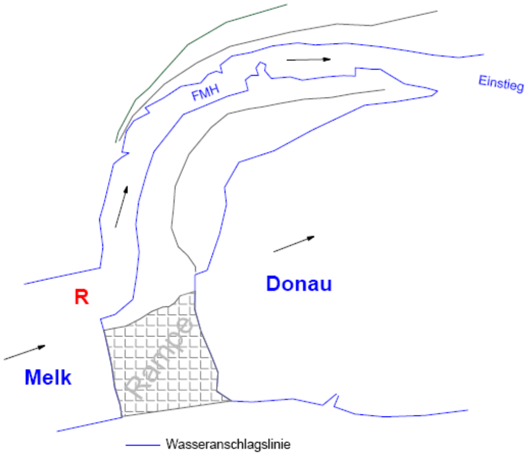
Examples for rock ramps and rough channels

Mündung Russbach

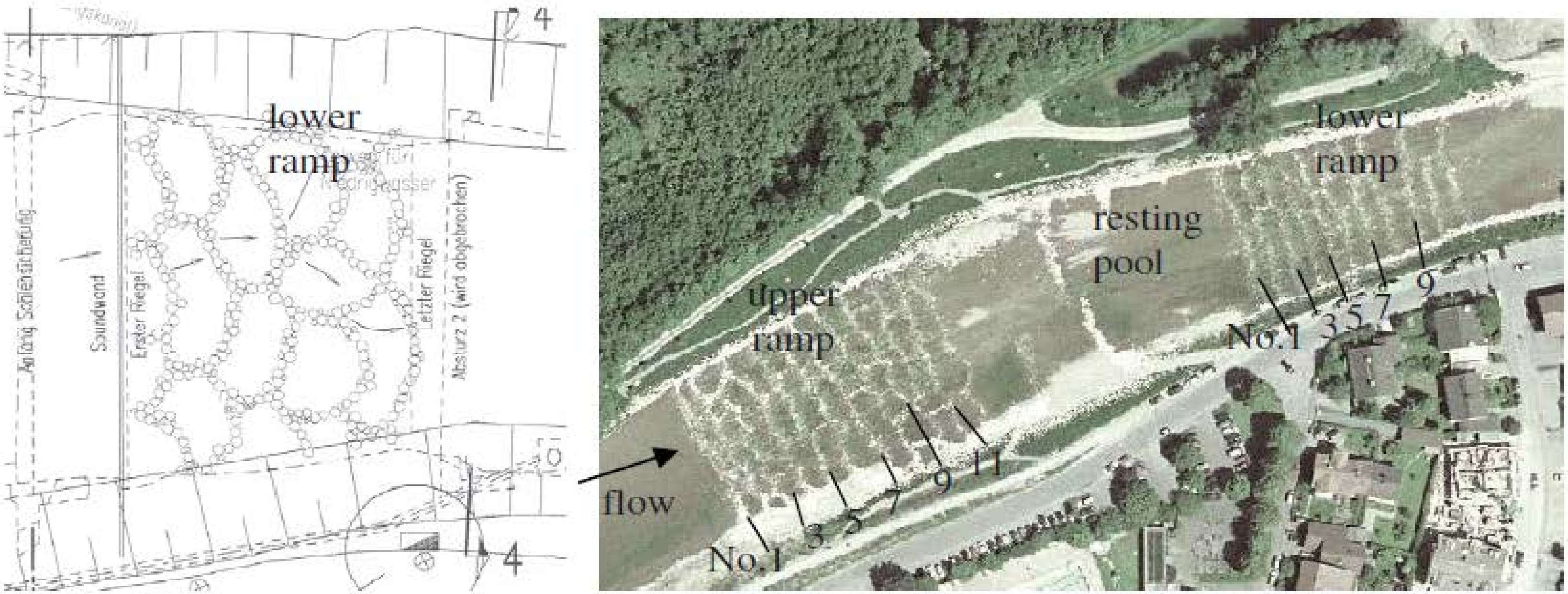
Sohlrampe Pielach

Melkrampe

Zitek et. al (2004)



Examples for a full-width ramp:



(a) blueprint

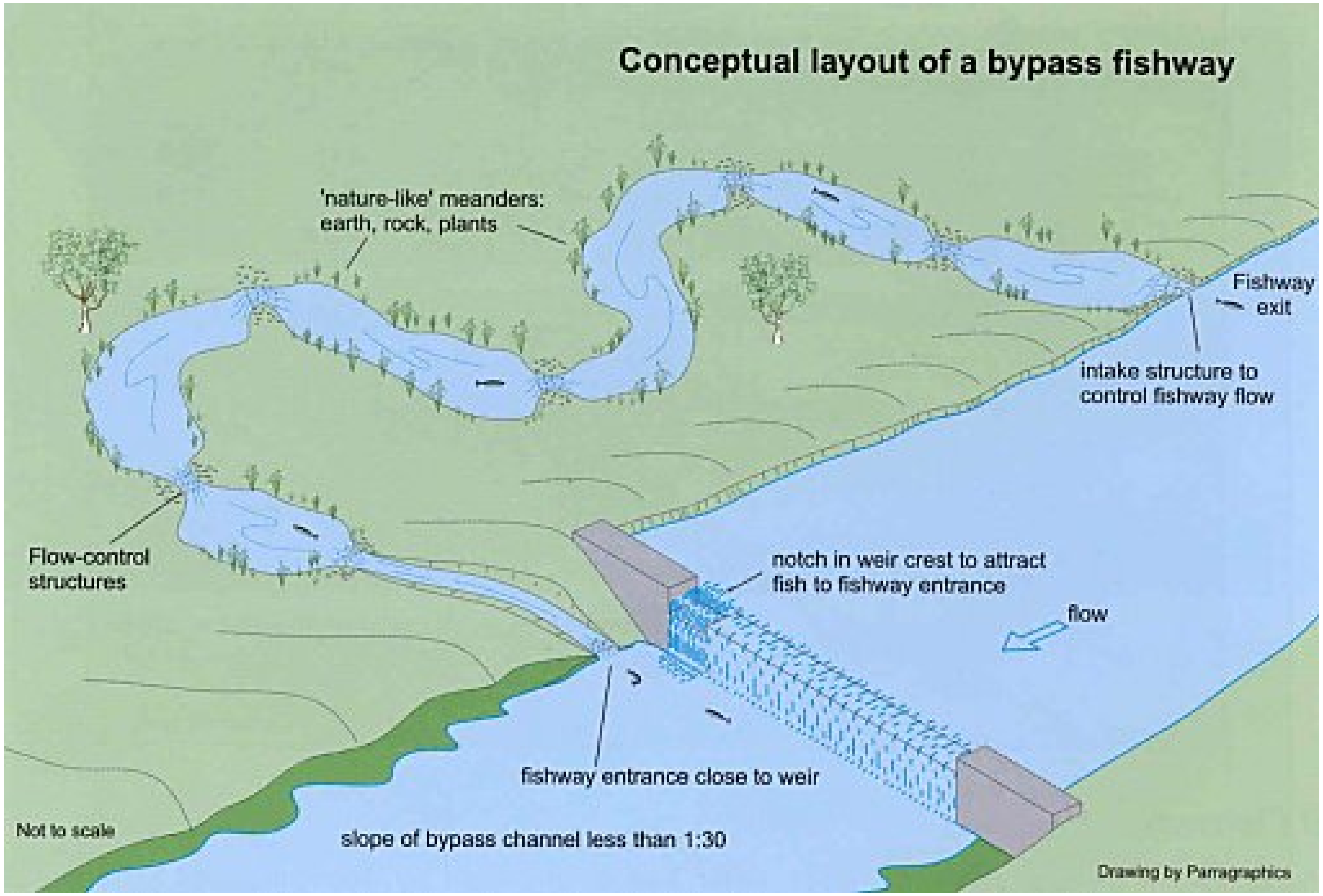
(b) Bird's eye view *in situ*

Figure 14

An example of a bottom ramp in the blueprint and after construction – the lower ramp of the full-width ramp in Kolbermoor: (a) *the ramp was designed as multiple pools to dissipate energy homogeneously during flood;* (b) *the construction is closer to a series of boulder sills in reality. Boulder sills are numbered from upstream to downstream for studying free passage (source: blueprint – Water Resources Bureau Rosenheim; photo – Bayern Viewer).*

Natural bypass channel:

Bypass fishways are low-gradient channels that mimic the structure of natural streams



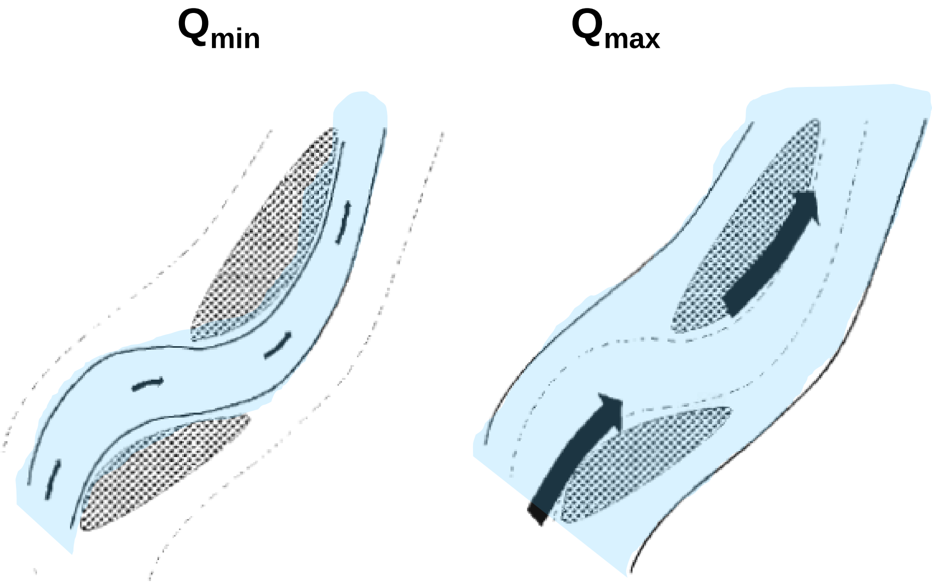
looks like an anabranch

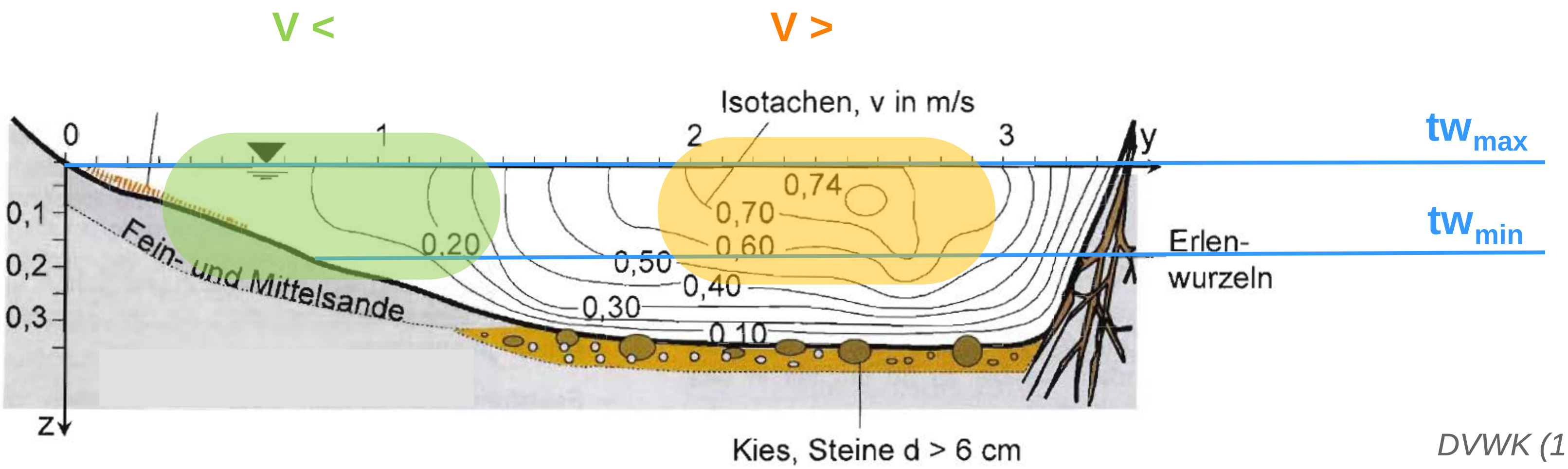
NSW gov.

Natural bypass channel:

important

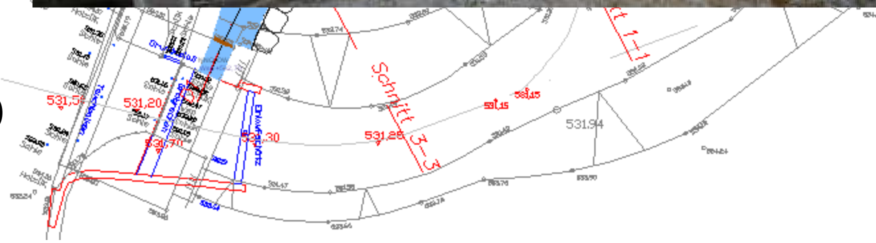
- *Passage at different flow rates possible !*
- *Nature-like meanders*
- *Rough, asymmetric cross-section*





DVWK (1996)

Natural bypass channel:



FAH KW Zwettl

Dotation: $Q = 200$ l/s
Gefälle: $I =$ max. 1:20
Sohlbreite: $b_{so} > 2{,}00$ m
Wassertiefe: $h > 0{,}20$ m
Fließgeschw.: $v_m < 0{,}6$ m/s
$v_{max} < 2{,}0$ m/s (lokal begrenzt)

Natural bypass channel:

KW Salzahammer

Nature-like pool-type fishway:

Definition:

- *consist of a series of interconnected pools bypassing an obstruction (rock sill)*

  - similar to the rock ramp with pools

Application:

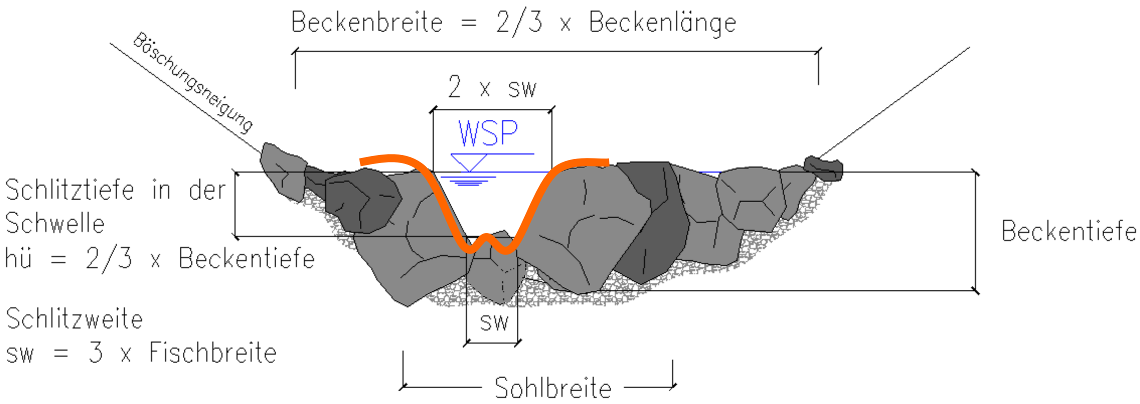
- *Higher slope than bypass channel possible,*
- *Less space needed*

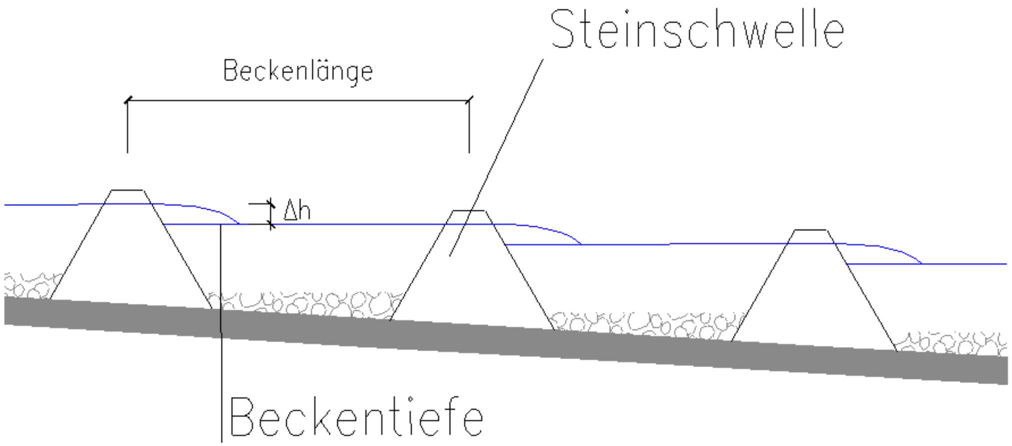
Attention:

- *Asymmetric shape of the sill between the pools*
- *Habitat like bypass channel*
- *Rough substrate needed*

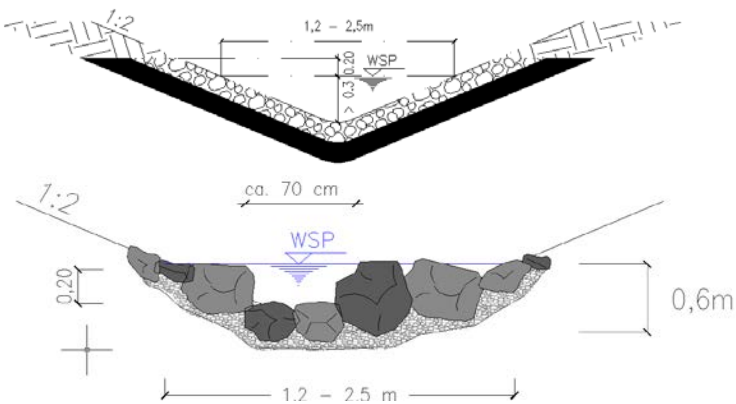
Nature-like pool-type fishway :

New W-shaped notch





Nature-like pool-type fishway:



Vertical slot fish pass:

Definition:

- A vertical-slot fish passage is similar to a pool-and-weir system
- Each "dam" has a narrow slot in it near the channel wall
- This allows fish to swim upstream without leaping over an obstacle

Application :

- Where less space is available

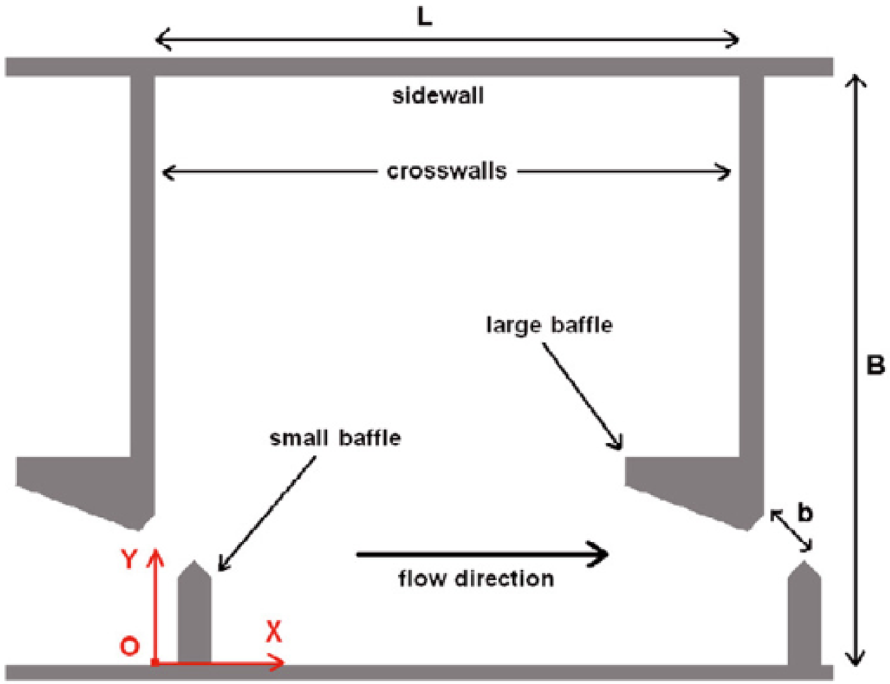
Attention:

- Pools have to be big enough to avoid high turbulence
- Crosswalls with baffles cause flow deviation
- Rough Substrate on the bottom

KW Murau – Dotation gestaffelt (Fotos ezb)

Vertical slot fish pass:

top view - pool



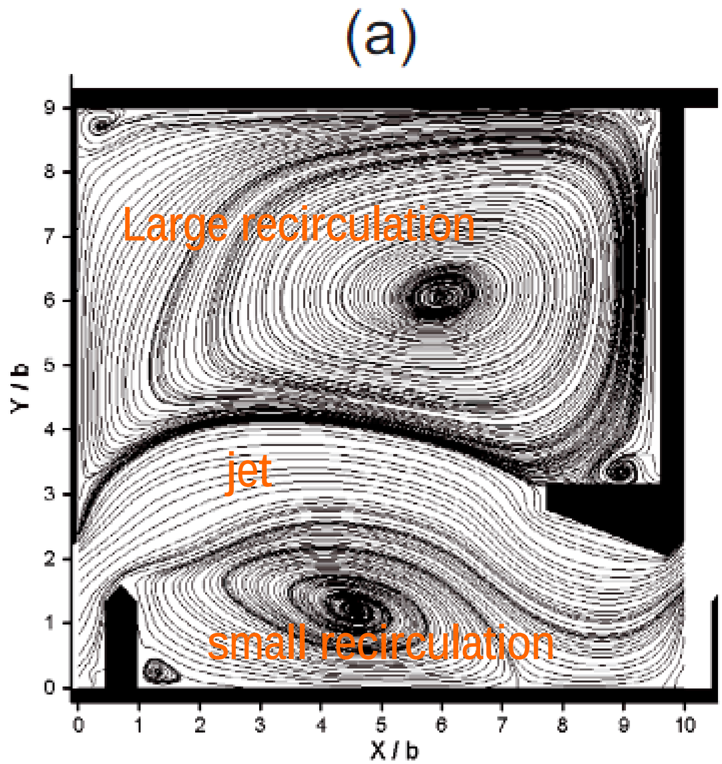
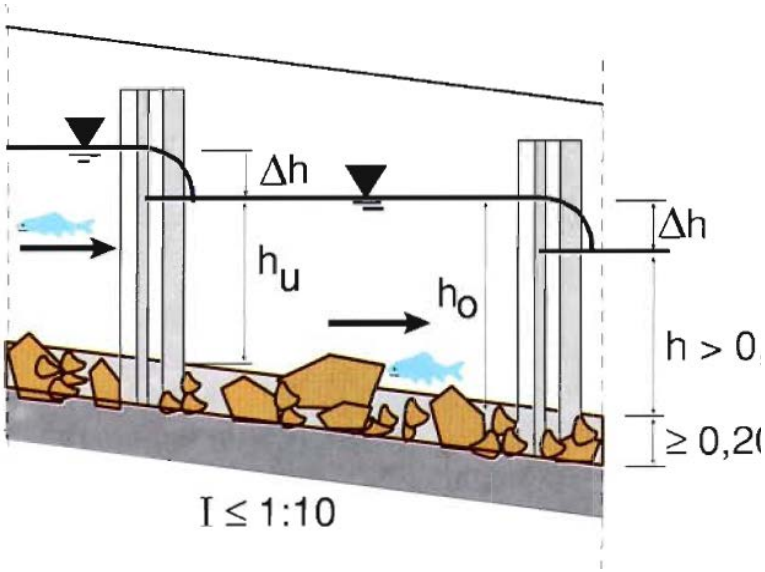


Figure 3
Topology of mean flow in the pool

Schlitzpass (vertical slot):

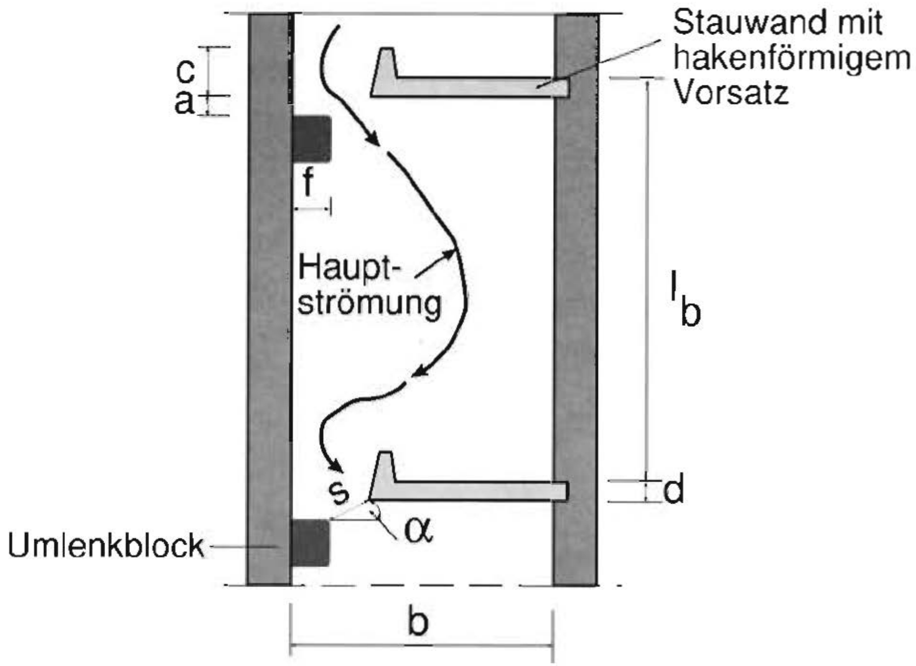
Längsschnitt

Schlitzpass (Beckendetail)

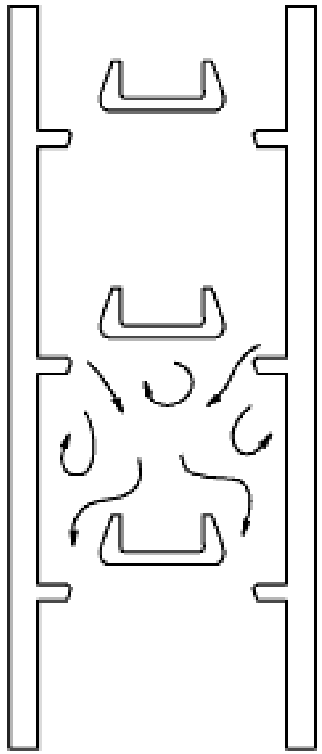


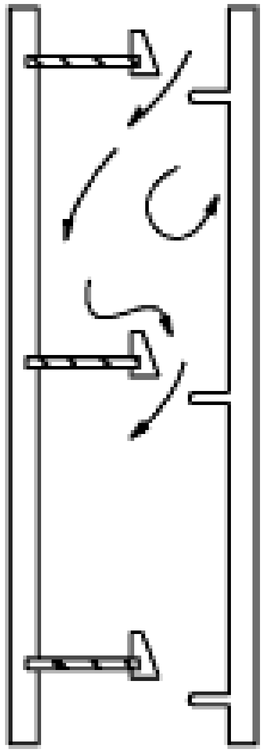
Draufsicht

Schlitzpass (Beckendetail)



Vertical slot fish pass:





top view – single and paired vertical slot fishway

Vertical slot fish pass:

Comparision of flow deviation

General requirements for fully functional fishways :

The aim of a fish passage facility is to attract migrants to a specified point in the river, downstream of the obstruction, and then to induce them, or even make them, pass upstream.

- *Findability and passabilty for all species and life stages*

  (~ 330 days a year, except during low flow and high flow conditions)

- *Correct or best location of the fishway in order to attract fish to the entrance*

- *Entrance close to the obstacle*

  (but downstream the turbulent zone)

- *Attraction flow 1-5 % of river discharge (MQ); depends on river size*

General requirements for fully functional fishways :

- *No barriers or sills at the entrance and exit (in german “Sohlanbindung”)*

  Connection to river bottom

- *Minimum residual flow – fishway discharge (especially at small hydro power plants)*

- *Fishway intake structure – inlet structure (adjustable, regulable, controllable)*

ATTRACTIVITY OF FISH PASSAGE FACILITIES:

In order for a fishway to be effective it is necessary for the migratory fish to find the entrance with as little delay as possible.

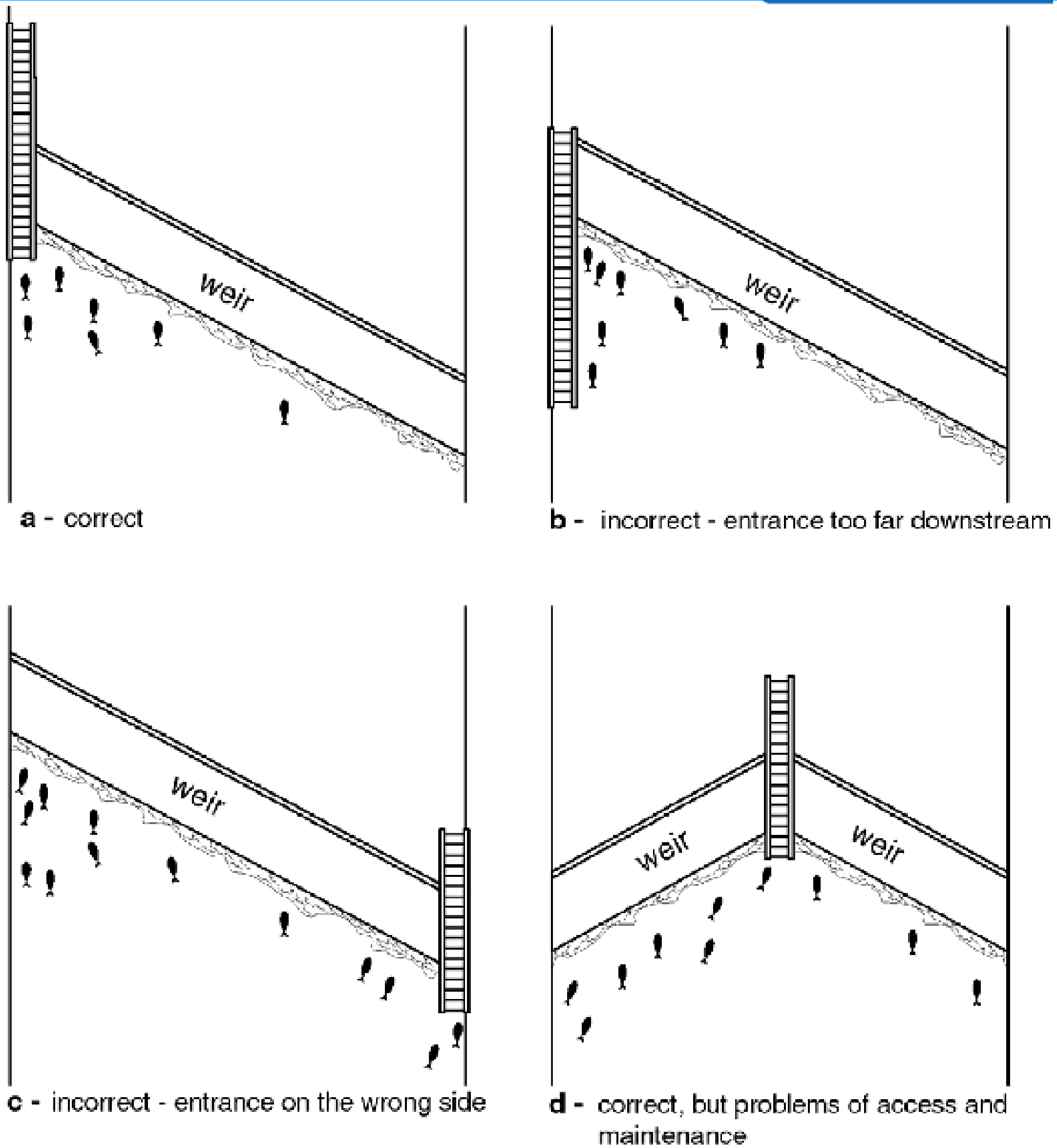
(fish entrance, i.e. the downstream end of the fishpass)

- *Considerations*
  - *the only stimulus to guide is the flow pattern*
  - *no turbulence*
  - *no recirculating zones*
  - *no static water*

Location of fishway

<u>*FACTORS INFLUENCING THE CHOICE OF LOCATION OF A FISHWAY:*</u>

- on or near the riverbank is preferable
- as far upstream as possible



oblique weir
Larinier (2002)

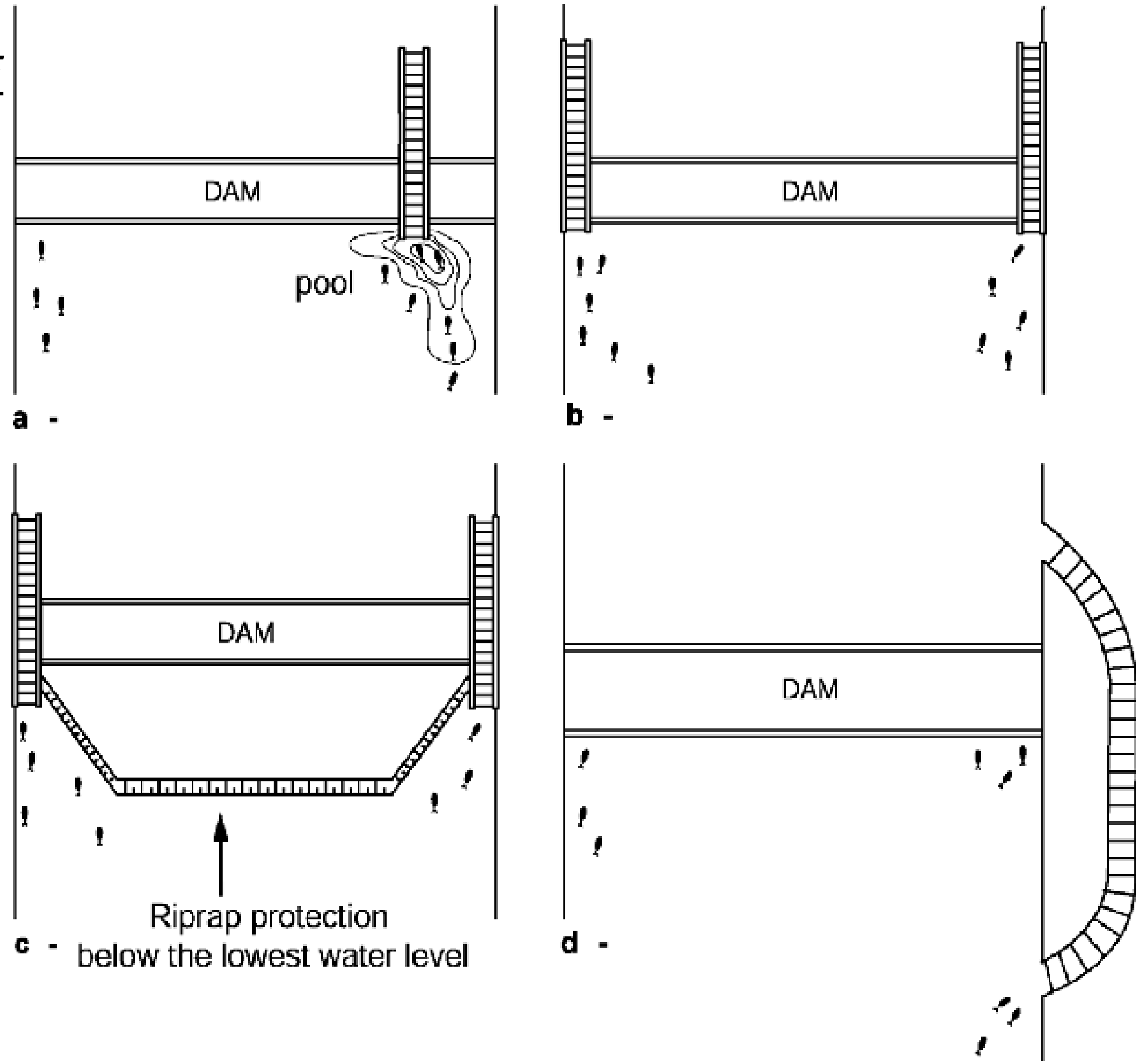
FACTORS INFLUENCING THE CHOICE OF LOCATION OF A FISHWAY:

- Entrance close to the pool (a)
- When obstruction is very wide – then 2 fishways (b)
- Modify the morphology of the riverbed downstream

  rip rap (c)
- Entrance far downstream – compensate with higher discharge (d)

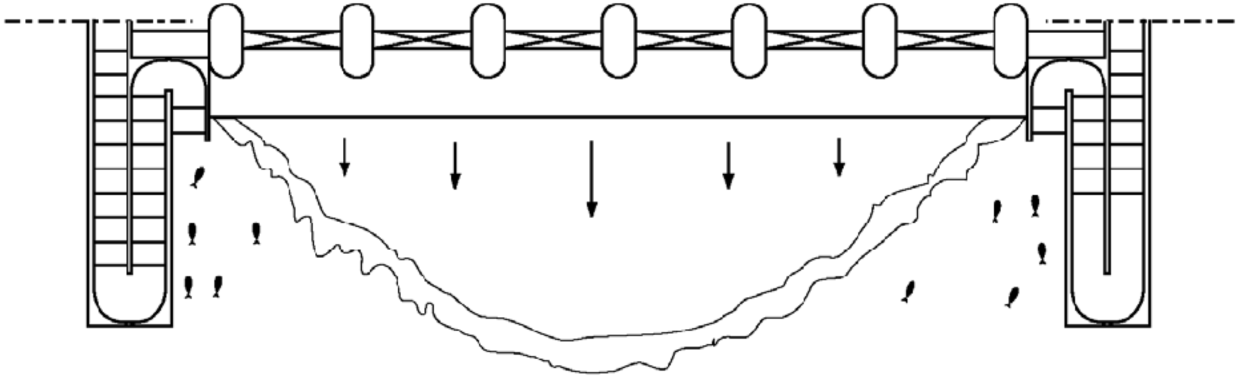
Weir at right angle to the direction of river flow

Larinier (2002)

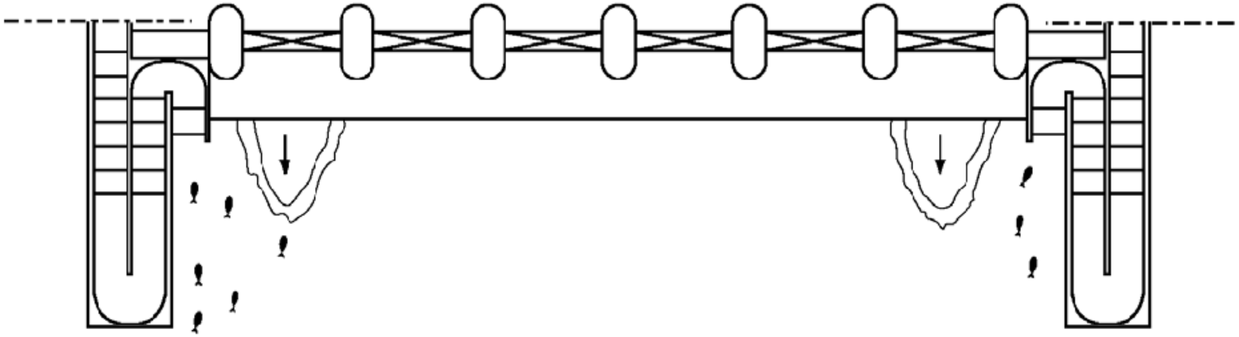


HYDRAULIC CONDITIONS AT THE ENTRANCE:

Flow patterns



a - Optimum discharge arrangement during high flow periods

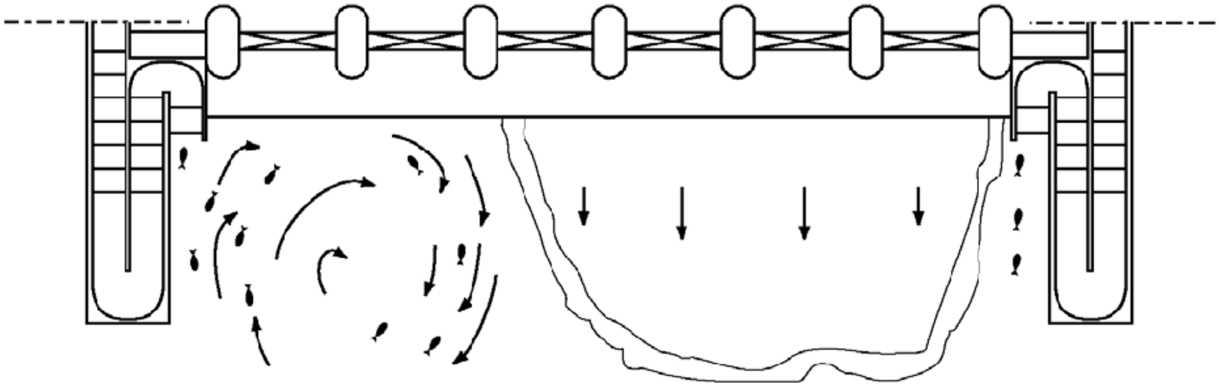


b - Optimum discharge arrangement during low flow periods

Larinier (2002)

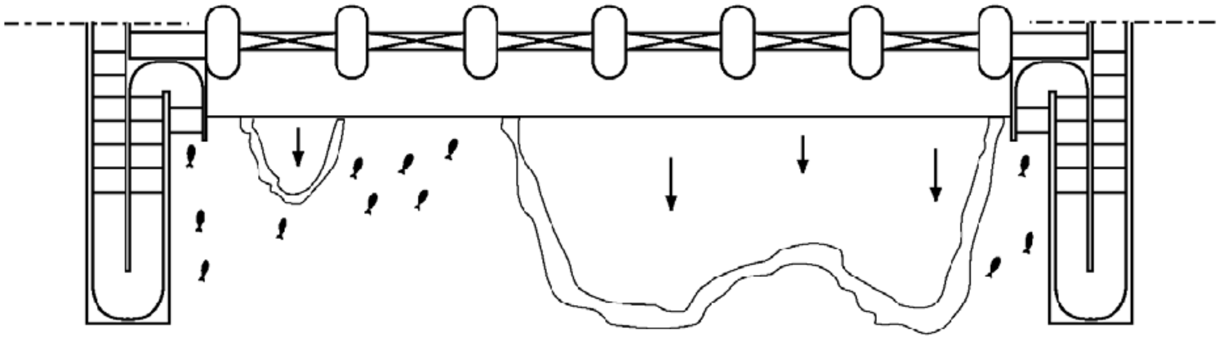
HYDRAULIC CONDITIONS AT THE ENTRANCE:

Flow patterns



X

c - Discharge arrangement to be avoided (recirculation eddy)



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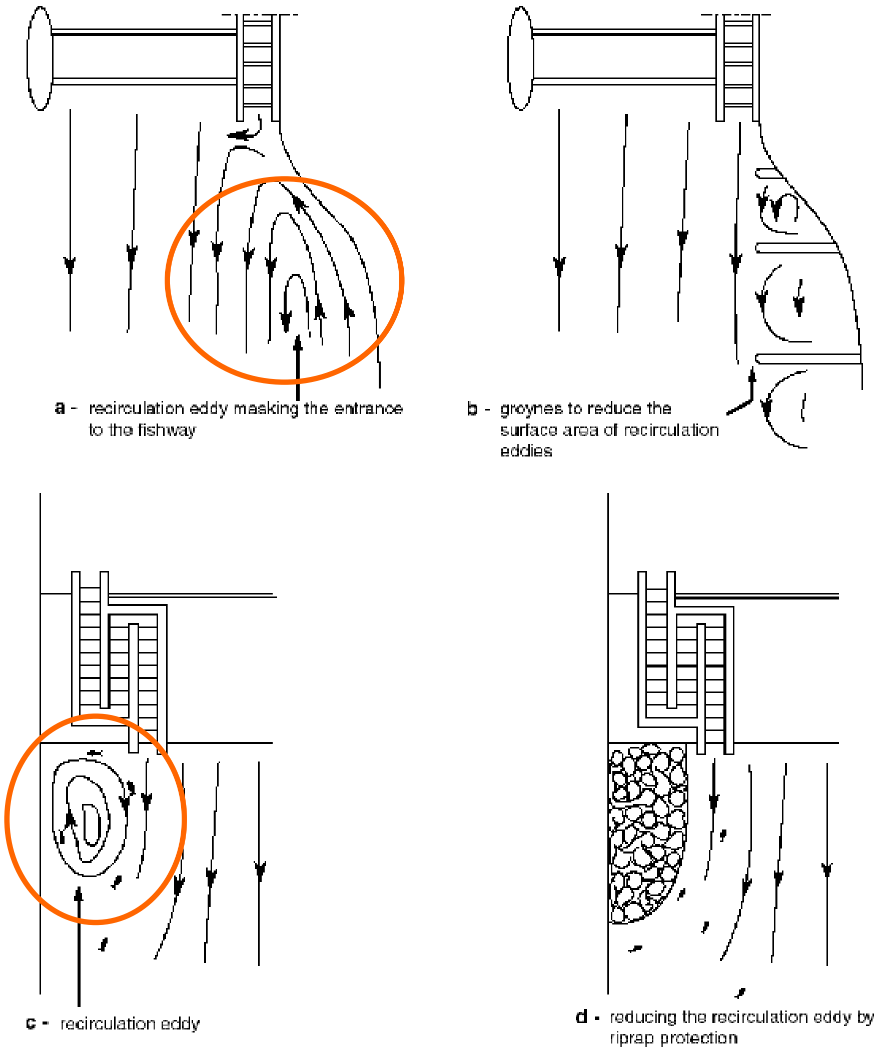
d - Discharge arrangement to be avoided : static water zone next to a fast flowing zone

Larinier (2002)

<u>HYDRAULIC CONDITIONS</u>

<u>AT THE ENTRANCE:</u>

Flow patterns

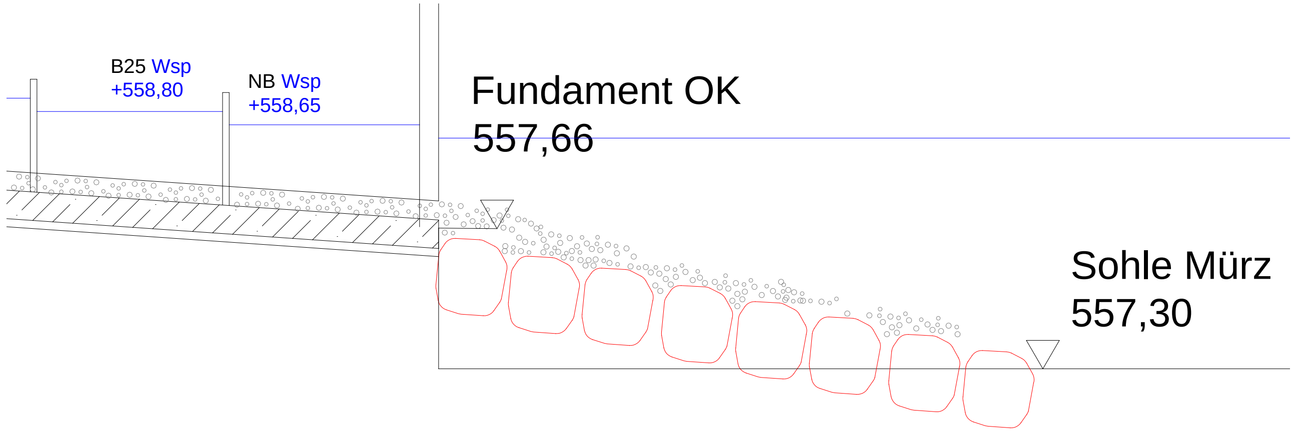


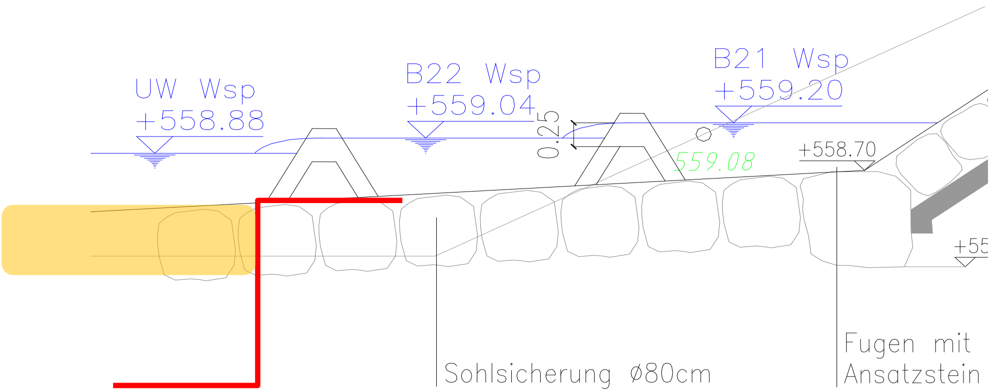
Larinier (2002)

Figure 6: Plan illustrating the principle of reducing recirculation eddies with groynes and riprap protection.

No barriers or sills at the entrance and exit

Anrampung von Sohlstufen in die FAH





<u>Important decision criterion:</u>

(1) New construction

assessment appropriate to the state of the art

- *Objective is to achieve at least level 2 „functioning“*
  Minimumcriteria:
  Findability and passabilty for all key species (Leitarten, typ. Begleitarten)
- *Fishregion approach*
  (Leitbild gem. Leitfaden BMLFW)
- *Operative specific values from guidelines and literature*
  (DVWK 1996, Handbuch Querbauwerke, Larinier, Jens, Gebler, etc.)
  <u>Austrian fish pass guideline</u>

definition of fishway minimum size:

- *According to fish species, fish size - Fish species with the biggest size*
  maximum swimming capacity of all fish
  minimum conditions relating to water depths…

  („größenbestimmende / maßgebende Fischart“)

- *Size of fishway depends on river type and river size*
  (1-5% attractive flow)

(Austrian fish pass guideline)

Construction criteria

<u>*specific values:*</u>

- *Pool length*

  Length 3 x length of maximum fish length

  >100 cm

- *Pool width*

  Width 2 x length of maximum fish length

  >70 cm

- *Avoid plane cascades and drops;*

- *Maximum height difference among pools (Δh – drop, maximum head difference)*

Epirhithral (Upper trout region)	*max. 0,20 m*
Metarhithral (Lower trout region)	*max. 0,18 m*
Hyporhithral (Grayling region)	*max. 0,15 m*
Epipotamal (Barbel region)	*0,10 - 0,13 m*

specific values:

- *max. flow velocity (slot and notch)*

Epirhithral (Upper trout region)	*2,0 m/s*	
Metarhithral (Lower trout region)	*1,9 m/s*	
Hyporhithral (Grayling region)	*1,7 m/s*	
Epipotamal (Barbel region)	*1,4 - 1,6 m/s*	*(rounded values)*

- *min. slot width / also for nature-like pool-type fishway)*

Epirhithral (Upper trout region)	*0,15 m*
Metarhithral (Lower trout region)	*0,20 m*
Hyporhithral small (Grayling region)	*0,20 m (MQ <2 m³/s)*
Hyporhithral large (Grayling region)	*0,25 m (Danube salmon 0,30 m….)*
Epipotamal small (Barbel region)	*0,20 m*
Epipotamal medium (Barbel region)	*0,25 m (Pike 0,30 m, Danube salmon 0,35 m)*
Epipotamal large (Barbel region)	*0,35 – 0,50 m (Danube 0,60 m)*

specific values:

- *Minimum water depth at the notch*

Epirhithral (Upper trout region)	*0,40 m*	
Metarhithral (Lower trout region)	*0,40 – 0,50 m*	
Hyporhithral (Grayling region)	*0,50 – 0,70 m*	
Epipotamal (Barbel region)	*0,46 - >1,00 m*	*(rounded values)*

- *Minimum water depth at the slot*

Epirhithral (Upper trout region)	*0,50 – 0,70 m*	
Metarhithral (Lower trout region)	*0,70 – 0,80 m*	
Hyporhithral (Grayling region)	*0,70 – 1,10 m*	
Epipotamal (Barbel region)	*0,65 - >1,65 m*	*(rounded values)*

specific values:

- Turbulence - volumetric dissipated power

Epirhithral (Upper trout region)	*160 W/m³*
Metarhithral (Lower trout region)	*130 -140 W/m³*
Hyporhithral (Grayling region)	*120 W/m³*
Epipotamal (Barbel region)	*100 W/m³*

Each specific value is to be considered separately;
and is definite ruling the dimensioning of the fishway!

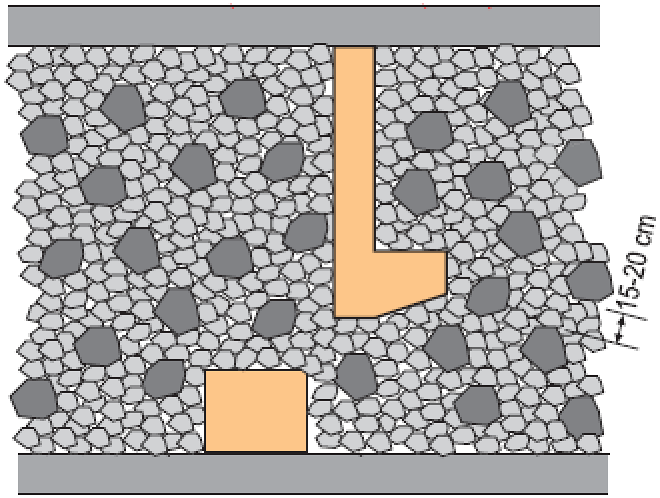
Recommended discharge:

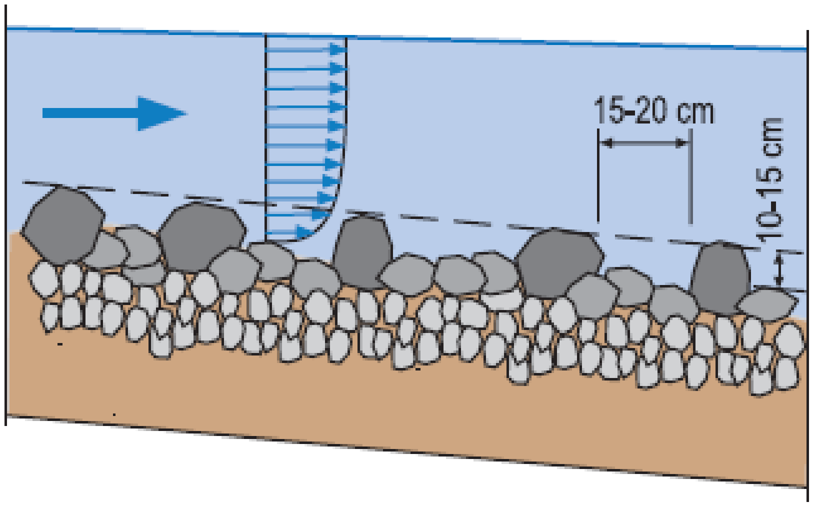
power plant typ	flowrate fish pass and attractive flow	kind of discharge
diversion plant	minimum flow	via fish pass
	dynamic discharge	via fish pass or additional pipe / channel to the entrance
river power plant (run-of-river hydroplant)	fishway minimum size	base flow via fish pass
	attractive flow 1-5% of river flow (from mean annual low flow till design flow of the plant)	via fish pass or additional pipe / channel to the entrance

Substrate:

Rough bottom substrate; all fishway types!

- *Migration of invertebrates*
- *Reduction of flow velocity at the bottom*





<u>Intake structure:</u>

Requirements:

- *Maintaining the flow rate*
- *Controllability – at graduated flow*
- *Compensate different water level (water surface elevations)*

  sometimes several intake structures are needed

- *To restrain floating debris*
- *Shutoff device when maintenance is needed*
- *High flow safety*
- *Passability to headwater*

Intake structure:

1) skimming wall (Tauchwand)
2) Slot

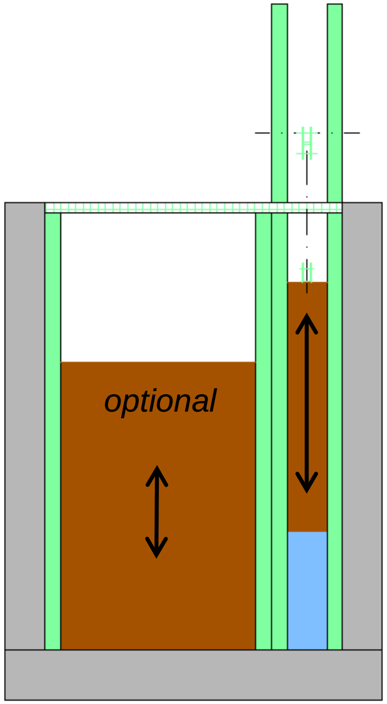
Intake structure:

(compensate different water level)

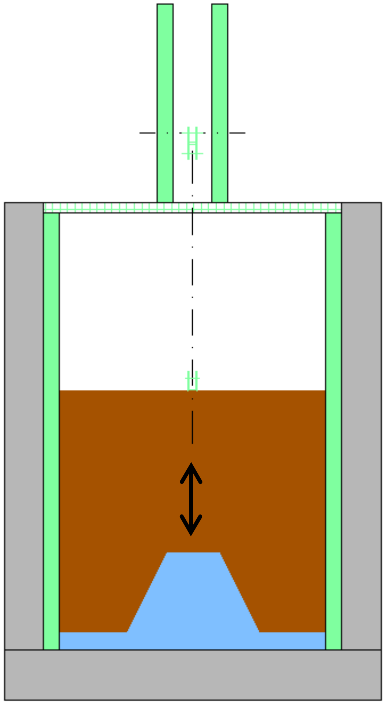
(1) *vertical slot (3 slots) is the intake structure*
(2) *submerged orifice (controllable)*
(3) *variable slot width*

Submerged orifice:

Slot *Trapezoid* *Flat design*



$depth_{max}$ >



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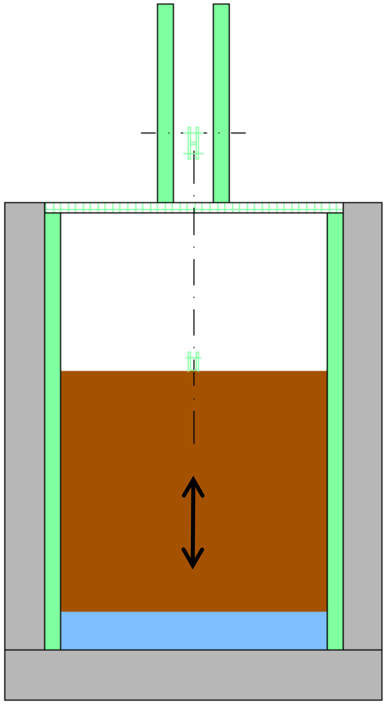


$depth_{max}$ < !!!

Sediment transport and maintenance:

Rock ramp ; Nature-like bypass fishway :

- *Dynamic sediment balance (erosion and sedimentation, almost no blockage due to floating debris)*

Vertical slot:

- *High risk of blockage and clogging (floating debris and sediment!)*

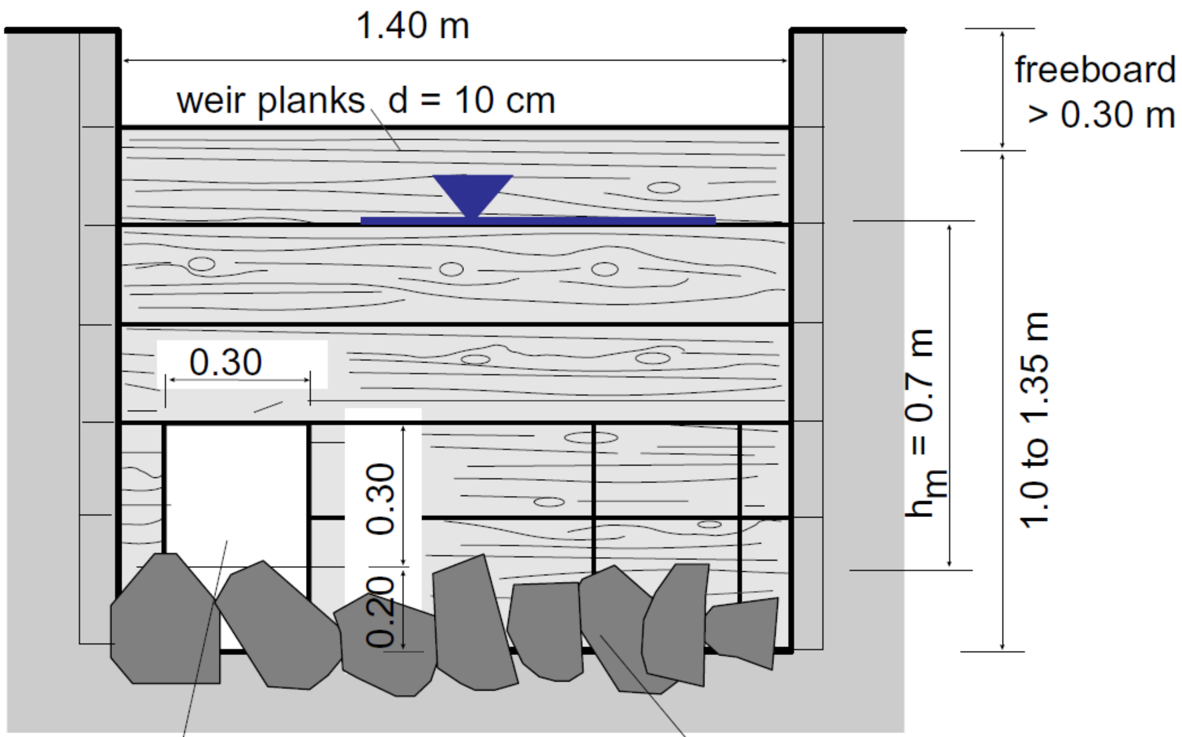
fishway has to be maintained regularly!!!

Review of types:

nature – like fishpass	*technical fispass*
*Rock ramp *)* *(mainly at sills without a power plant)*	*Pool-type fishway*
*Rough channel - Fishramp *)* *(similar to rock ramp with pool structures,* *partial width rock ramp)*	*Vertical slot fishway *)*
*Nature-like bypass fishway *)* *or natural bypass channel *)*	*Denil Fishway*
*Nature-like pool-type fishway *)*	*Bristle fish pass*
	Eel and elver fishways
	Trap and transport fishways
**) recommendet types*	*Lock Fishway*

Pool-type fishway:

Cross-section through the pools

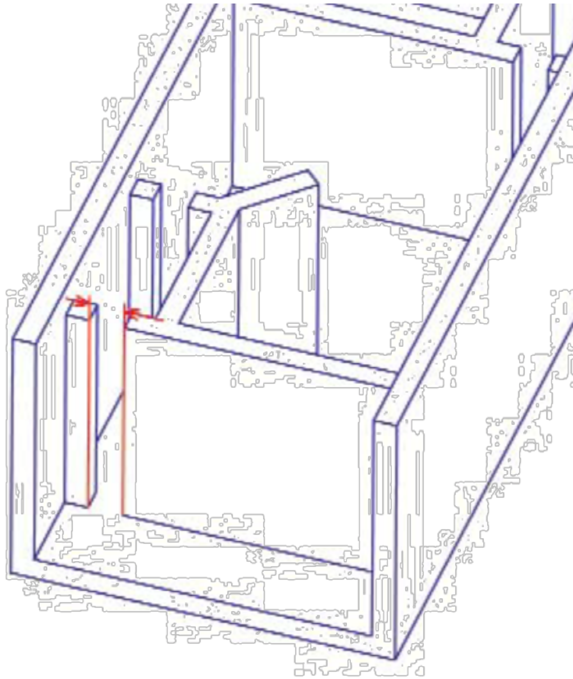


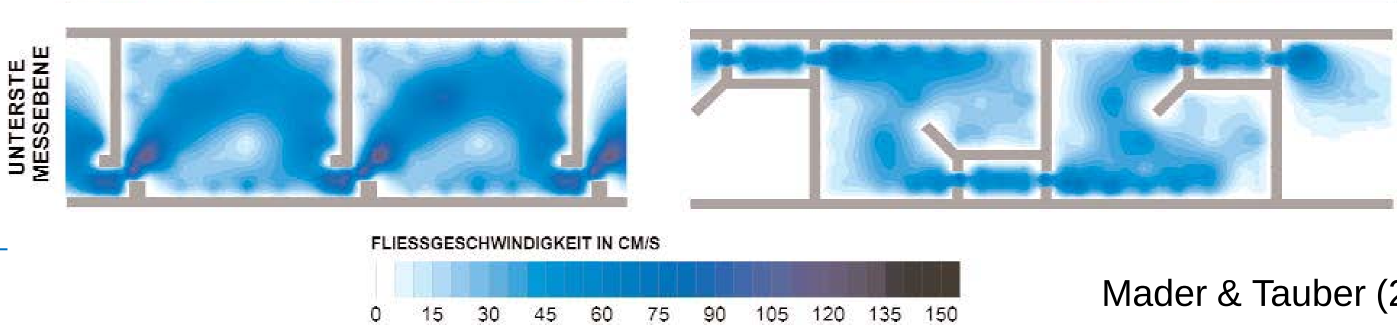
submerged orifices
30 × 30 cm,
arranged alternately

bottom substrate: boulders d = 30 cm,
pressed to a depth of 10 cm
into concrete before it sets

Vertical slot fishway - enature® FISHPASS:

NEUER MULTISLOT - E²MS

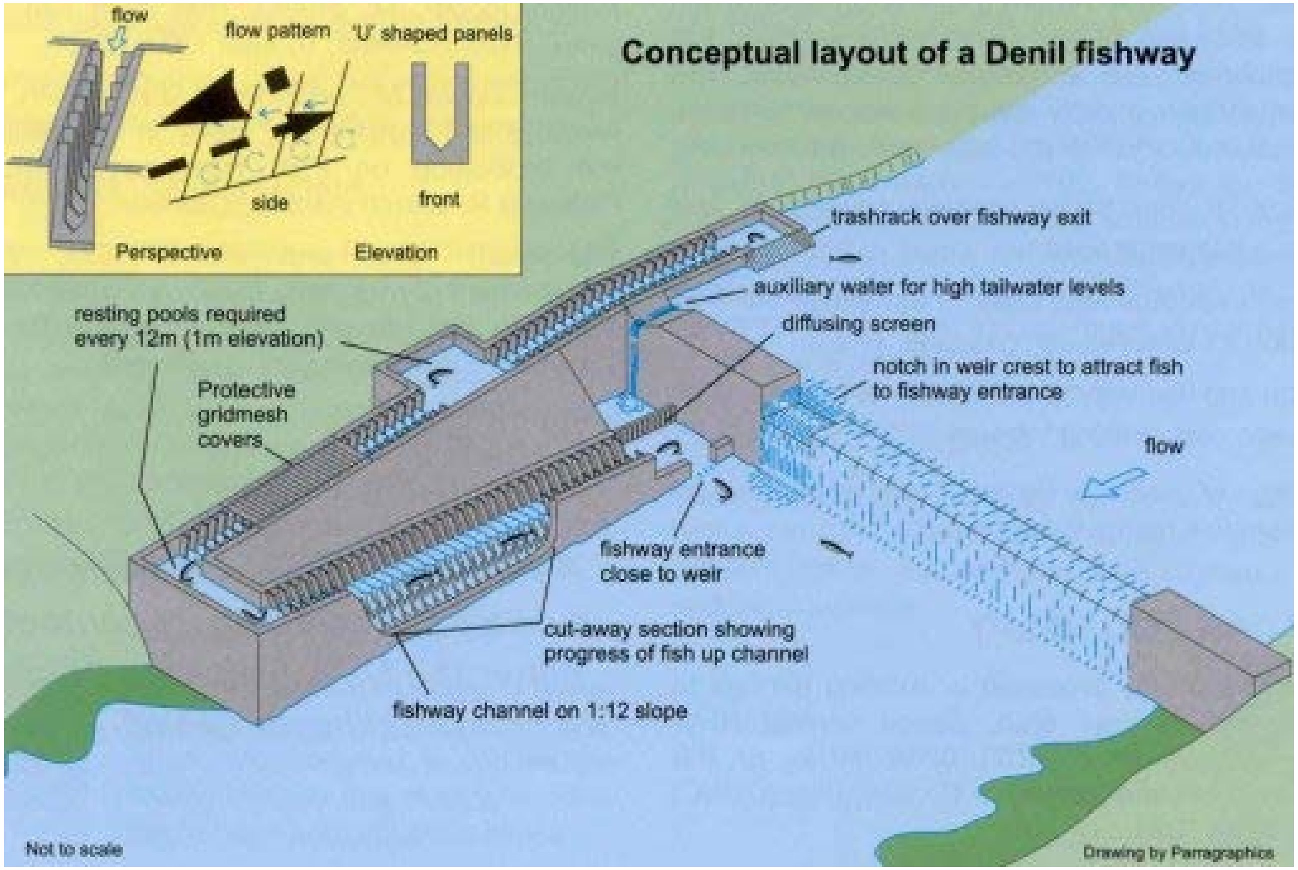




Mader & Tauber (2010)

Denil Fishway (baffle fishway):

*This style of fishway uses **a series of symmetrical close-spaced baffles in a channel** to redirect the flow of water, allowing fish to swim around the barrier.*



NSW gov.

Denil Fishway

(baffle fishway):

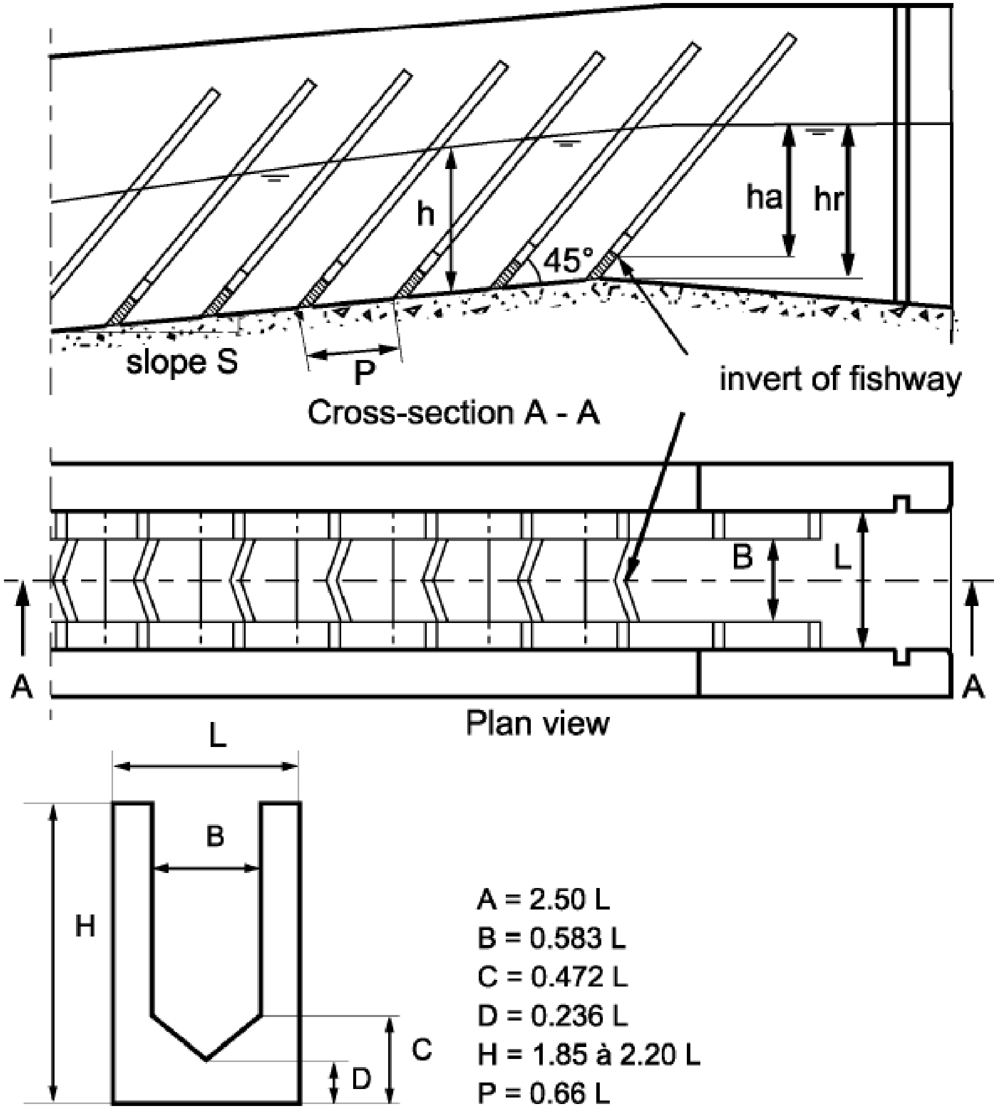


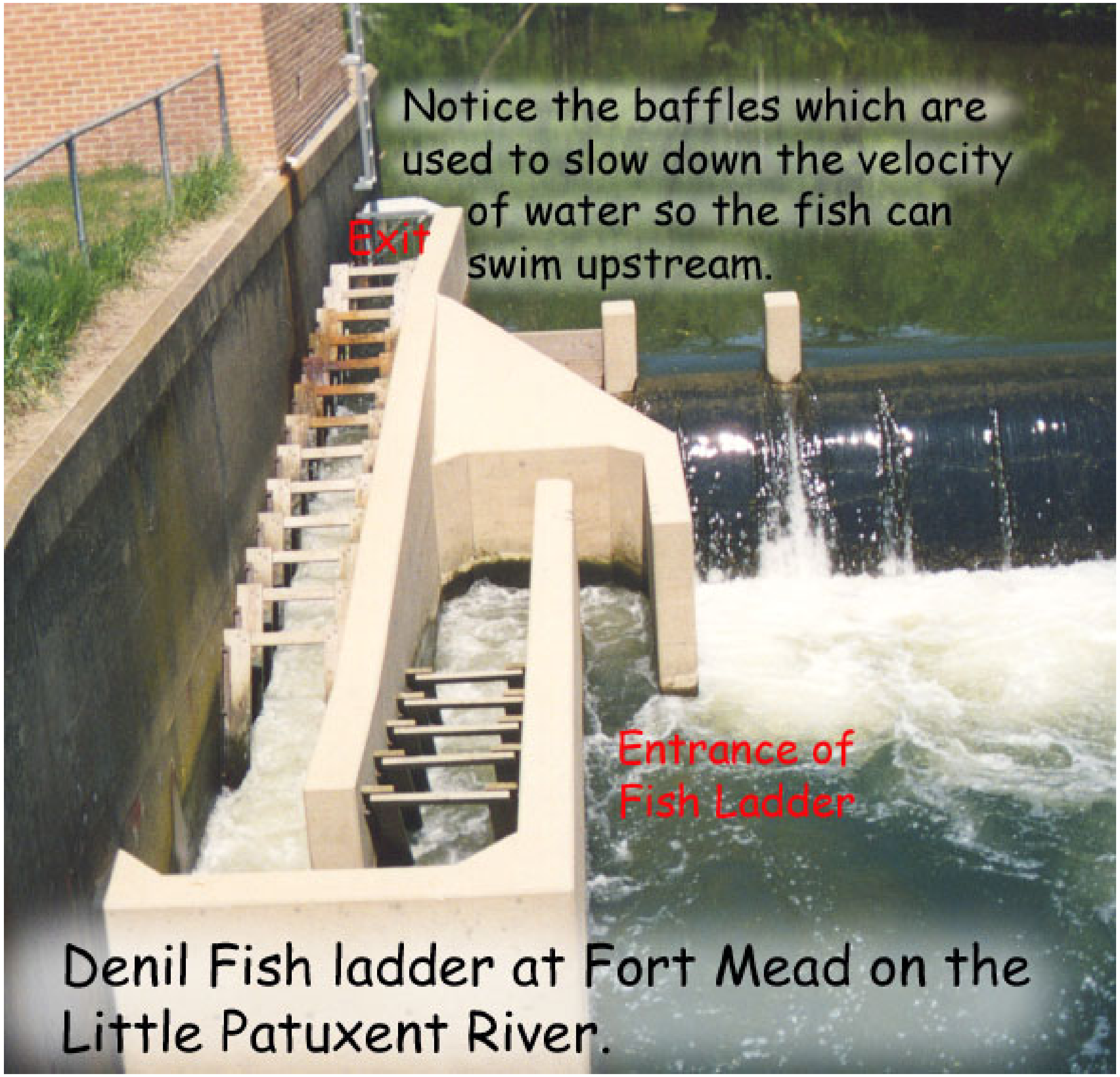
Figure 1: Characteristic parameters of a fishway with plane baffles.

Larinier 2002

Denil Fishway

(baffle fishway):

???



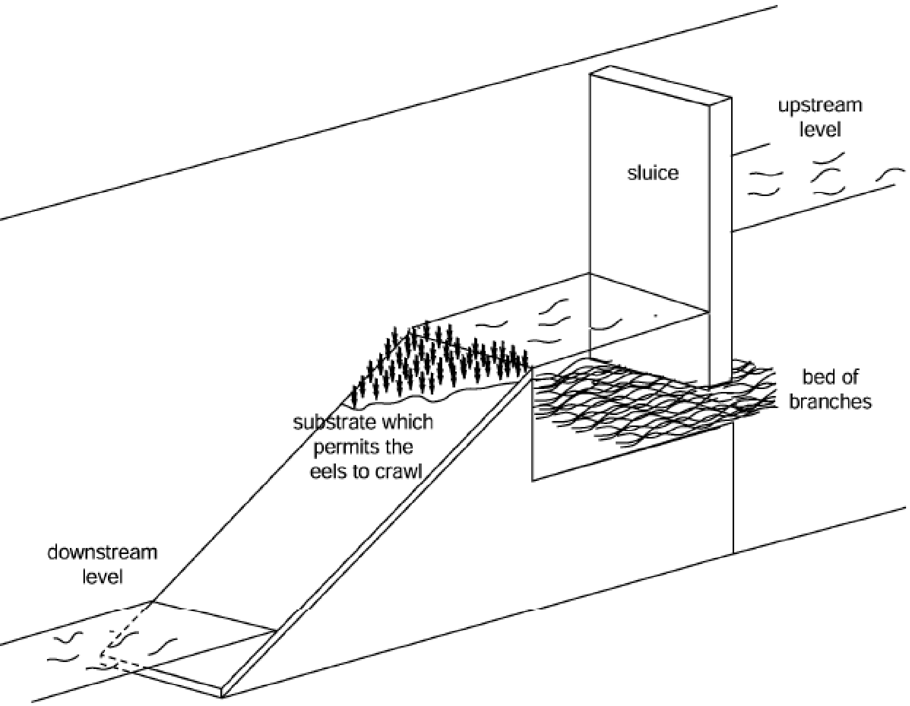
Bristle fish pass:

Bristle fish pass:

Nestmann (2004)

Eel and elver fishways:

(elver - durchsichtige Jungform des Flussaals)



Regulation of the flow discharge and eel passage with a layer of branches under the sluice gate.

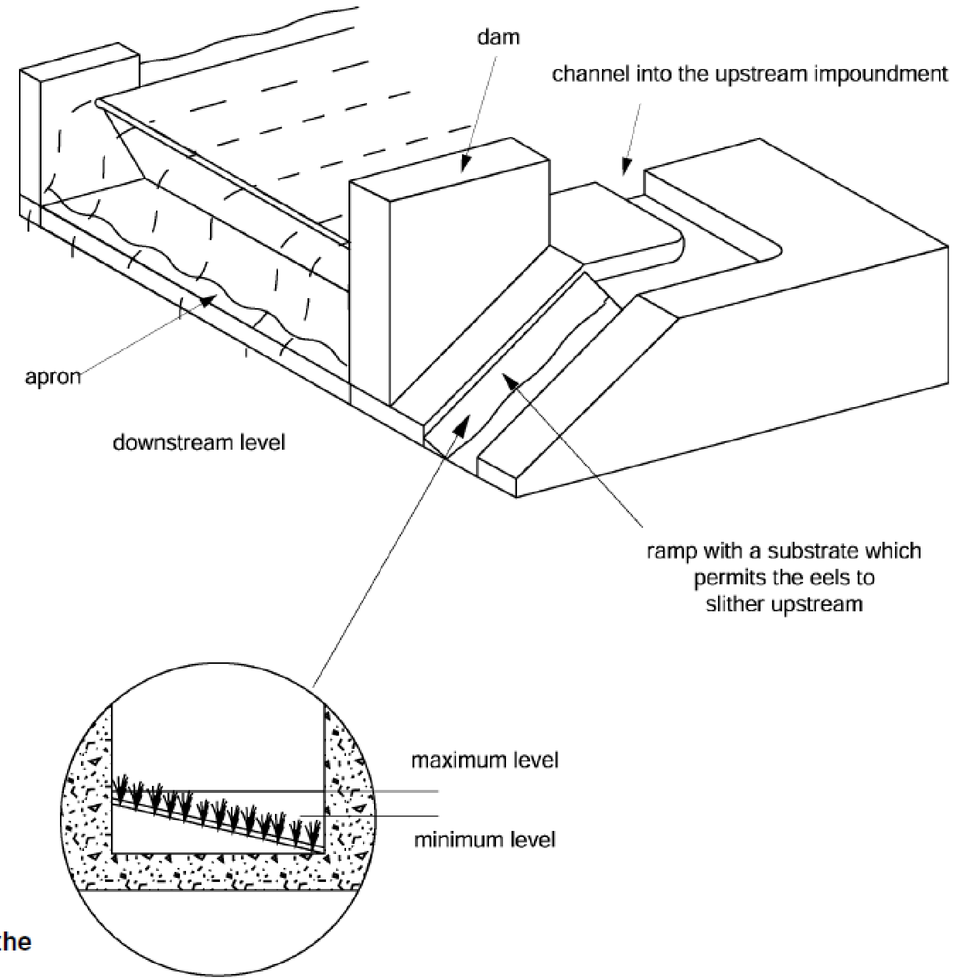
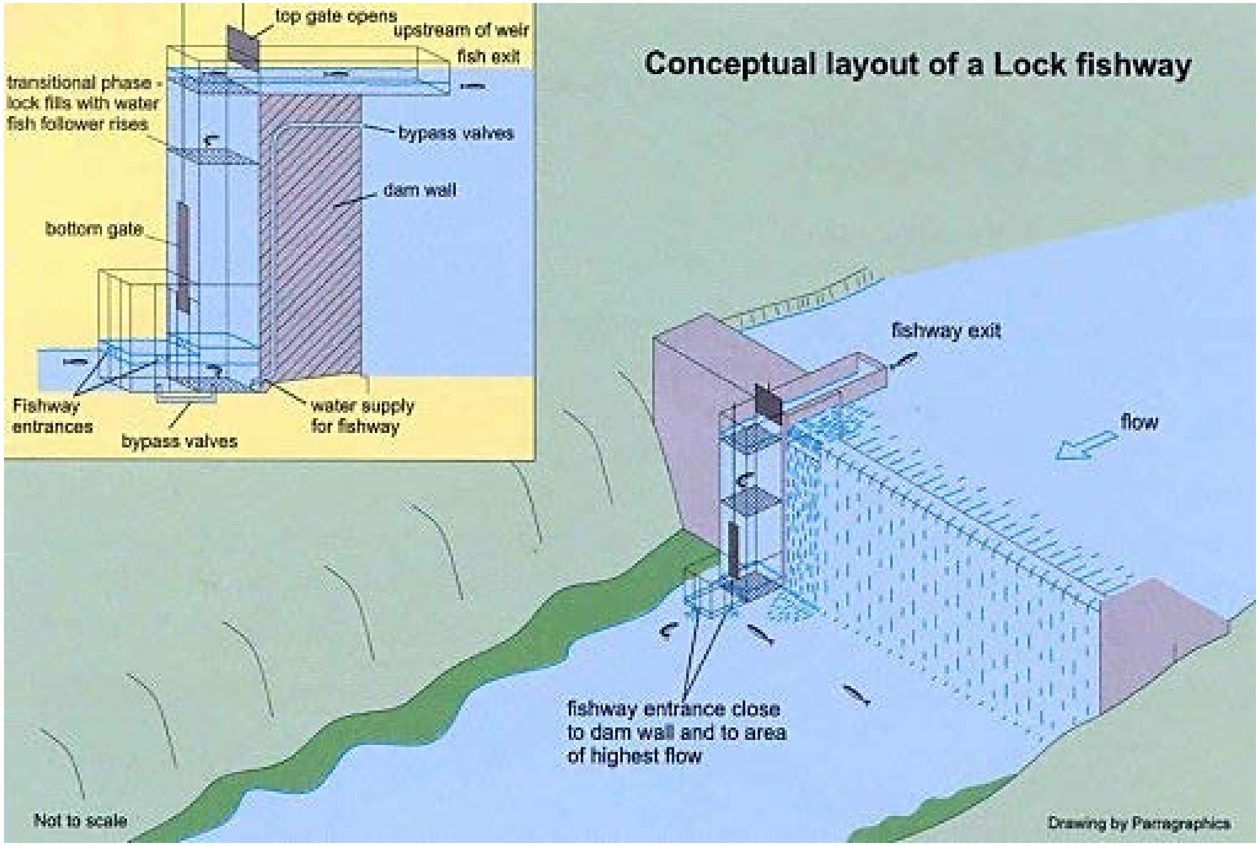


Figure 1: Schematic plan of a fishway for elvers and young eels.

Porcher (2002)

Lock Fishway:

Lock fishways operate by attracting fish through an entrance similar to that of a pool-type fishway, but instead of swimming up a channel the fish accumulate in a holding area at the base of the lock. This holding area is then sealed and filled with water to reach a level equal to the water upstream of the barrier.



NSW gov.

Trap and transport fishways:

*The trap-and-transport type of fishway involves attracting and trapping fish below a barrier and then **physically transporting them over the barrier.***

NSW gov.

Archimedes screw:

new invention / concept

hydro compact
WASSER KRAFT SCHNECKE

ALBRECHT fishLift INSIDE

Patent
Walter Albrecht
Am Ursprung 7
A-3283 St. Anton/Jeßnitz

innovative -services.at
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Das Technikernetzwerk

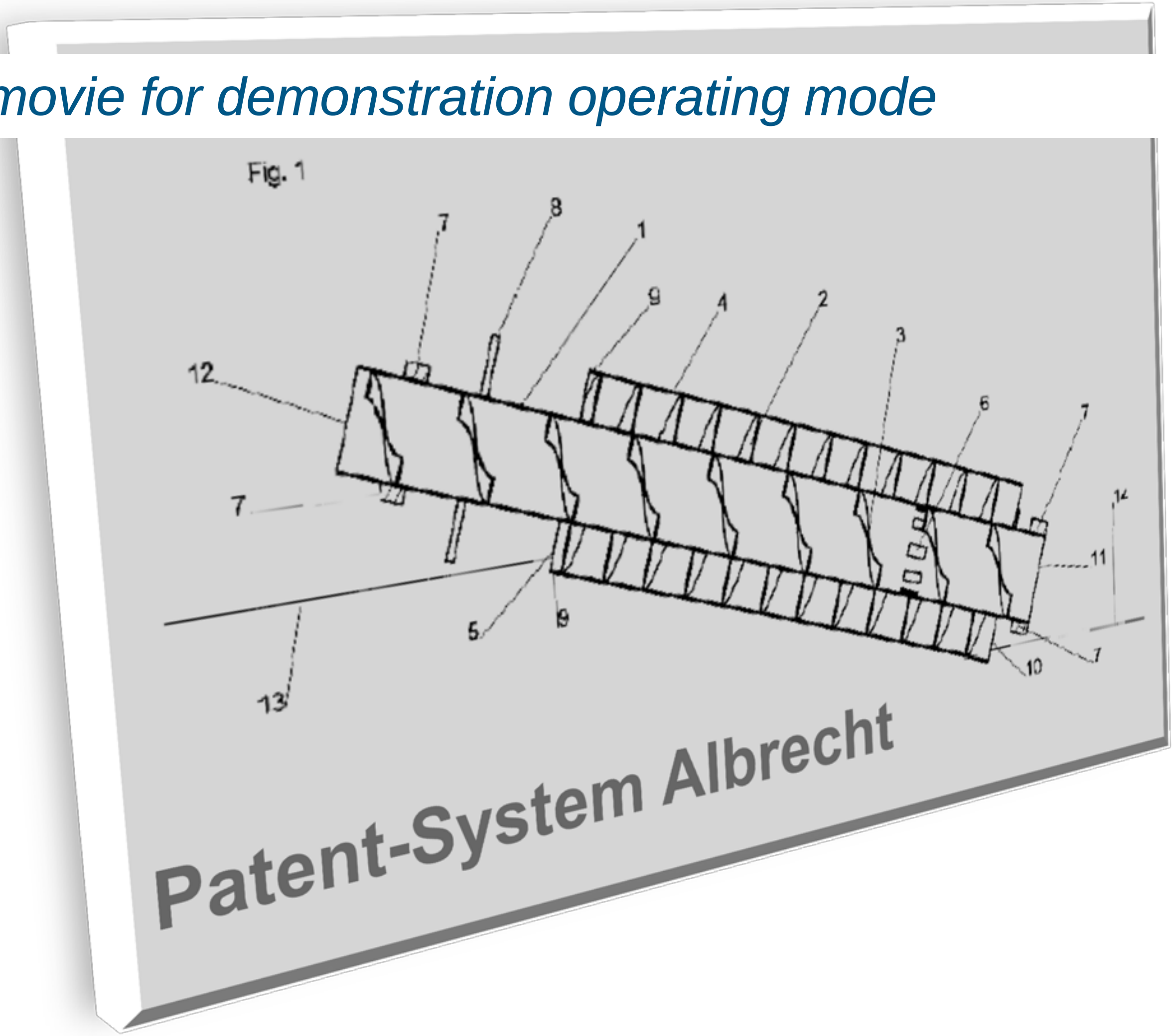
Archimedes screw:





Archimedes screw:

short movie for demonstration operating mode



<u>Questions – fishecological monitoring:</u>

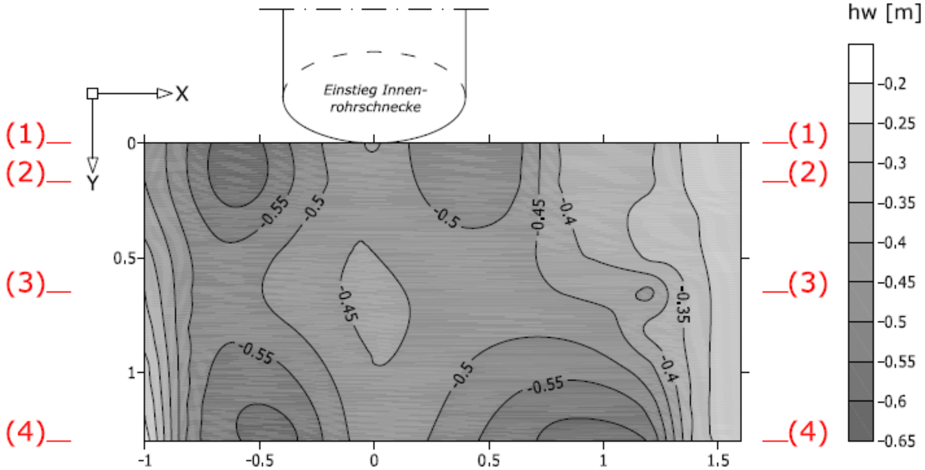
- Which species migrate upstream?
- Which life stages (juvenile / adult) migrate upstream?
- Is there a risk of injury caused by migrating upstream?

Hydro-Compact Archimedes screw

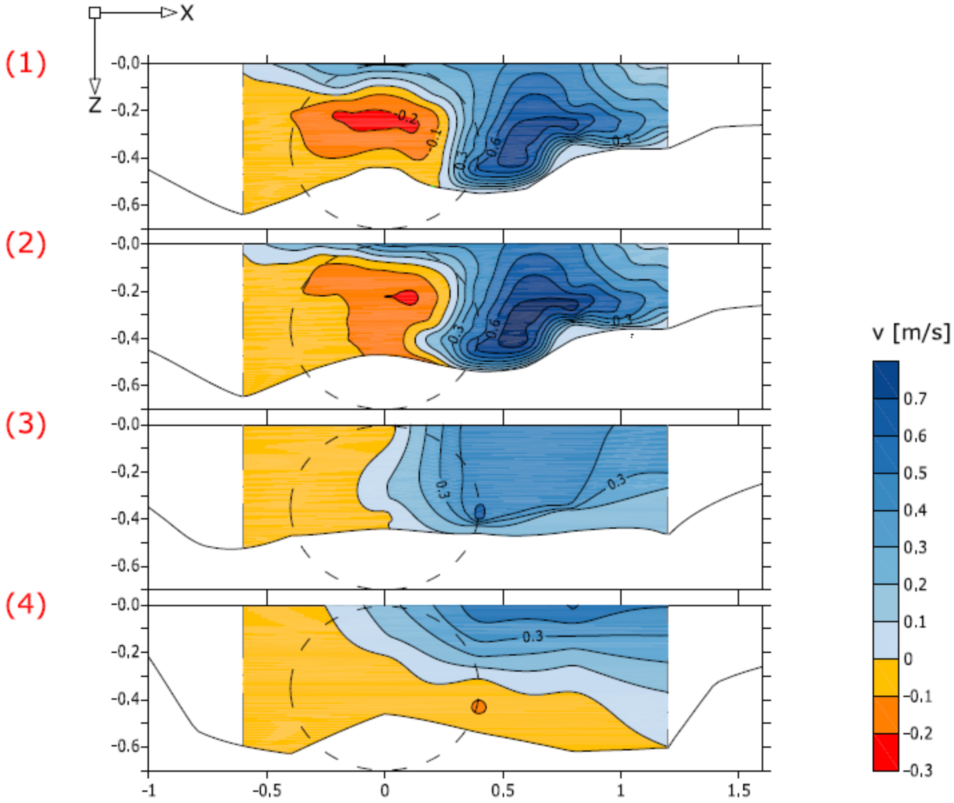
Experiment set up:

Morphometric measurement:

Draufsicht Unterwasser
Sohle unter Wsp



Fließgeschwindigkeitsverteilungen im Querprofil
4 Schnittebenen



Result Up-Stream Passage:

Balance	*Fish Species*				*Sum*
	Grayling	Brown Trout	Bullhead	Rainbow Trout	
	Ind. (n)	Ind. (n)	Ind. (n)	Ind. (n)	*∑ Ind. (n)*
Stocking 09.03.2012	27	185	94	66	*372*
Upstream passage till 18.03.2012	15	107	9	20	*151*
E-Fishing 28.03.2012	-	3	3	15	*21*
Missing	12	75	82	31	*200*
Proportion of upstream passage (%)	56%	58%	10%	30%	*41%*

Hydro-Compact Archimedes screw

Fish migration:

- no injuries at all