9. Separation manhole

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9. Separation manhole

Goals of this chapter

To know

- types of separation manholes
- their application range
- their design process
- constructional aspects
- where additional guidelines are provided

9. Separation manhole

Content

9.1 Introduction
9.2 Side weir
9.3 Bottom opening (leaping weir)
9.4 Pro memoria

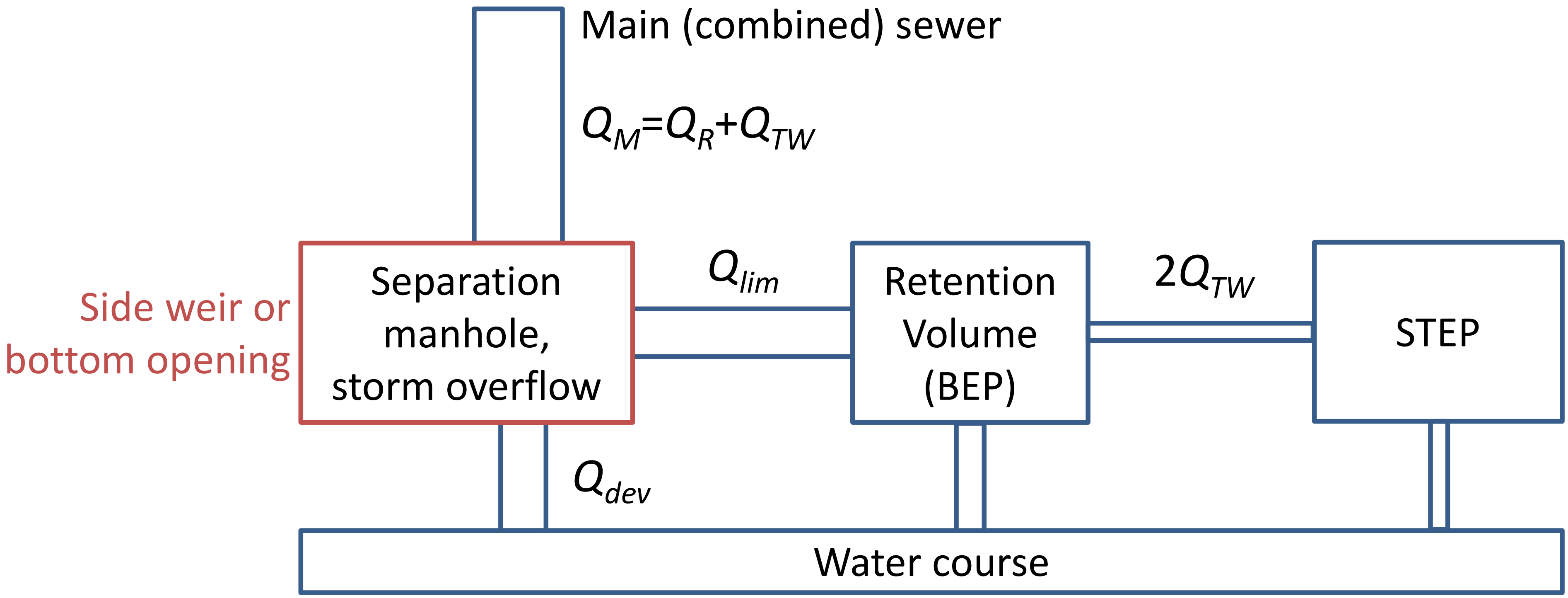
Literature

W.H. Hager (1999). *Wastewater Hydraulics*, Springer, Berlin.
VSA (2013). Abwassereinleitung in Gewässer bei Regenwetter (STORM). TechnRiLi Band 2A, Regenüberläufe und Regenbecken.
SIA-Dokumentation 40 (1980). Sonderbauwerke der Kanalisationstechnik I.
ATV A111 (1994). Richtlinien für die hydraulische Dimensionierung und den Leistungsnachweis von Regenwasserentlastungsanlagen.
Séminaire VSA/EPFL (2013). *Hydraulique des canalisations.*

9.1 Introduction

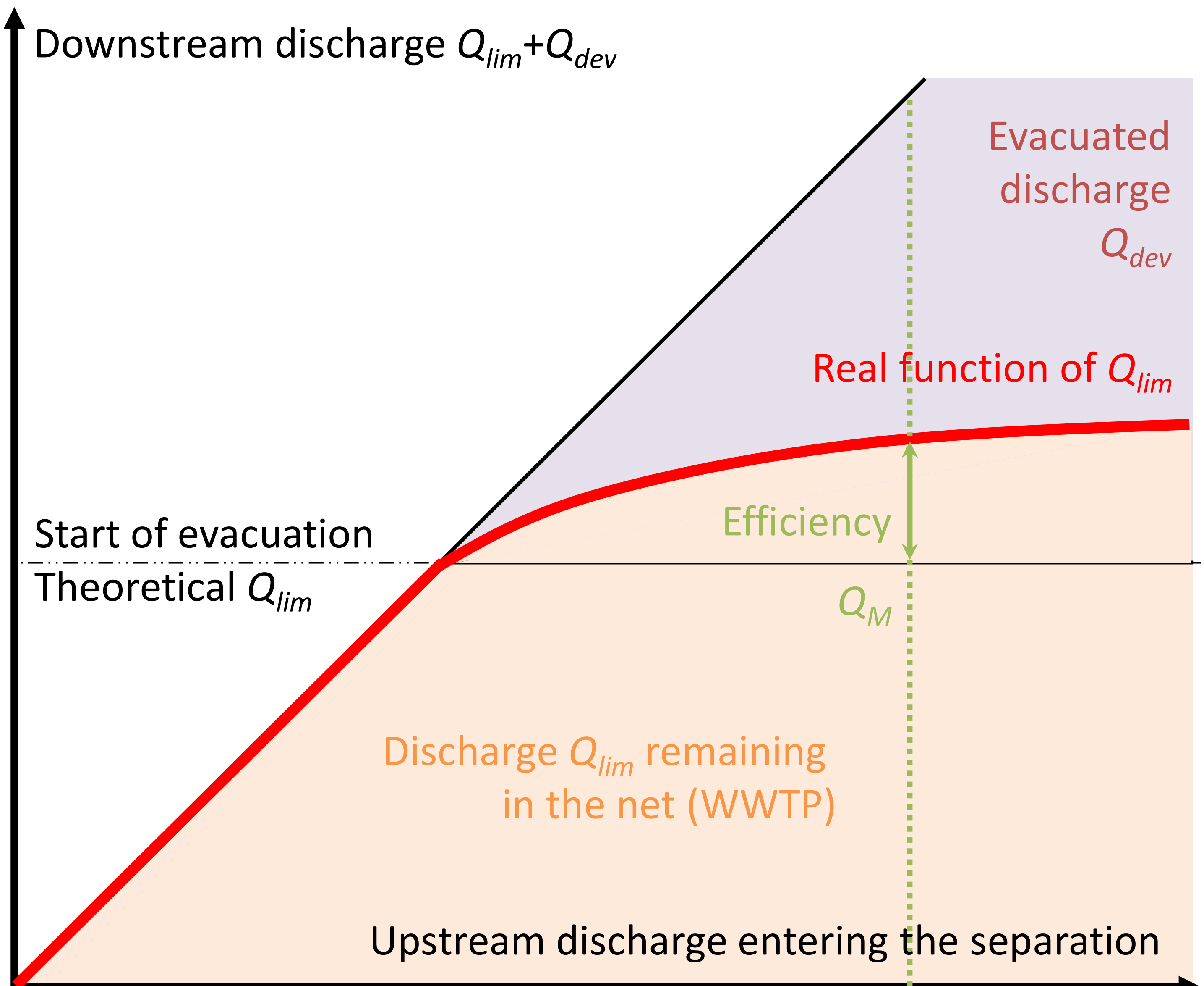
9.1 Introduction

Application in combined sewer



9.1 Introduction

Goal of separation manhole (combined sewer)



9.1 Introduction

"a combined sewer system depends significantly on the performance of the lateral outlets" (Hager, 1999)

With poor design:

- Uncontrolled overflow
- Inefficient exploitation of retention volume
- Flooding of water treatment plant
- Pollution of water courses

Two types

1. Side weir with high crest, contraction in plan view, throttling, for $F_o<0.75$
2. Bottom opening (leaping weir), rectangular slot at bottom of U-profile, for $F_o>1.5$

9.1 Introduction

Basic types of outlet manholes

Side weir

Bottom opening

9.1 Introduction

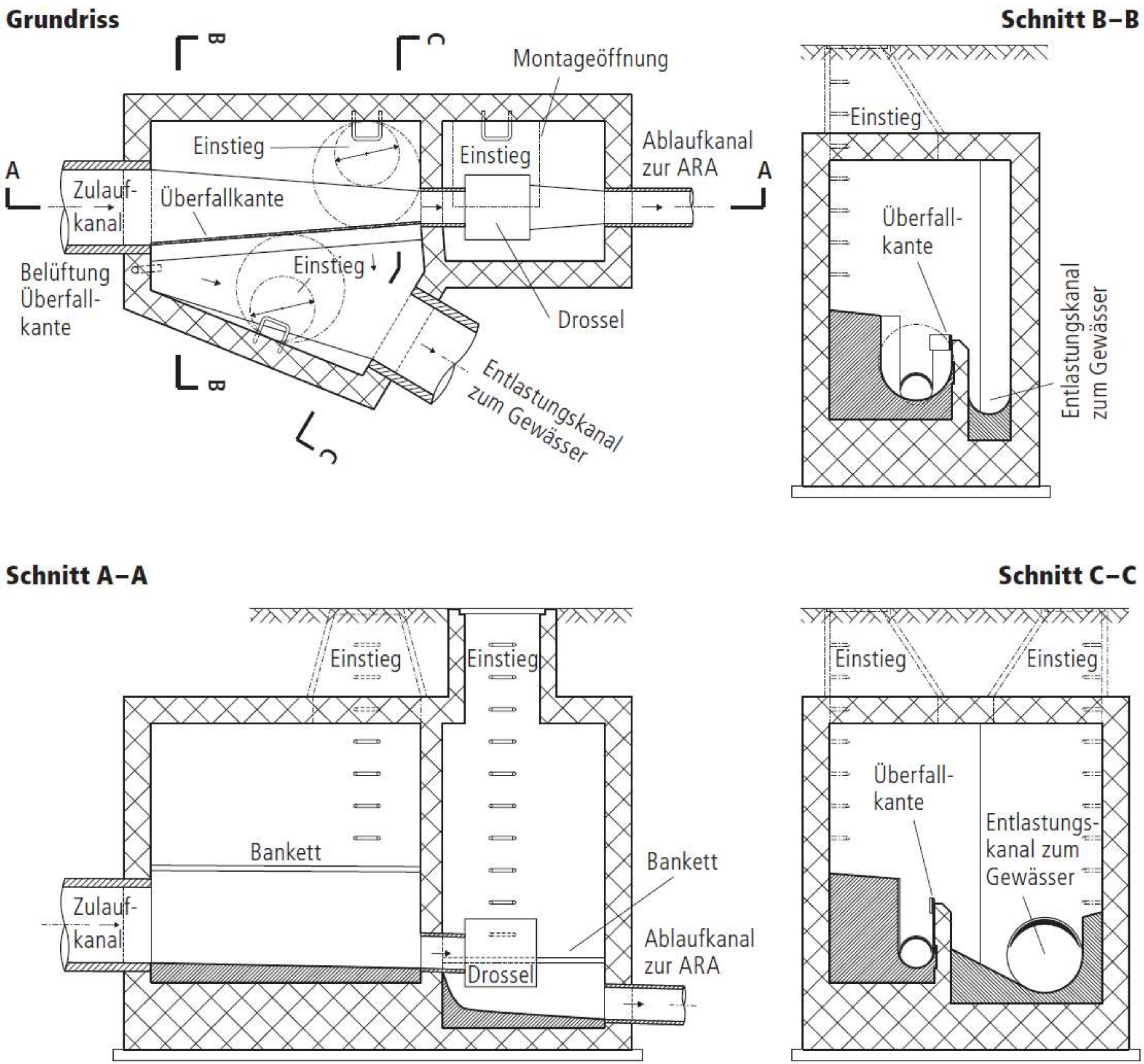
Separation manholes are often combined structures

Possible additional functions

- Thrash racks on side weir crest to avoid the restitution of floating “big” mechanical particles
- Sediment trap at side weir to avoid sand in the STEP
- Retention volume upstream of restitution channel
- Discharge measurement

9.2 Side weir

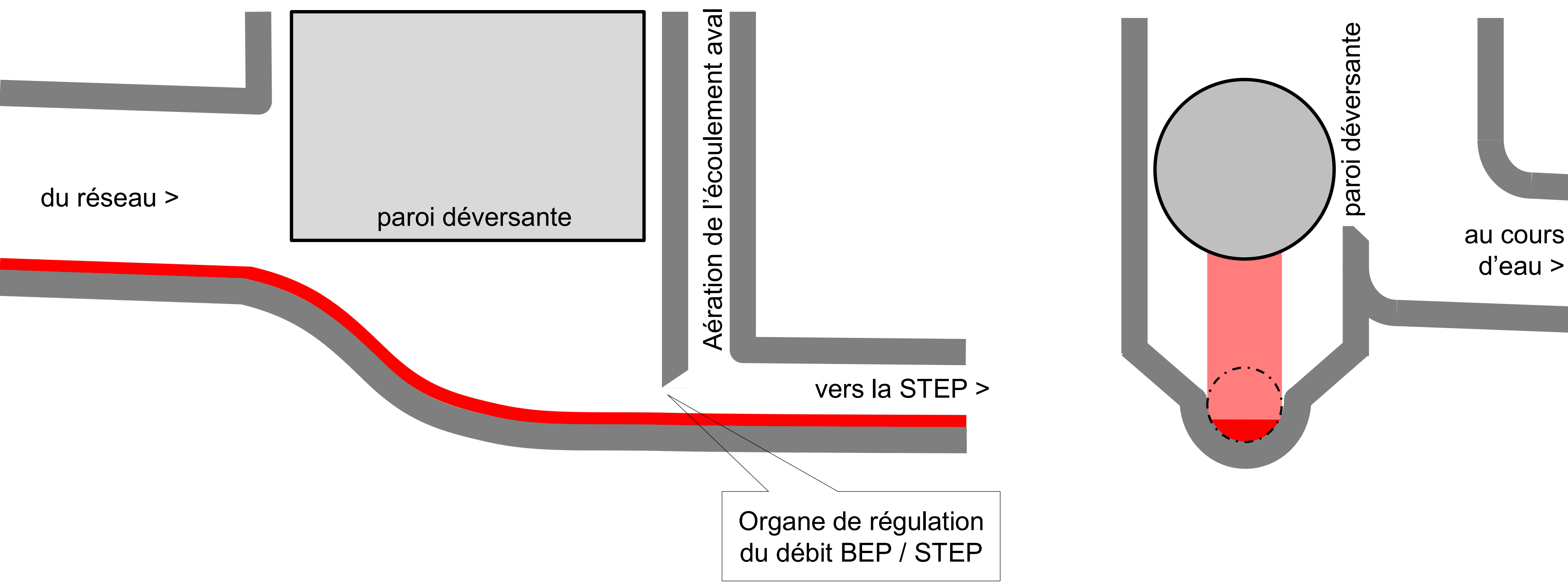
9.2 Side weir (SIA)



9.2 Side weir

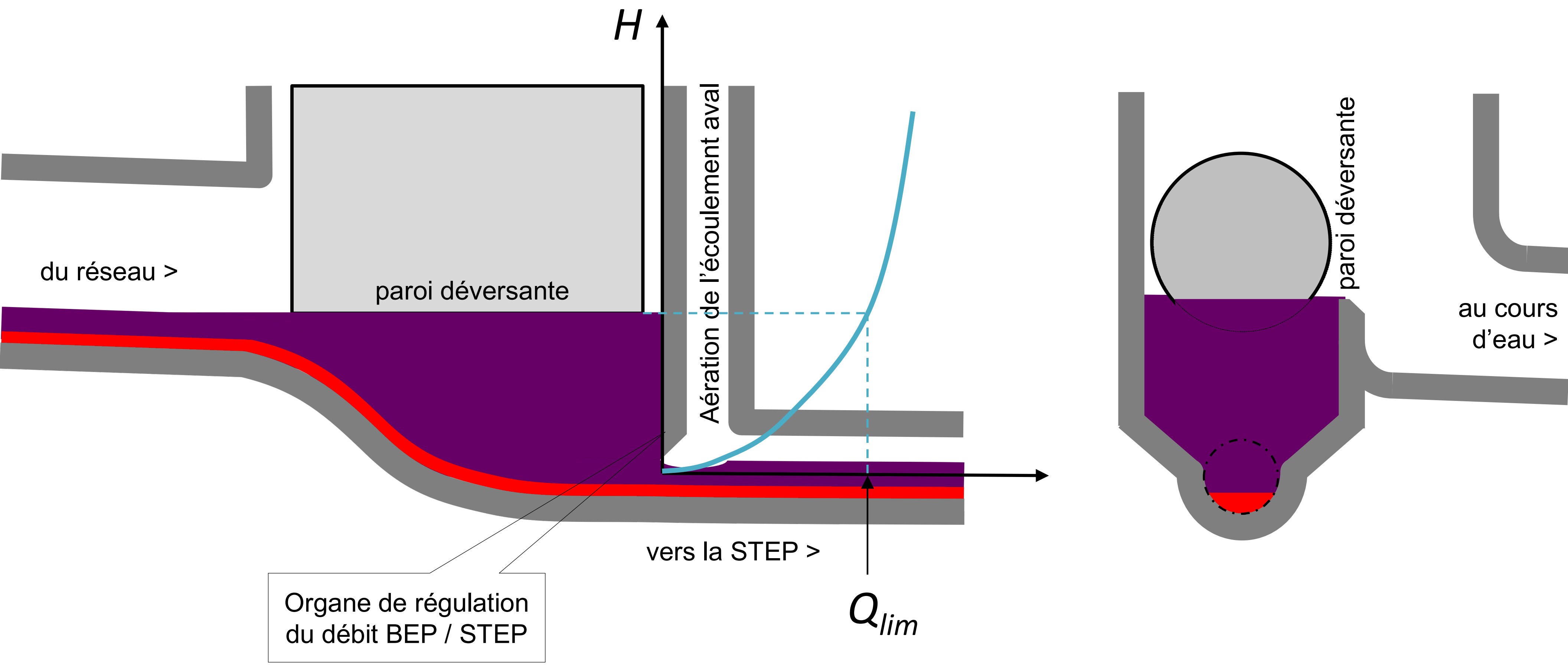
9.2 Side weir

Dry weather discharge up to $2Q_{TS}$



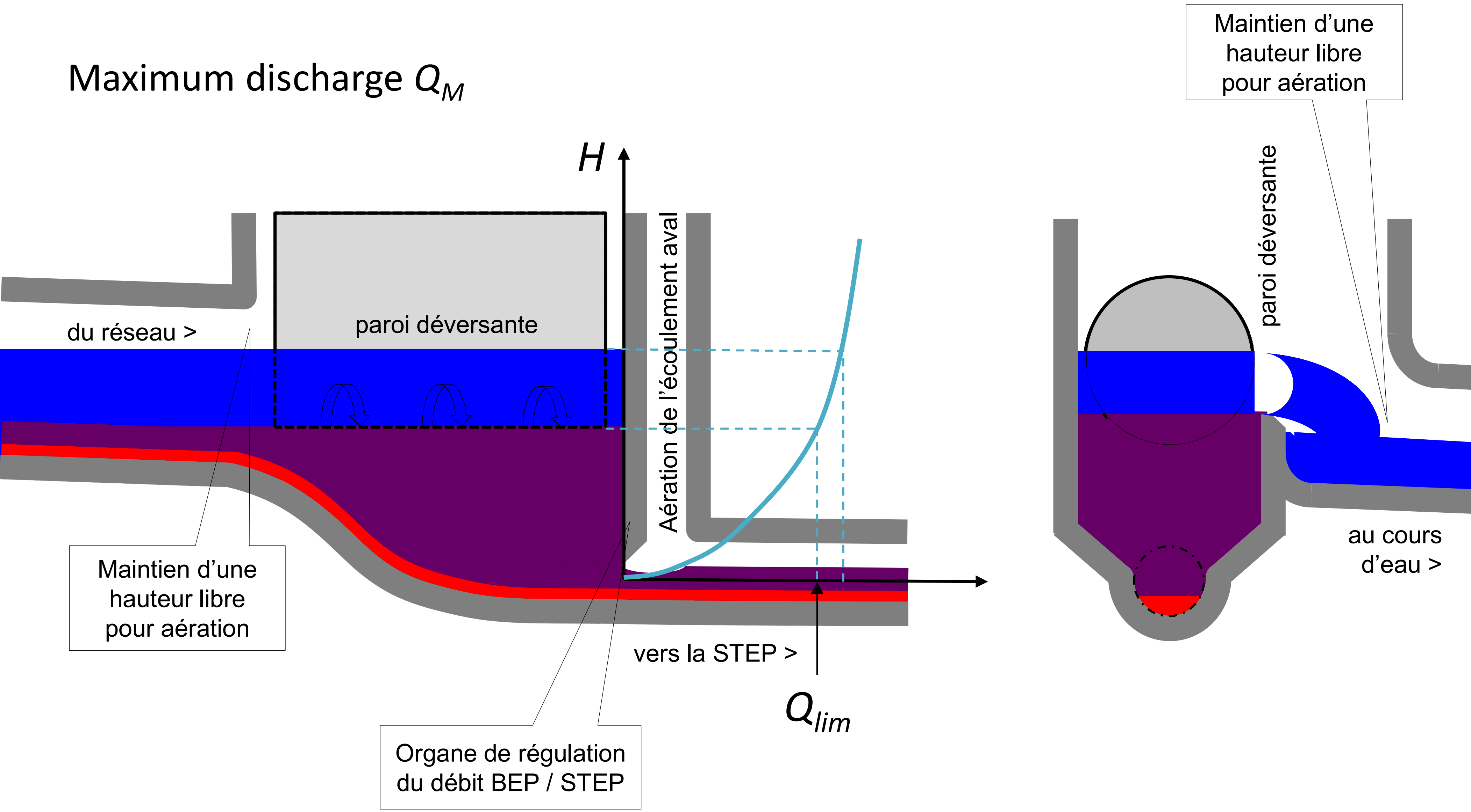
9.2 Side weir

Up to limit (first flush) Q_{lim}



9.2 Side weir

Maximum discharge Q_M



9.2 Side weir

Options
- High or low crest
- Converging or parallel
- short or long weir
- throttling pipe, regulation plate
- overflow at one or two sides

SIA 40: Side weir, two-sided overfall , horizontal sharp-crested weir, high crest
Advantages:
- Throttling possible
- Use of conduit volume as storage (avoid chocking, check minimal velocities)
- Transported load near bottom: less material flushed into retention
- Lower risk that water from water courses flows back into treatment plant

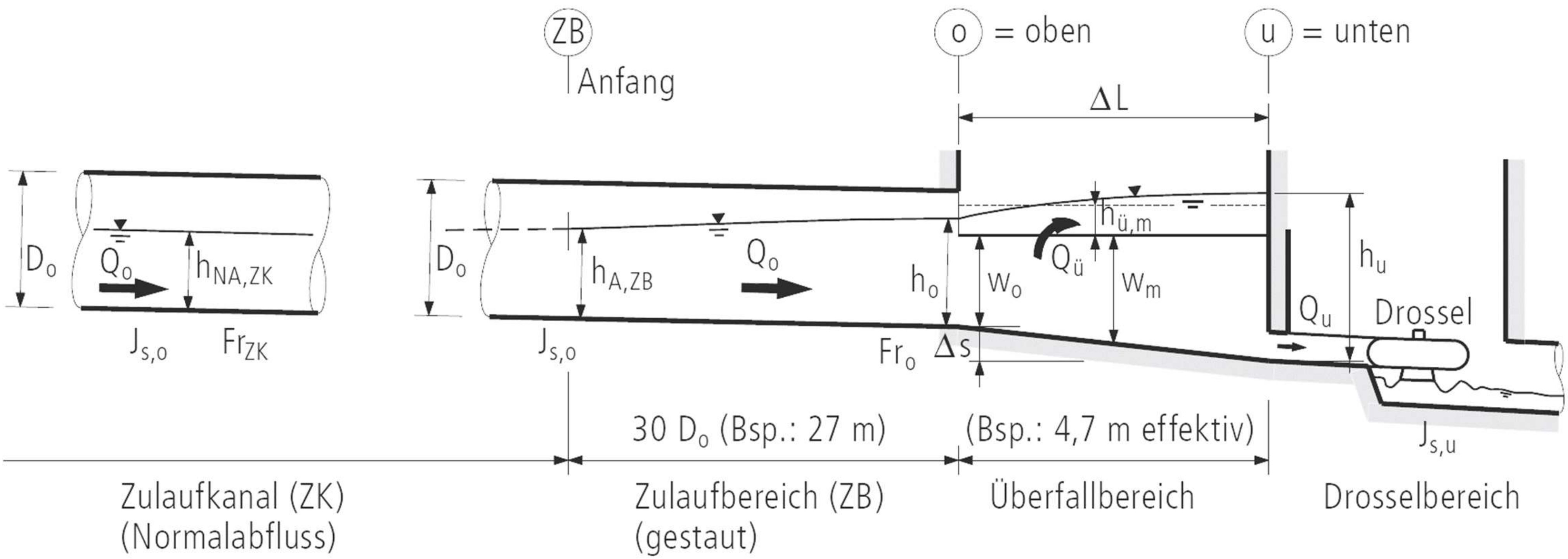
Disadvantages (as compared to low crested side weir)
- Longer
- Submergence of upstream sewer
- Sedimentation because of small minimum velocities

9.2 Side weir

Elements (VSA)

Side weir with high crest

- Linear constriction (converging)
- Steep bottom along weir
- Backwater
- Crest horizontal, sharp crested (adjustable plate)



9.2 Side weir

Concept Hager (2010)

Hager et al. (1982) proposed lateral outflow intensity (approximation)

$$\frac{\mathrm{d}Q}{\mathrm{d}x} = -0.6nc_k\sqrt{gH^3}\left(y-W\right)^{3/2}\left[\frac{1-W}{3-2y-W}\right]^{1/2}\left[1-\left(\theta+S_{os}\right)\sqrt{\frac{3\left(1-y\right)}{y-W}}\right]$$

with

- n as number of lateral outflow sides (n=1 or 2)
- c_k as crest coefficient (c_k=1 for sharp-crested weirs)
- $y=h/H$ with h as flow depth
- $W=w/H$ with w weir height
- $\theta=(D_u-D_o)/L$ as contraction inclination

9.2 Side weir

Concept VSA (TechRiLi 2A 2013, Hager 2010)

$$\frac{\Delta Q}{\Delta L} = 0.2 n c_w \sqrt{g}\left(h_o + 2h_u - 3w_m\right)^{3/2}\left[\frac{h_u - w_m}{5h_u - 2h_o - 3w_m}\right]^{1/2}$$

with

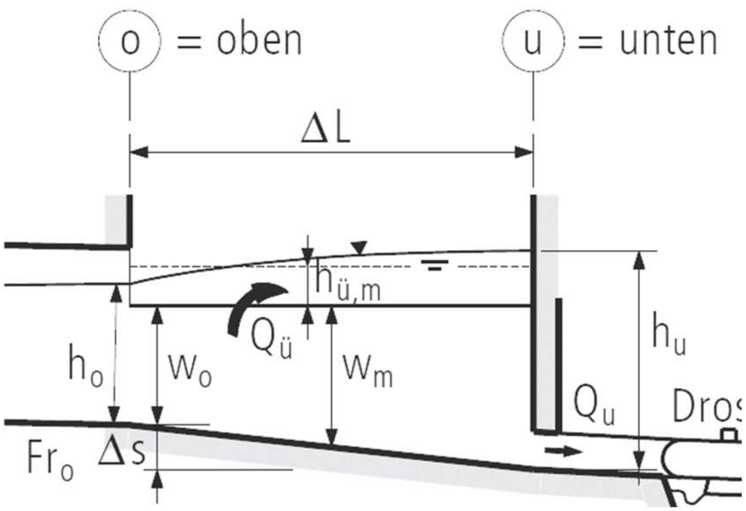
- n as number of lateral outflow sides (n=1 or 2)
- c_w as crest and convergence coefficient (c_w=1 for prismatic and sharp-crested weirs)

$$h_m = h_o + \frac{2}{3}\left(h_u - h_o\right)$$

$$A_o = \left(\frac{\pi}{8}\right)D_o^2 + \left(h_o - \frac{D_o}{2}\right)D_o \cong D_o h_o \cong D_o h_u$$

U-shaped profile

$$h_o = h_u - \frac{Q_o^2}{2gA_o^2}$$



9.2 Side weir

Design recommendations (ATV A110, Hager 1999)

- $3 \leq L/D_o \leq 6$
- $w > 0.5D_o$, better $0.67D_o$
- Linear contraction with $D_u/D_o = 0.1$ to 0.4
- Approach F_o below 0.75
- Symmetrical sharp-crested overflow geometry

For interaction of side weir and throttling pipe see Hager (1999), chapter 10.3

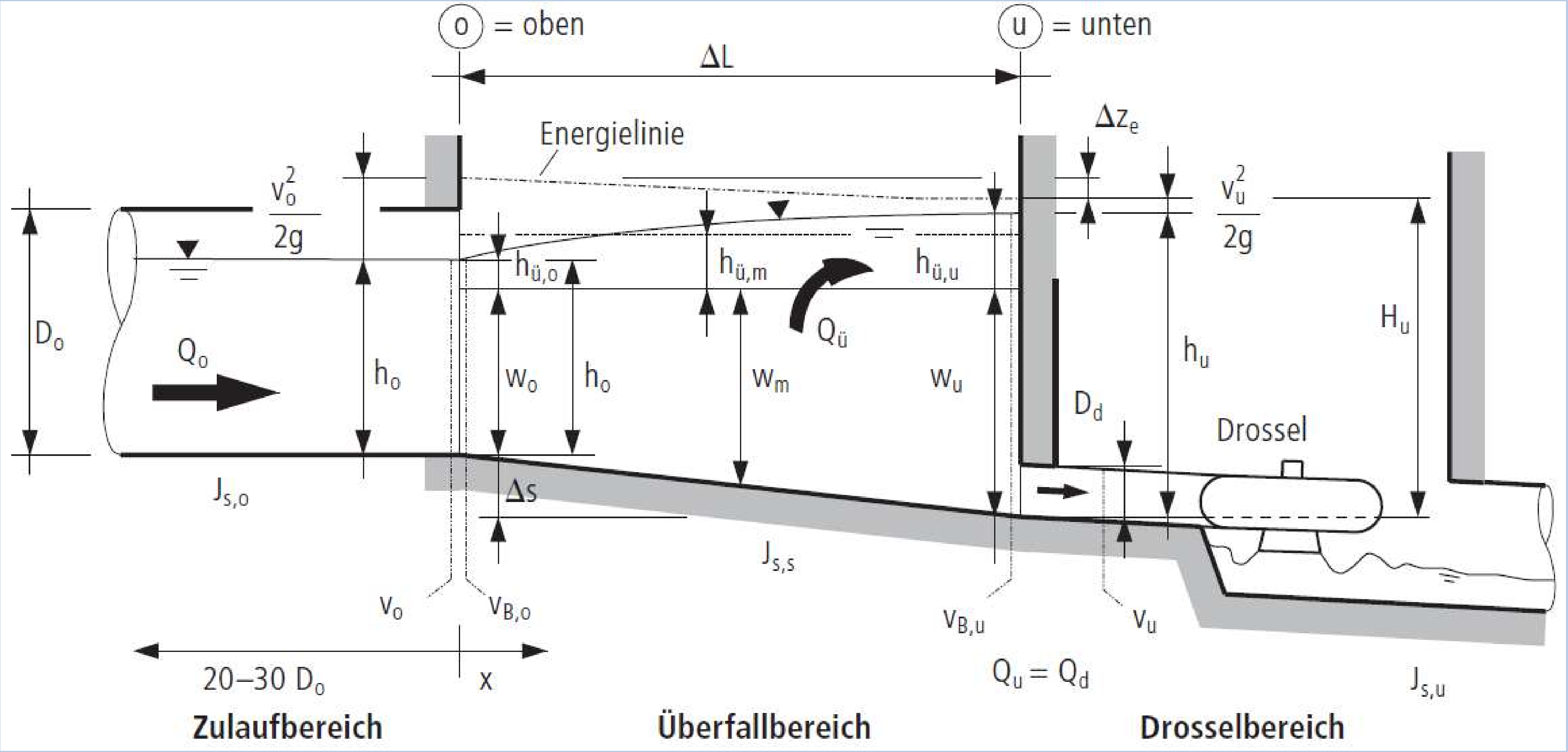
Design recommendations (VSA 2013)

- $\mathsf{F}_O < 0.75$
- $0.6 < w_o/D_o < 0.8$
- $\Delta s > 3$ to 5 cm
- Approach pipe length $30D_o$, respect minimum velocity and slope!
- $\Delta Q/\Delta L \leq 0.3$ m^2/s
- Symmetrical sharp-crested overflow geometry

9.2 Side weir

Example
D_o=1.0 m, J_{SO}=0.002, n=2, c_w=2, Q_M=1.0 m^3/s, Q_{lim}=0.07 m^3/s, w_o=0.6 m, w_u=0.6 m, ΔL=3.5 m

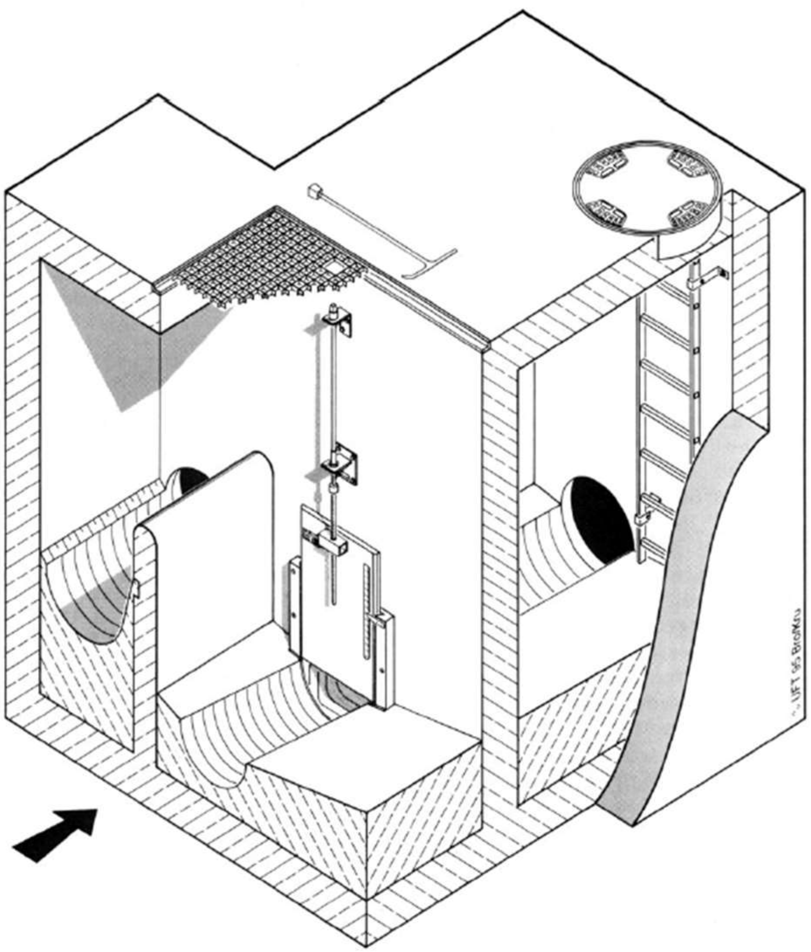
Compute h_U

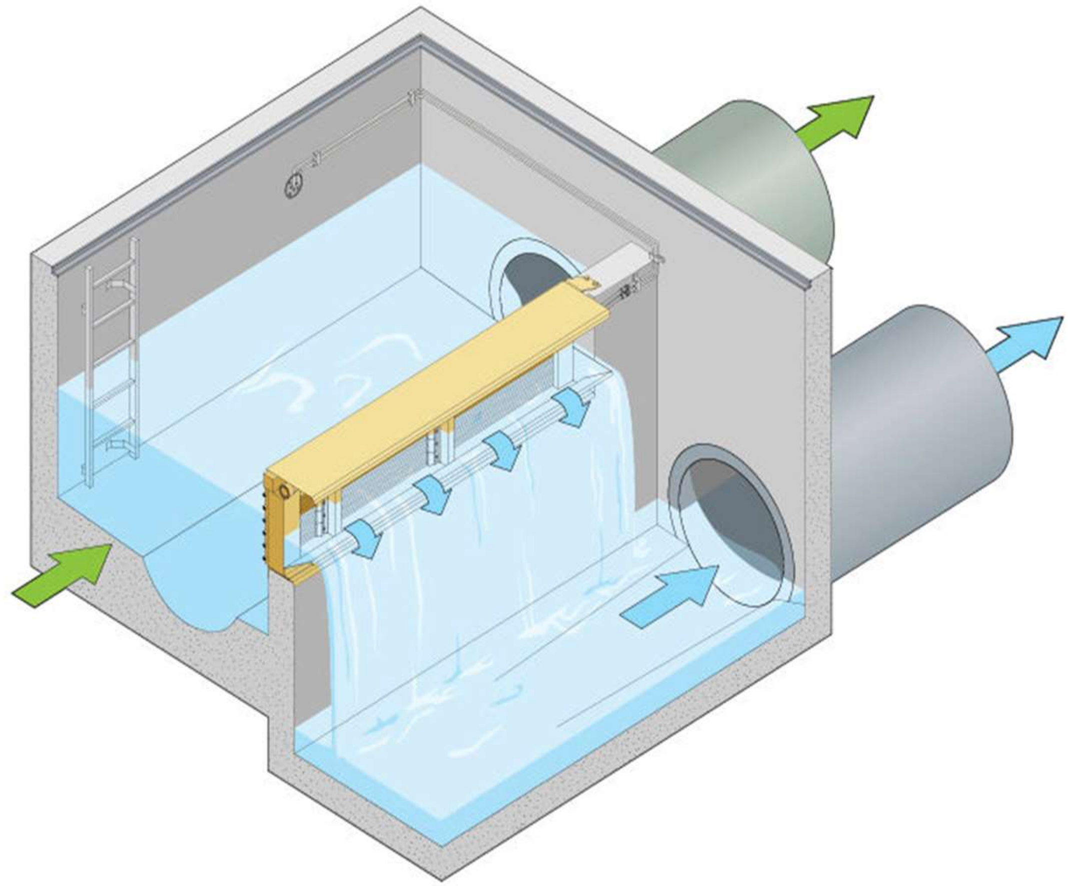


9.2 Side weir

9.2 Side weir

Equipment: regulating valve, fine rack, or sand trap

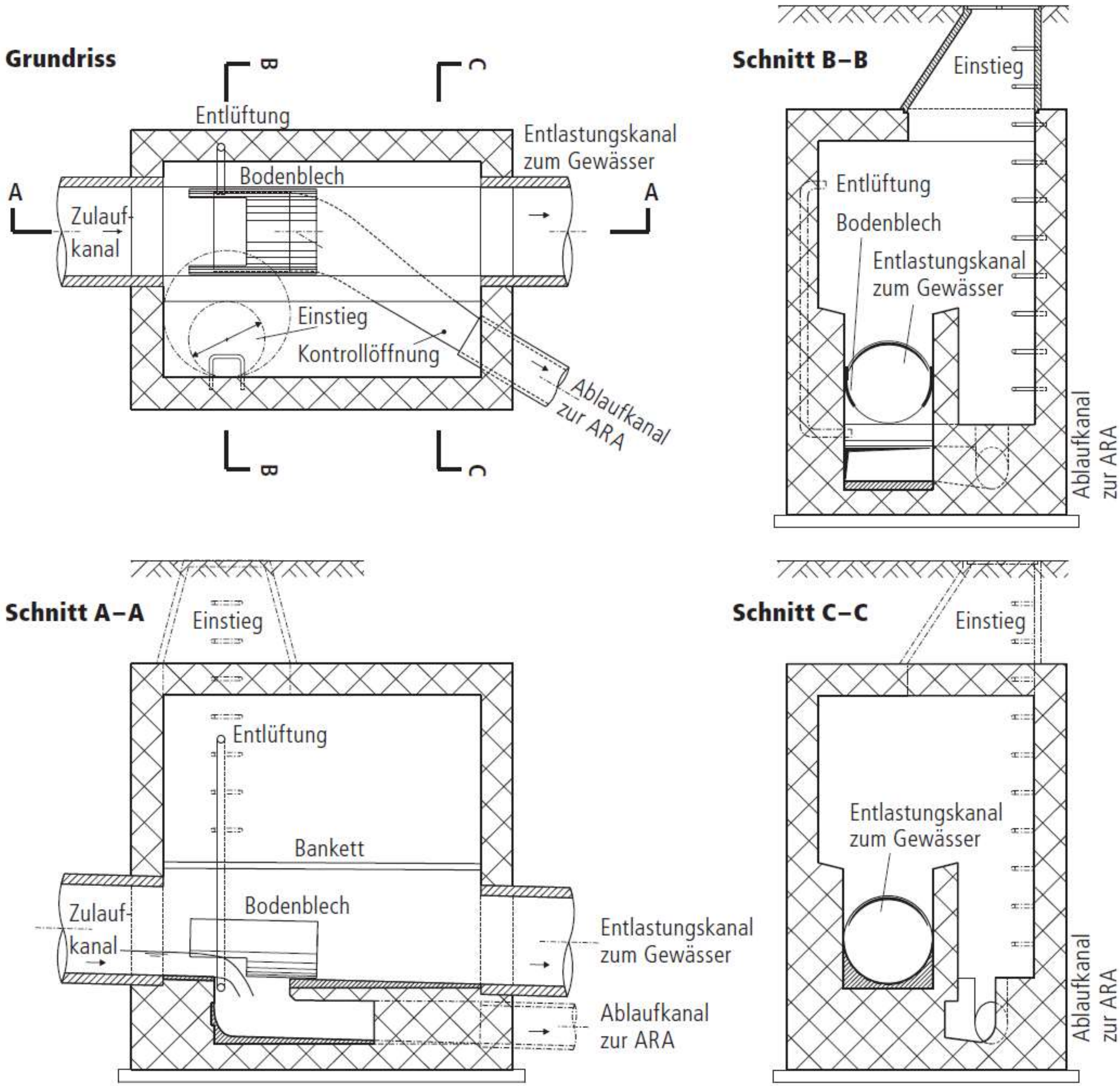




9.3 Bottom opening (leaping weir)

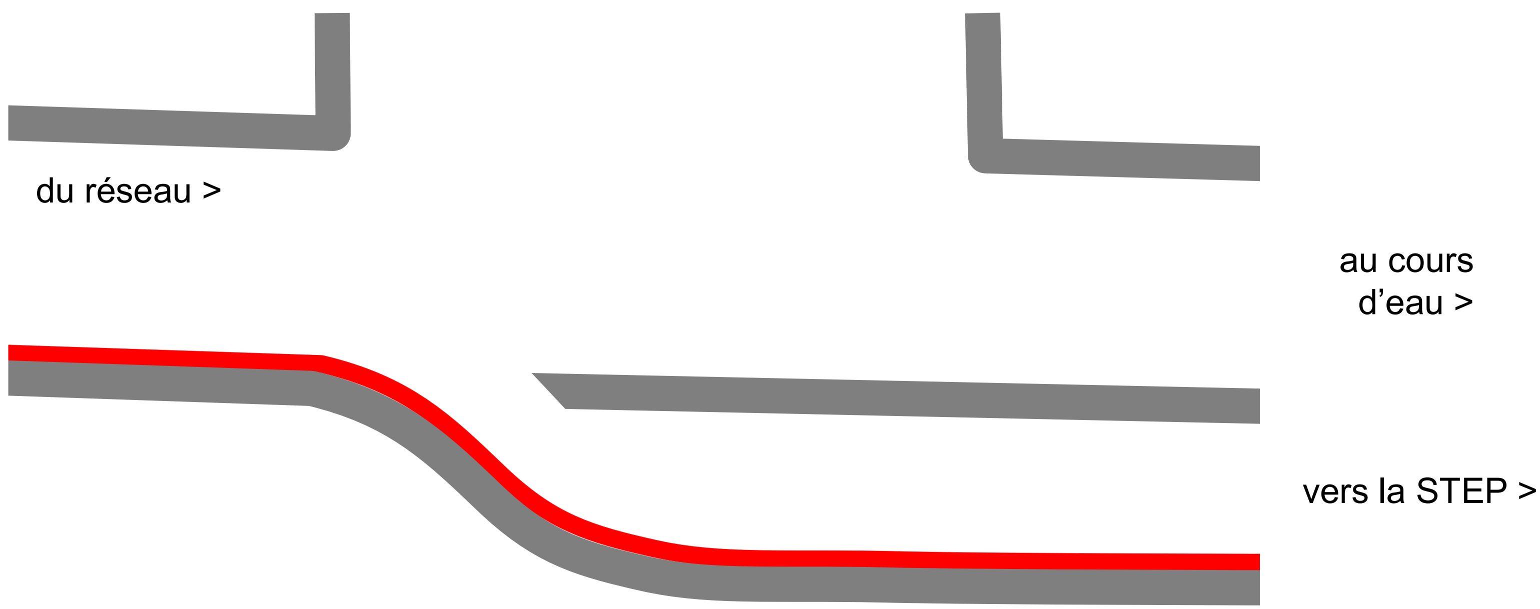
9.3 Bottom opening

VSA



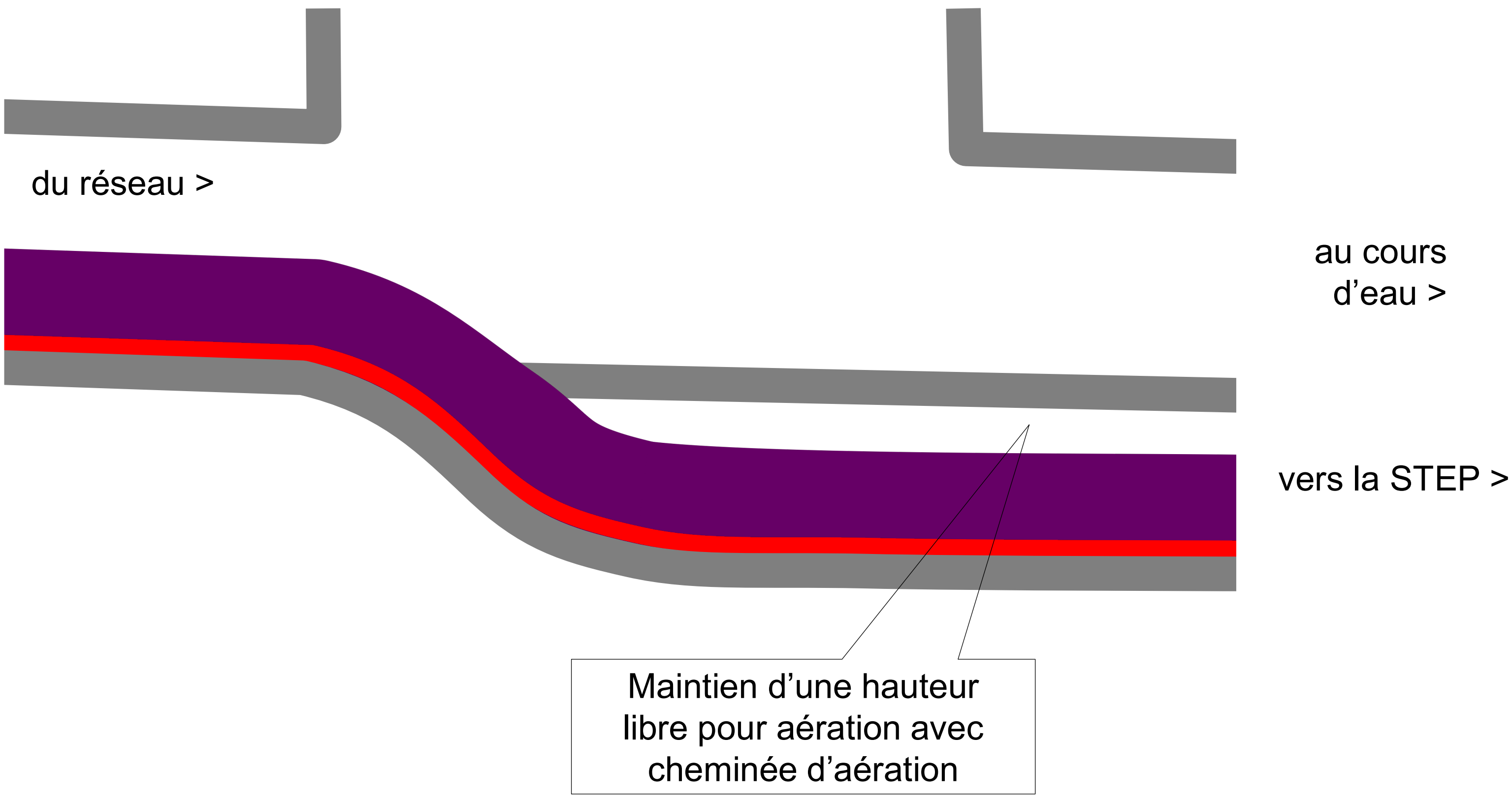
9.3 Bottom opening

Dry weather discharge up to $2Q_{TS}$



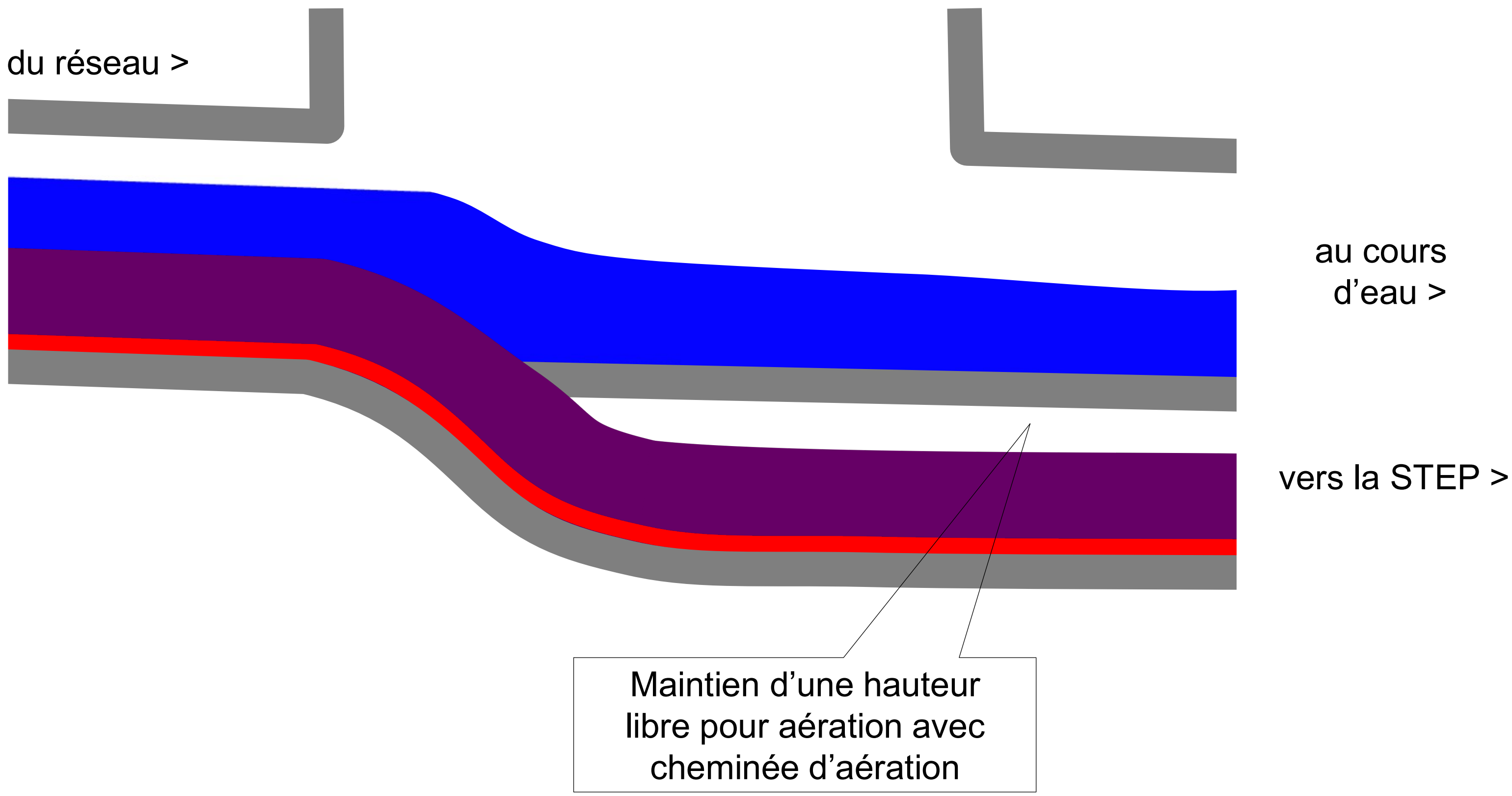
9.3 Bottom opening

Up to limit (first flush) Q_{lim}



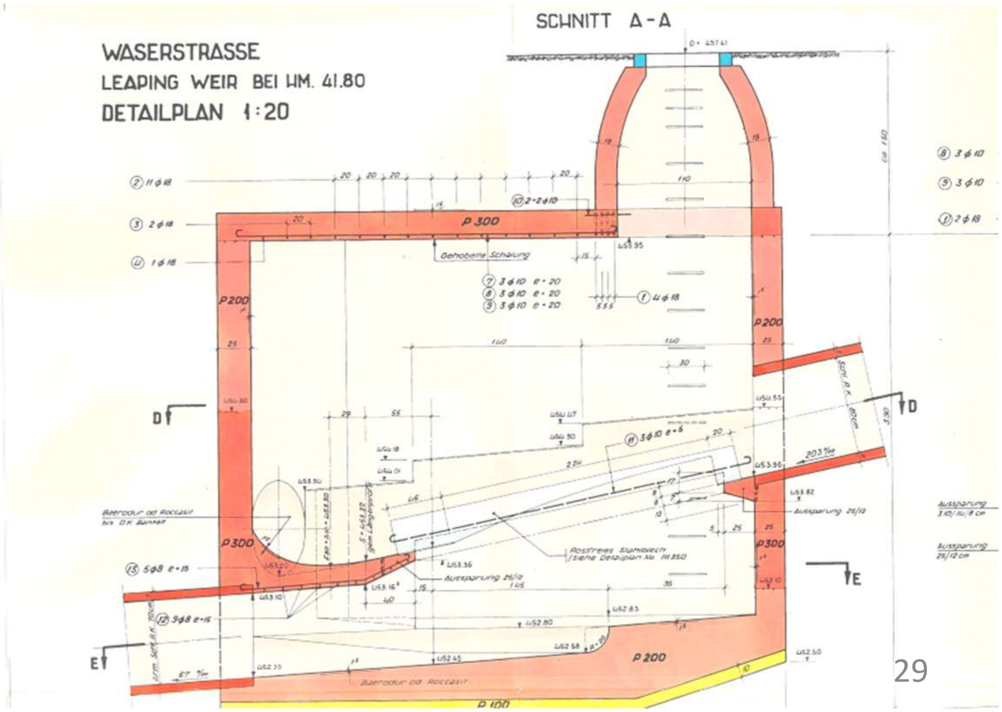
9.3 Bottom opening

Maximum discharge Q_M



9.3 Bottom opening

ERZ, Zürich



9.3 Bottom opening

Photos: Christian Eicher

9.3 Bottom opening

Layout

- Super-critical approach flow, length of 20 to 30 D_o
- Prismatic and u-shaped profile
- Unchanged bottom slope
- F_o>1.5
- Cutting-out a part of the conduit bottom
- Opening rectangular with width *b* and length *L* for Hager (2010)
- Opening rectangular with ellipse at end for ATV 111
- No submergence in branch to treatment plant
- Aeration required
- Movable plate to modify opening dimensions

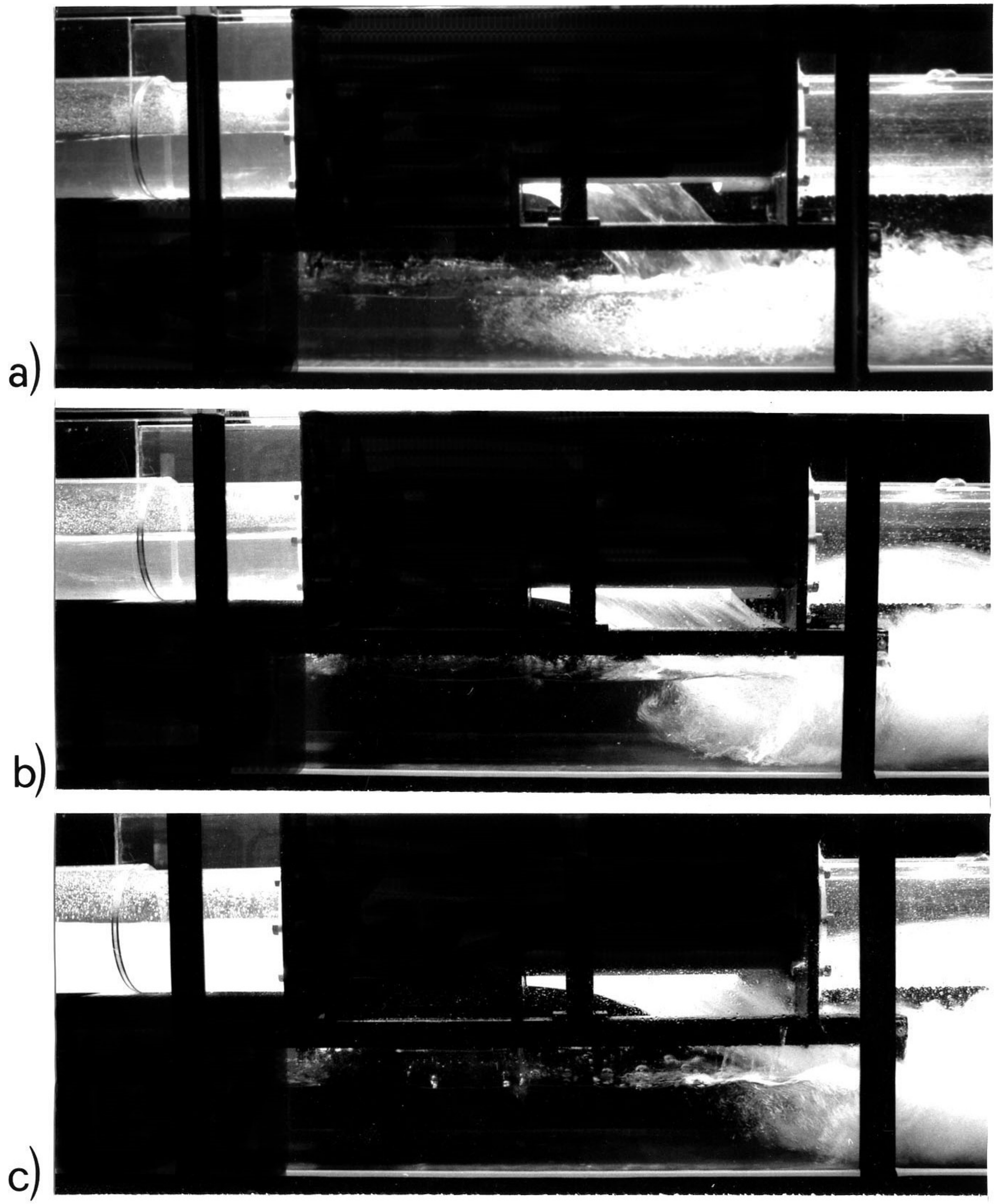
Relevant discharges

1. Dry-weather discharge Q_{TW} to SETP (Intraday (instantaneous) peak of dry-weather discharge being underrun 80% of the days)
2. Design discharge $Q_K=2Q_{TW}$ to STEP
3. Maximum discharge Q_M during storm events, with separation accuracy of 20% related to $2Q_{TW}$ (maximum discharge to STEP $1.2 \cdot 2Q_{TW}$)

9.3 Bottom opening

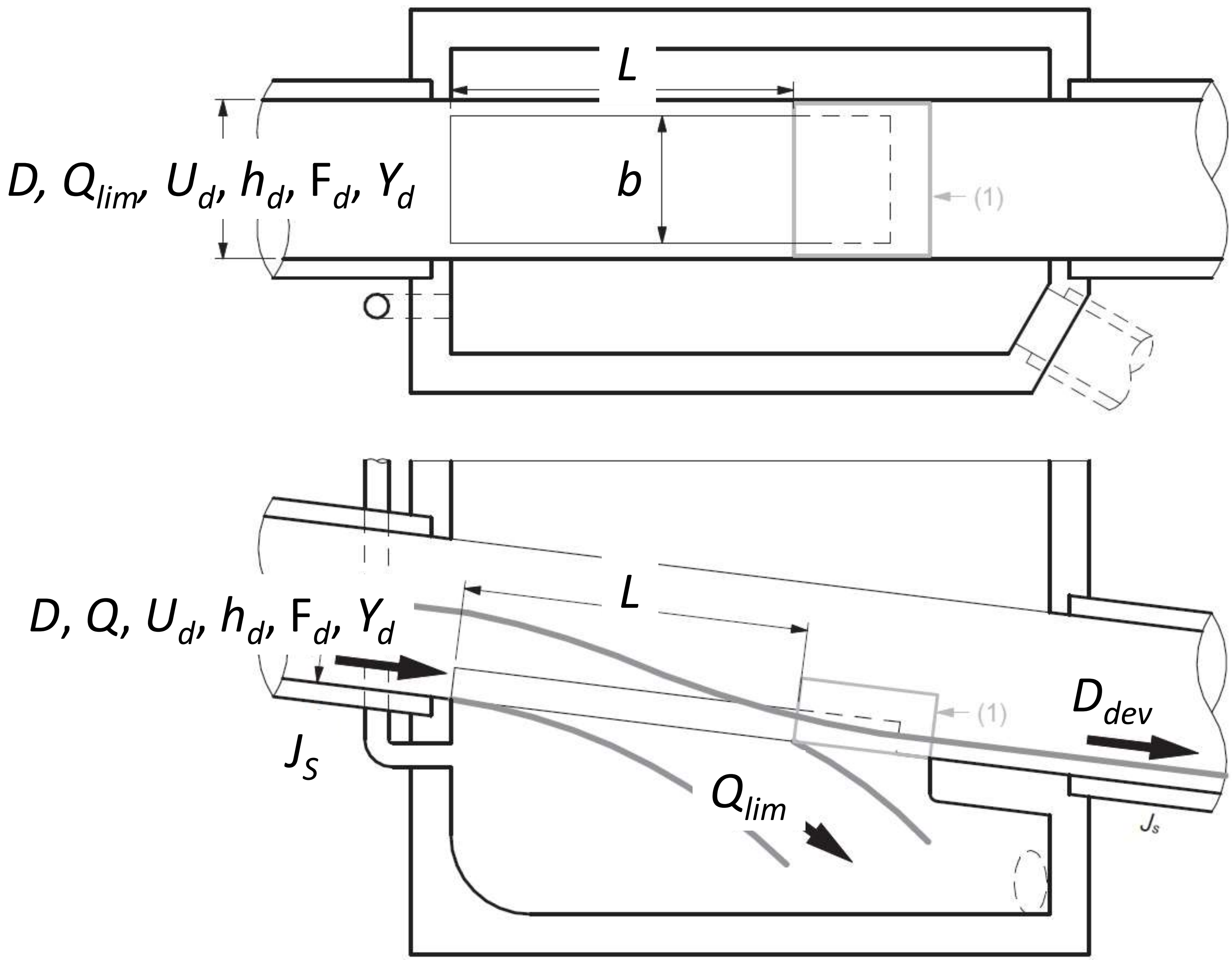
Side view for increasing discharge

Hager (2012)



9.3 Bottom opening

Ouverture de fond (SIA D 0264)



9.3 Bottom opening

Ouverture de fond : Dimensionnement DWA (DWA A111)
(sur la base de Taubmann 1970, ouverture parabolique)

Pour le débit de dimensionnement Q_{lim} et des valeurs de l'écoulement uniforme dans la conduite amont de D (→ U_d, h_d et Y_d)

Longueur de l'ouverture pour J_s<0.2

$$L = 1.5 U_d \sqrt{\frac{h_d}{g}}$$

Longueur de l'ouverture pour 0.2<J_s<0.4

$$L = 1.7 U_d \sqrt{\frac{h_d}{g}} + 1.15 h_d J_s$$

Largueur de l'ouverture typiquement 0.6≤β≤0.8

$$\beta = \frac{b}{D} = 2\left(Y_d - Y_d^2\right)^{1/2}$$

9.3 Bottom opening

Ouverture de fond : Dimensionnement SIA / VSA (Pfister and Ribi 2017)
(sur la base de Hager 2010, ouverture rectangulaire)

Pour le débit de dimensionnement Q_{lim} et des valeurs de l'écoulement uniforme dans la conduite amont de D ($\rightarrow U_d$, h_d F_d, et Y_d)

Largueur de l'ouverture
typiquement $0.6 \leq \beta \leq 0.8$

$$\beta = \frac{b}{D} = 2\left(Y_d - Y_d^2\right)^{1/2}$$

Longueur de l'ouverture
pour $J_s<0.2$

$$L = \frac{Q_{lim} - \left(0.1 D^2 \beta^{1.5} \mathrm{F}_d \sqrt{2 g h_d Y_d}\right)}{0.61 D \beta \sqrt{2 g h_o} (1 - J_S)^3}$$

3.6.3. Les ouvrages de séparation

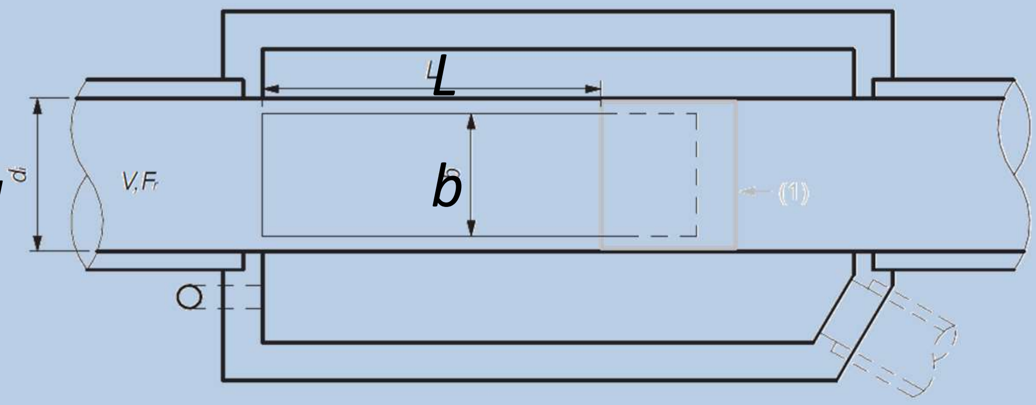
Ouverture de fond : Dimensionnement SIA / VSA

D=0.75 m, J_S=0.035, Q_M=1.17 m^3/s, Q_{lim}=0.22 m^3/s

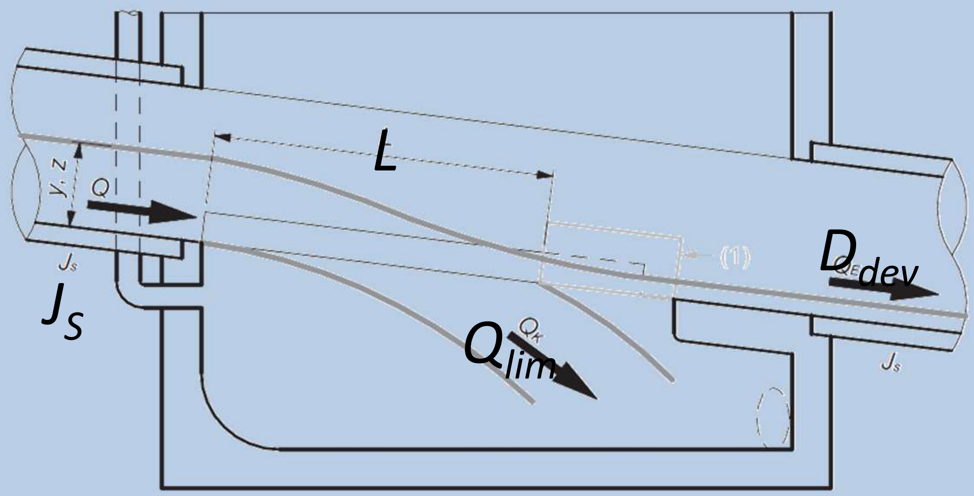
Dimensions de l'ouverture ?

Degré de précision ?

D, Q_{lim}, U_d, h_d, F_d, Y_d



D, Q, U_d, h_d, F_d, Y_d



9.4 Pro memoria

9.4 Pro memoria

General

- Separation manholes are applied to limit the inflow discharge to the treatment plant
- They are operating during rain events in combined sewer systems
- Q_K=2Q_{TW} to STEP and rest to retention
- Two types: Side weir (F_o<0.75) and bottom opening (F_o>1.5)

Side weir

- Read VSA technical guideline STORM
- For inflow F_o<0.75
- Use side weir with high crest, two-sided, with horizontal and sharp-crested lip
- The lip should consist of movable plate to allow for adjustments

9.4 Pro memoria

Bottom opening

- Inflow with $F_o \geq 1.5$ (stable super critically)
- Inflow length >30*D* with uniform flow
- U-shaped profile, extension of circular profile
- Bottom opening rectangular with area *b* times *L*
- Relative width $0.6 \leq \beta \leq 0.8$
- Relative length $L = h_o F_o$
- No backwater from outlet to retention basin
- Separation accuracy respected if $0.6 \leq \beta \leq 0.8$
- Flexible plate to optimize function

Questions?