# Lecture 11

# Combined Sewage and Stormwater treatment

# Sources of pollution

As main rainwater pollution sources are to be mentioned:

- **Pollution from the air** (e.g. aerosols, dusts and gaseous substances like carbon monoxide, sulphur dioxide, nitric oxide and hydrocarbon.)
- **Pollution from traffic surfaces** (e.g. oils, abrasion of tyres and the breaking systems, vegetation (e.g. leaves), excretions of animals, soil erosion, industry, trade and agriculture.)
- **Incorrect discharge** (e.g. like private car wash, etc.)

# Objectives of rainwater treatment

## 1. Reduction of the concentration:

- frequent street cleaning
- gully with improved pollutant retention
- frequent sewer cleaning
- flushing help
- roof material selection (lead, copper, zinc)

## 2. Quantity-reduction:

- Infiltration of not harmfully polluted rainwater
- direct discharge of minimally polluted roof and traffic surfaces into a body of water
- Prevention of drainage or inflow of unpaved surfaces
- Utilization of rainwater as non-potable tab water
- measures for the reduction of sewer infiltration water

# Objectives for rainwater treatment

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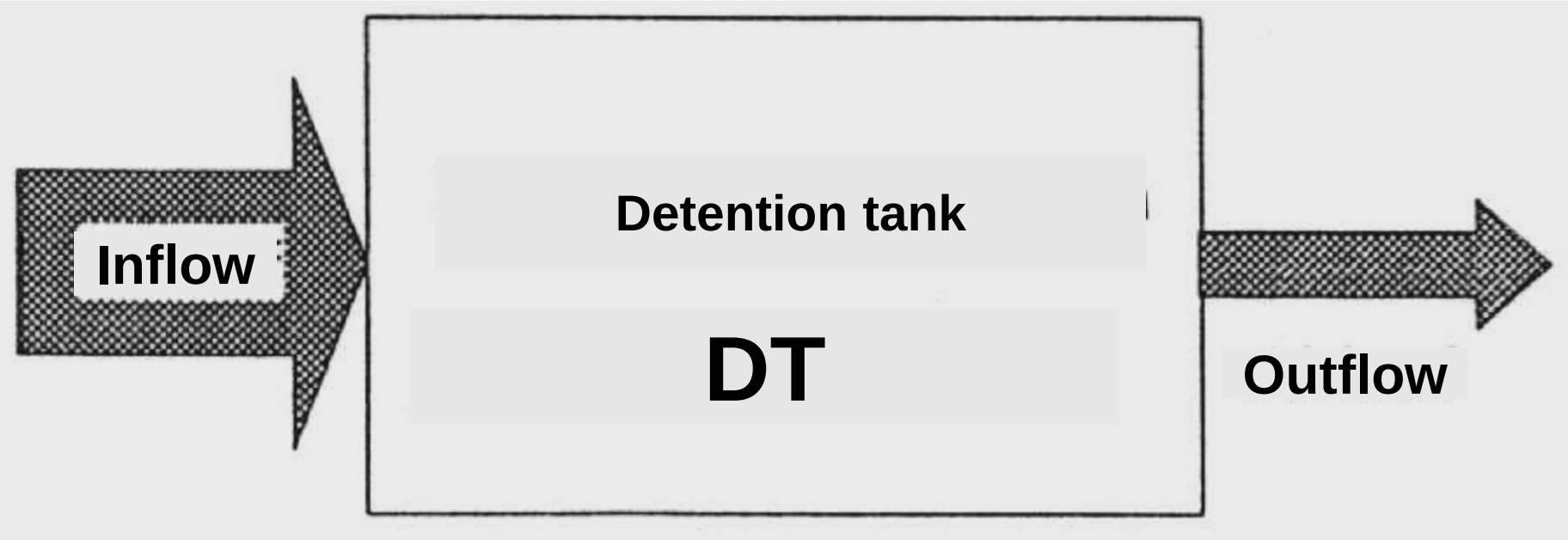
## 3. Evaluation of all measures under the aspect of “total emission”

Settlement areas stress the waters because of:

- Rainwater discharge out of separate sewerage systems
- Discharge out of combined sewer systems
- Discharge out of wastewater treatment plants

# Functional diagram of a stormwater retention tank



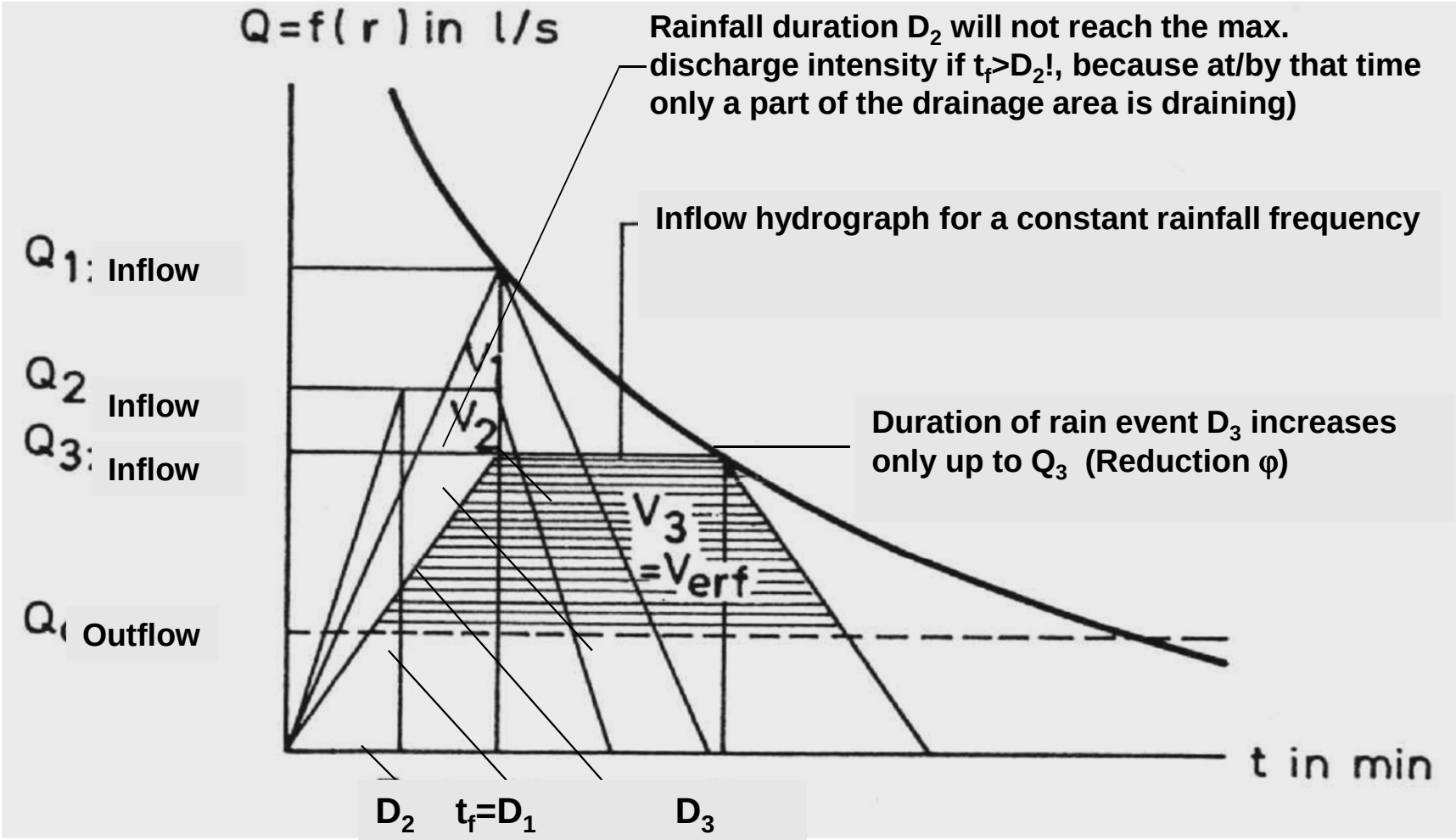

[ATV-A 128E]

# Application of a stormwater retention tank

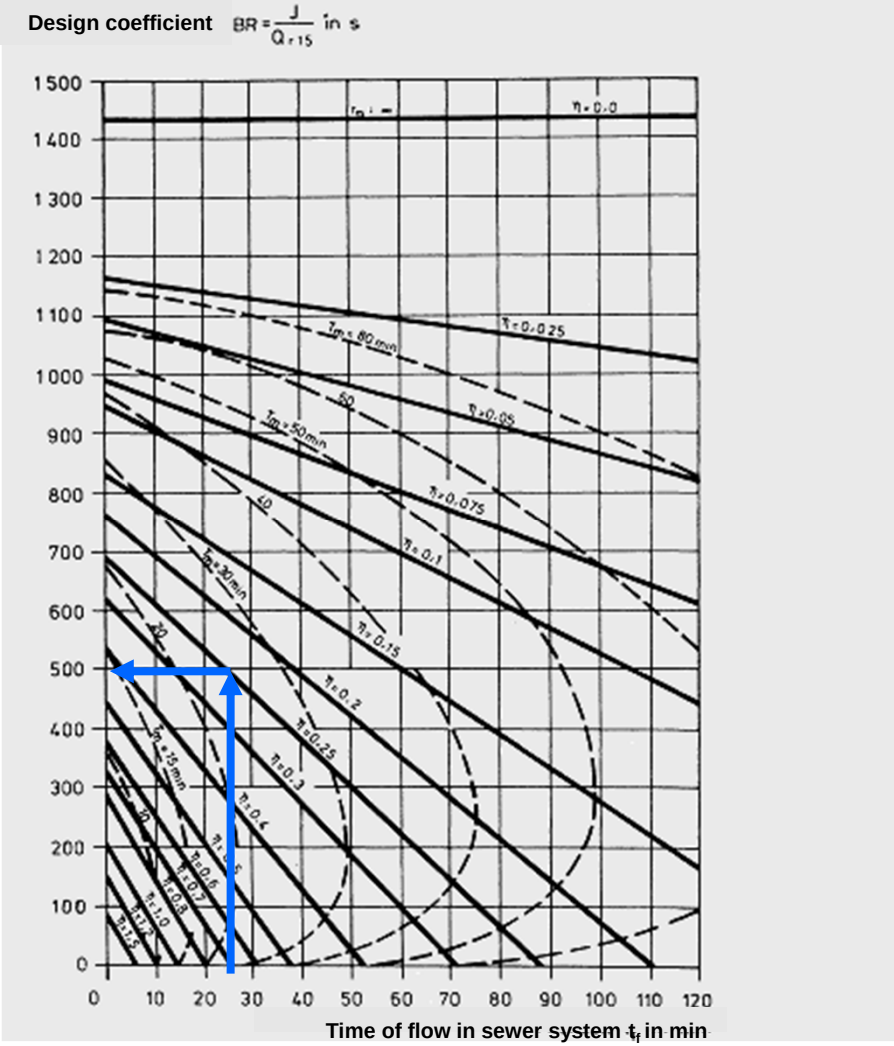
Under the following aspects the construction of a stormwater **retention tank** can be taken into consideration:

- Saving of construction costs of sewer networks
- Connection of new areas with an existing sewer system
- Rehabilitation of overloaded networks
- Protection of the receiving water body

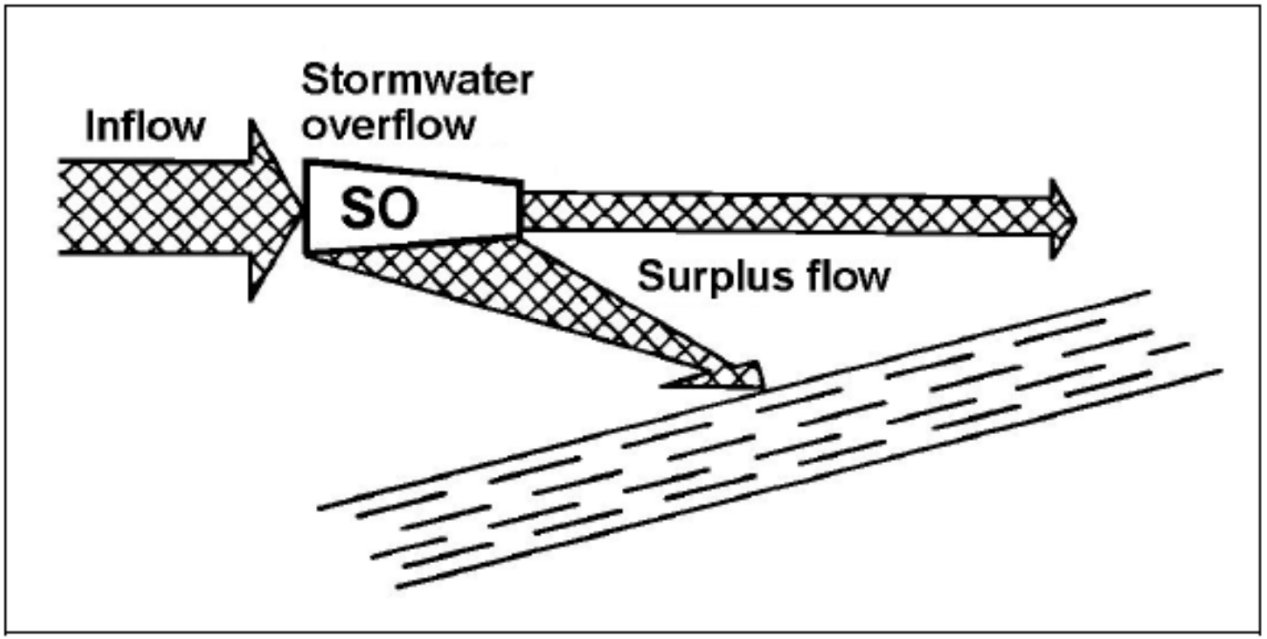
# Determination of the stormwater retention tank volume



# Dimensioning diagram for stormwater retention tanks



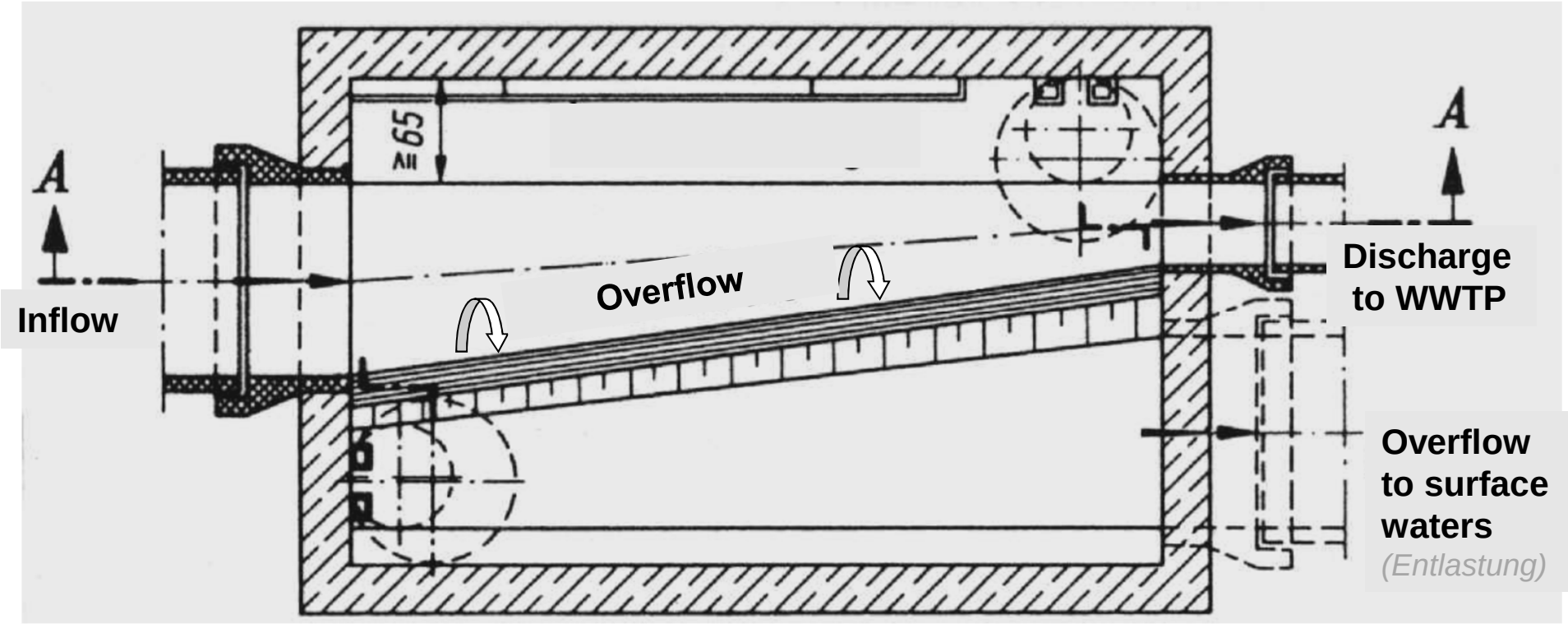
# Functional diagram of a combined sewage overflow



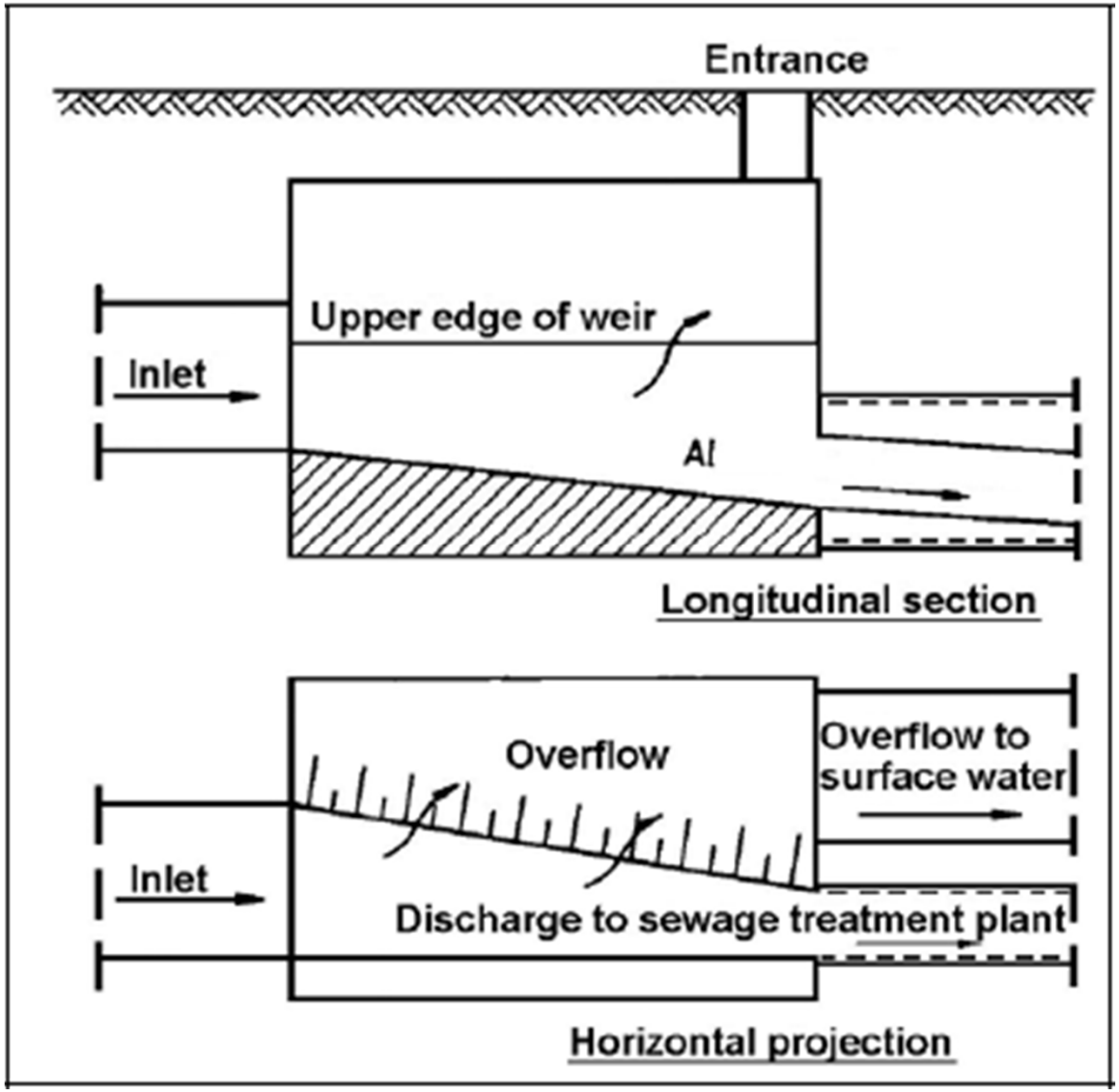

[ATV-A 128E]

Combined Sewage Overflow (CSO) - *Regenüberlauf (RÜ)*

# Combined Sewage Overflow (CSO)

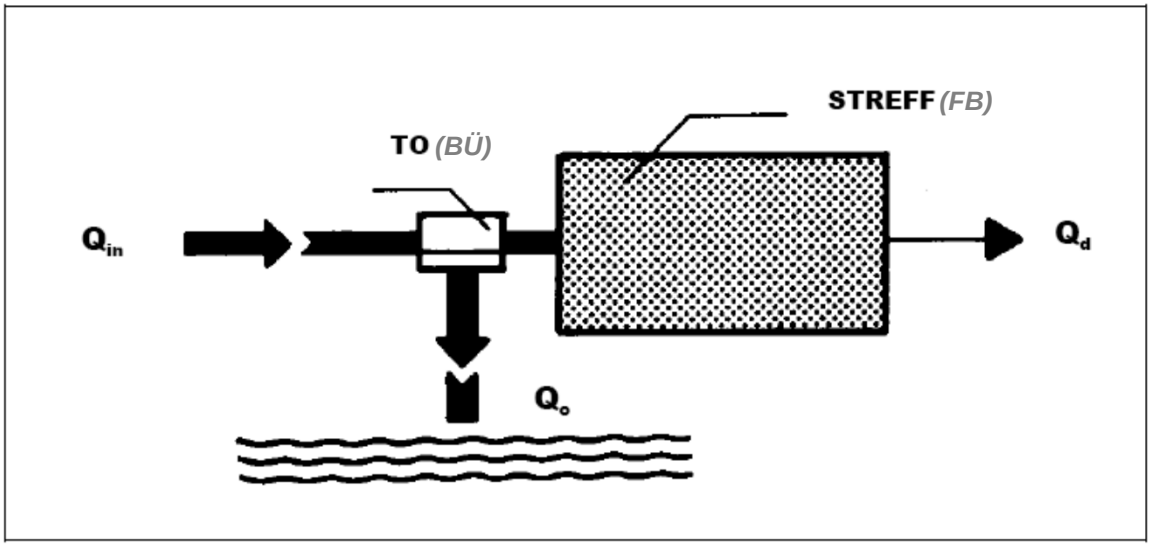


# Combined Sewage Overflow (CSO) with one-sided, raised weir




[ATV-A 128E]

# Stormwater tank retaining the first flush of storm water in main stream and by-pass stream (Catchtank)



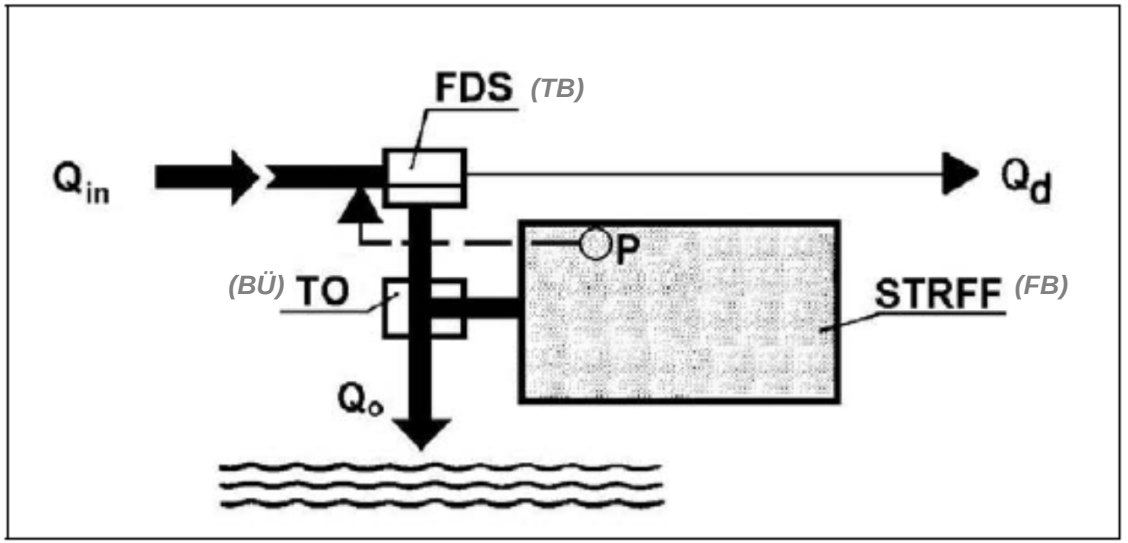

Tank Overflow **(TO)**
*Beckenüberlauf (BÜ)*

Stormwater Tank Retaining the First Flush **(STRFF)**
*Fangbecken (FB)*

Flow-dividing Structure **(FDS)**
*Trennbauwerk (TB)*

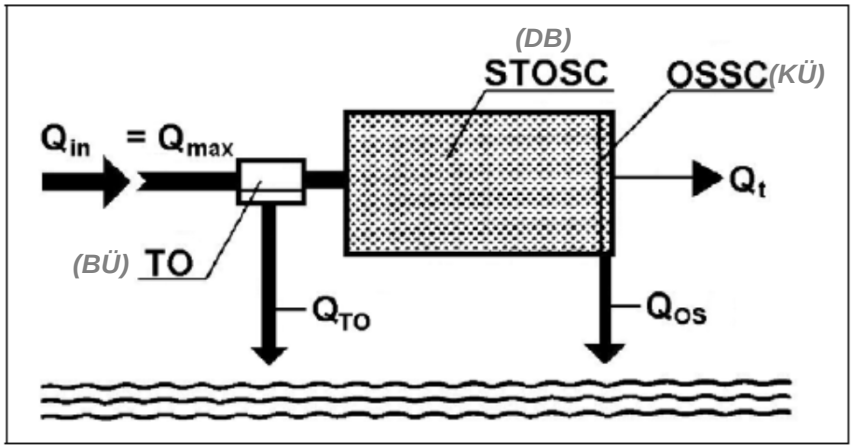
Tank Overflow **(TO)**
*Beckenüberlauf (BÜ)*

Stormwater Tank Retaining the First Flush **(STRFF)**
*Fangbecken (FB)*




**[ATV-A 128E]**

# Stormwater tank with overflow for settled combined wastewater in main stream and by-pass (Running Through Tank)




**Main Stream**
Tank Overflow **(TO) -** *Beckenüberlauf **(BÜ)***

Stormwater tank with overflow for settled combined wastewater**(STOSC)** – *Durchlaufbehälter **(DB)***

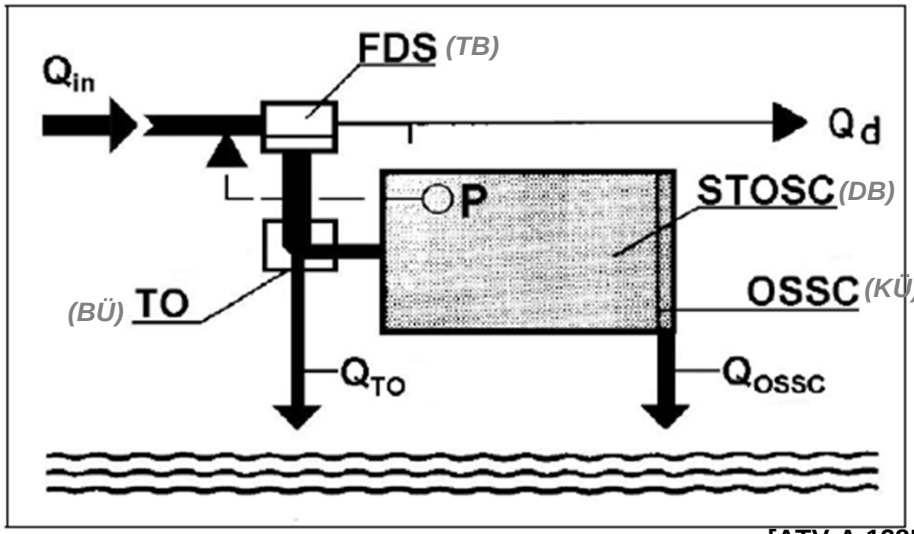
Overflow Structure for Settled Combined wastewater **(OSSC) –** *Klärüberlauf **(KÜ)***

Flow-dividing Structure **(FDS) -** *Trennbauwerk **(TB)***

Tank Overflow **(TO) -** *Beckenüberlauf **(BÜ)***

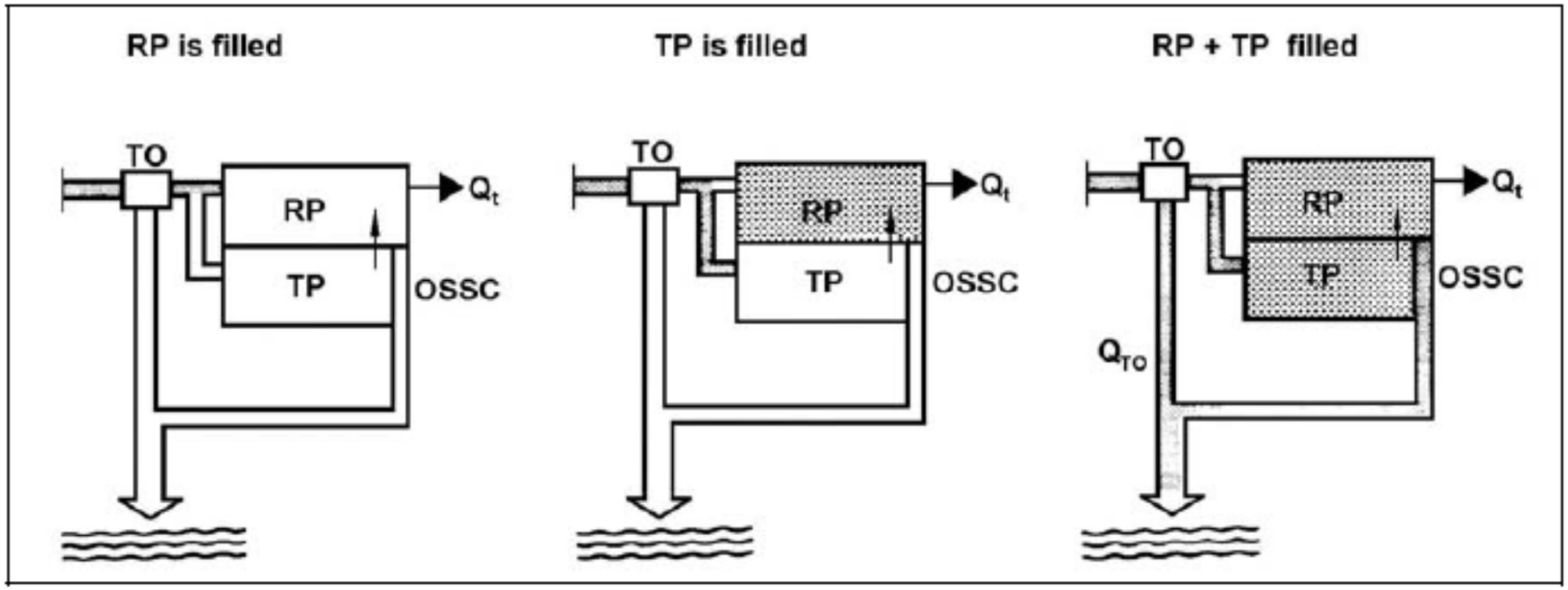
Stormwater tank with overflow for settled combined wastewater **(STOSC)** - *Durchlaufbehälter **(DB)***

Overflow Structure for Settled Combined wastewater **(OSSC) –** *Klärüberlauf **(KÜ)***




[ATV-A 128E]

# Composite tank in main stream




Composite tank in main stream – *Verbundbecken (im Hauptschluss)*

RP = Retention Part
TP = Treatment Part

# Advantages and disadvantages of Composite Tanks (CT)

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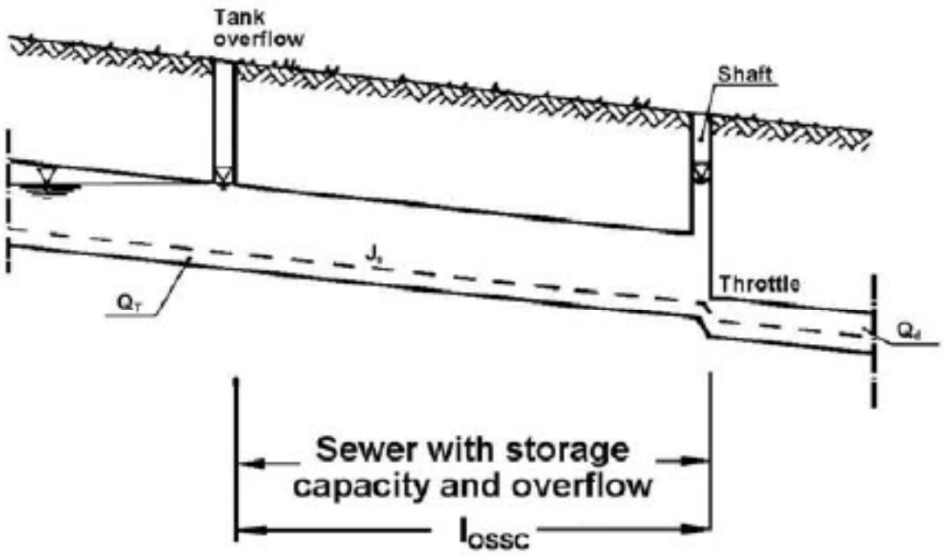
## Advantages:

- Retention and treatment effect in one tank
- Division of volume between retention and treatment parts selectable
- By subdivision into several chambers the back-up frequency and thus the maintenance resources in the neighbouring through flow part are reduced significantly.

## Disadvantages:

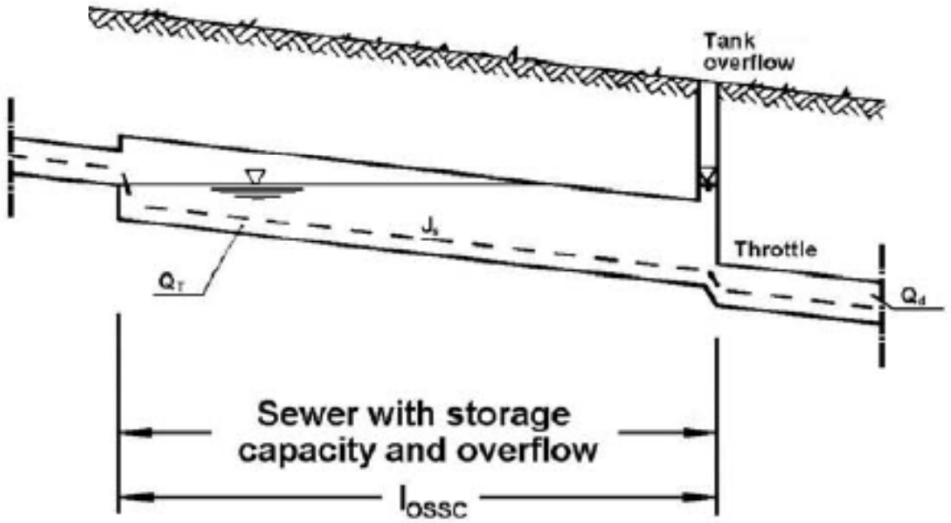
- Smaller treatment effect compared with a STOSC
- Structurally and operationally more expensive

# Sewer with storage capacity and top and bottom overflow




**SSCTO**
(Sewer with storage capacity and top overflow)

**SSCBO**
(Sewer with storage capacity and bottom overflow)



# Advantages and disadvantages of sewers with storage capacity

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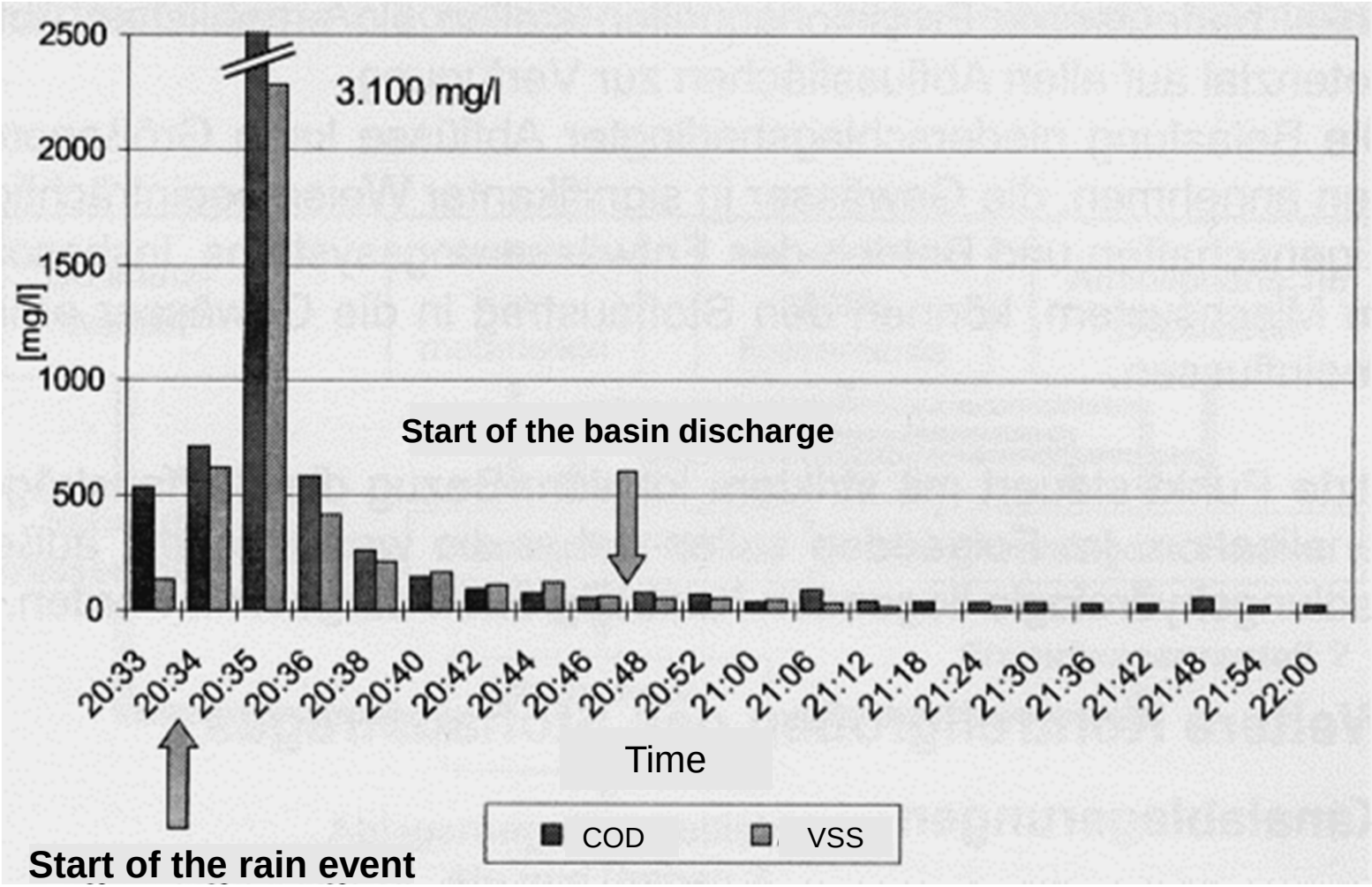
## Advantages:

- No structure in addition to the sewer necessary
- Emptying with natural gradient

## Disadvantages:

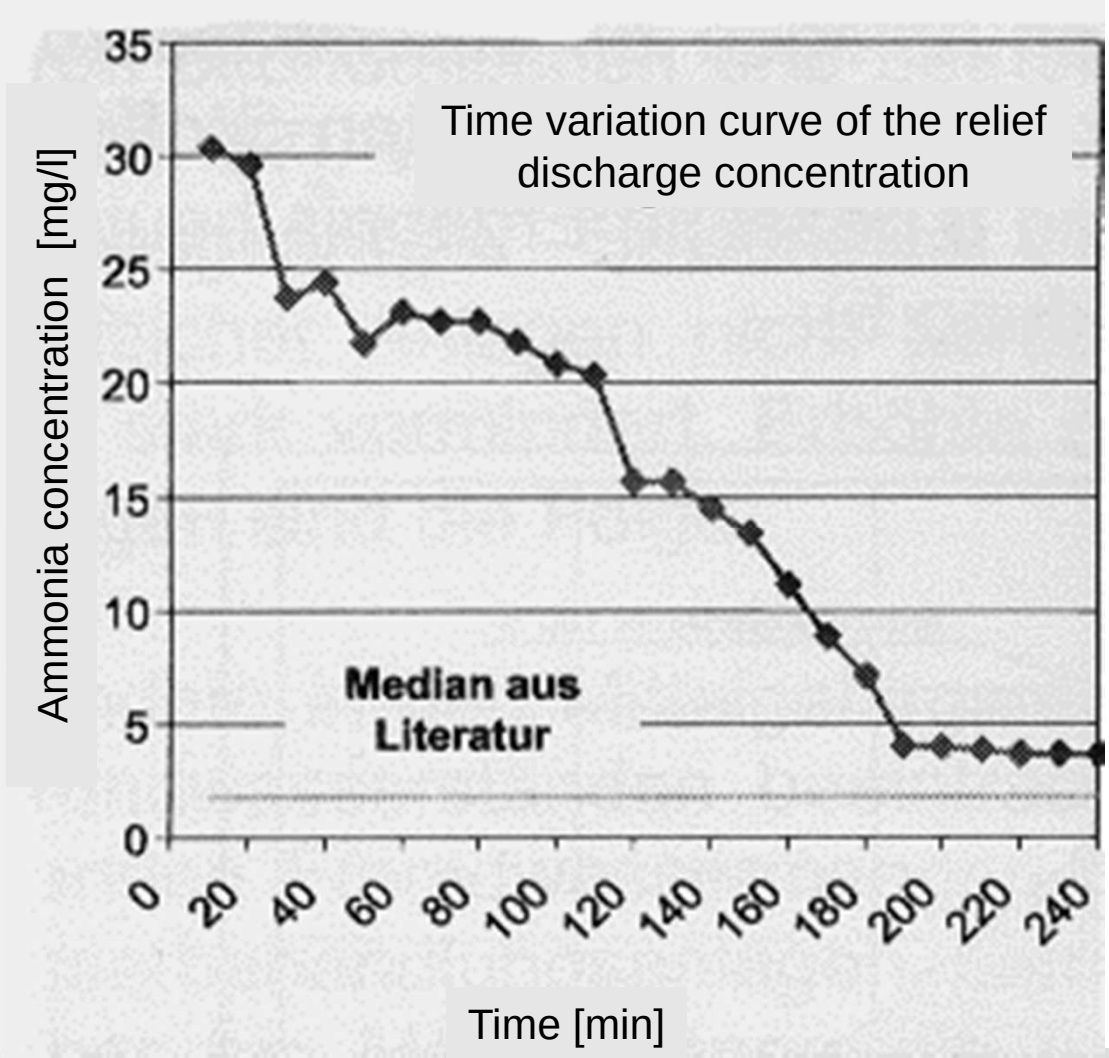
- Deposits cannot be excluded
- Volumes of SSCBO (Bottom Overflow) larger than with STOSC
- With overflow of SSCBO partial washing out of storage volume contents into the surface water body

# „Classical“ flush in a small catchment area



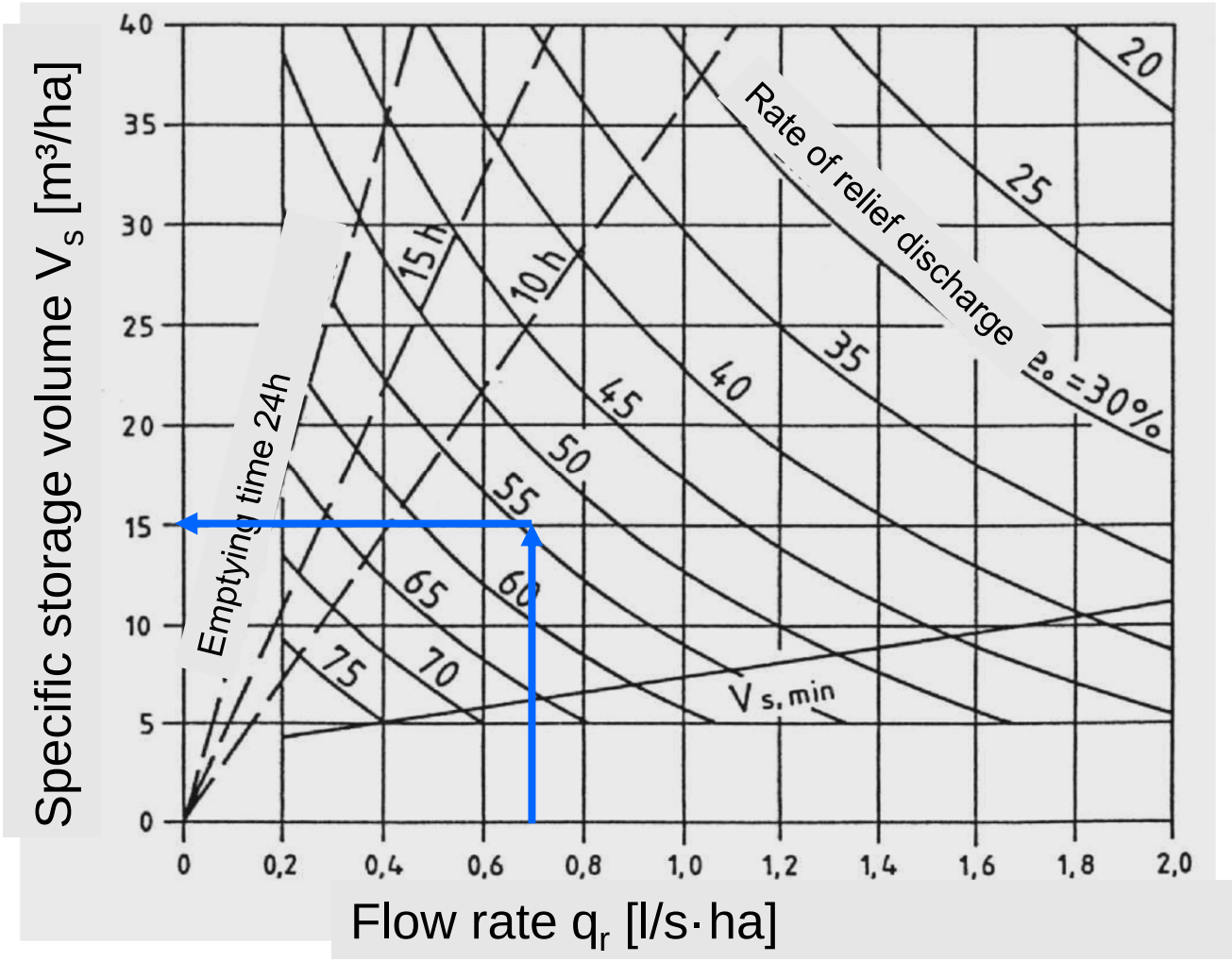

[Fuchs, 2003]

# Ammonia concentration of the relief discharge *(Entlastungsabfluss)* in a channel with storage capacity

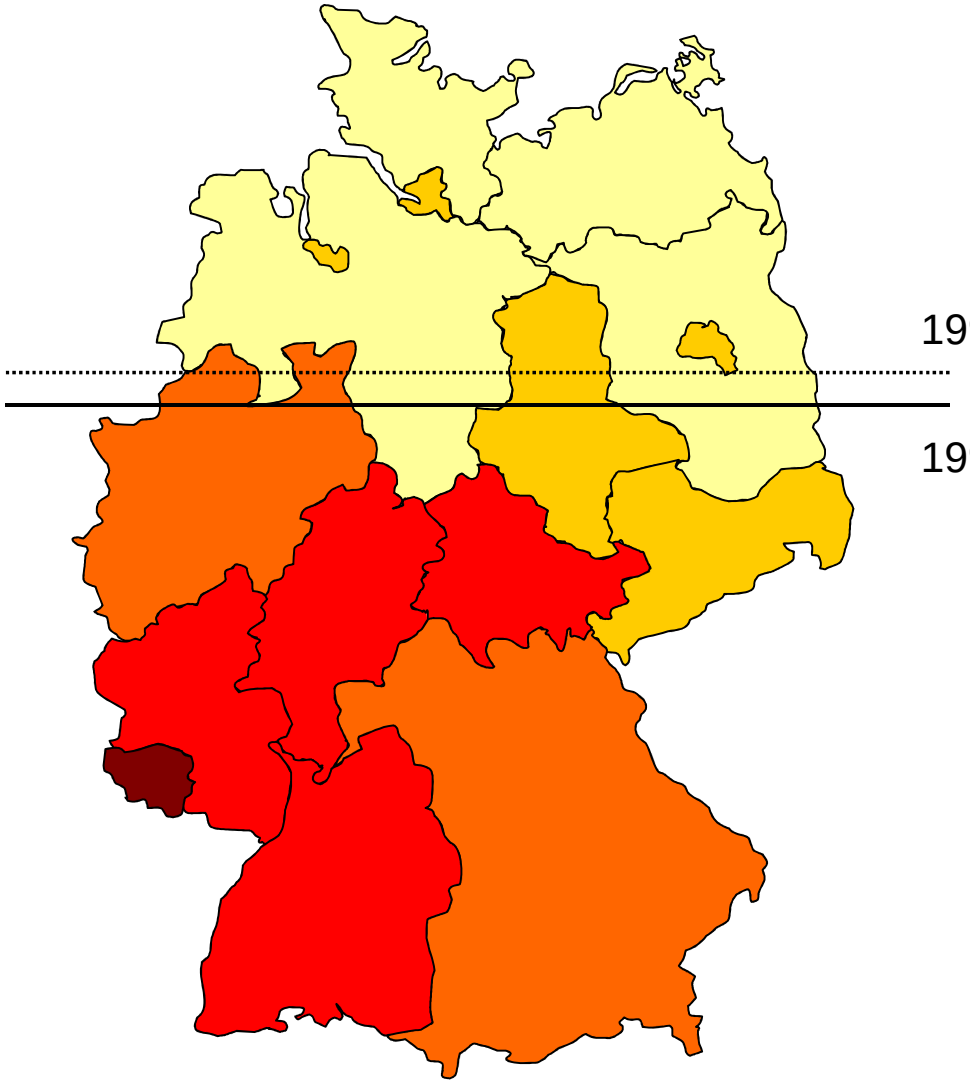



[Fuchs, 2003]

# Specific storage volume depending from stormwater flow rate and allowable overflow ratio



# Distribution of separate and combined sewerage systems in Germany



1992

Equator of combined **sewage**

1998

- 0% - 19,9%
- 20% - 39,9%
- 40% - 59,9%
- 60% - 79,9%
- 80% - 100%

in percent of population served,
pale 100% separate systems, dark 100% combined

# Statistical sewer figure from selected states in Europe in comparison with the USA and Japan

| | Belgium | Denmark | France | Germany | Great Britain | Nether-lands | Spain | Japan | USA |
|---|---|---|---|---|---|---|---|---|---|
| Total area in 1000 km² | 31 | 43 | 544 | 357 | 244 | 41 | 506 | 378 | 9,363 |
| Population in million people | 10 | 5 | 58 | 82 | 58 | 41 | 41 | 120 | 281 |
| Average density of population in heads/km² | 325 | 121 | 106 | 230 | 237 | 371 | 81 | 180 | 30 |
| Connection to public sewers in % of population | 60 | 94 | 80 | 93 | 98 | 92 | 85 | 54 | 70 |
| Connection to public owned WWTP in % of population | 20 | 92 | 77 | 91 | 82 | 88 | 60 | | 70 |
| Connection to combined sew-ers in % of population | 70 | 47 | 75 | 63 | 70 | 85 | 88 | 25 | 15 |

[Brombach, 2004 supplemented]

# Efficiency of combined sewage overflow CSO-treatment-plants

| | Settleable solids | Filtratable solids | $BOD_5$ | COD | $N_{tot}$ |
|---|---|---|---|---|---|
| **Settling tanks** | 62 | 45 | 30 | 45 | 40 |
| **Hydrodynamic treatment** | 50 | -- | -- | 40 | -- |
| **Sieve** | (90) | 35 | 33 | 39 | -- |
| **Flotation** | -- | 43 | 35 | 41 | -- |
| **Flocculation +Flot.** | 96 | 88 | 76 | 72 | >90 |
| **Flocculation + Filtr.** | (99) | 86 | 97 | 44 | >90 |
| **Soil Filter** | -- | 90 | 70 | 65 | 80 |

[Hahn, 1997]

# Number and volume of CSO-treatment plants in operation in Germany

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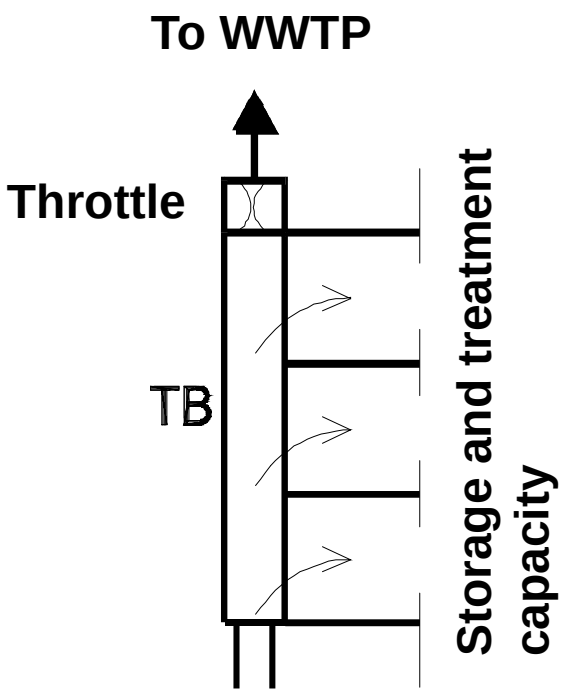
| | Type of structure | Number of units | Storm storage capacity [m³] |
|---|---|---|---|
| **CSO-tanks** | All types of CSO-tanks in combined systems | 20,080 | 13,104,000 |
| **CSO** | Combined sewer overflows with no significant storage | 20,020 | 0 |
| **RR** | Retention reservoirs with emergency overflows in comb. and sep.systems | 9,392 | 18,169,000 |
| **CTT** | All types of CSO-tanks in combined systems | 1,572 | 1,871,000 |
| | **Total** | **51,064** | **33,144,000** |
| | **Storage capacity in the state of North Rhine Westphalia** (Mertsch and Geiger 2005) | | |
| **CSO-tanks** | All types of CSO-tanks in combined systems | 7,101,947 m³ | |
| **CTT** | Clarifier type tanks in storm outlets from seperate systems | 3,165,260 m³ | |

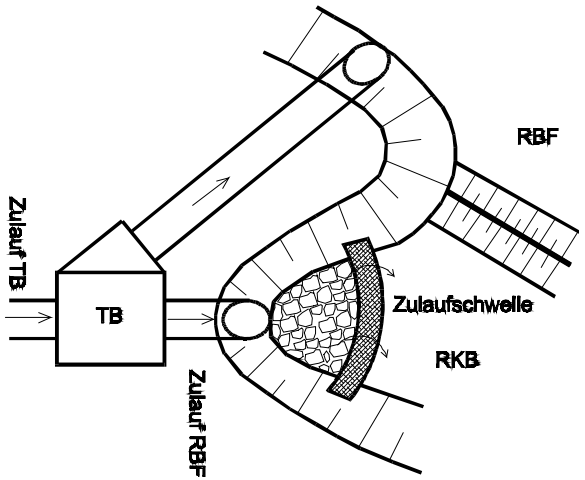
[Census 1998 supplemented]

# Feed structures




a) Areal distribution of the inflow over the width of the basin *(Flächenhafte Verteilung des Einlaufes über die Beckenbreite)*

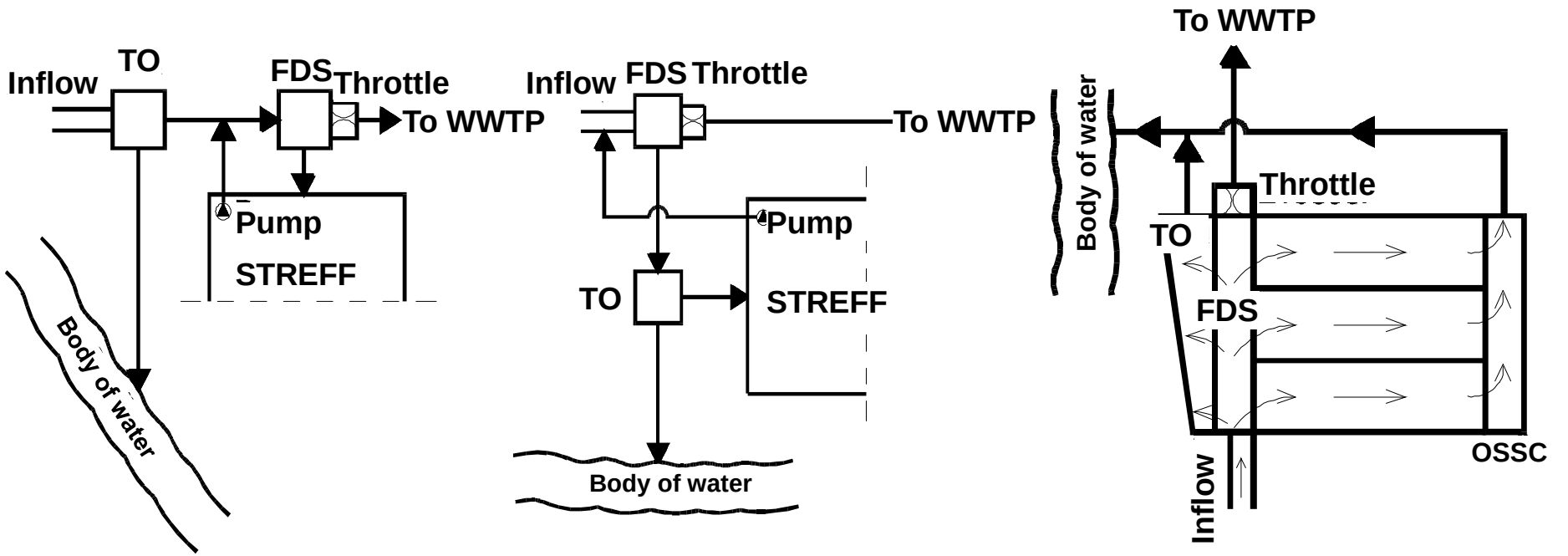
b) Inflow shaft *(Zulauftulpe (Quelleschacht))*




c) Punctate, frontale introduction *(punktförmige, frontale Einleitung)*

[after Geiger et Nafo, 2000]

# Flow-dividing structures



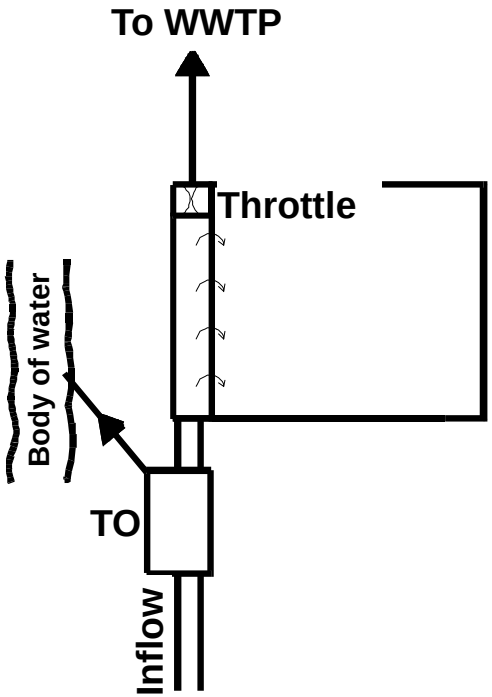

d) Flow-dividing Structure (FDS) between tank overflow (TO) and stormwater tank retaining the first flushh (STREFF)
*(Trennbauwerk zwischen Beckenüberlauf und Speicher-/Behandlungsraum)*

e) Flow-dividing structure in front of tank overflow (TO) and stormwater tank retaining the first flushh (STREFF)
*(Trennbauwerk vor Beckenüberlauf und Speicher-/Behandlungsraum*

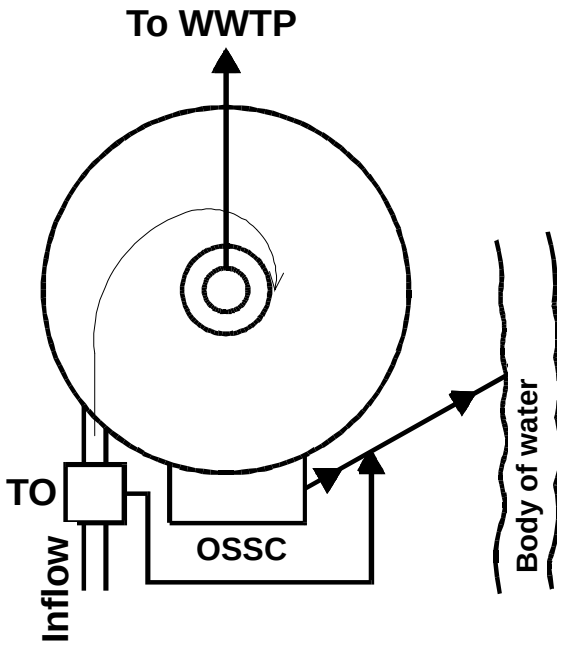
f) Flow-dividing structure combined with a tank overflow (TO) and overflow structure for settled combined wastewater (OSSC)
*(Trennbauwerk kombiniert mit Beckenüberlauf und Speicher-/Behandlungsraum)*

[after Geiger et Nafo, 2000]

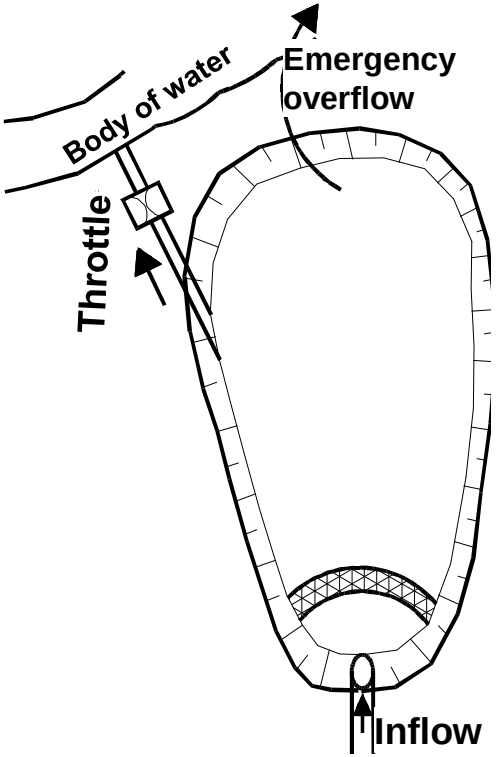
# Storage and treatment capacity




g) Rectangular basin
*(Rechteckbecken)*
(here interceptor tank
(Fangbecken))



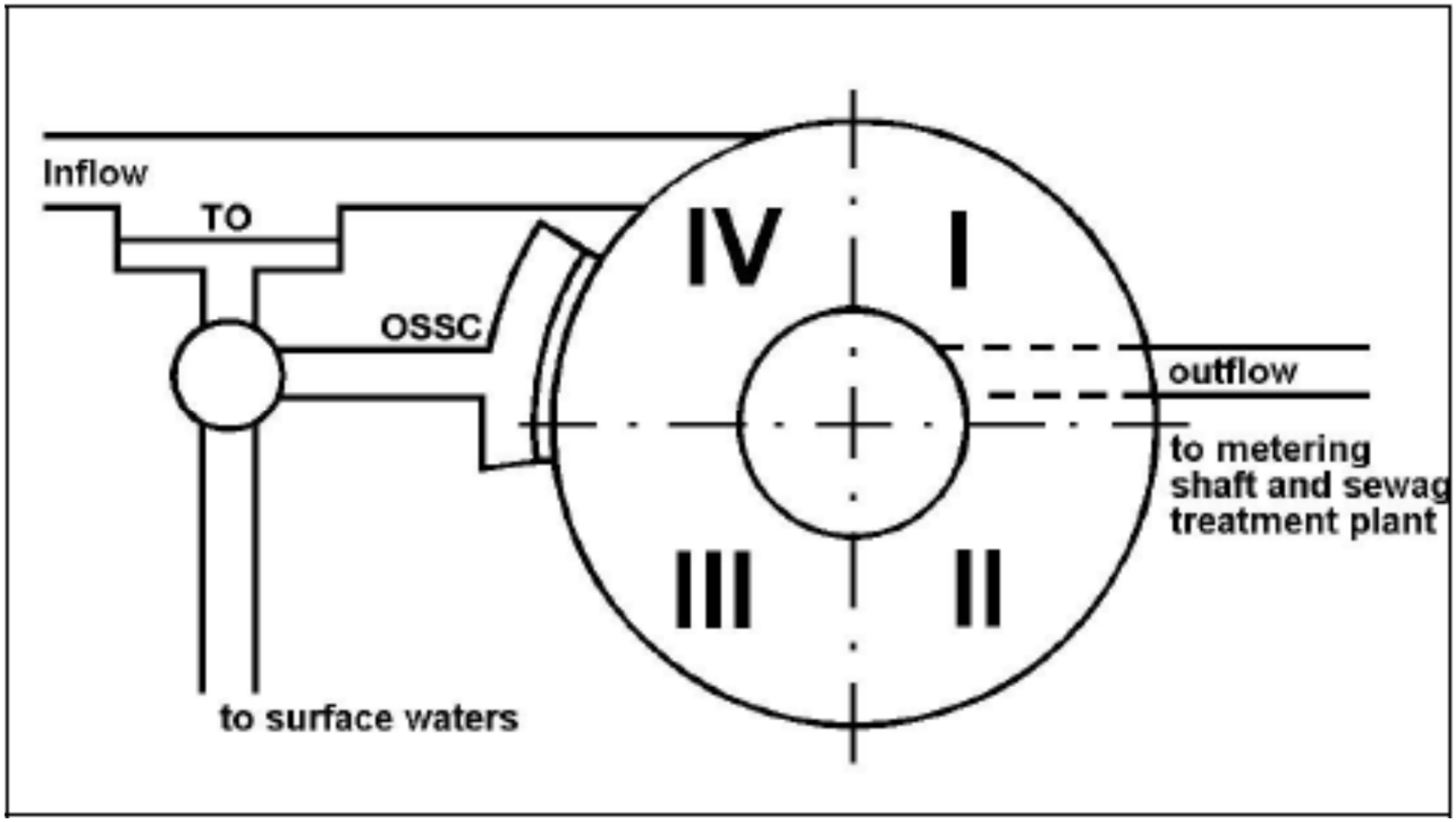

h) Circular tank
*(Rundbecken)*




i) Earth basin
*(Erdbecken)*

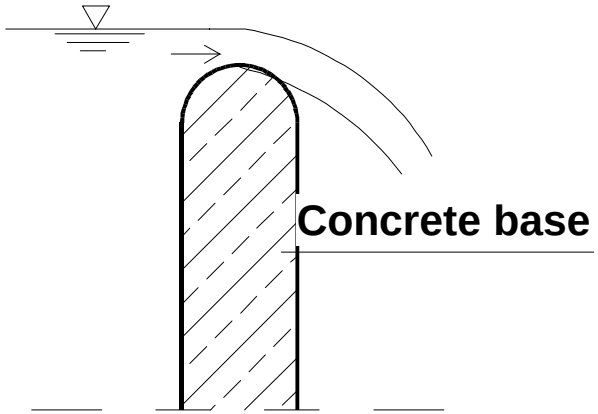
[after Geiger et Nafo, 2000]

# Functional diagram of a circular storm-water tank with overflow for settled combined wastewater

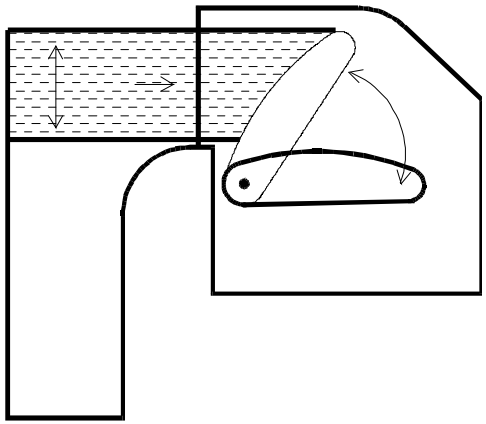



**[ATV-A 128E]**

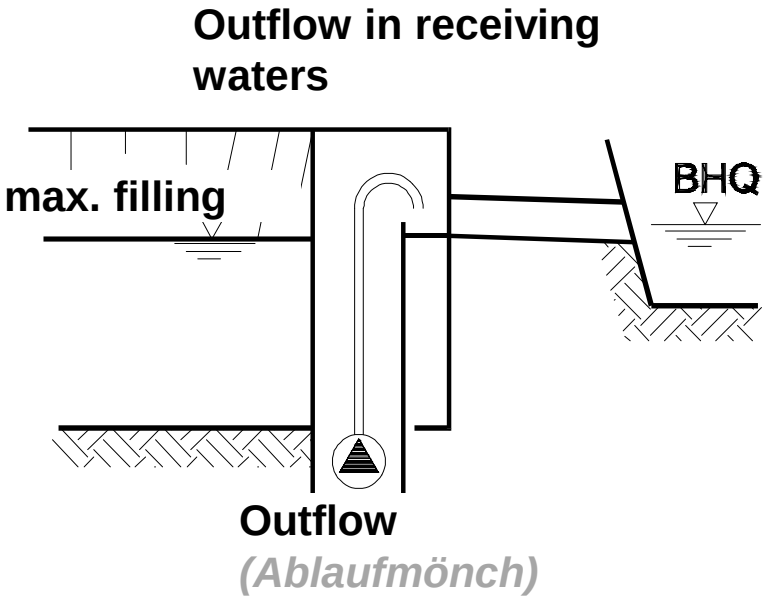
# Stormwater and basin overflow




j) Fixed sill, weir
*(feste Schwelle, Wehr)*



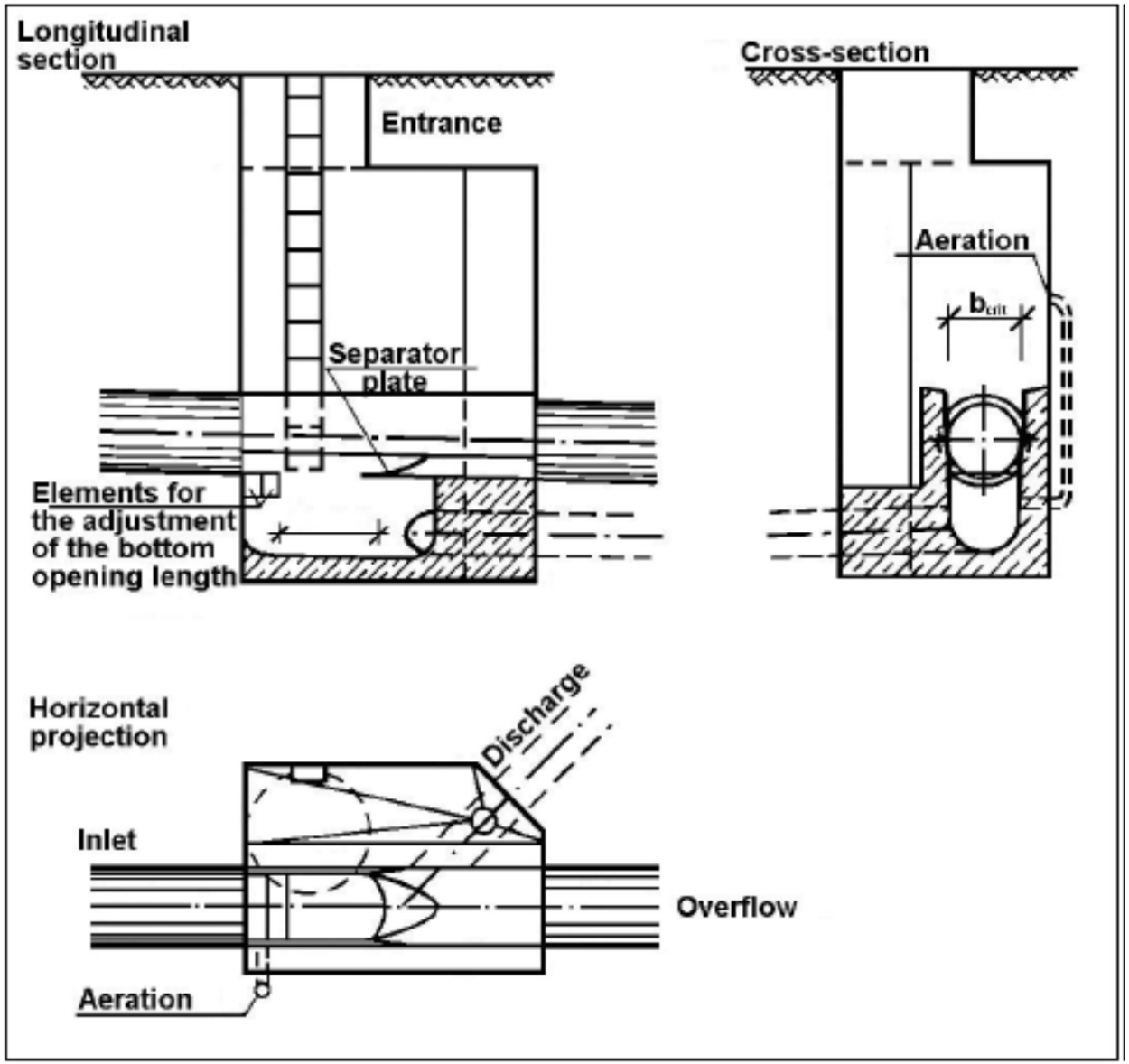
k) Float-controlled shutter weir)
*(Schwimmergesteuertes Klappenwehr)*




l) Pump

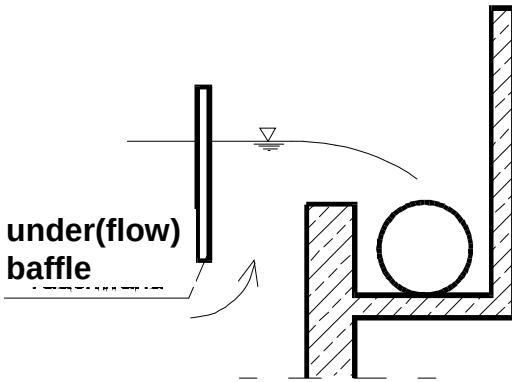
[after Geiger et Nafo, 2000]

# Stormwater overflow with floor opening

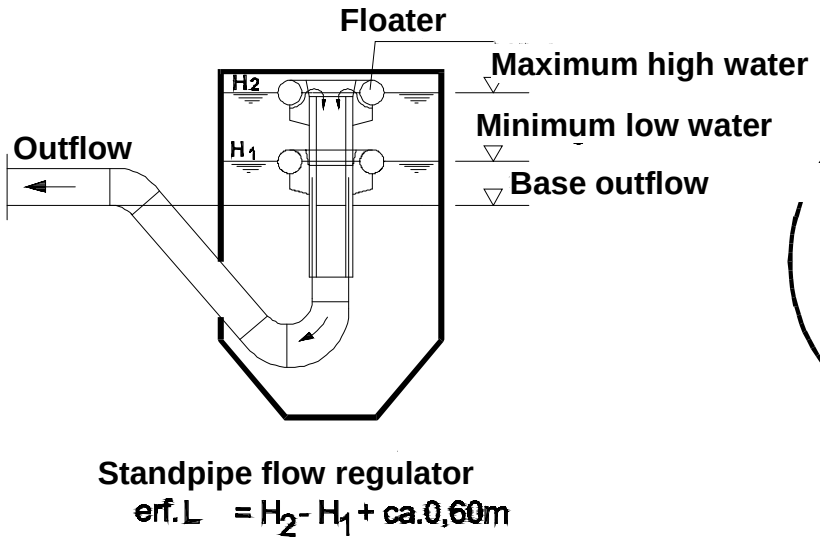



[ATV-A 128E]

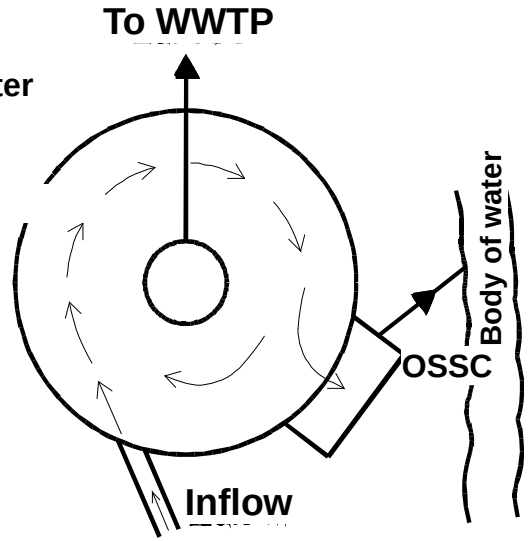
# Overflow structure for settled combined wastewater *(Klärüberlauf)*




m) Overflow structure for settled combined wastewater with vertical inflow *(KÜ mit senkrechter Anströmung)*



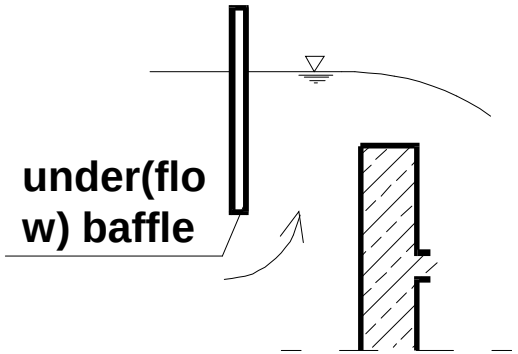

n) Floating overflow structure for settled combined wastewater *(schwimmender KÜ)*



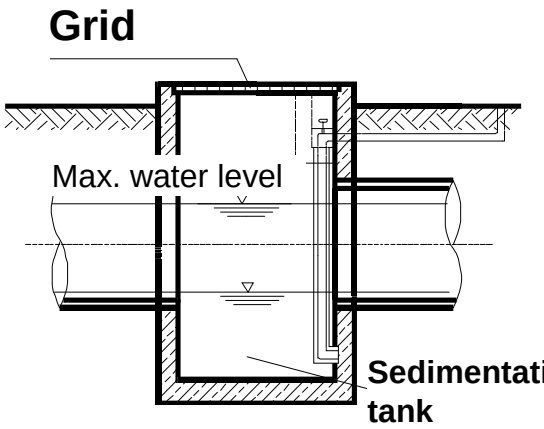

o) Overflow structure for settled combined wastewater with tangential inflow *(KÜ mit tangentialer Anströmung)*

[after Geiger et Nafo, 2000]

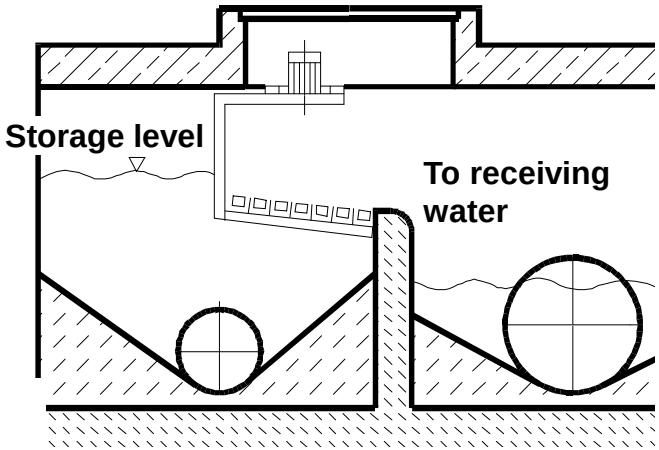
# Retention of floating material/ phase-seperation *(Schwimmstoffrückhalt/ Phasentrennung)*




p) Fixed under (flow) baffle *(feste Tauchwand)*



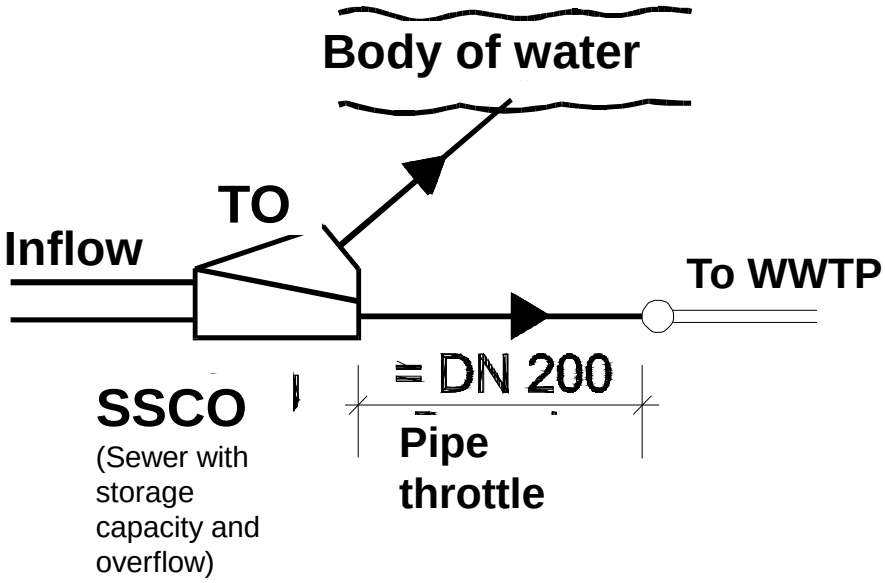

q) Grit chamber *(Sand-, Geröllfang)*



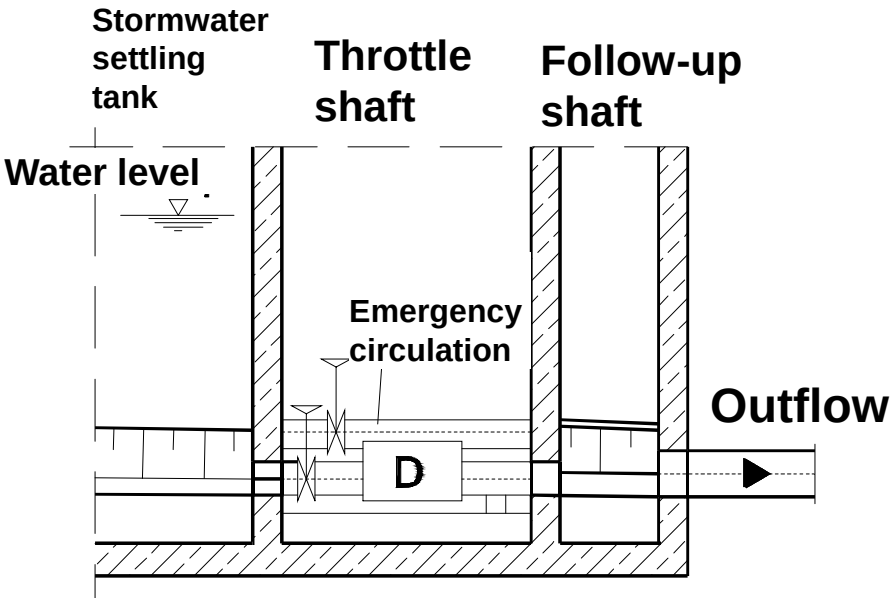

r) Sieve and screening plant *(Sieb-, Rechenanlage)*

[after Geiger et Nafo, 2000]

# Throttle structures *(Drosselbauwerke)*



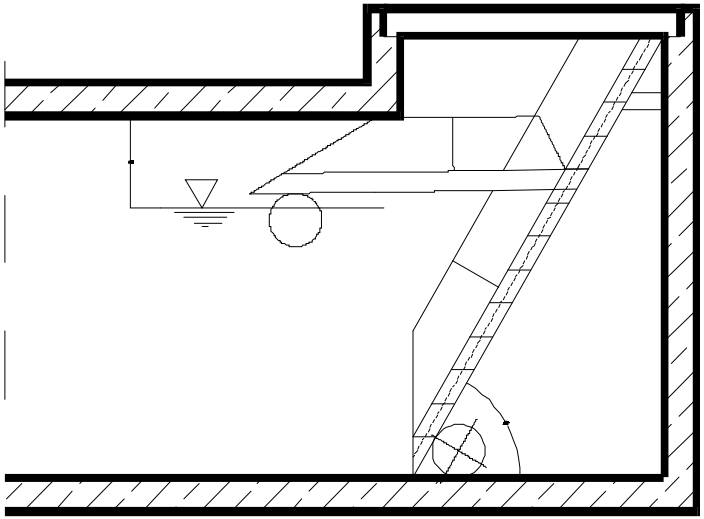

s) Pipe throttle
*(Drosselstrecke (Rohrdrossel))*



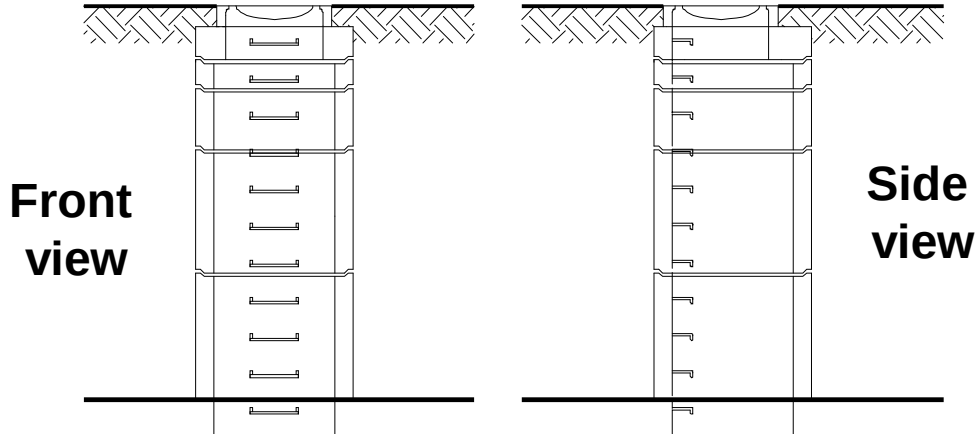

t) Throttle shaft
*(Drosselschacht)*

[after Geiger et Nafo, 2000]

# Inspection installations



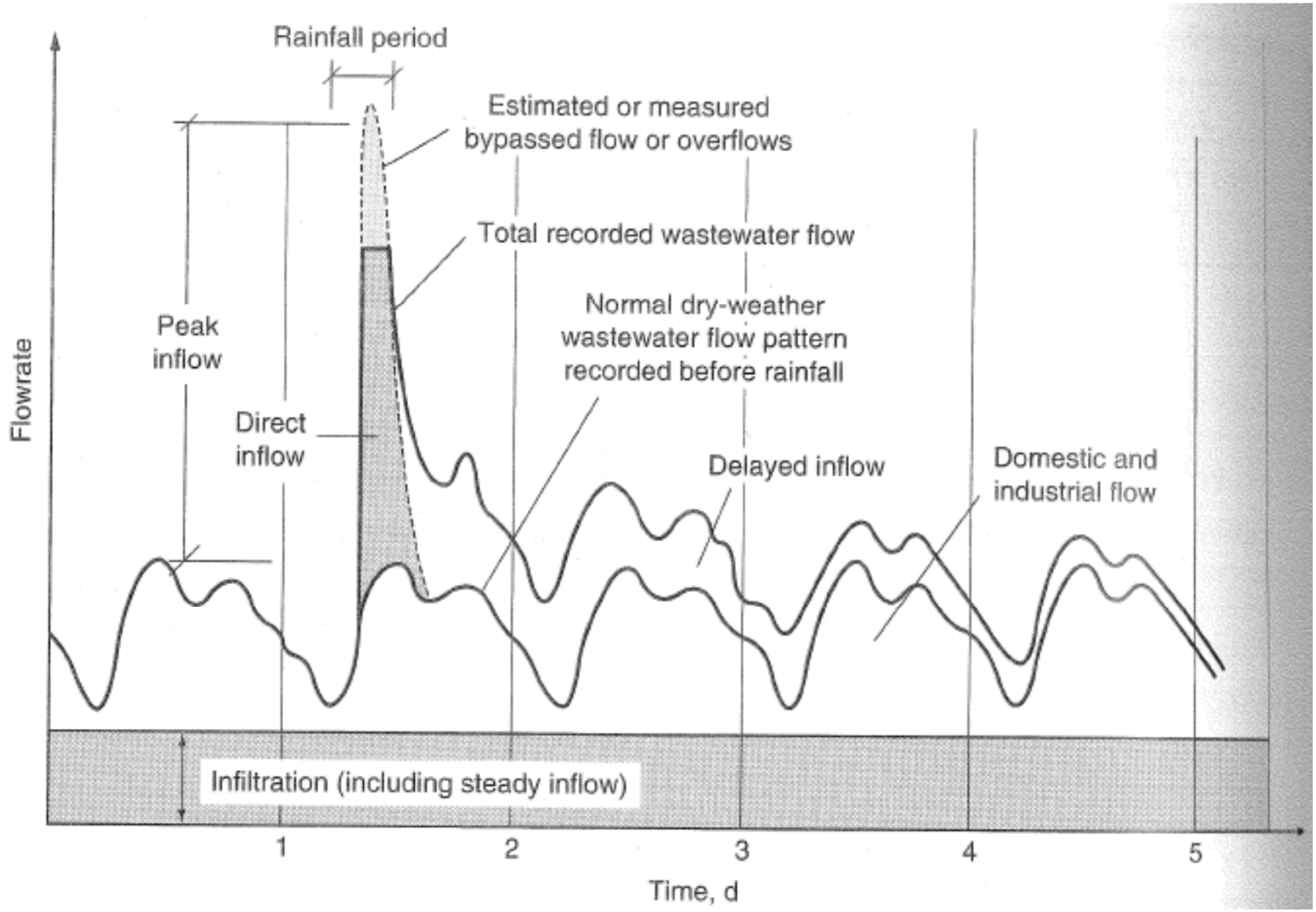
u) Floating stairs *(aufschwimmbare Treppe)*




v) Ladder *(Steigleiter)*

[after Geiger et Nafo, 2000]

# Graphic identification of infiltration/inflow




[Wastewater Engineering – Treatment and Reuse]