Water management in urban areas

Design, Building site preparation

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The urban water assignment

**Administrative assignment:**
- Safety → “dry feet”
- Healthy environment
  - Public health
  - Ecologic quality
  - “Pleasant living and work environment for all layers of the society”

**Technical assignment:**
- Surface water
- Water quality
- Ground water
Steps

Step by step approach

- Step 1: The surface water
  - 1.a. Separate urban water from surrounding water
  - 1.b. Determine the drainage options
  - 1.c. Determine water level, freeboard, $dH_{\text{max}}$
  - 1.d. Determine the needed storage
  - 1.e. What do we calculate as storage?
  - 1.f. Reduce damage when exceeding the design standard
  - 1.g. Hydraulic discharge capacity

- Step 2. The water quality
- Step 3. Ground water
  - 3.a. Drainage depth, drain dept, drainage level
  - 3.b. Type of drainage system
  - 3.c. Lay-out of system
  - 3.d. Type of drainage tube
Step 1: The surface water
1.a. Separate urban water from surrounding water

With a weir or pumping station

Because:

1. Strict standards
   - Water level variations
   - Water quality
2. Other ground level
3. Other interest (party)
4. Other water administrators
5. Other operational control
1.b. Determine the drainage options

Drainage city ⇔ Drainage river basin

• Fast drainage ⇔ Slow Drainage

• “spread” discharge peak
1.b. Determine the drainage options

Drainage city ⇔ Drainage river basin

City can help rural area!

Enquiry on connection city ⇔ river basin

From results:

**Maximal discharge capacity** $Q_{\text{max}}$

[mm/day of l/s/ha]

Of urban area
1.c. Determine water level, freeboard, $dH_{\text{max}}$

As a function of:
- Consolidation
- Seepage
- Hydraulic gradient for sewer-discharge
- Desirable ground water-regime
- Drainage
1.c. Determine water level, freeboard, $dH_{\text{max}}$

**Known values**

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeboard (m)</td>
<td>0.9 – 1.3</td>
</tr>
<tr>
<td>$dH_{\text{max}}$ (m) $T=10$ year</td>
<td>0.3 – 0.5</td>
</tr>
<tr>
<td>Design discharge (mm/day)</td>
<td>12 - 14</td>
</tr>
</tbody>
</table>
1.d. Determine the required storage
1.d. Storage $\Leftrightarrow$ Discharge capacity

- Storage and discharge are “exchangeable”!
- Slow discharge small box
- Needed Storage = function of discharge capacity and velocity water input

Depending on urban design
1.d. Determine the required storage

Hydrological model

- Reservoir-model precipitation-discharge model

Precipitation (t)

Discharge capacity $Q$

Precipitation discharge

- losses
- delay

STORAGE(t)

seepage and drainage water
1.d. Determine the required storage

Hydrological model

- Reservoir precipitation-discharge model

Take in account:
- Water losses
- Disconnected area
- Infiltration, vegetated swails

Precipitation (t)

FAST
- Losses
- Delays

SLOW
- Losses
- Delays

Storage (t)

Q

seepage, drains
1.d. Determine the required storage

Extreme value statistics

*Use 100 years precipitation data*

=> **100 years of stored volume**

(Statistics afterwards)

=> *how much storage needed*

1x / per 10, 20 ...100 year?
1.d. Determine required storage

Results

Storage-Discharge-capacity-lines

- Discharge capacity (l/s/ha)
- Storage m³/ha

Storage lines for different return periods: T = 20 year, T = 10 year, T = 5 year
1.d. Storage – discharge capacity lines

![Diagram showing storage capacity and discharge capacity for two options, Option 1 and Option 2, with different return periods (T = 10 years and T = 20 years). The diagram indicates the maximum discharge capacities (Q_{max}) for each storage capacity (m^3/ha) and discharge capacity (l/s/ha).]
1.d. Storage – discharge capacity curves

WATCH OUT:
small $Q \rightarrow$ Large Storage
in case of extreme weather

Storage $m^3/ha$

Discharge capacity (l/s/ha)

$T = 20$ year

$T = 10$ year

$Q_{max}$
1.d. Storage – discharge capacity curves

**Results**

Discharge capacity [mm/dag]

Surface water storage [m3/ha]

200 m3/ha

T=5
T=10
T=25
T=50
T=100
T=250
1.e. Storage in m³ to storage in m²

What do we consider as storage?

- $A_{\text{surface water}} \times dH_{\text{max}}$

2. Storage on the river bank or in an inundation area?

3. [Storage on the street (or verge) and in the ground is **deducted in the storage-discharge model!**]
1.e. What do we consider as storage?

Storage on river bank and inundation area

Start situation

And/or inundation area

more surface water
1. e. Storage in m$^3$ to storage in m$^2$

Example:
\[ dH_{\text{max}} = 0.4 \text{ m} \]
\[ B = 200 \text{ m}^3/\text{ha} \]
So \[ A_{\text{surface water}} = 5 \% \]

- \( A_{\text{surface water}} \) can also realized as inundation area
- Keep enough hydraulic capacity in the canal
1.f. Reduce damage when exceeding the design standard

Most forgotten step!!
- Enough storage on the street, verge, green areas, etc.
- High barrier in basements
- Enough drainage, crawlspace and roads
- Vital infrastructure parts “high” water secure
  (electrics, mobile network, drinking water, gas)
1.f. Storage on the street

- 0.15 m floor
- 0.3 m street
- 0.15 m floor
- 0.3 m street
1.g. Hydraulic discharge capacity

Discharge by U-gutter
(Japan)
Step 2. The water quality
2. Water quality standards & values

Water framework directive
- Water body => GEP, MEP => take measures

Functions => standards
- Fishing water, swimming water, ...

Policy “vierde Nota Waterhuishouding”
- Make use of ecological processes
- Deal with pollution sources
- Make selective disconnections

Which direction should we choose?
2. Usage demands good quality

Functions as:
- Ecologic diversity
- Irrigation water
- Fishing water
- Swim water
- Energy supply
- ...

Good water quality

so:
1. Control sources!
   - over flows, traffic, building material, air pollution, pesticides, dogs, etc.
2. Stimulate ecological purification
3. Monitoring & testing
4. [Adjusting ...]
2. Ecological purification

- Stimulate
  - Settlement
  - Flow velocity
  - Sun light
2. Improve water quality

- Has a influence on organization
- Of the surface water
- **And** the neighborhood

- So **after step 1**
- (Design quantity surface water)
- **Add design in favor of water quality and ecology**
Step 3. Ground water

- Strongly related to step 1 and step 2
- Depended on soil, geo-hydrology, construction
- More parties responsible:
  - Private space
  - Municipality for public area and discharge private
3. Ground water control

Can be achieved by:
- Raising the ground level
- Larger freeboard / lowering water level
- More intensive drainage (drainage, IT-sewer, canals)

OR less strict standards because of
- Controlling consolidation
- Buildings without crawlspace
- Design of street
- Wet gardens and public green
3. Ground water control

By means of:
- Raising the ground level elaborate later
- Larger freeboard / lowering water level see step 1
- More drainage (sewer, canal) elaborate now

Or less strict standards because of:
- Controlling consolidation see step 1
- Buildings without crawlspace
- Design of street
3. Ground water control

Variables:
- Drainage depth
- Drainage- or discharge level
- Depth of drain pipe
- Drainage system
- Lay-out / location of the drain
- Drain pipe type and covering
- Diameter drainage pipe

Design step by step
3.a. Drainage depth, depth of drain pipe, drainage level

Drainage depth $= \text{function (design area and buildings)}$

see standards / guidelines

Drainage level $= < \text{freeboard or pump drainage}$

Choose with help of a hydrological model (simple or complex)

Because of

- seepage (quantity & quality of that water)
- infiltration rain water
- relation with the type of drainage system
3.a. Standards on drainage-depth

Depends on usage in building and living phase

- **static**: drainage-depth with discharge design
- **dynamic**:
  - Ground water level with exceeding frequently
    (e.g.: 0,7 m-mv and max. 14 days/year)
  - GHG (average highest ground water level)
3.b. Type of drainage system
3.b. Type of drainage system

Public space:
“Road-fill drainage”, “sewer trench drains”, preferably on property borders, vegetated swale, infiltration trench with drain

Private space:
Ring drain or building-block drain

DO NOT discharge on storm sewers from improved separated system;
Do discharge on storm sewer of normal separated systems.

Enough cleaning points!
Preferably enable digging up
3.c. Lay-out of system

Estimate drain distance $L$ with Hooghoudt:

$$ q = \frac{(8 \times K_2 \times d \times h + 4 \times K_1 \times h^2)}{L^2} $$
3.c. Lay-out of system

Where can we lay pipes?

- Where in public area (building side phase)
- Where in private area (constructor)
- Maintenance (living phase, municipality) ★
3.d. Type of drainage tube

Tubes:
- PVC corrugated tube
- IT sewer pipe

Covering materials:
- polypropeen (non woven) or granular
- in sand $O_{90} > 450$; $O_{90}$ of 600-700 often suitable

$O_{90}$—figure means, that 90% of the pores are smaller than a micrometer
Summary:

The urban water assignment combines
- Surface water
- Water quality
- Ground water

These factors are directly related with
- The urban design of the site
- Controlling consolidation
- ....

And therefore have to be dealt with at the same time