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# Hydraulic structures. Dams and reservoirs

## Dam outlet works and Energy dissipation - 2

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University of Nis

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Strengthening of master curricula in water resources management for the Western Balkans HEIs and stakeholders

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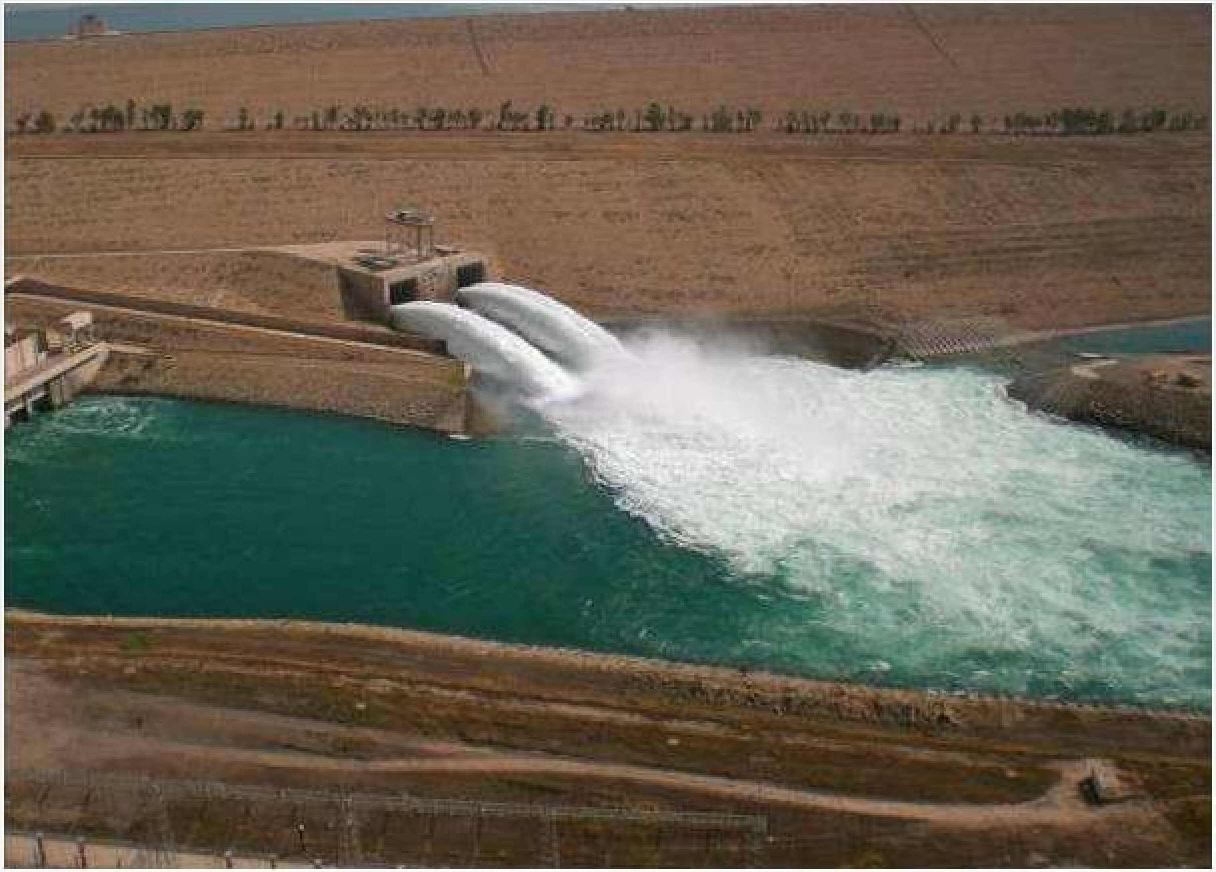
# HYDROENGINEERING STRUCTURES-4

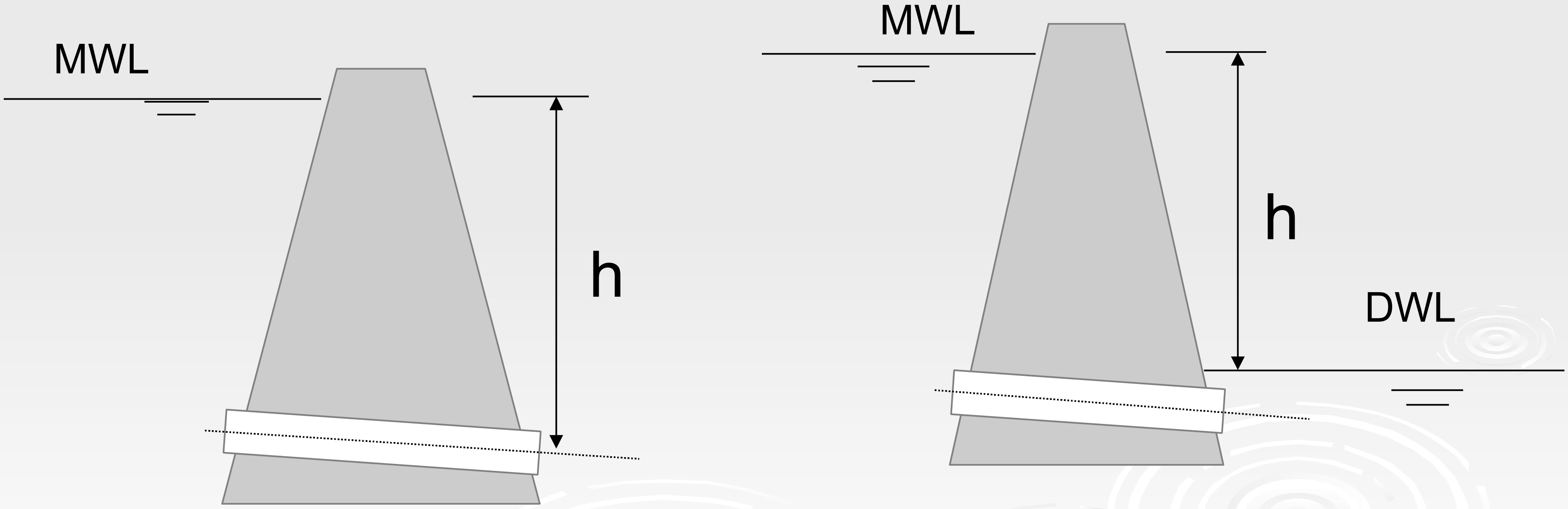


# Dam Outlet Works and Energy Dissipation

1. Introduction
2. Design flood
3. Spilways
4. **Bottom outlets**
5. **Energy dissipation**

Bottom outlets are openings in the dam used to draw down the reservoir level. According to their hydraulic operation they are **pressure pipe** outlets.

**h - pressure**



# Elements of the bottom outlet

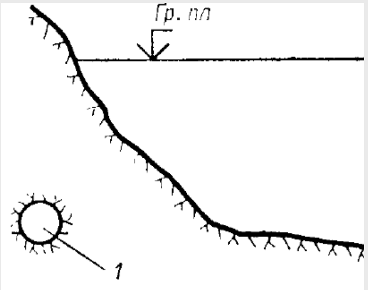
- intake structure
- emergency gate
- controle gate
- pipe on pressure

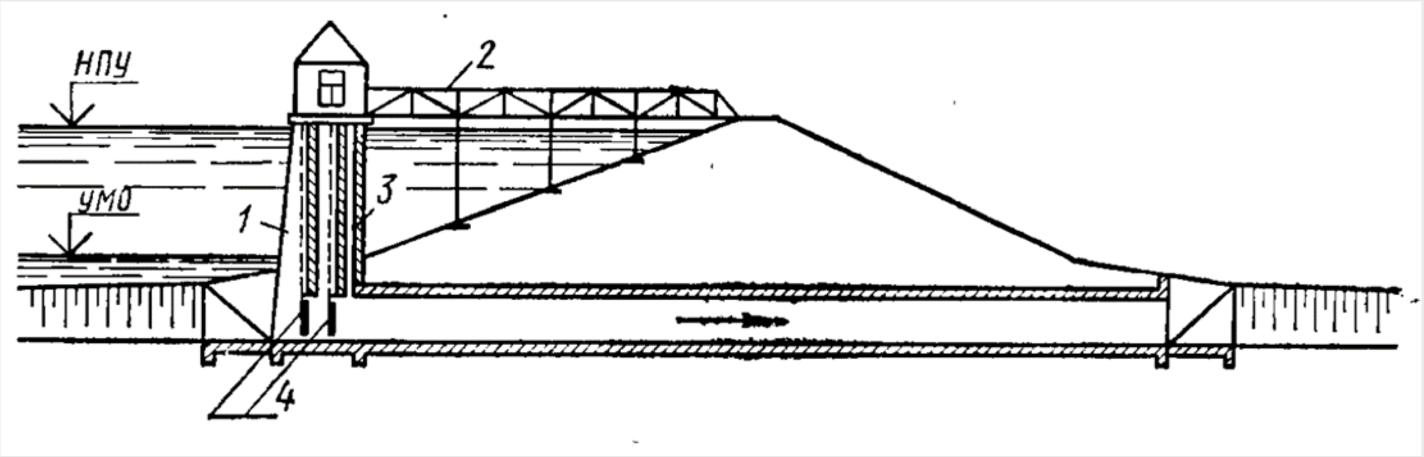
## Intake structure

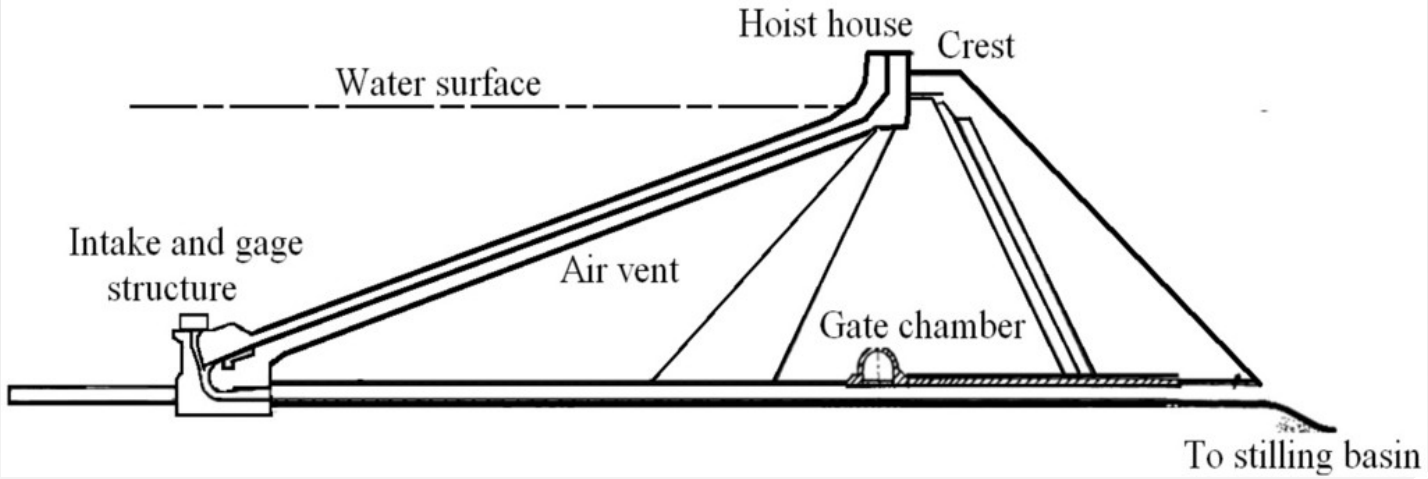
The entrance to the outlet supports **trashrack** and provisions for installation of **stoplog devices**.

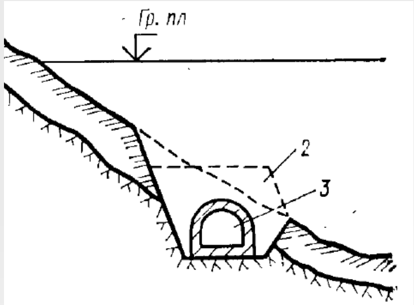
**The submerged intake structure is adopted.**

Note the inlet construction and shape are designed to reduce the head loss.



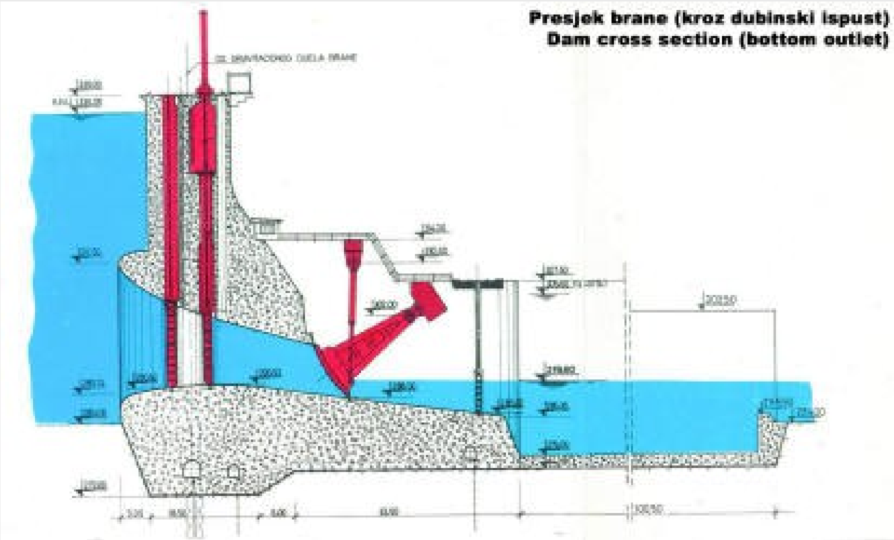



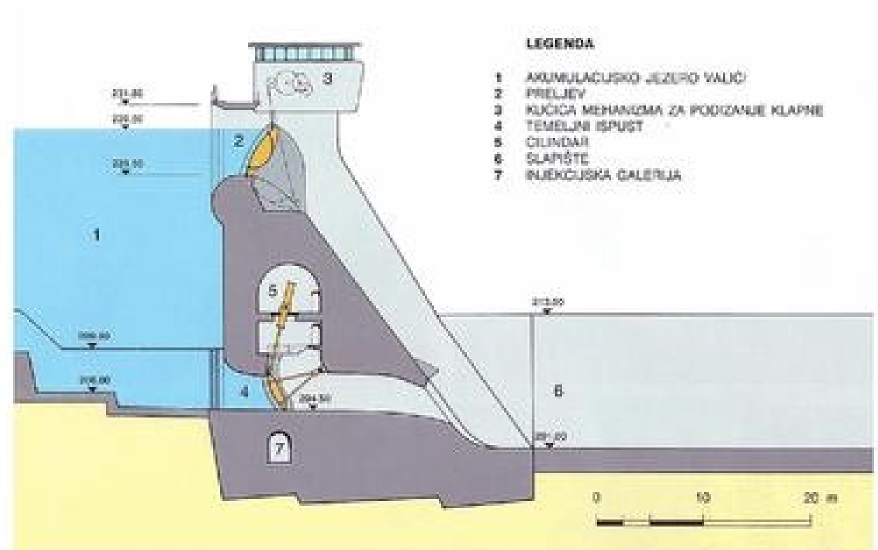




# Outlets in the embankment dams

# Outlets in concrete dams




***Hydraulic design***




The **control gate** is placed downstream from the steel pipe entrance.

The **emergensy gate** is placed upstream.

The flow is under pressure.

## *Hydraulic design*

$$\text{for T=time of empting}$$

$$D = ?$$

$$Q_{max} = \mu.F.\sqrt{2.g.H_{max}}$$

D – diameter of the pipe

F – cross section area of the pipe

$H_{max}$ - pressure

$$\mu = \frac{1}{\sqrt{1 + \Sigma \xi_{м} + \frac{\lambda l}{D}}}$$

Water quality coefficient

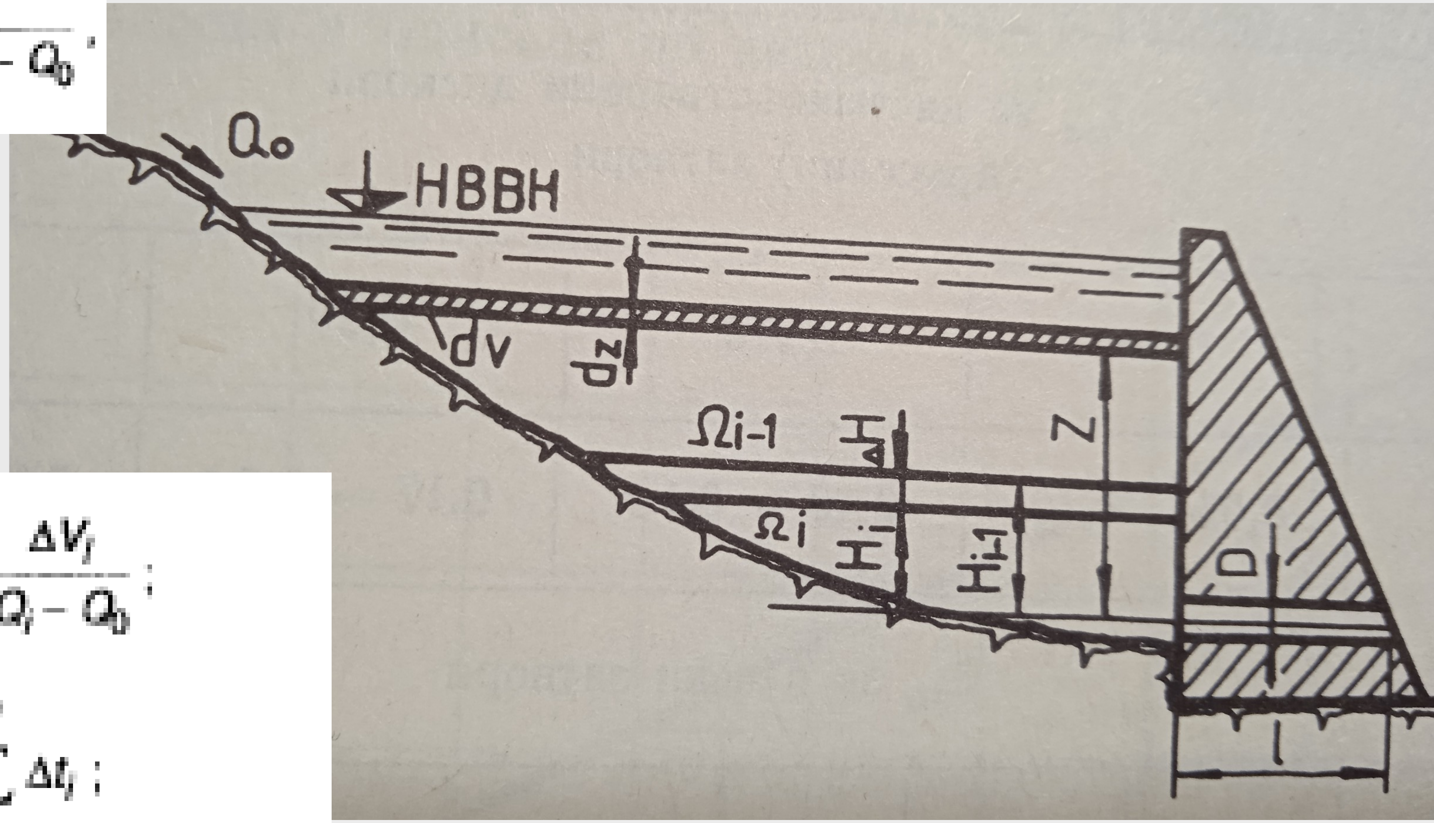
$$\Sigma \xi_{м} = \xi_{вх} + \xi_{зо} + \xi_{кр} + \xi'_{реш}$$

losses

$\xi_{вх} = 0.50$ $\xi_{зо}$=0,10-0,16 (for a/D = 0,15) $\xi_{кр}$ =0

| *d*, mm | 40 | 70 | 100 | 150 | 200 | 300 | 500 |
|---|---|---|---|---|---|---|---|
| $\xi_{см.реш}$ | 12.0 | 8.5 | 7.0 | 5.9 | 4.7 | 3.7 | 2.5 |

$$T = \int_0^H \frac{\Omega \, dz}{\mu\omega\sqrt{2gz} - Q_0},$$




$$\Delta t_i = \frac{\Delta V_i}{Q_i - Q_0};$$

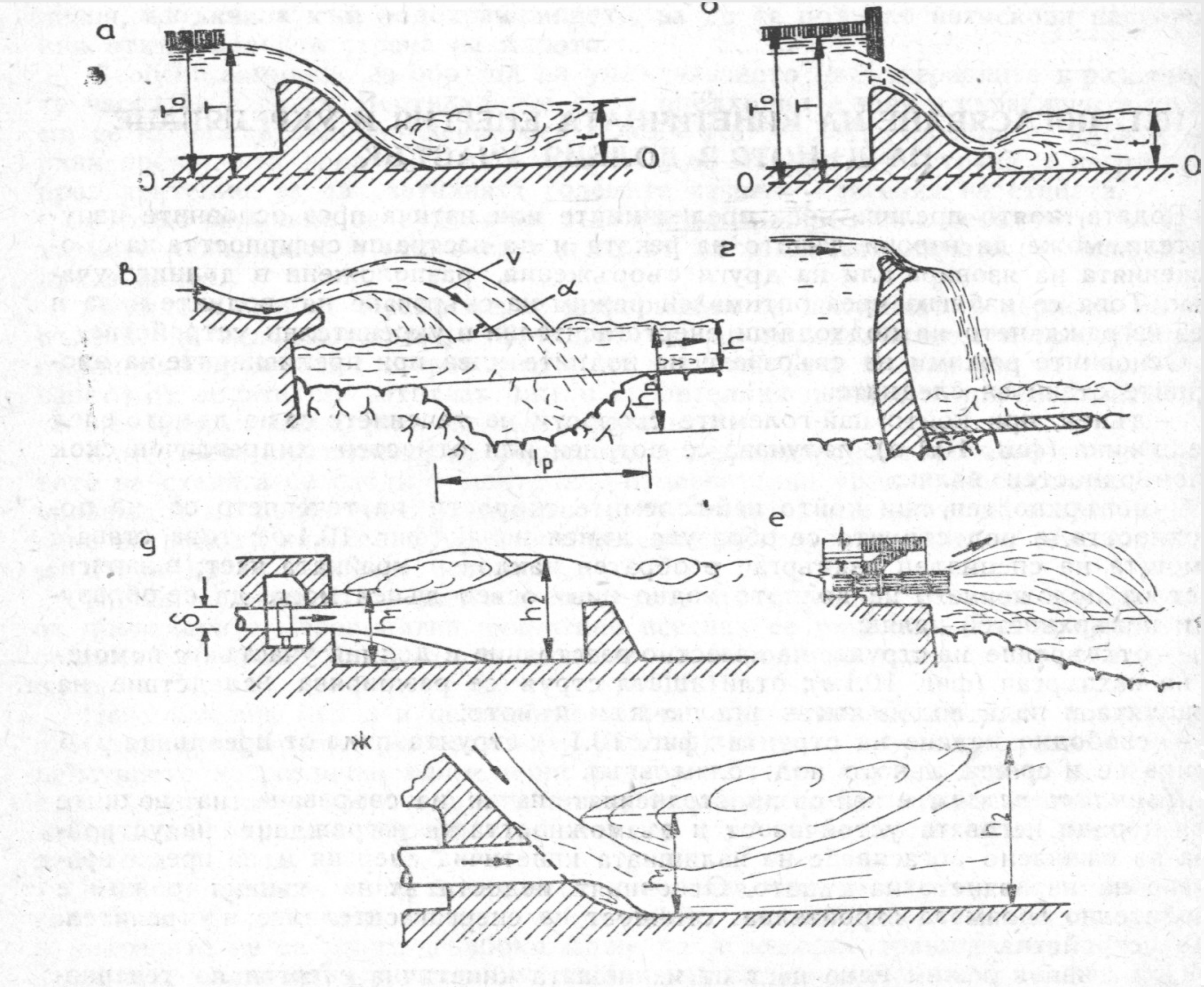
$$T = \sum_{i=1}^{n} \Delta t_i;$$

$$\Delta V_i = \frac{\Omega_{i-1} + \Omega_i}{2} \Delta H_i;$$

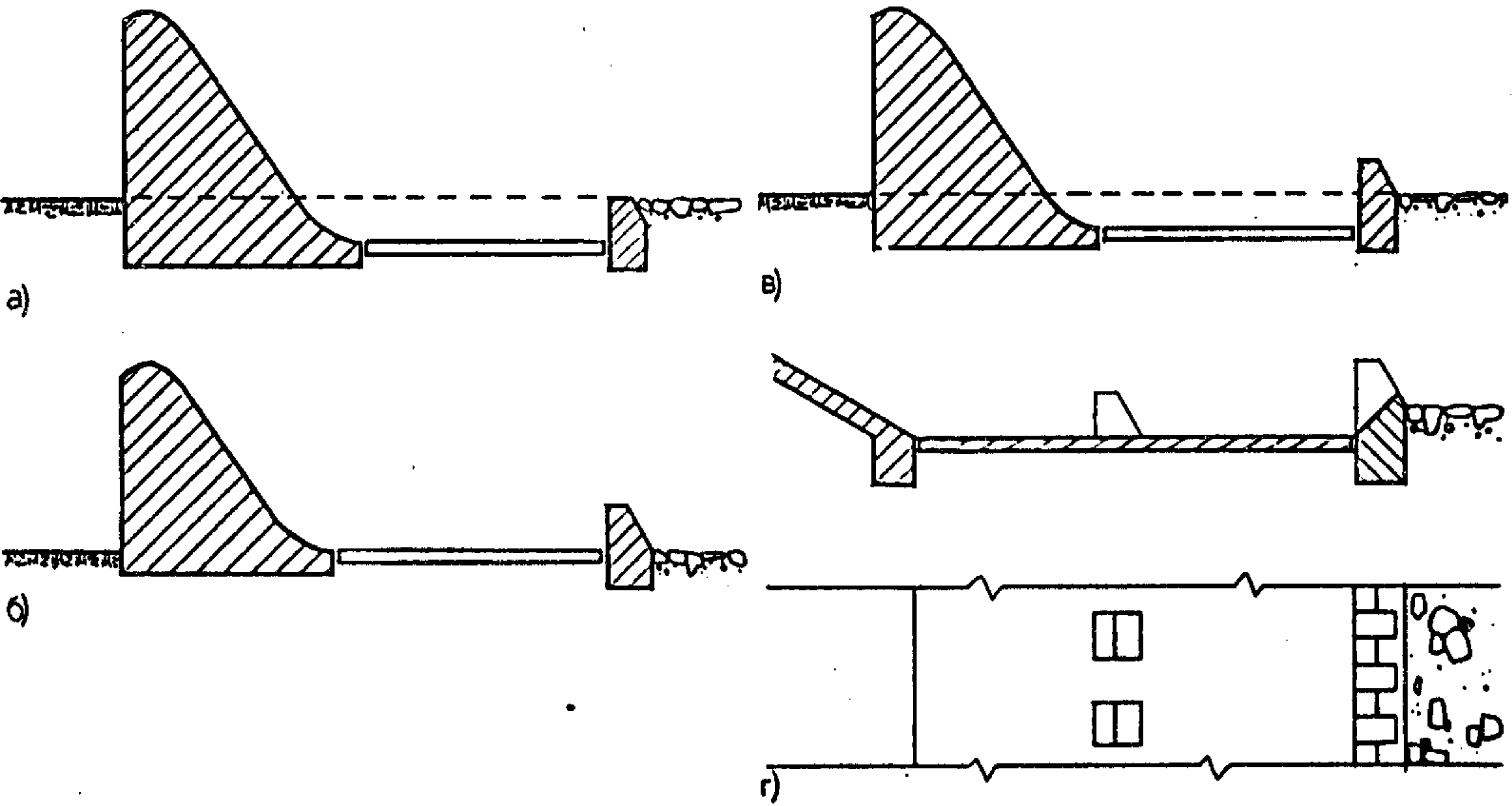
$$Q_i = \mu\omega\sqrt{2g}\sqrt{H_{cp}}.$$

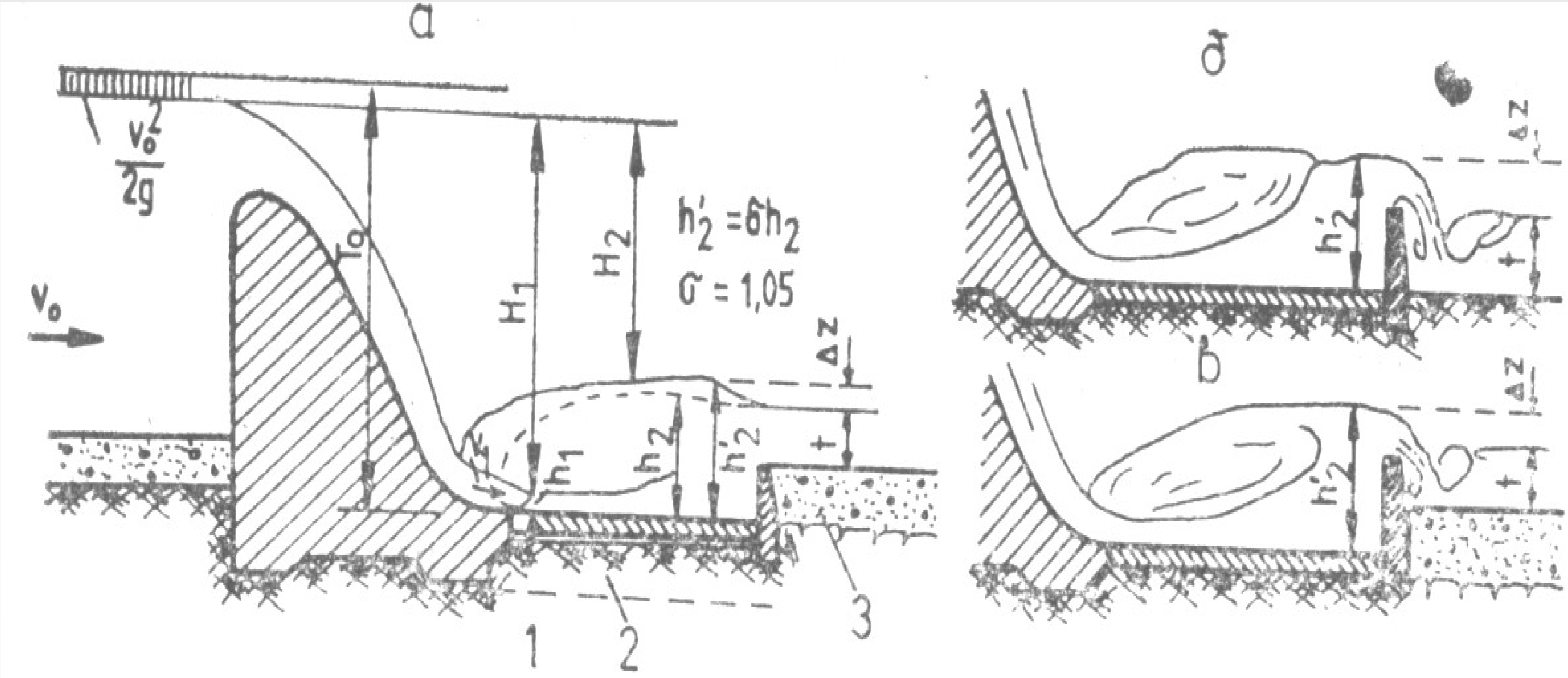
„T“ must be15-30 days

# Energy dissipation



# Design of stilling bassins

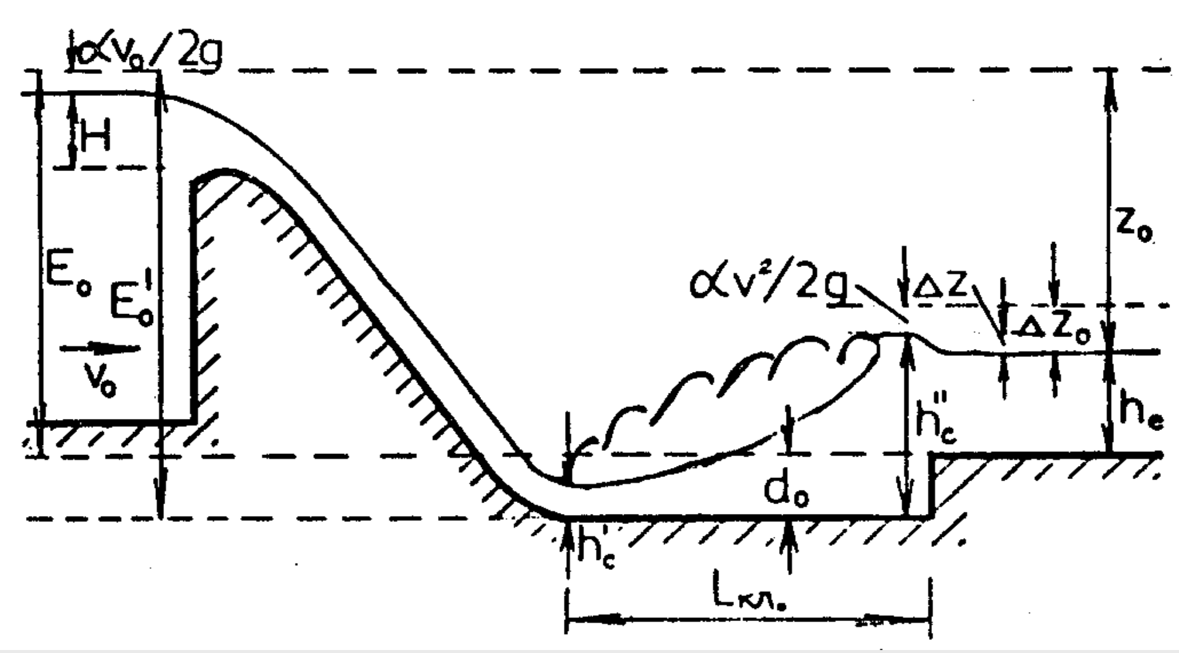



a
$\frac{v_0^2}{2g}$
$T_0$
$H_1$
$H_2$
$h'_2 = 6h_2$
$\sigma = 1,05$
$v_0$
$\Delta z$
$h_1$
$h_2$
$h'_2$
t
1
2
3
б
в

$$d_0 = h_c'' - h_e - \Delta z$$

$$\Delta z = \Delta z_0 - h_v$$

$$h_v = \frac{\alpha v_c''^2}{2g} = \frac{\alpha q^2}{2g h_c''^2}$$




$$q = \varphi h_e \sqrt{2g\Delta z_0} \quad \Rightarrow \quad \Delta z_0 = \frac{q^2}{\varphi^2 2g h_e^2}$$

$$\Delta z = \frac{q^2}{\varphi^2 2g h_e^2} - \frac{\alpha q^2}{2g h_c''^2} = \frac{q^2}{2g}\left(\frac{1}{\varphi^2 h_e^2} - \frac{\alpha}{h_c''^2}\right)$$

$\varphi = 0{,}95$ when ($h_e > h_{kp}$)

$$d_0 = h_c'' - h_e - \frac{q^2}{2g}\left(\frac{1}{\varphi^2 h_e^2} - \frac{\alpha}{h_c''^2}\right)$$

Iteration calculations:

1st iteration:

$$d_0 = h_c'' - h_e \Rightarrow E_0' = E_0 + d_0 \Rightarrow h_c \Rightarrow h_c''$$

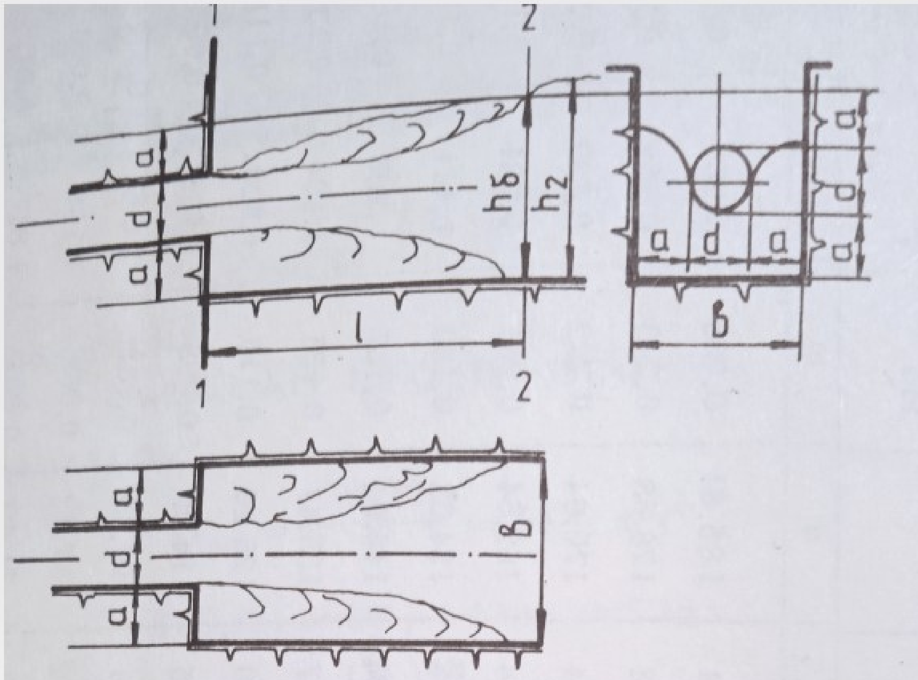
$$d_0 = h_c'' - h_e - \frac{q^2}{2g}\left(\frac{1}{\varphi^2 h_e^2} - \frac{\alpha}{h_c''^2}\right)$$

2nd iteration:

$$E_0'' = E_0 + d_0' \Rightarrow h_c \Rightarrow h_c''$$

$$d_0'' = h_c'' - h_e - \frac{q^2}{2g}\left(\frac{1}{\varphi^2 h_e^2} - \frac{\alpha}{h_c''^2}\right)$$

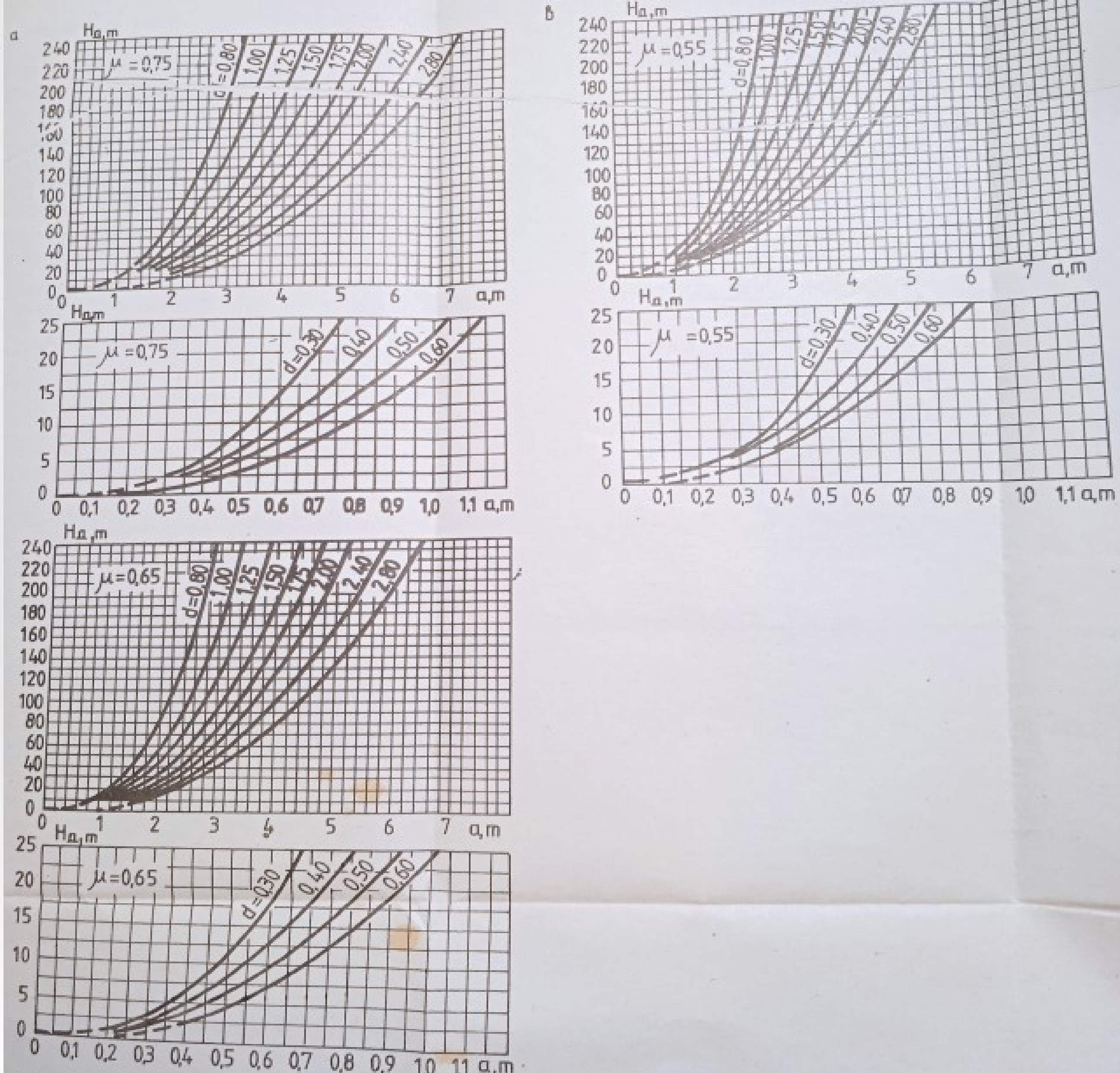
# Desing stilling basin for bottom outlet




$$l = (9{,}60 \div 13{,}40)\, a;$$

$$b = d + 2a;$$

$$h_б = d + 2a.$$


а
Hа,m
μ = 0,75
d=0,80 1,00 1,25 1,50 1,75 2,00 2,40 2,80
a,m
Hа,m
μ = 0,75
d=0,30 0,40 0,50 0,60
a,m
Hа,m
μ=0,65
d=0,80 1,00 1,25 1,50 1,75 2,00 2,40 2,80
a,m
Hа,m
μ=0,65
d=0,30 0,40 0,50 0,60
a,m
в
Hа,m
μ =0,55
d=0,80 1,00 1,25 1,50 1,75 2,00 2,40 2,80
a,m
Hа,m
μ =0,55
d=0,30 0,40 0,50 0,60
a,m

26 Графи

Day 09: #4

# Exercise

## Spillway design and its stillinng basin

Please define the diameter of a bottom outlet, draw its rating curve and define the parameters of its stilling basin!