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Operation and Management of Irrigation Systems

Water Distribution Principles.

Canal Control Structures.

Flow Measurement Structures

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Strengthening of master curricula in water resources management for the Western Balkans HEIs and stakeholders
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1. Types of Irrigation Water Distribution

- **Scheduled irrigation**
  - The farmers are divided in groups
    - ✓ Queue in a group (limited irrigation time)
    - ✓ Large farm discharge *d*

Restriction of irrigation time.

- **“On-demand” irrigation**
  - The farmers irrigate independently.
    - ✓ No queue
    - ✓ Limited discharge *d* for each farmer

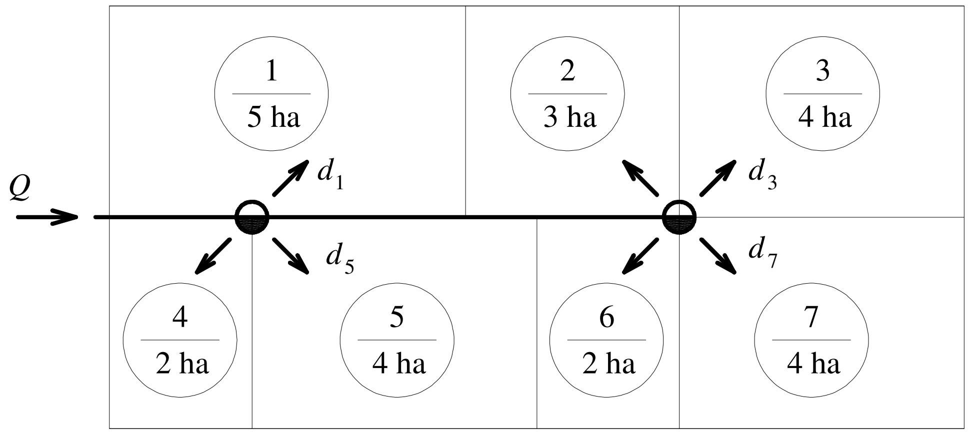
Restriction of irrigation discharges.

The distributed water volume is equal in both types of distribution!
The type of distribution affects discharges only!

1. Types of Irrigation Water Distribution

Scheduled irrigation - Consecutive Delivery

- Let us assume the following case:
  - ✓7 farms with different areas f_i [ha];
  - ✓Each farm is supplied by an outlet which has discharge d_i [ℓ/s];
  - ✓Total area of all farms is F [ha];
  - ✓The total time for irrigation of all farms is T, [h];
  - ✓The water duty (hydromodule) of all area is q [ℓ/s/ha];
  - ✓All farm outlets are supplied with a single pipe;
  - ✓The design discharge at the head of the pipe is Q [ℓ/s];



1. Types of Irrigation Water Distribution

Scheduled irrigation - Consecutive Delivery

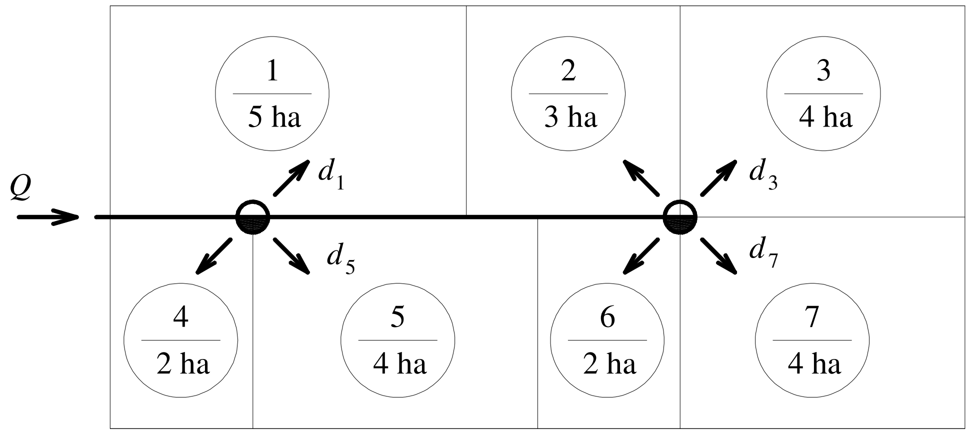
- The farms are irrigated one after another.
- The farm discharges are constant: $d_i = Q$

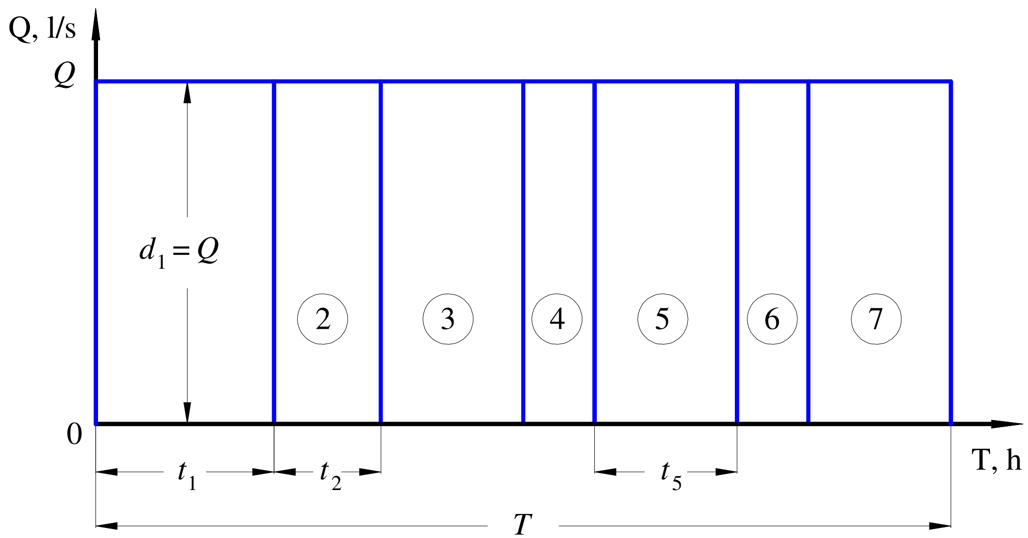
and $Q = qF$, l/s

q - the water duty, l/s.ha.

$$F = \sum f_i$$

- The irrigation duration for a given farm is $t_i = \frac{f_i}{F} T$





1. Types of Irrigation Water Distribution

Scheduled irrigation - Simultaneous Delivery

- All farms are irrigated at the same time
- The discharge of each owner is:

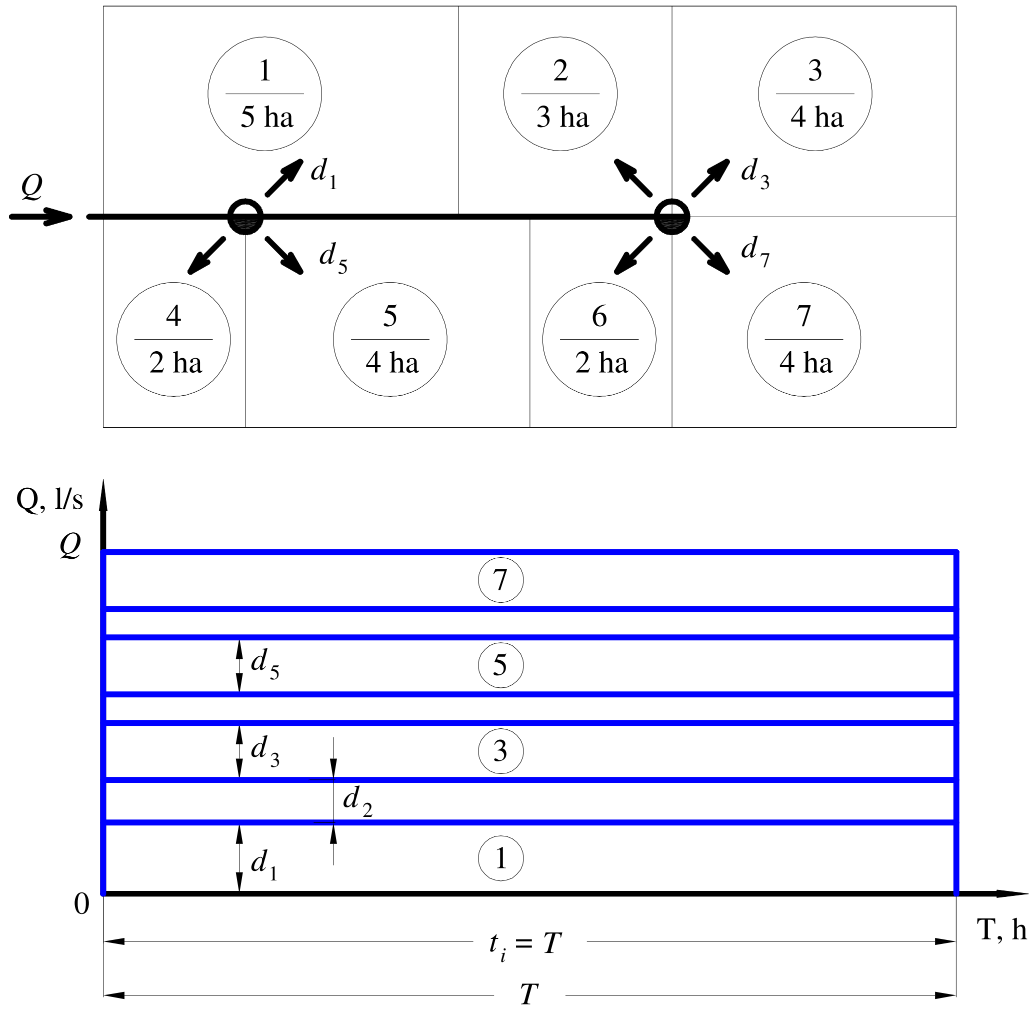
$$d_i = \frac{f_i}{F} Q \quad ,\text{l/s}$$

and $$Q = qF \quad , \text{l/s}$$

$$F = \sum f_i$$

- The irrigation duration of each farm is

$$t_1 = t_2 = \ldots = t_i = \ldots = t_n = T$$



1. Types of Irrigation Water Distribution

Scheduled irrigation – Pros (+) and Cons (-)

➢ Consecutive Delivery

- ✓ Main pipe size has constant size ⇒ expensive pipes, i.e. expensive network
- ✓ Farm discharges are big ⇒ farmers can use highly efficient irrigation equipment
- ✓ Irrigation time of small farms is very short ⇒ a farmer may miss his turn ⇒ violation of schedule is possible
- ✓ The delivery type can be converted, if needed; Main pipe and outlets have enough capacity.

➢ Simultaneous Delivery

- ✓ Main pipe size decreases downstream ⇒ cheap pipes, i.e. cheap network
- ✓ Farm discharges of a small farms are small ⇒ farmers cannot use highly efficient irrigation equipment
- ✓ Irrigation time of all farms is too long ⇒ all farmers must irrigate long ⇒ **no freedom.**
- ✓ The delivery type cannot be converted; Main pipe and outlets have no enough capacity

1. Types of Irrigation Water Distribution

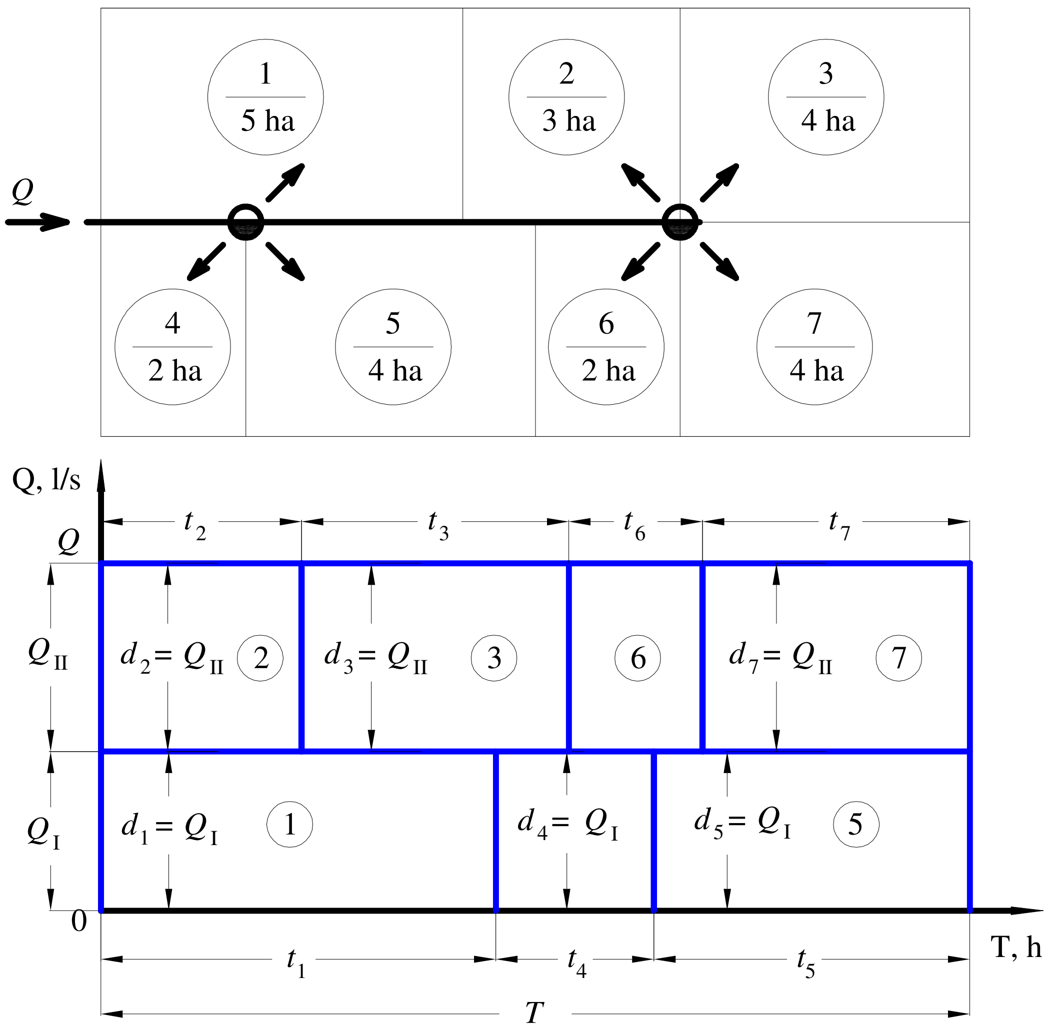
Scheduled irrigation - Mixed Delivery

- The farms are divided into groups
  - ✓ The groups irrigate simultaneously
  - ✓ Within the group farms are irrigated one after another
- The discharge of the group is proportional to its area

$$Q_j = \frac{F_j}{F} Q$$

- The irrigation duration for a farmer within the group is proportional to its area

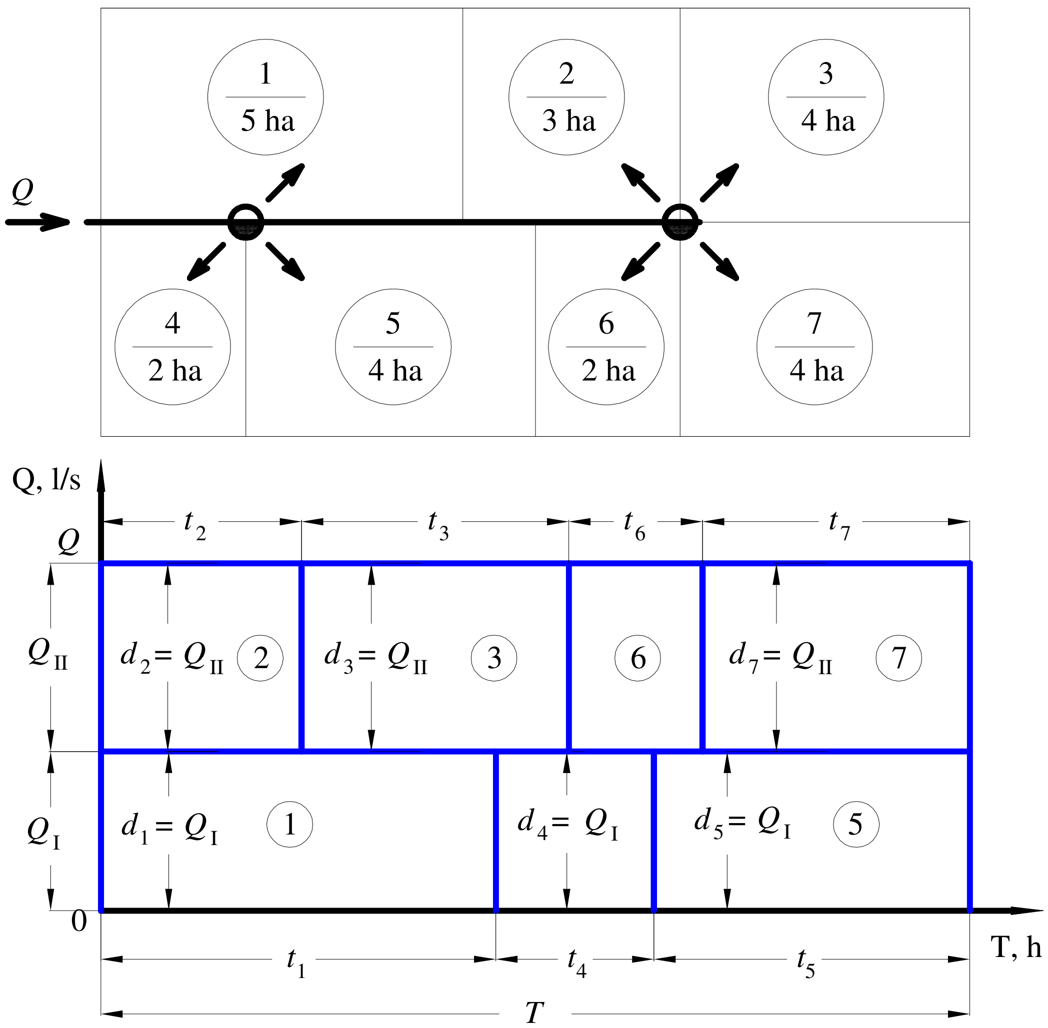
$$t_{j,i} = \frac{f_{j,i}}{F_j} T$$



1. Types of Irrigation Water Distribution

Scheduled irrigation - Mixed Delivery

- ✓ Main pipe size decreases downstream ⇒ the same as for simultaneous delivery, i.e. cheap network
- ✓ The farm discharges are bigger than these for simultaneous delivery and smaller than these for consecutive delivery
  - ✓ All farms can be irrigated by highly efficient irrigation equipment
- ✓ Farmers have relatively long time for irrigation
- ✓ Possible switch to simultaneous delivery



1. Types of Irrigation Water Distribution

"On-demand" irrigation

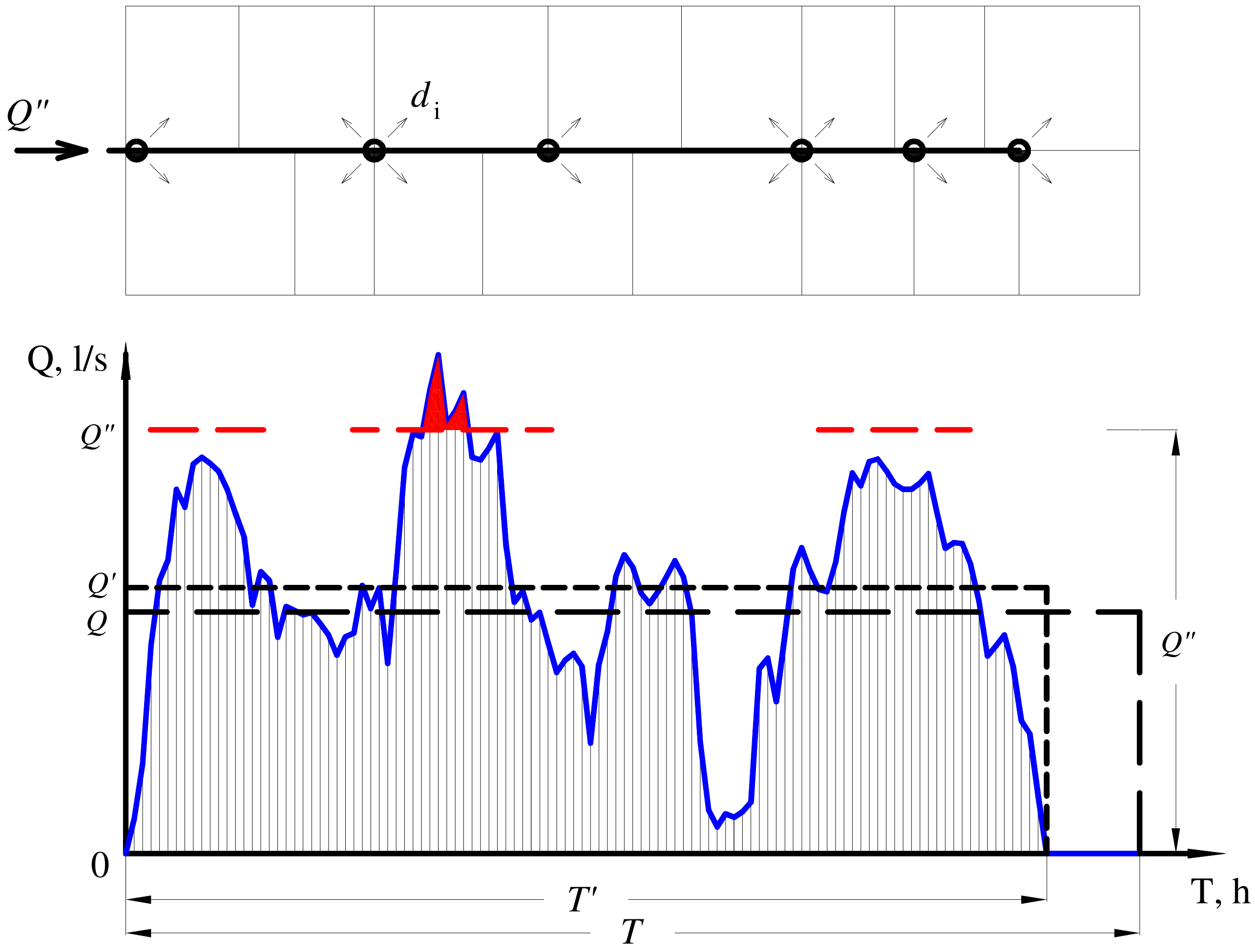
- Every owner irrigate whenever he wants

Q – the continuous discharge for scheduled irrigation;

$$Q = qF$$

Q' – the average discharge throughout the period *T'*;

Q" – the "on-demand" design discharge;



1. Types of Irrigation Water Distribution

"On-demand" irrigation

- ✓Each farm has its own outlet, which has discharge d_i, proportional to the farm area f_i.
- ✓Every farmer can irrigate whenever he/she wants
- ✓The water duty for the whole area q is the same as for scheduled irrigation
- ✓The irrigation period is T [h]
- ✓If it is assumed unlimited capacity for the main pipe and the system is operated absolutely free from any restrictions, then the discharge variation in the period T will be presented with the blue line shown on previous page.
  - – The system is in real operation for period $T' < T$. There are idle periods;
  - – There are discharge peaks when (almost) all outlets are open
    - » These peaks have very short duration (marked in **red** on the graph)

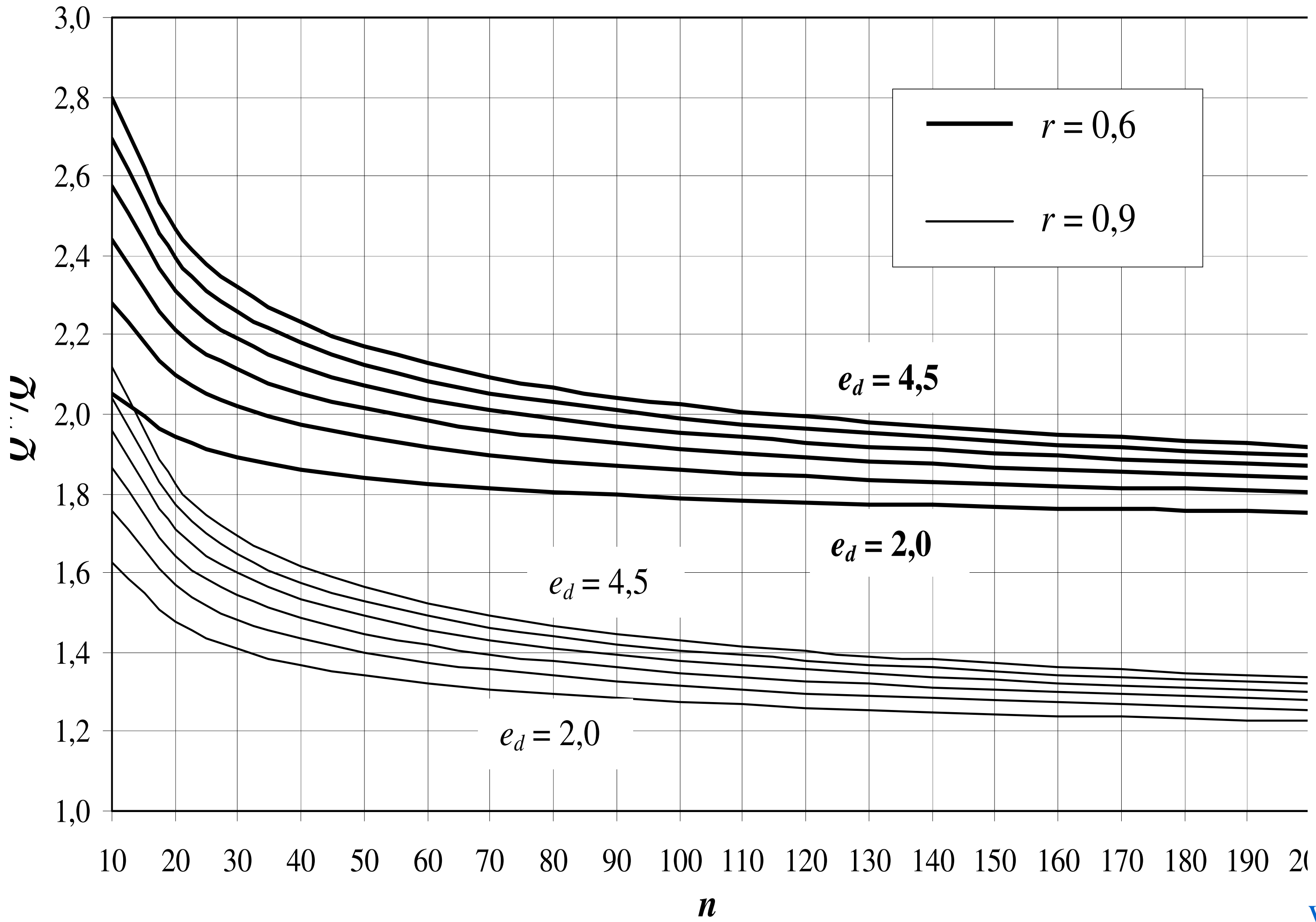
1. Types of Irrigation Water Distribution

"On-demand" irrigation

- ✓It is not advisable to design the network for big discharges with short duration – the network will be too expensive
- ✓ *René Clément (France)* developed a formula for estimation of the design discharge Q''.
- ✓The actual on-demand discharge Q is a stochastic variable
- ✓The discharge Q'' is estimated for probability of 95% (or 99%) that it is not surpassed
  - In 95% (or in 99%) of cases the needed discharge is less or equal to Q''
  - In 5% (or in 1%) of cases the needed discharge is greater than Q''.

1. Types of Irrigation Water Distribution

Variation of ratio *Q″/Q* versus the number of outlets being served *n* for different values of degree of freedom e_d and network utilization coefficient *r* at P_q = 95% (FAO-59, 2000)



1. Types of Irrigation Water Distribution

"On-demand" irrigation

- The ratio Q''/Q expresses the oversizing of the network in comparison to scheduled distribution.
  - ✓ n is the number of outlets served by the pipe section
  - ✓ e_d is the ratio between the nominal discharge of the farm outlets d and the needed discharge for continuous irrigation of the plots.
- The biggest values of Q''/Q are when n is small, i.e. in the end sections of the networks (laterals)
  - ✓ oversizing from **1,6** to **2,4** times.
- The head sections of the network are less oversized
  - ✓ oversizing from **1,2** to **1,9** times.
- In usual case ($P_q = 95\%$, $r = 0,83$ and $e_d = 3$) Q'' is **30÷60% bigger** than continuous discharge at scheduled distribution Q.

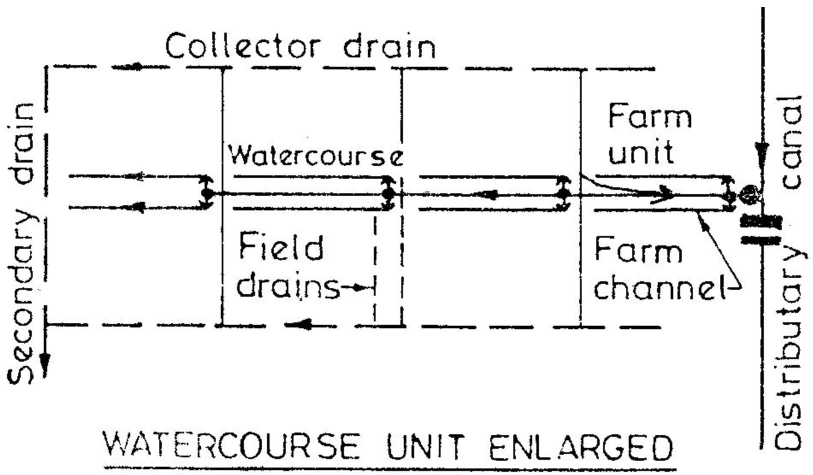
1. Types of Irrigation Water Distribution

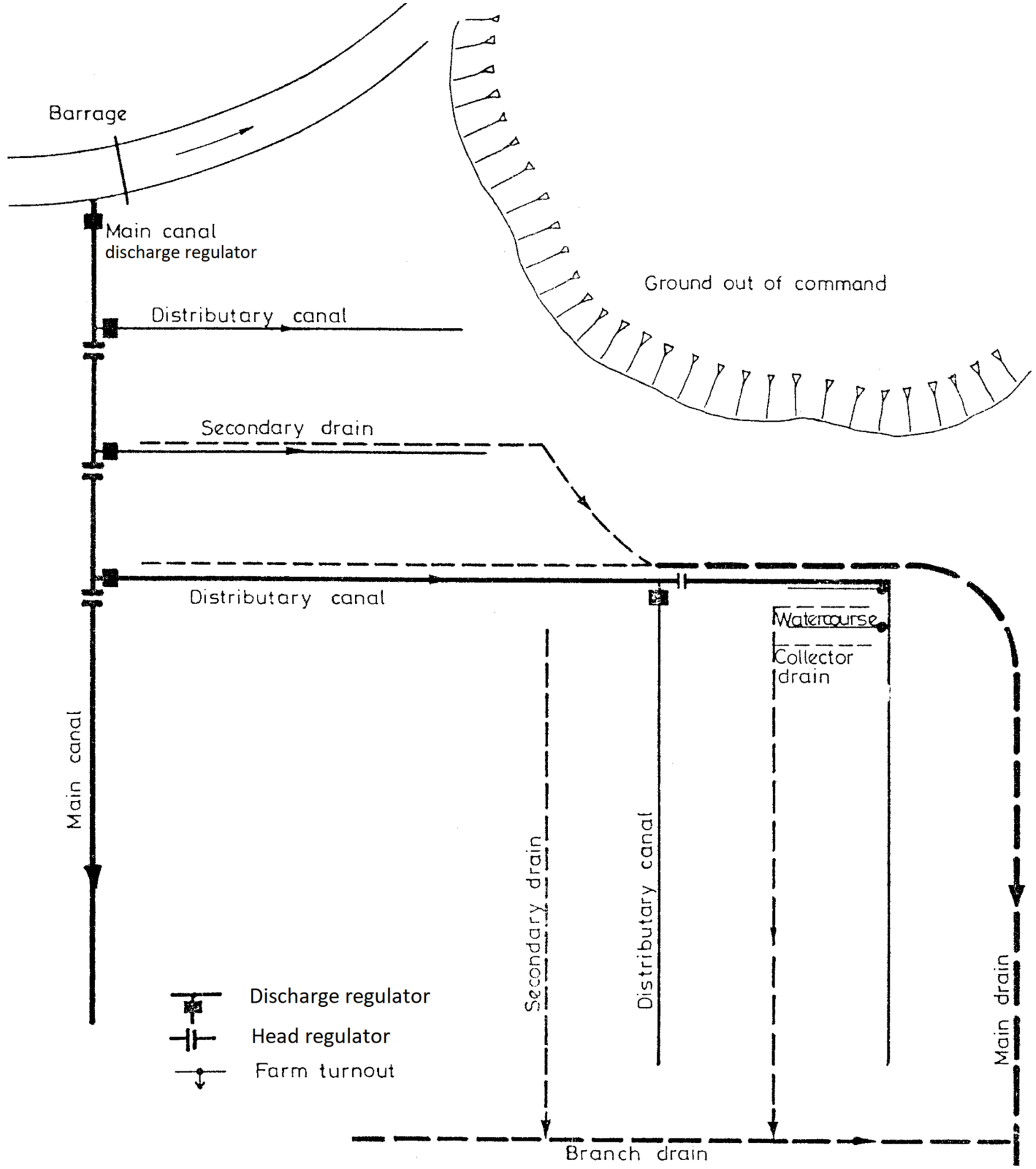
Implementation

- Scheduled irrigation
  - ➢ The Delivery network of IS is designed for simultaneous delivery
  - ➢ The Distribution networks of Irrigation Fields in Bulgaria were designed for Mixed delivery
  - ➢ The network within the farm is designed either for consecutive, or for mixed delivery
- “On-demand” irrigation
  - ➢ Mainly for pressurized distribution networks of so called *Collective farms* (analog of Bulgarian *Irrigation Fields*)
  - ➢ Sometimes used for open channel distribution networks of ISs

2. Need of Flow Control

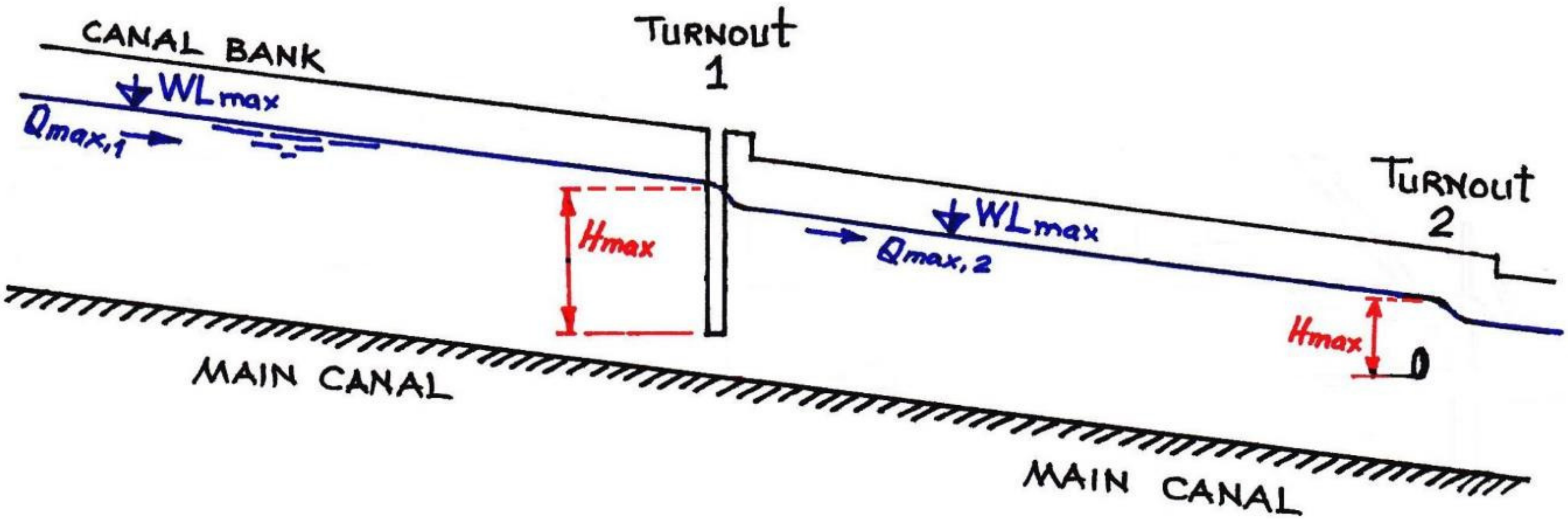
- Canals in IS
  - Main canal
  - Secondary canals
    - ✓ also called Distributary canal (Distributor – in BG)
  - Tertiary networks
    - ✓ Watercourses
    - ✓ Farm canals





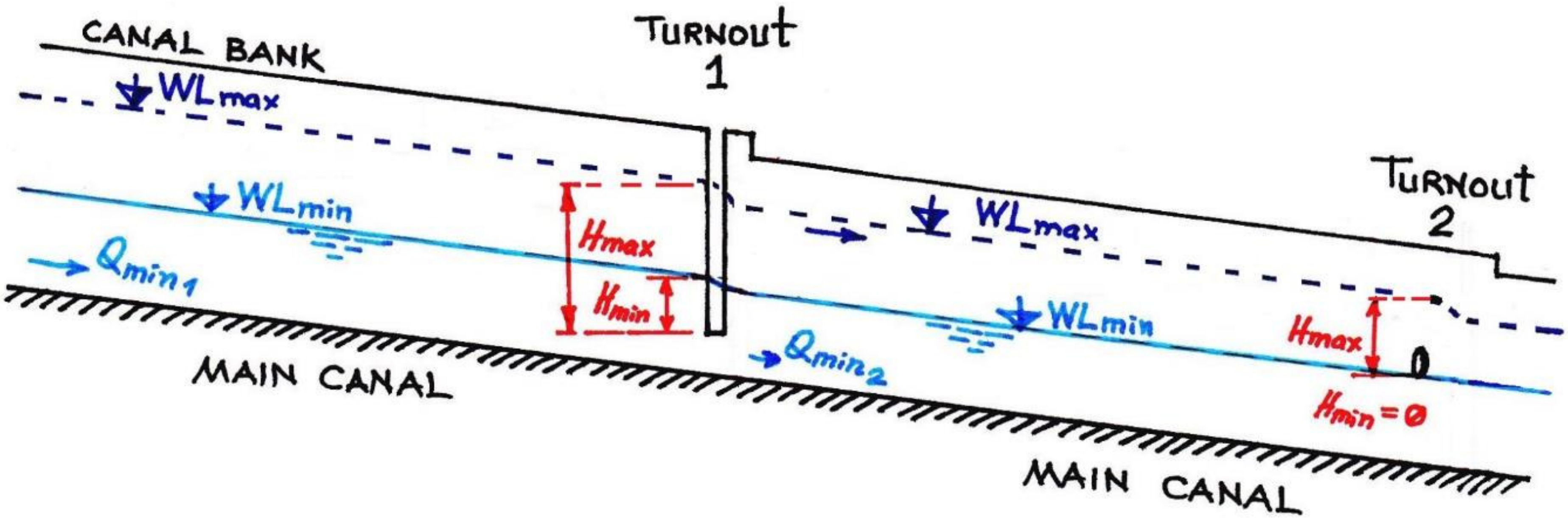
2. Need of Flow Control

- All delivery network is designed for maximal discharge, i.e. for maximum water level
- The position of the turnouts (and division boxes) is chosen according local conditions
- The maximum discharge through turnouts should be assured when the water level in major canal is minimal, i.e. head is *min*.



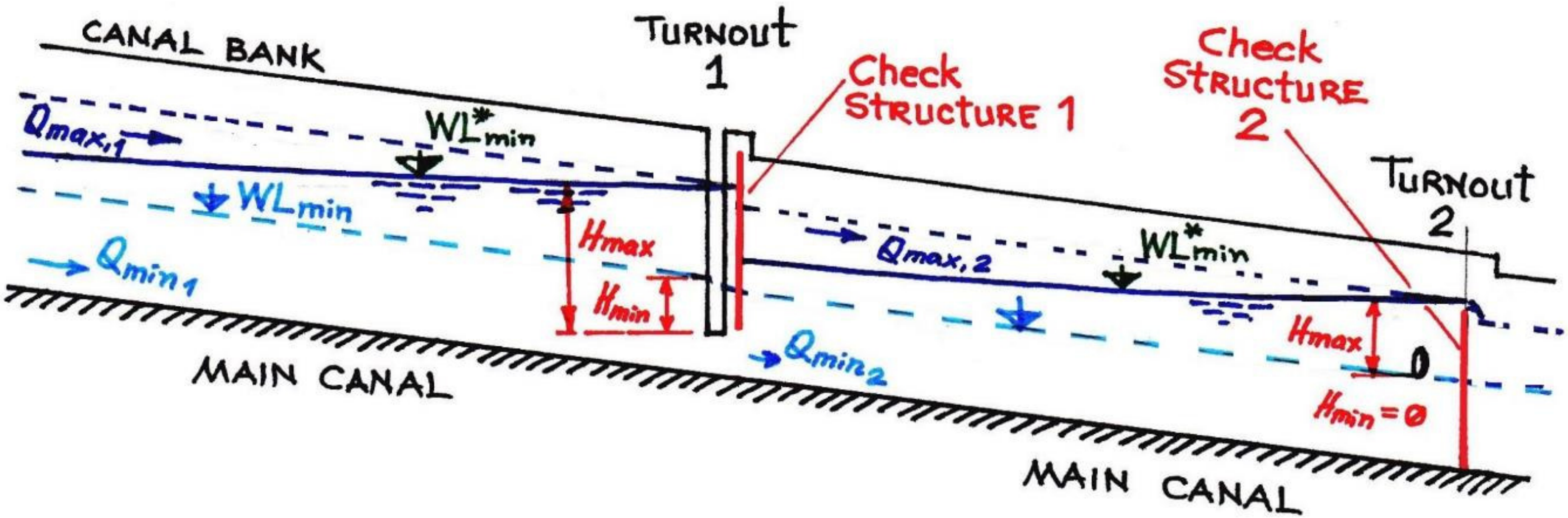
2. Need of Flow Control

- At minimum discharge in Main canal the water level drops
  - ➢ Some turnout entrances may occur above the water level
  - ➢ Head at turnouts varies significantly
  - ➢ Any change in discharge in Main canal causes change in water level, i.e. change in head at turnouts, thus the discharge of the turnouts is also changed. A lot of adjustments are needed at turnouts



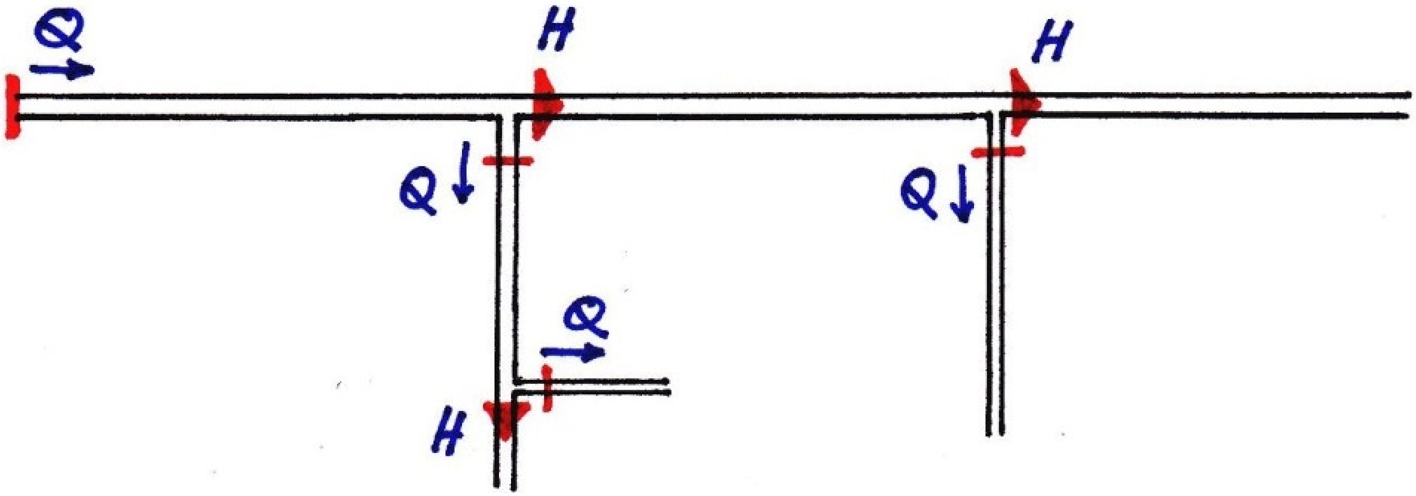
2. Need of Flow Control

- Check structures are used for Flow Control
- Check structures at Main canal are needed keep constant head
  - ➢ To avoid frequent discharge adjustments at turnouts,
  - ➢ To decrease discharge variation
  - ➢ To facilitate flow measurement
  - ➢ To make flow measurement more accurate



Basic Principles of Flow Control

- Flow control is used for both main flow parameters – discharge Q and head H (water level)
  - At turnouts the water level (head *H*) is regulated to be approximately constant.
  - At the head of each canal the discharge *Q* is adjusted (controlled)
- These 2 principles are used for water control in each level of the Delivery Network



3. Flow Control Systems and Structures

- **Upstream Control Systems**

Designed and operated for Scheduled Distribution in IS

- Head (Water Level) Control Structures
  - ✓ Sliding Gate / Sluice Gate (undershot structure)
  - ✓ Long Crested Weir (overshot structure)
  - ✓ AMIL gates (undershot structure)
  - ✓ Leaf gates / Rubicon FlumeGate (overshot structure)

- **Downstream Control Systems**

Designed and operated for On-demand Distribution in IS

- Head (Water Level) Control Structures
  - ✓ AVIS regulators (undershot structures)
  - ✓ AVIO regulators (orifice structures)

3. Flow Control Systems and Structures

- <u>Discharge Regulators</u>

Some of them can be used also as flow measurement structures

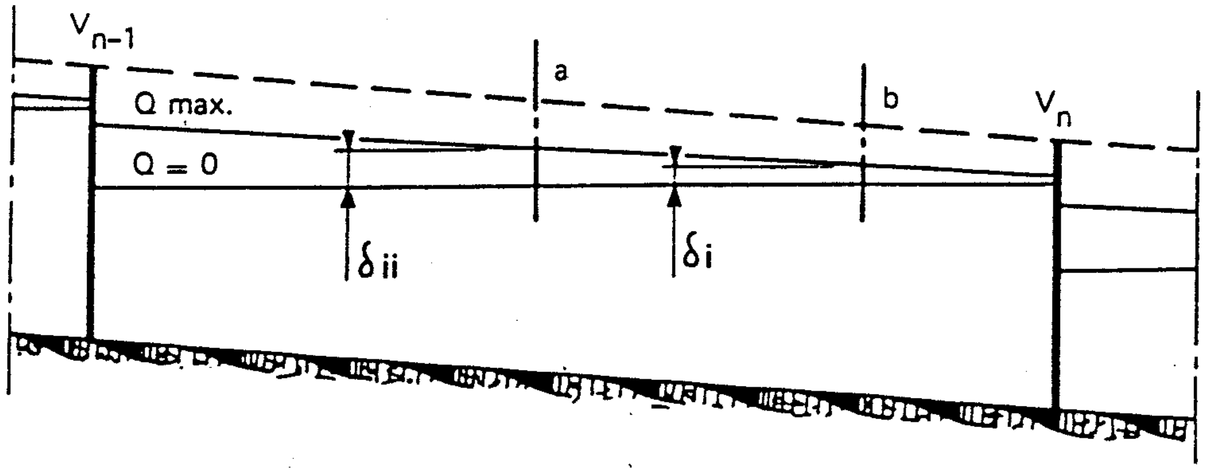
  - ✓ Sliding gates (undershot structure)
  - ✓ Baffle Distributors (undershot structure)
  - ✓ Khamadov Distributor (undershot structure)
  - ✓ Metergate (orifice/undershot structure)

- <u>Flow measurement Structures</u>
  - ✓ Flumes (Parshall flume, Venturi)
  - ✓ Weirs (Broad crested weirs, Sharp crested weirs)

N.B. There are other structures for discharge regulation and for flow measurement.

4. Upstream Control Systems

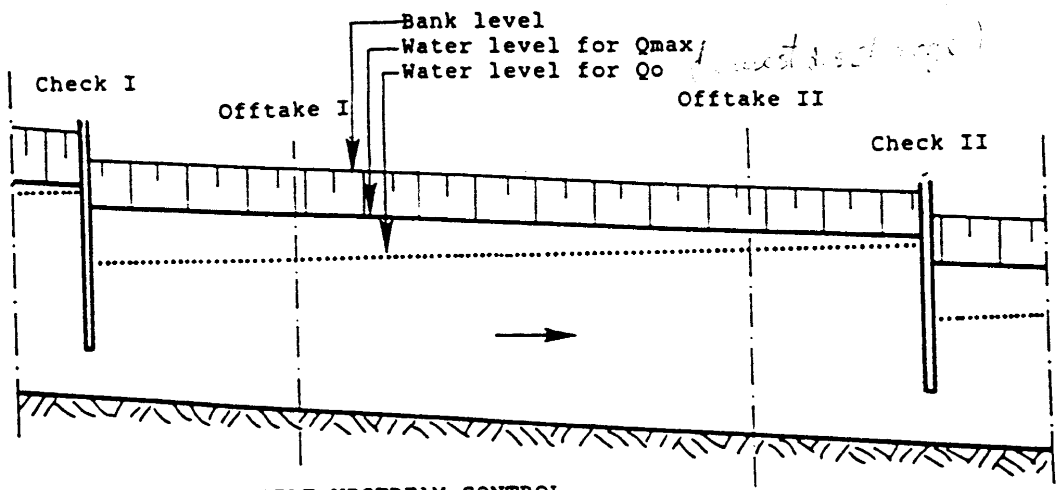
- Operation principle
  - The upstream water level at canal regulators located at Main and Secondary Canals is maintained fairly constant
  - The water is released from the headworks on the basis of pre-set schedule, which is done after the consumers send their requests
  - Gate operators adjust the discharges of tertiary unit turnouts according to requests, sent in advance, and according to the preset schedule



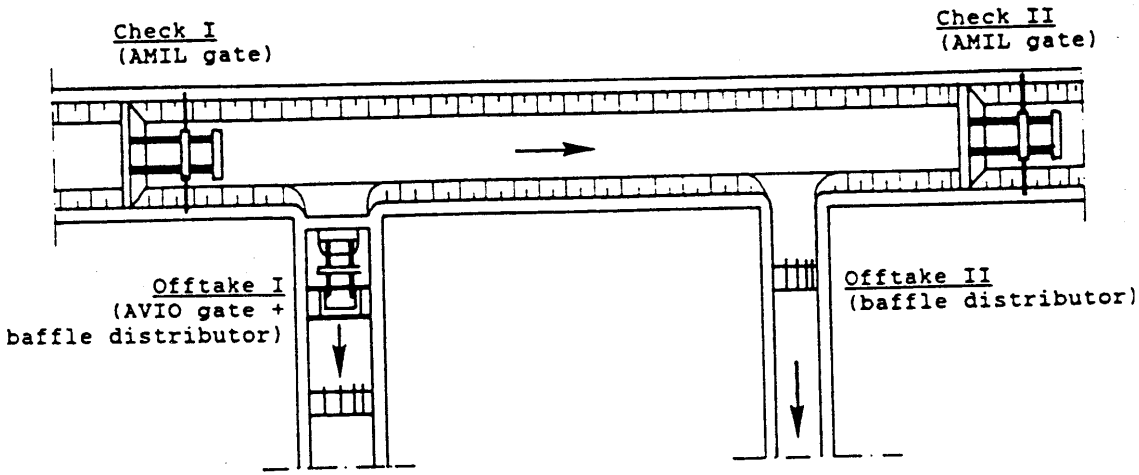
LONGITUDINAL SECTION OF CANAL REACH

4. Upstream Control Systems

- **Canal reaches**
  - Automated and non-automated systems have the same canal reach specifics.
  - The water level @ Q_{max} is approx. parallel to canal bed
  - The water level @ Q = 0 is horizontal
  - Canal bank – parallel to canal bed
  - The canal slope should be less than critical.
  - It is preferable that the turnouts are situated just upstream of the regulator, where the water level is maintained fairly constant.



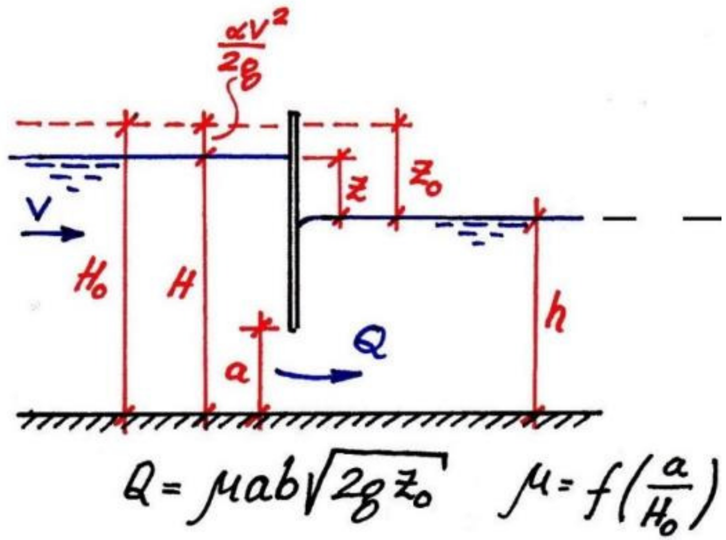
LONGITUDINAL PROFILE UPSTREAM CONTROL

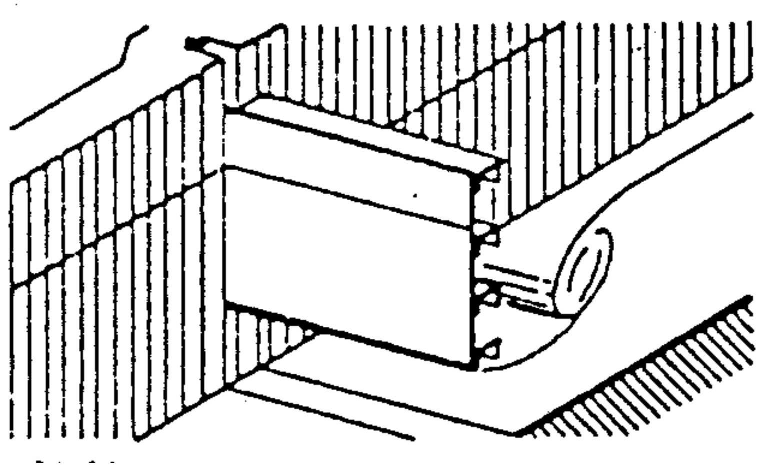


SCHEMATIC SITUATION OF REACH FOR UPSTREAM CONTROL

4. Upstream Control Systems

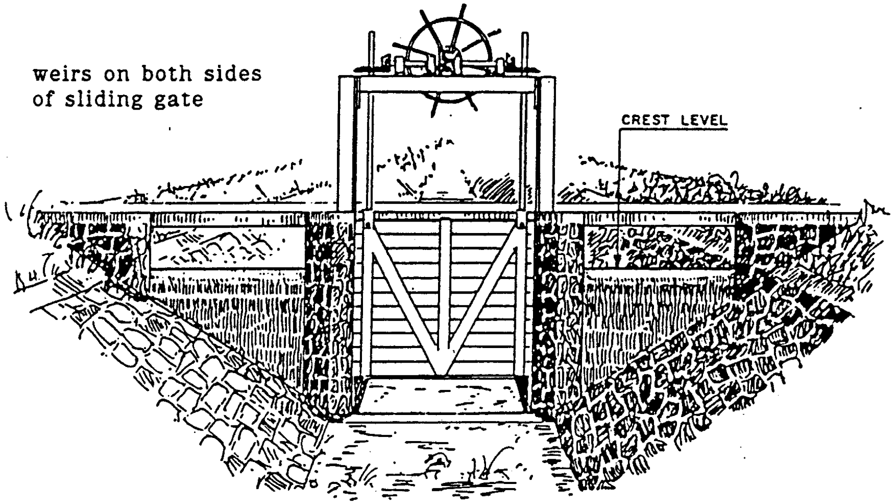
- **Water Level Regulators**
  - **Sliding gates** (sluice gates)
    - ✓ The upstream water level is regulated by adjusting the gate opening ***a***
    - ✓ This is undershot structure
    - ✓ The flow has to be submerged
    - ✓ Lots of adjustments are needed
      - – If gate opening a is changed, at first Q increases.
      - – This leads to increase of the downstream depth h.
      - – Increase of h leads to decrease of the head z_0, thus Q decreases ⇒
      - – New adjustment is needed





4. Upstream Control Systems

- **Water Level Regulators**
  - **Sliding gates** (sluice gates)
    - ✓ The gate and the frame are mounted on a wall, which has weir on both sides of the gate
    - ✓ The weirs are needed in case that the gate opening is not enough to convey the flow (if the gate is not adjusted on time).
    - ✓ There is a small bridge (called also catwalk or walk way) to allow access to the lifting device
    - ✓ **Widely used in Bulgaria,** although they are **not suitable for head regulators**



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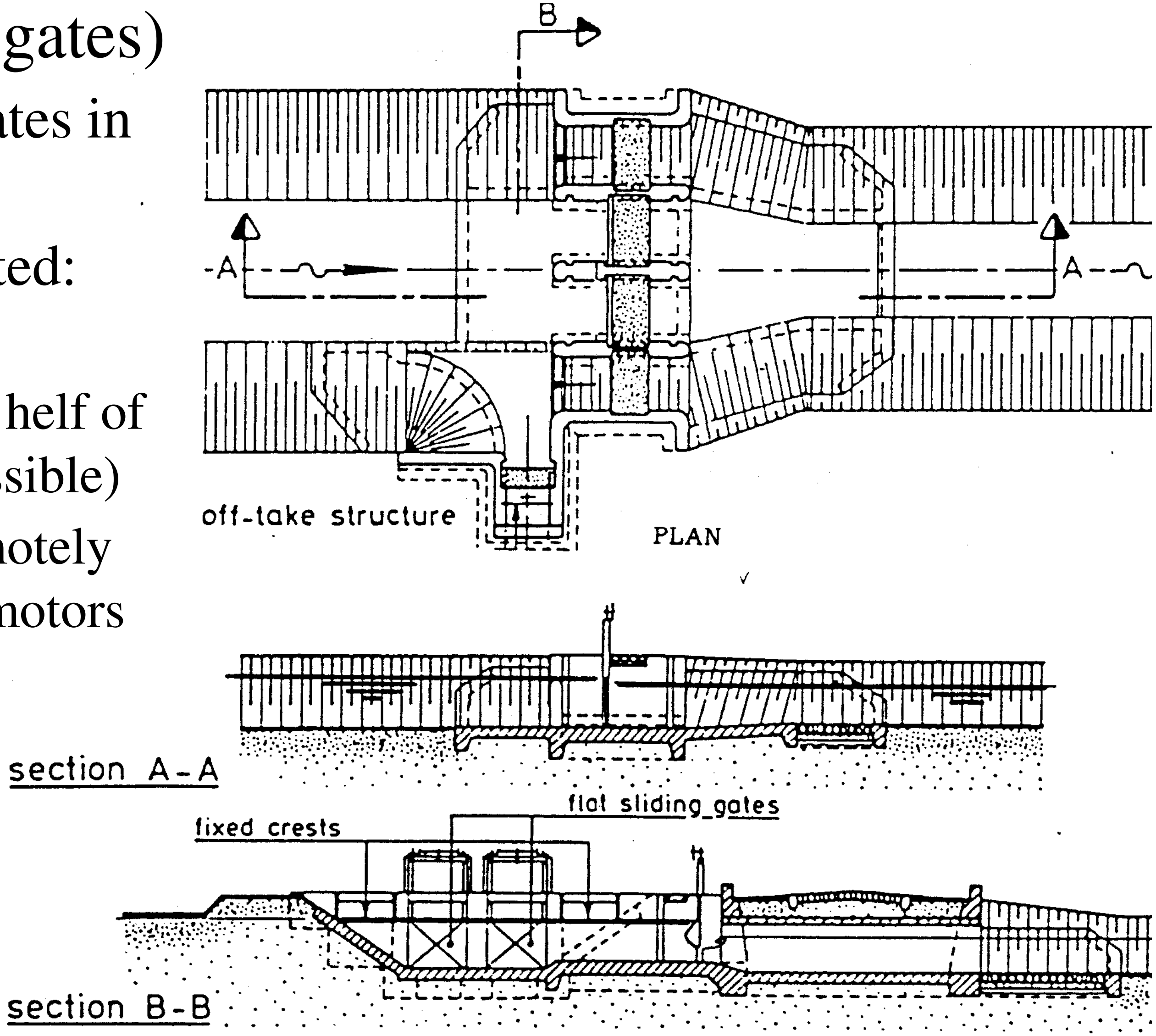
4. Upstream Control Systems

- **Water Level Regulators**
  - **Sliding gates** (sluice gates)
    - ✓ For big canals 2 or 3 gates in parallel can be installed
    - ✓ Sliding gates are operated:
      - Manually (typical)
      - Manually, but with a helf of electric motors (if possible)
      - Remotely – using remotely commanded electric motors



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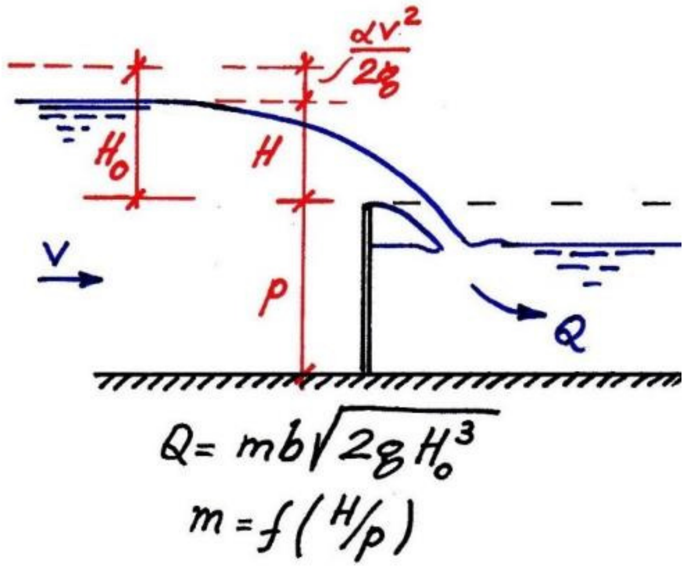
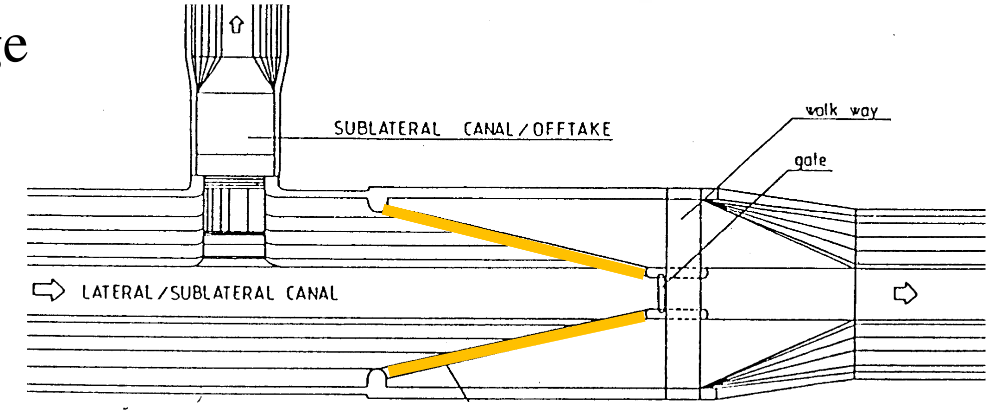
4. Upstream Control Systems

- **Water Level Regulators**
  - **Long Crested Weirs**
    - ✓ The weir should be in free flow conditions, i.e. the weir should not be submerged

      – when the crest length b is great a small change in head H leads to great change in discharge *Q*.

      – in the opposite – big change in discharge *Q* leads to small change in head *H* – thus, the water level can be kept in practically constant





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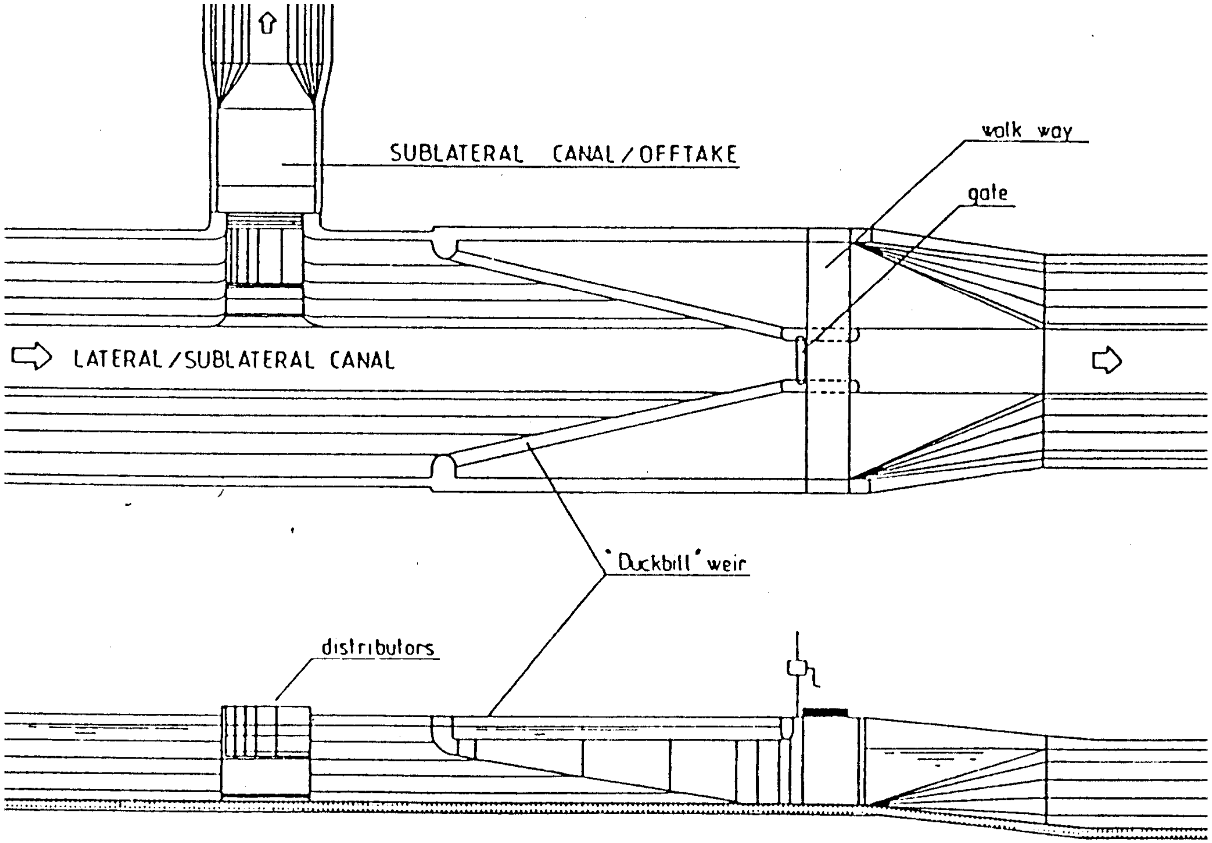
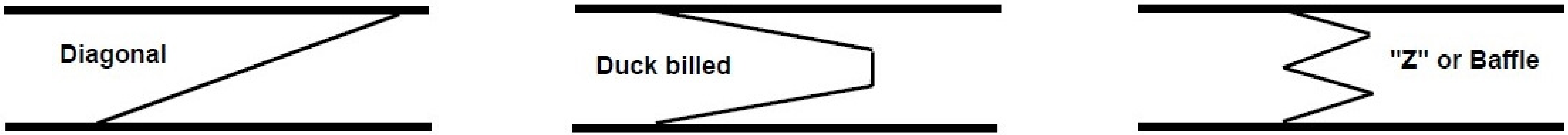
4. Upstream Control Systems

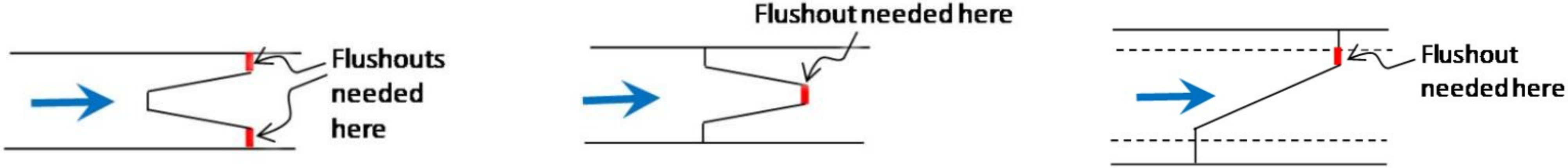
- **Water Level Regulators**
  - **Long Crested weirs**
    - ✓ Permanent structures
    - ✓ Needs canal widening just downstream of the structure to prevent the submergence



4. Upstream Control Systems

- **Water Level Regulators**
  - **Long Crested weirs**
    - ✓ There are several types of constructions

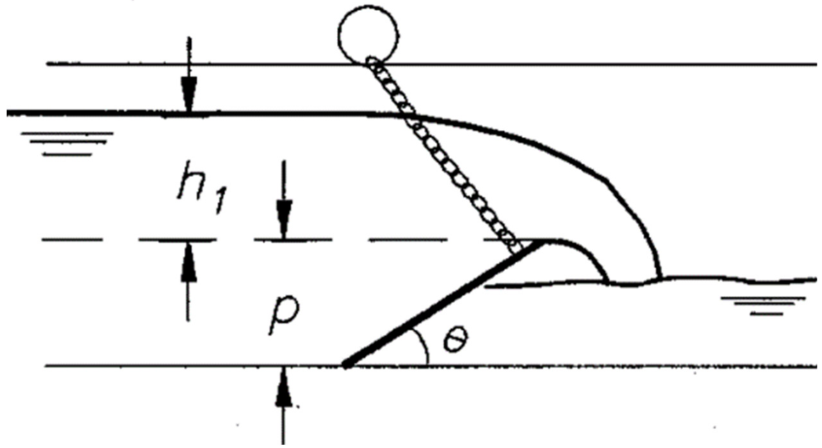




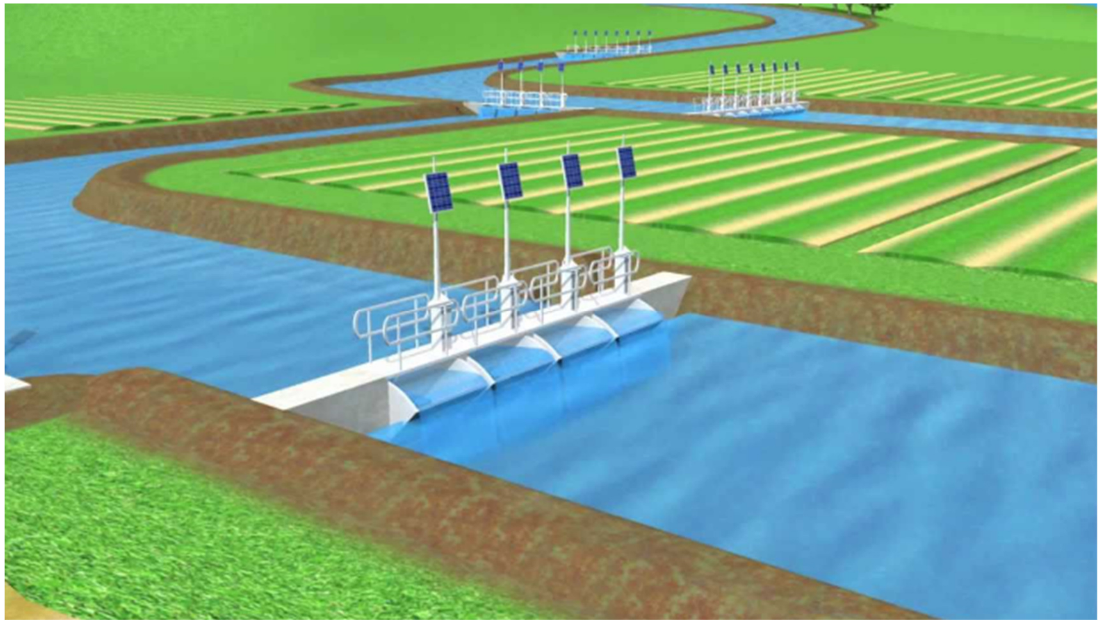
✓ It needs openings at the tip of the weir (flushouts), made with sliding gates, to allow flushing out of the sediments, caught by the structure

4. Upstream Control Systems

- **Water Level Regulators**
  - **Overshot Gates**
    - ✓ Weirs with adjustable crest hight
    - ✓ By adjusting the angle of the gate θ, the weir crest level is changed, thus the head h_1 is changed and also discharge Q.

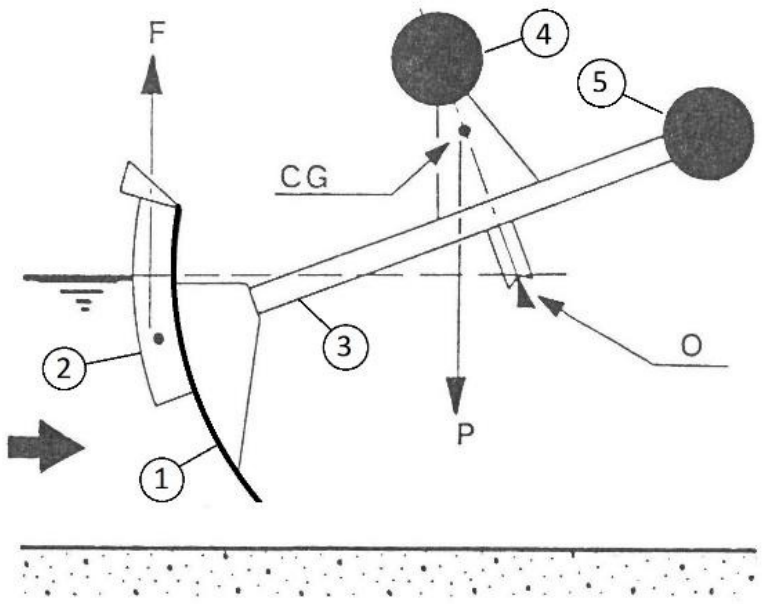


Rubicon Flume Gate
Adjustments are made using electric motors powered by solar panels



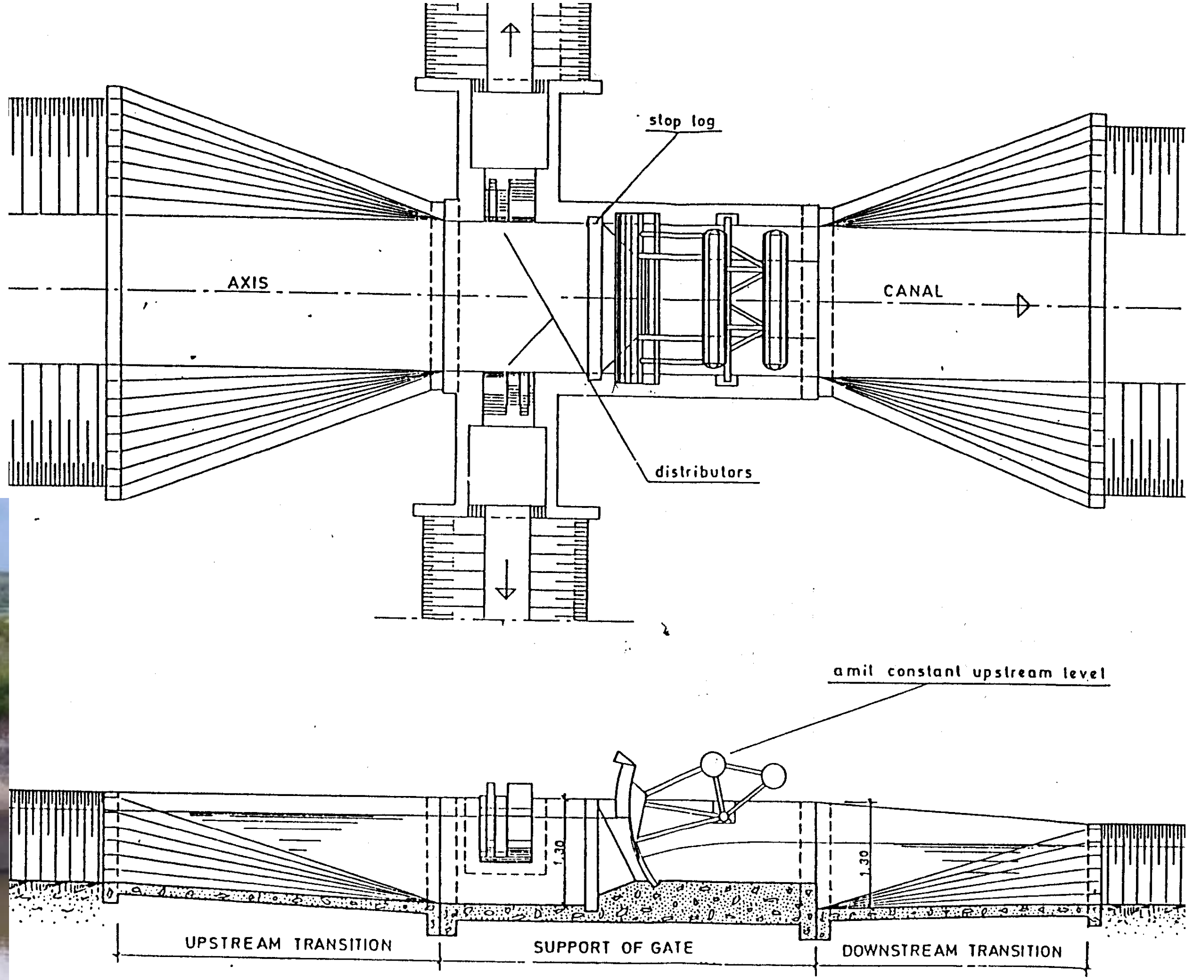
4. Upstream Control Systems

- **Water Level Regulators**
  - **AMIL Gates**
    - ✓ French construction (and patent until 1990's)
    - ✓ The construction parts are:
      - gate leaf ① - cylindrical, with center point O;
      - float ②, welded to ①
      - frame ③
      - counterweights ④ and ⑤.



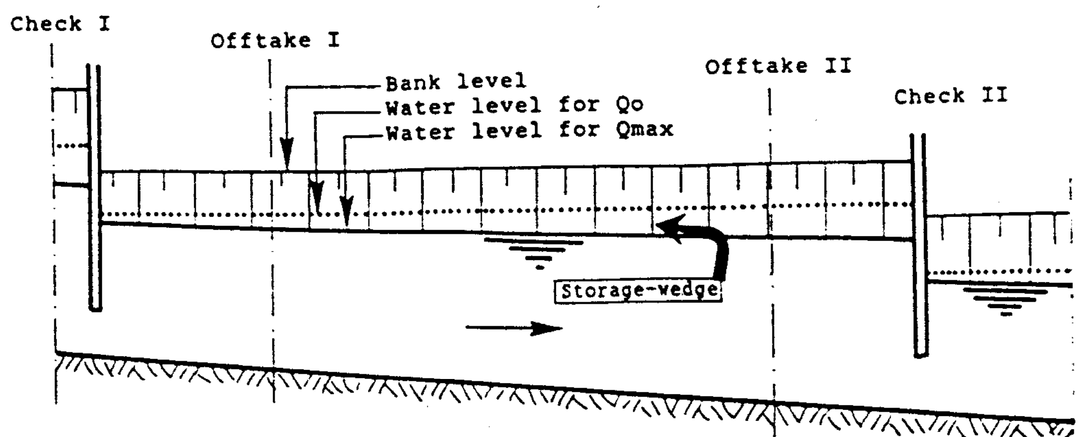
- ✓ When the discharge Q increases, the upstream water level rises, which causes the rising of the float, and thus opening of the gate leaf. The discharge Q_{AMIL} through the gate also increases.
- ✓ When the discharge Q decreases, the upstream water level decreases ⇒ the float and the gate leaf move down ⇒ Q_{AMIL} also decreases.

- **Water Level Regulators**
  - **AMIL Gates**
    - The canal cross section at the gate should have very steep walls

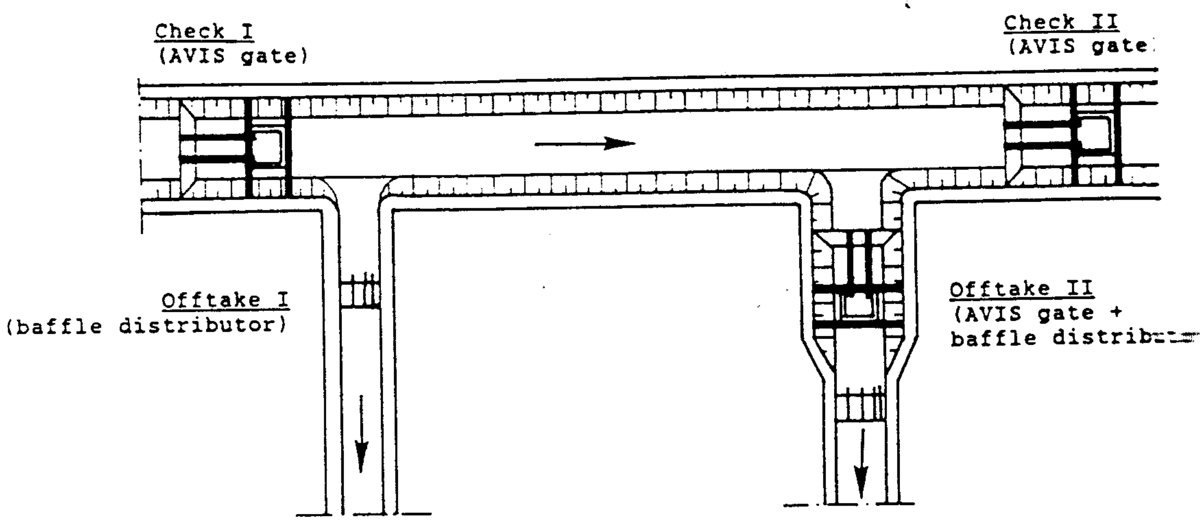


5. Downstream Control Systems

- **Canal reaches**
  - When hydraulically operated regulators are used (such as AVIS gates), ***the distance between regulators must be thoroughly determined***.
  - Because of the lag time the volume between water levels @ Q = 0 and Q_{max} must be enough to store the volume of water released through upstream regulator for the period of time between closing of the downstream regulator and closing of the upstream regulator.



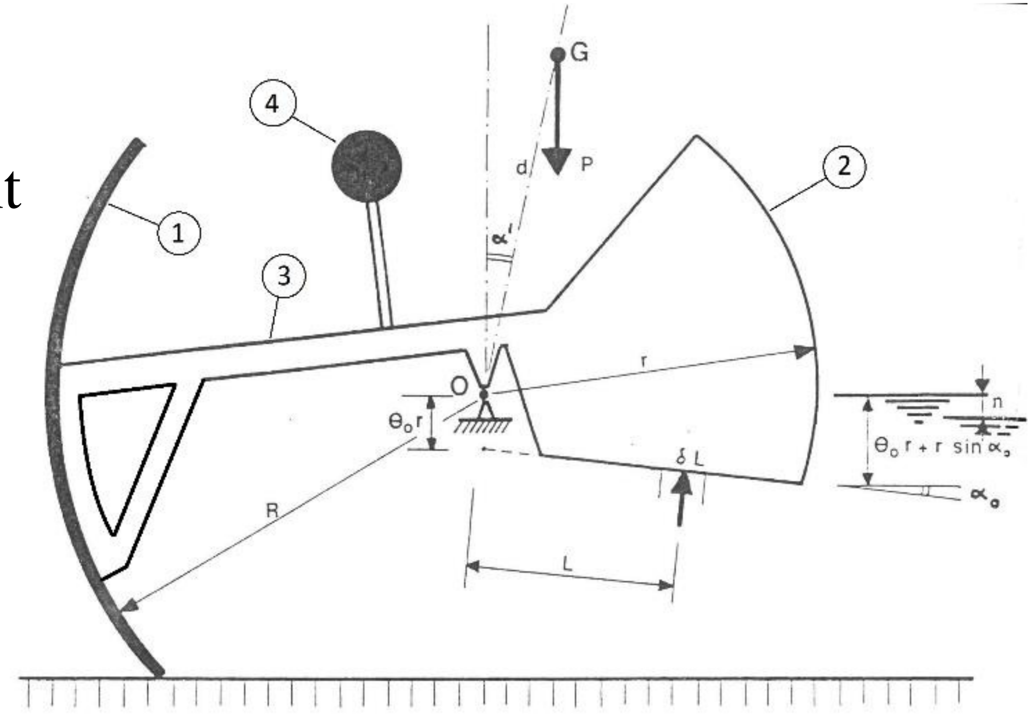
LONGITUDINAL PROFILE DOWNSTREAM CONTROL



SCHEMATIC SITUATION OF REACH FOR DOWNSTREAM CONTROL

5. Downstream Control Systems

- **Water Level Regulators**
  - **AVIS Gates**
    - ✓ French construction (and patent until 1990’s)
    - ✓ The construction parts are:
      - gate leaf ① - cylindrical, with center point O;
      - float ②,
      - frame ③
      - counterweight ④.

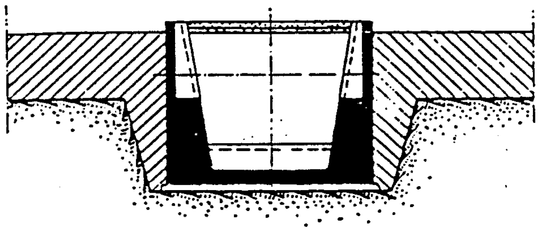


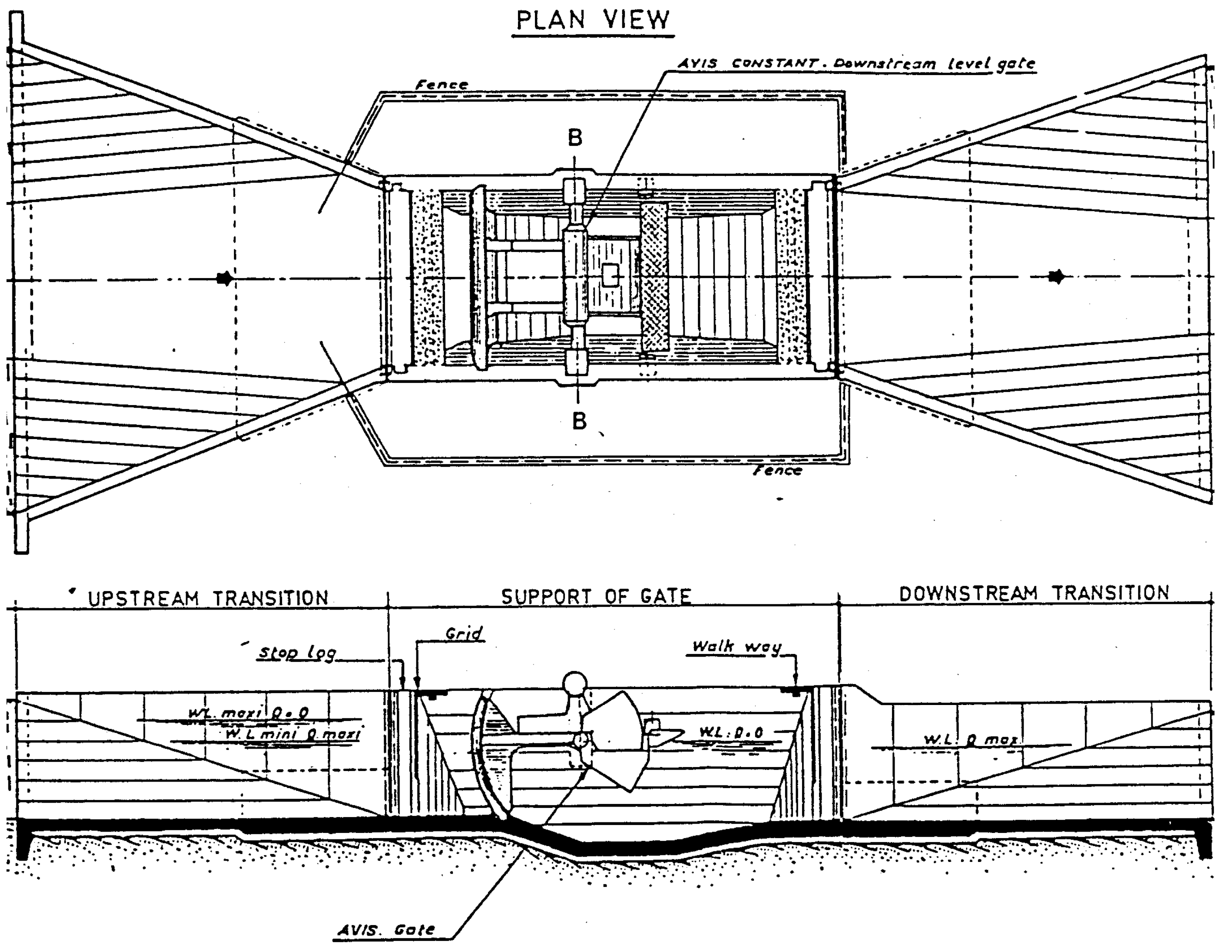
- ✓ The operation principle is the same as for AMIL gates – the float ② causes rotation of the gate leaf ①.
- ✓ When the downstream discharge *Q* increases, the downstream water level drops, which causes the opening of the gate.
- ✓ In contrast, when nobody uses water the water level increases, this the gate closes.

5. Downstream Control Systems

- **Water Level Regulators**
  - **AVIS Gates**
    - ✓ The canal cross section at the gate should have very steep walls
    - ✓ The bottom below the float is slightly deeper.
    - ✓ The float is located in the middle of the canal cross section

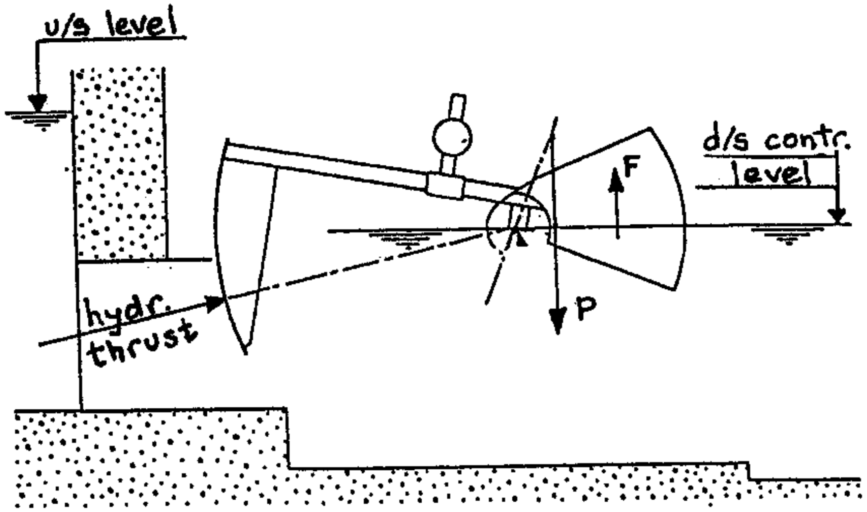
SECTION B.B

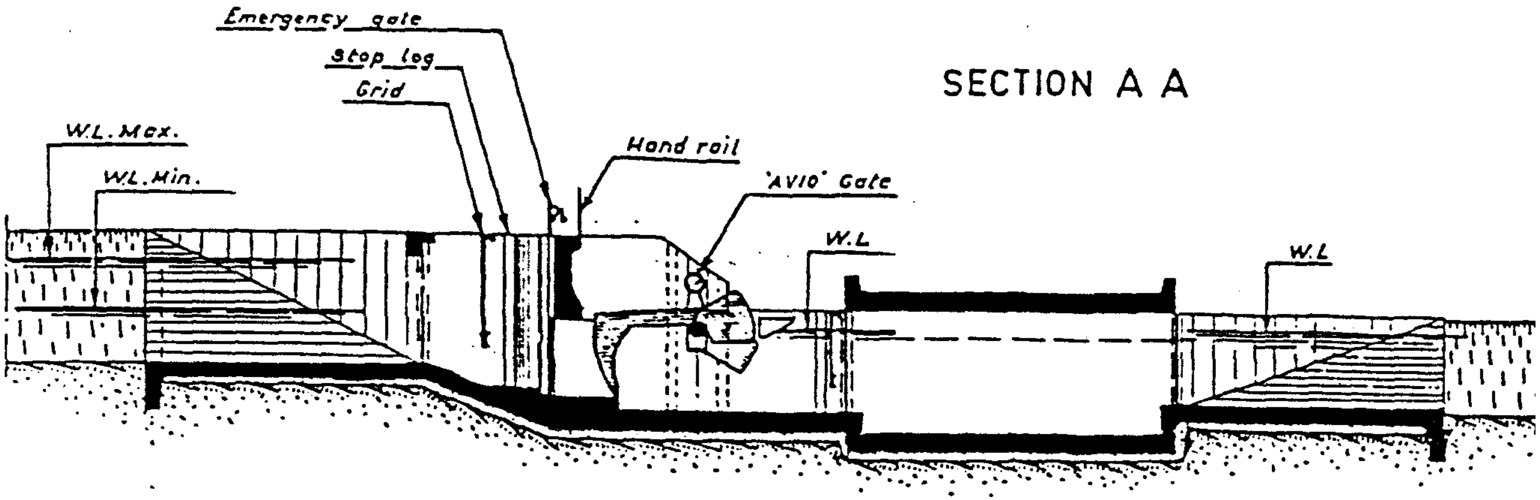




5. Downstream Control Systems

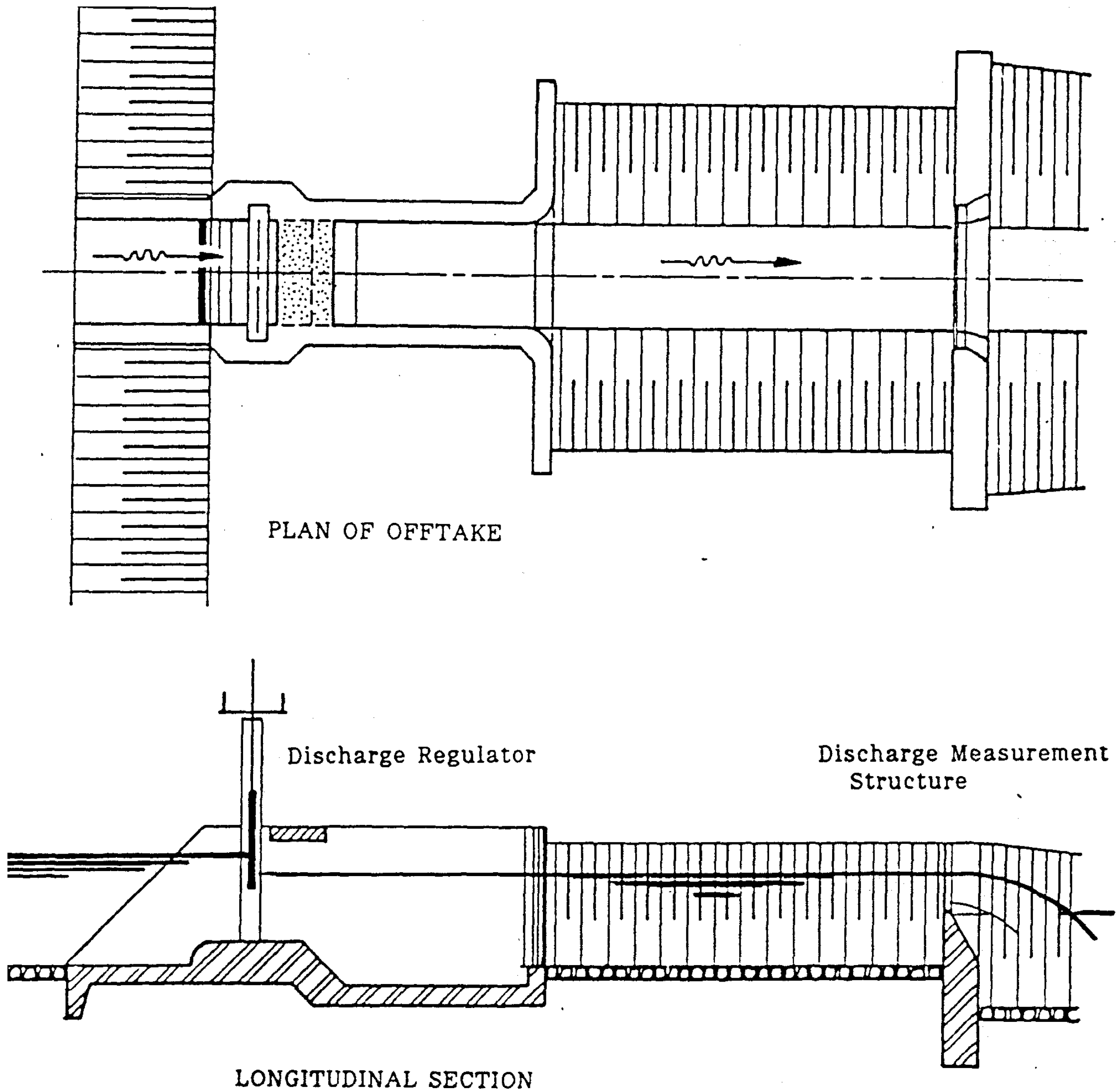
- **Water Level Regulators**
  - **AVIO Gates**
    - ✓ Designed for intakes from large and deep canals
    - ✓ The leaf is set against an orifice
    - ✓ The leaf decreases the incoming flow, when the downstream water level increases





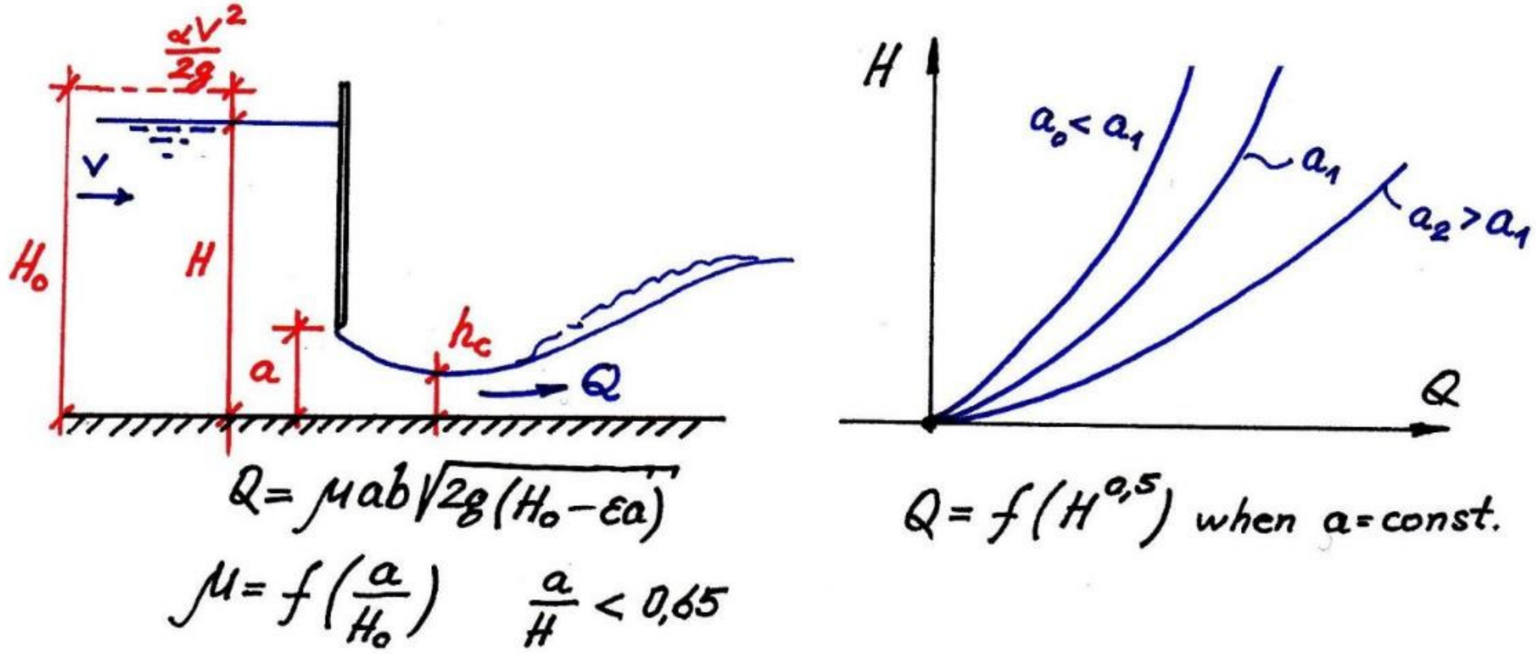
6. Discharge Regulators

- **Sliding gates**
  - ✓ Cheap structures
  - ✓ When used for discharge regulation they should operate in ***free flow conditions***
  - ✓ If the flow is submerged it is difficult to regulate the discharge
    - In this case it is recommended to install discharge measurement structure downstream of the sliding gate (for example – Cipolletti weir)



6. Discharge Regulators

- **Sliding gates** – free flow conditions



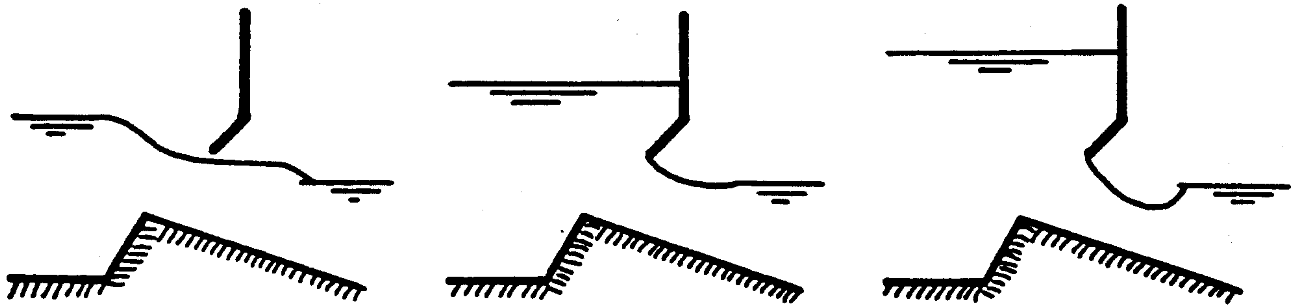
- ➢ Relatively big change of head *H* produces relatively small change in the discharge *Q* – ***suitable*** structures to maintain *fairly constant Q*
- ➢ At free flow conditions the discharge *Q* is not influenced by downstream water depth
- ➢ Only the head ***H*** and the gate opening ***a*** affect the discharge *Q*

Co-funded by the Erasmus+ Programme of the European Union

6. Discharge Regulators

- **Baffle Distributors**
  - French design
    - ✓ There are 2 types - single baffle and double baffle regulators

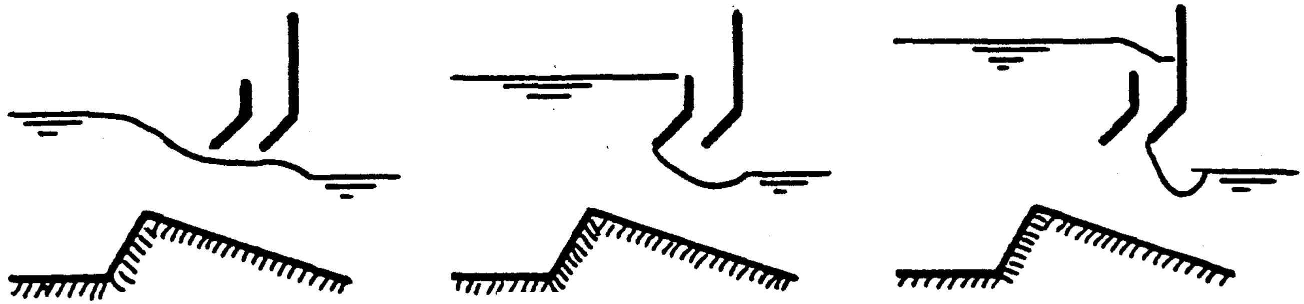
Single baffle



weir *unsubmerged flow through orifice*

- ✓ The baffles are fixed
- ✓ The regulator operates in two modes – as a weir (unsubmerged) and as undershot structure - orifice (unsubmerged flow)

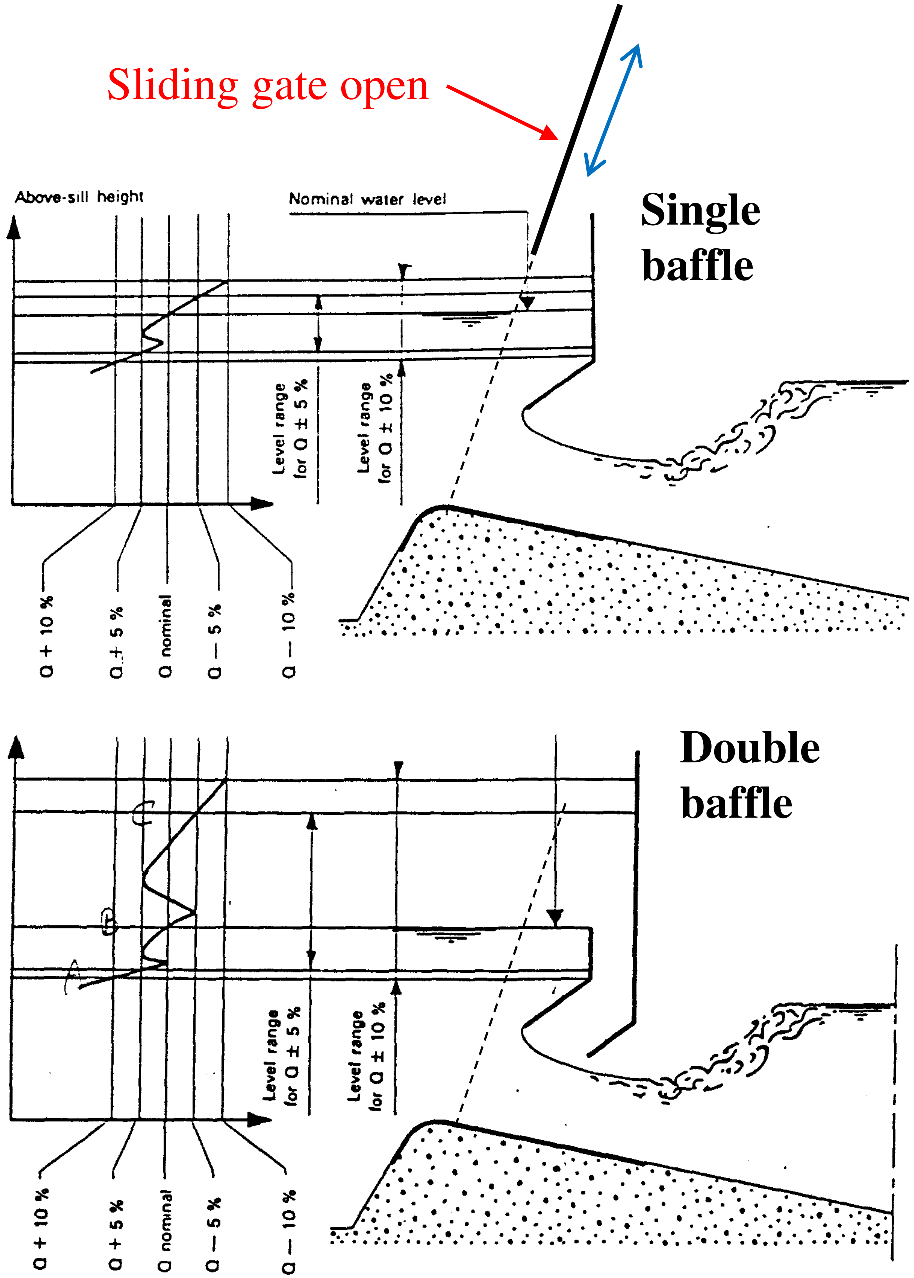
Double baffle



weir *unsubmerged flow through orifice*

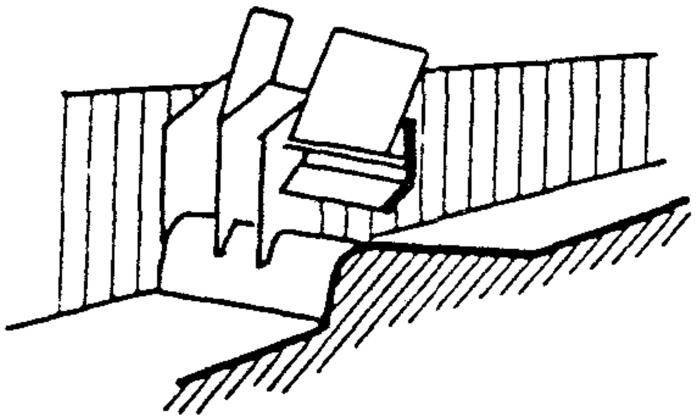
6. Discharge Regulators

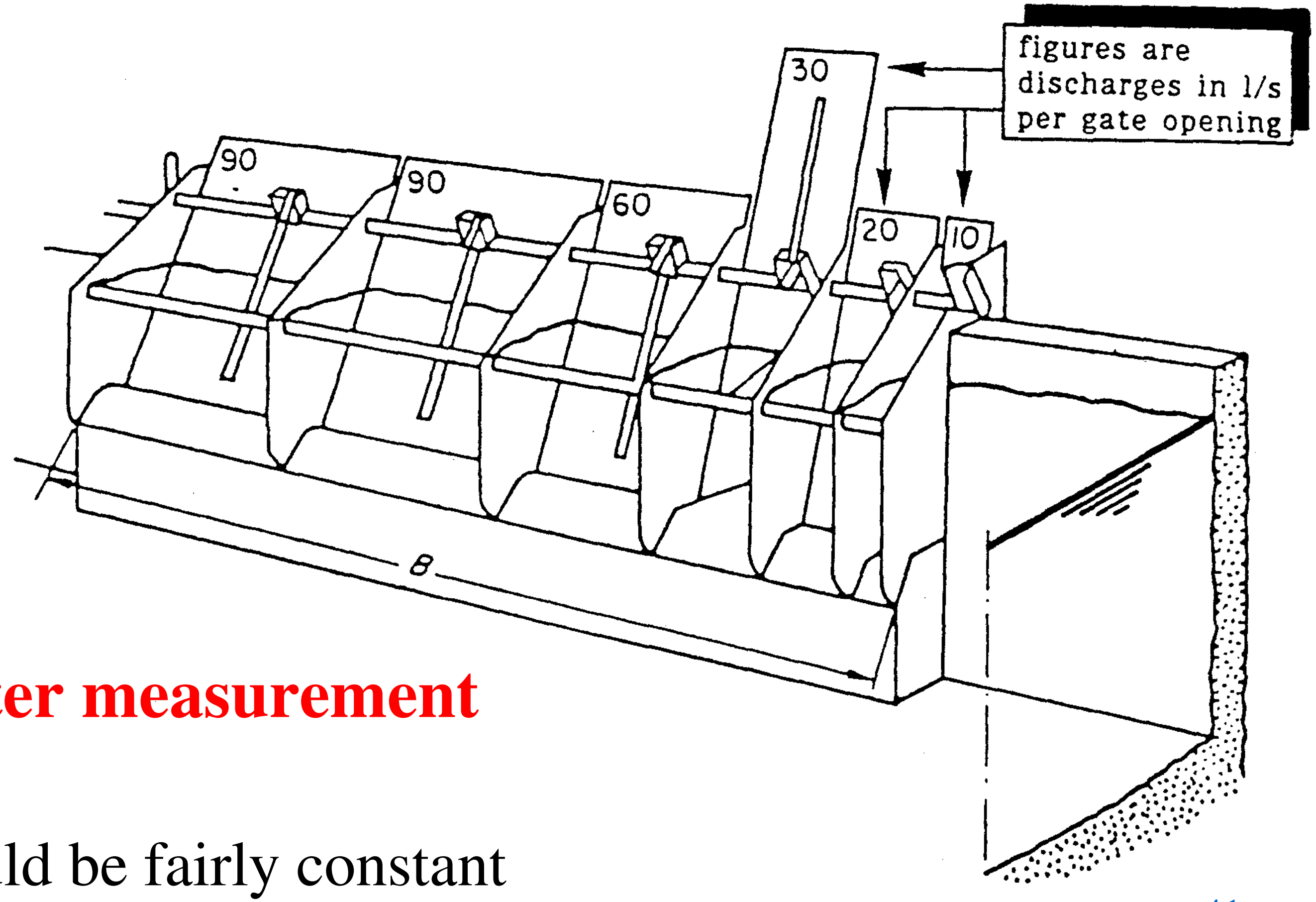
- **Baffle Distributors**
  - ✓ A sliding gate is used to open or close one baffle section
  - ✓ The sliding gate is not used for regulation
  - ✓ At relatively high change in upstream head *H* (±10%), the discharge *Q* is maintained within ±5% of design flow.
  - ✓ The baffles are made of metal
  - ✓ They are placed over a concrete structure



6. Discharge Regulators

- **Baffle distributors**
  - ✓ The baffle distributors contain several sections
  - ✓ Each section is designed for a standard discharge



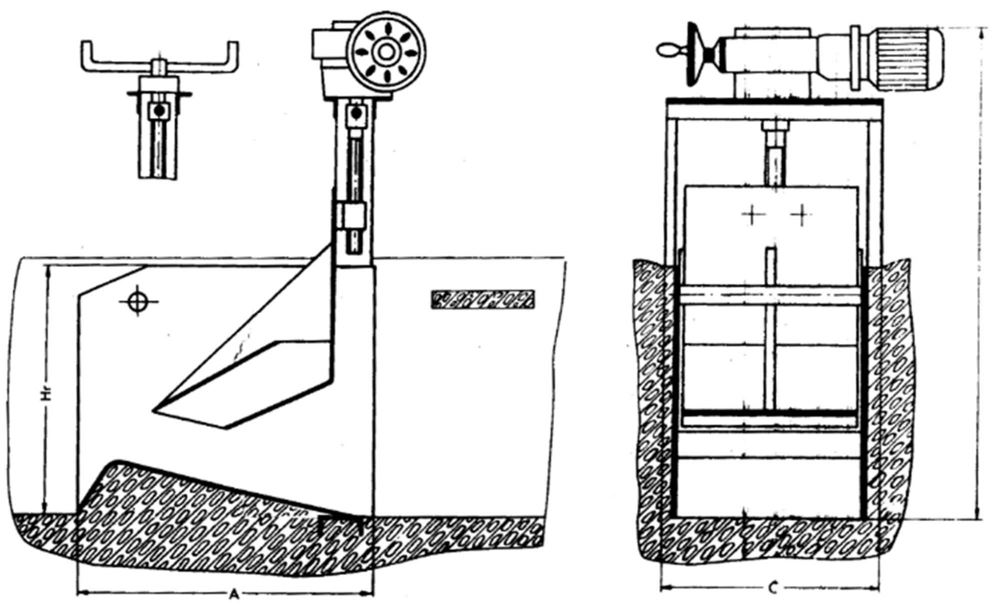


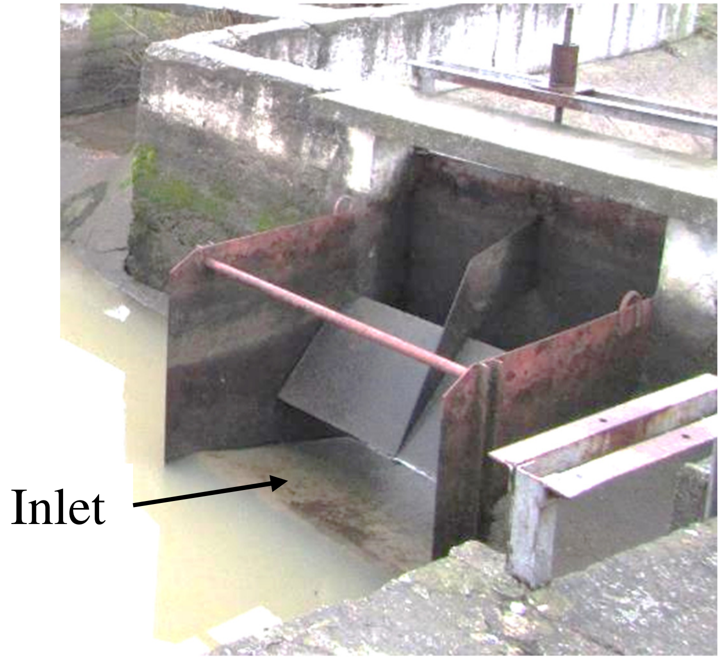
➢ **Can be used as water measurement structure**
  - ✓ Head at inlet should be fairly constant

6. Discharge Regulators

- **Khamadov Distributor**
  - ✓ Designed in USSR
  - ✓ Operate using the same principles as Baffle distributors
  - ✓ Difference – the baffles are welded on a sliding gate
  - ✓ The discharge is adjusted by gate opening.
  - ✓ There is no need of sections – the structure is very compact

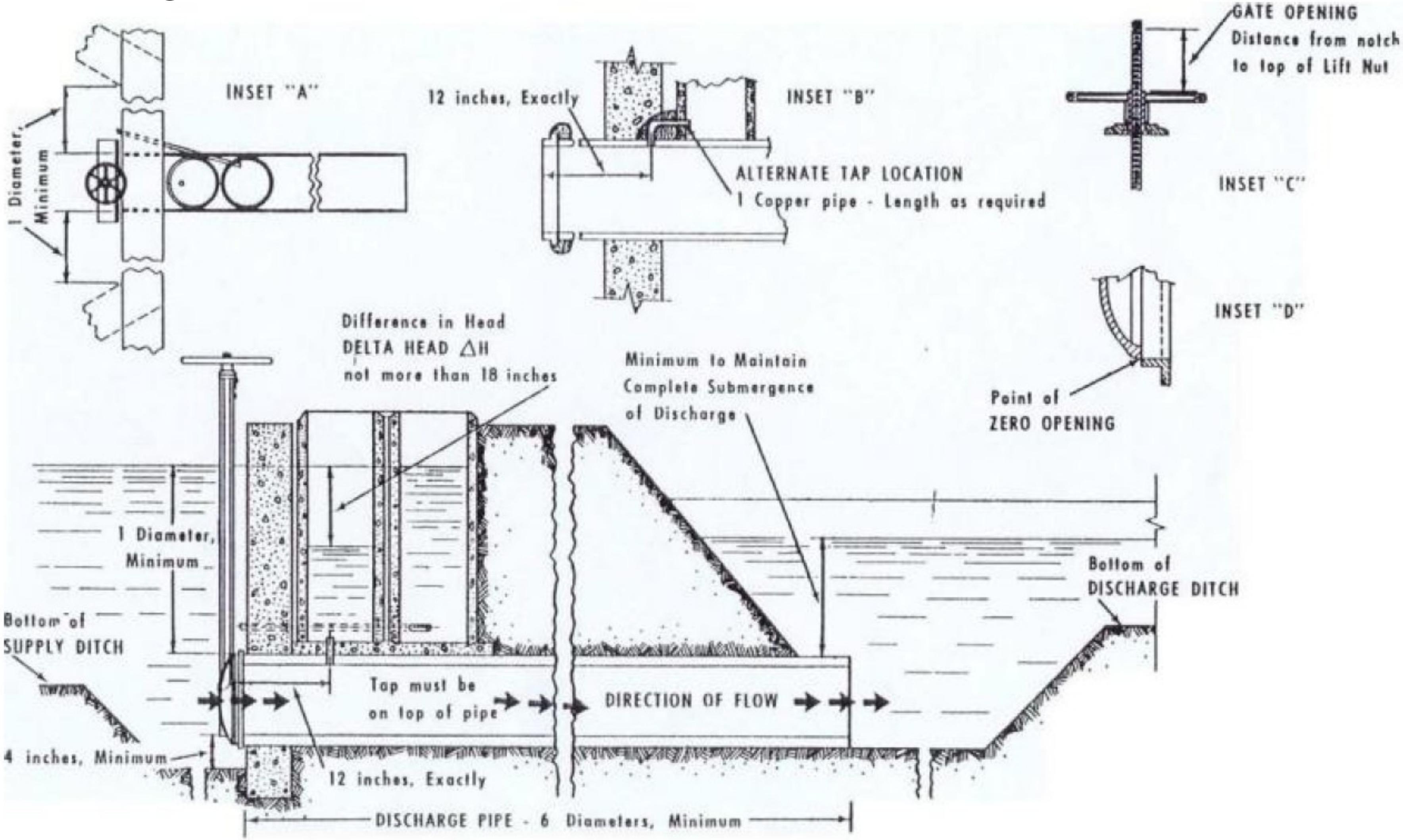
Khamadov Distributor (Дозатор „Хамадов“)





6. Discharge Regulators

- **Metergates**
  - Designed in USA (US Bureau of Reclamation)



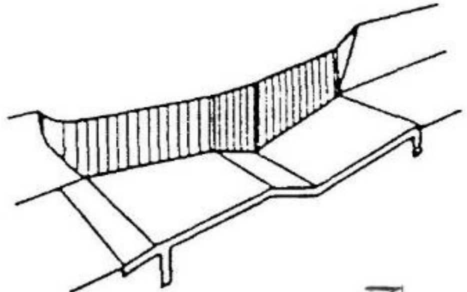
6. Discharge Regulators

- **Metergates**
  - ➢ The inlet and outlet parts may be prefabricated
  - ➢ **Can be used as water measurement structure**
    - ✓ Head at inlet should be fairly constant

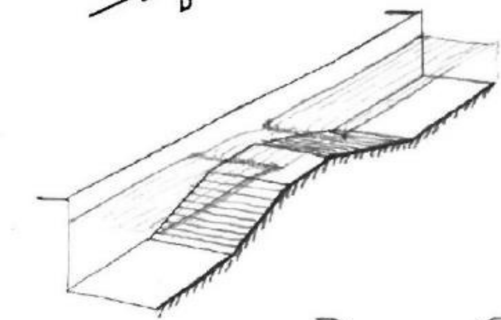
Pictures provided by prof. C.M. Burt from ITRC at CalPoly (USA) for Strategy for management and development of hydro-melioration in Bulgaria

7. Discharge Measurement Structures

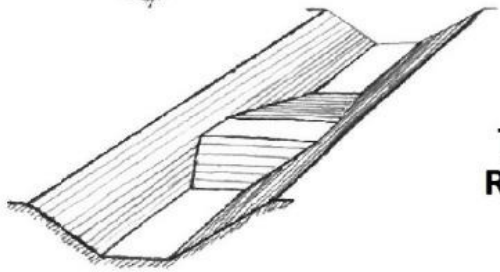
- **Measurement of Transit Flows**
  - ➢ Flumes
    - ✓ **Parshall flume**
    - ✓ Venturi flumes
      (Long Throated flumes)
  - ➢ Weirs
    - ✓ Broad crested weirs
      - – **Trapezoidal**
      - – **Replogle Flume**
      - – Classic
    - ✓ Sharp crested weirs
      - – Cipoletti



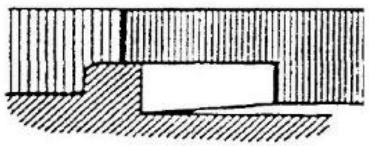
Parshall Flume
ISO 9826



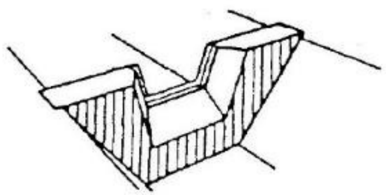
Trapezoidal Weirs
ISO 4362



Trapezoidal Weir
Replogle Flume (ASCE)



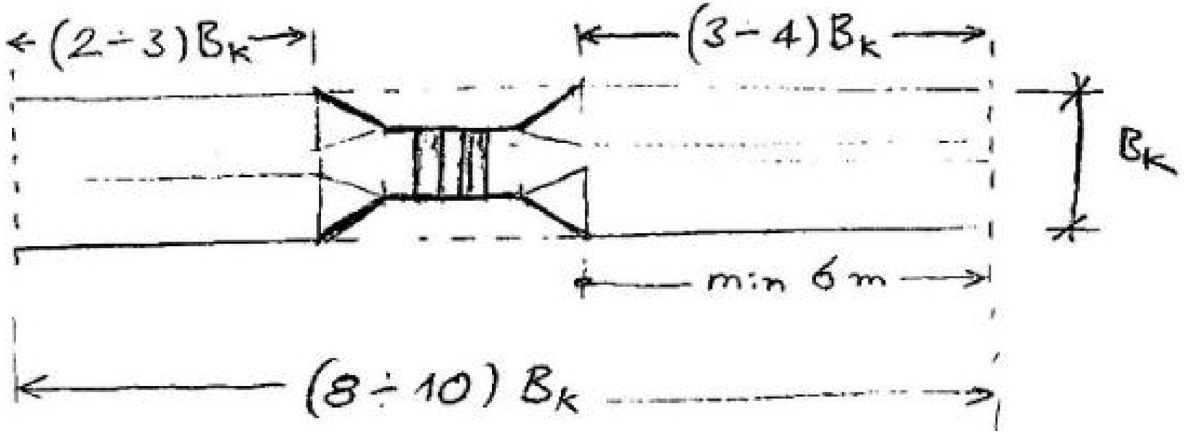
Broad Crested Weir



Sharp Crested Weir
Cipoletti

7. Discharge Measurement Structures

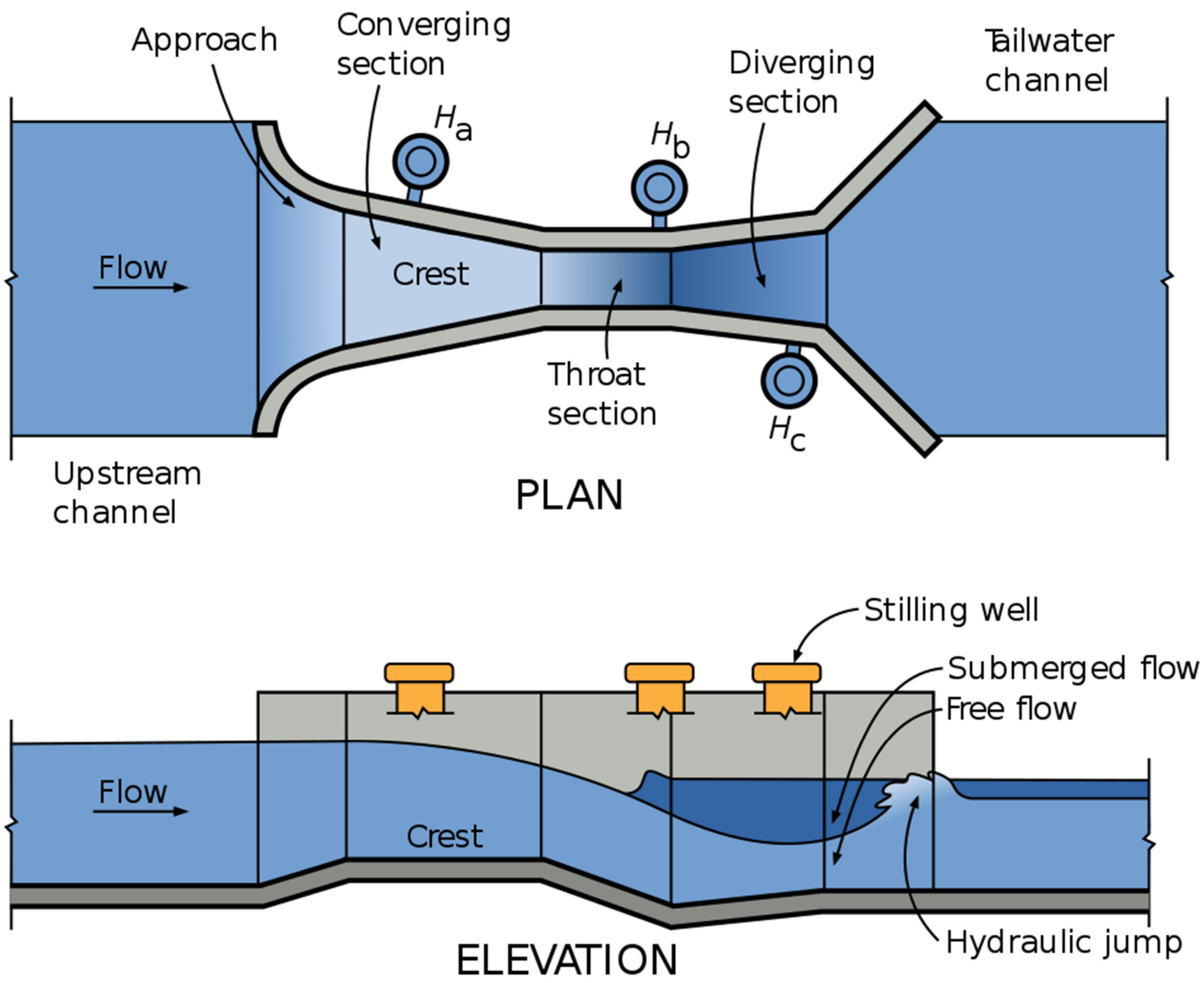
- <u>General requirements</u>
  - ➢ Canal cross section and longitudinal slope – constant
    - ✓ Cross section – symmetrical about the axis
  - ➢ Canal axis to coincide with the axis of the structure
  - ➢ Straight canal section – L ~ 10 time the water surface width $B_к$
    - ✓ $(2 \div 3)B_к$ upstream and $(3 \div 4)B_к$ downstream of structure



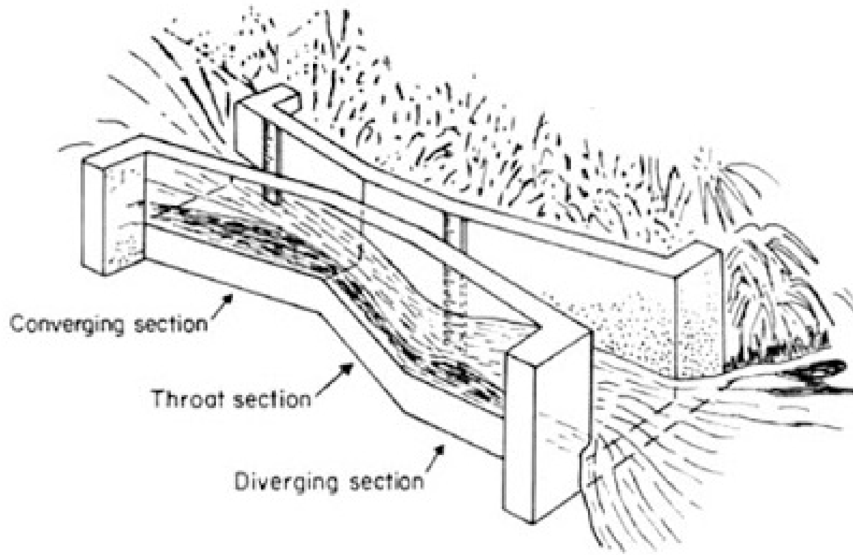
  - ➢ The throat width b of the measurement structure should be less than $B_к$ – e.g. $b = (1/2 \div 1/3)B_к$.

7. Discharge Measurement Structures

- **Flumes**
  - ➢ **Parshall Flume**

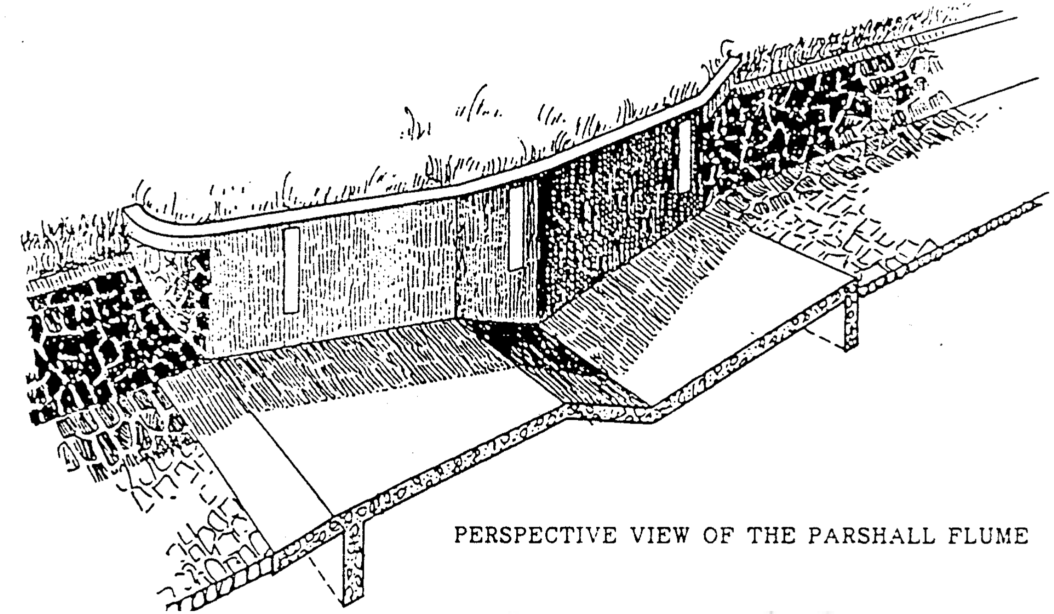


- The flume has standardized dimensions, i.e. standard sizes.
- ✓ According to ISO 9826.
- Discharge Q_{max} = 0,4 ÷ 4,0 m^3/s
- There are non-standard flumes – for discharges $Q_{max} \leq 90$ m^3/s.

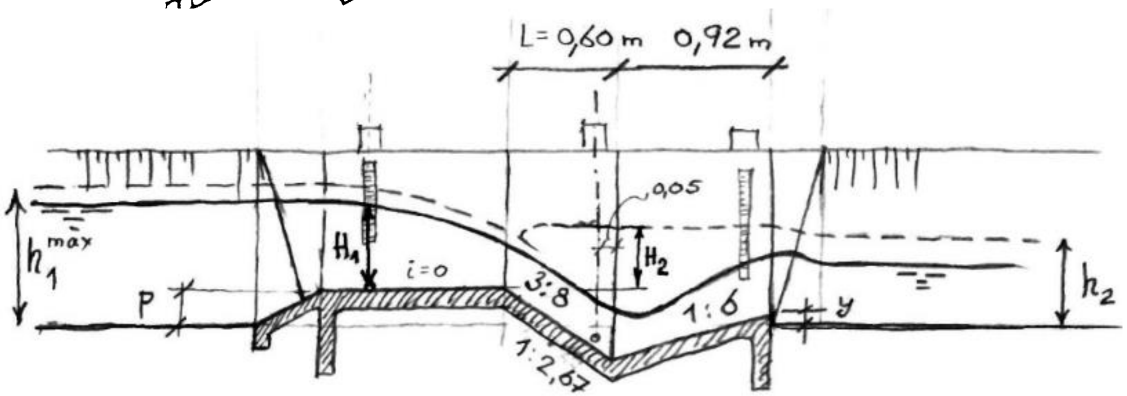


7. Discharge Measurement Structures

- **Flumes**
  - ➢ **Parshall Flume**



PERSPECTIVE VIEW OF THE PARSHALL FLUME



- Operates at free flow conditions, as well as submerged when $H_2/H_1 \leq 0{,}95$
- Large operating range –

  $Q_{min} = (1{,}5\% \div 2{,}5\%)Q_{max}$.

Accuracy:

- ➢ **$\pm$2% at free flow conditions**
- ➢ **$\pm$5% at submerged flow**

- Advantages:
  - ➢ Relatively small head losses;
  - ➢ Operates both at free and submerged flow
  - ➢ Conveys floating debris and bed load
  - ➢ May be installed in existing canals

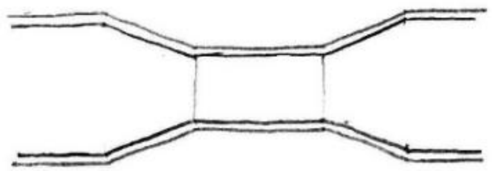
Disadvantages:

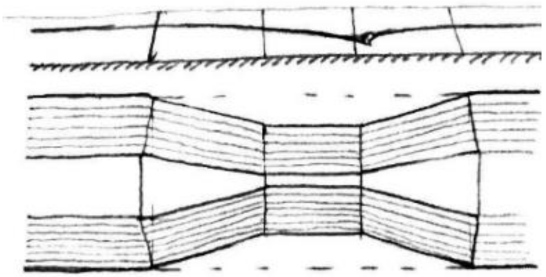
- ➢ High requirements for accuracy of construction – lengths, slopes, etc.
- ➢ Relatively expensive

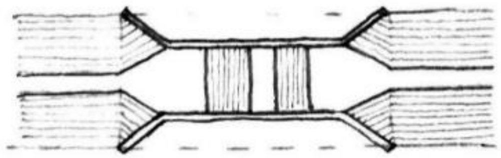
Co-funded by the Erasmus+ Programme of the European Union

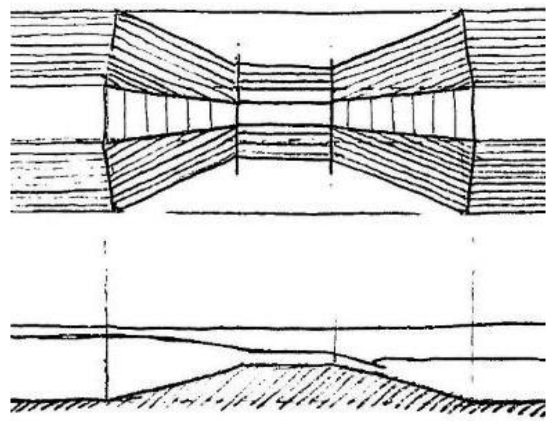
7. Discharge Measurement Structures

- **Flumes**
  - **Venturi Flumes**
    - ✓ Operating principle – to create *vena contracta*, i.e. flow contraction
    - ✓ Contraction can be
      - Horizontal
      - Horizontal and vertical
    - ✓ The cross section can be
      - Rectangular
      - Trapezoidal
      - Triangular
    - ✓ The water depth is measured at the converging section (inlet section)
    - ✓ Suitable for installation in exiting canals, due to small head losses, i.e. small backwater effect.
    - ✓ Individual design to meet requirements


Horizontal contraction, rectangular cross section

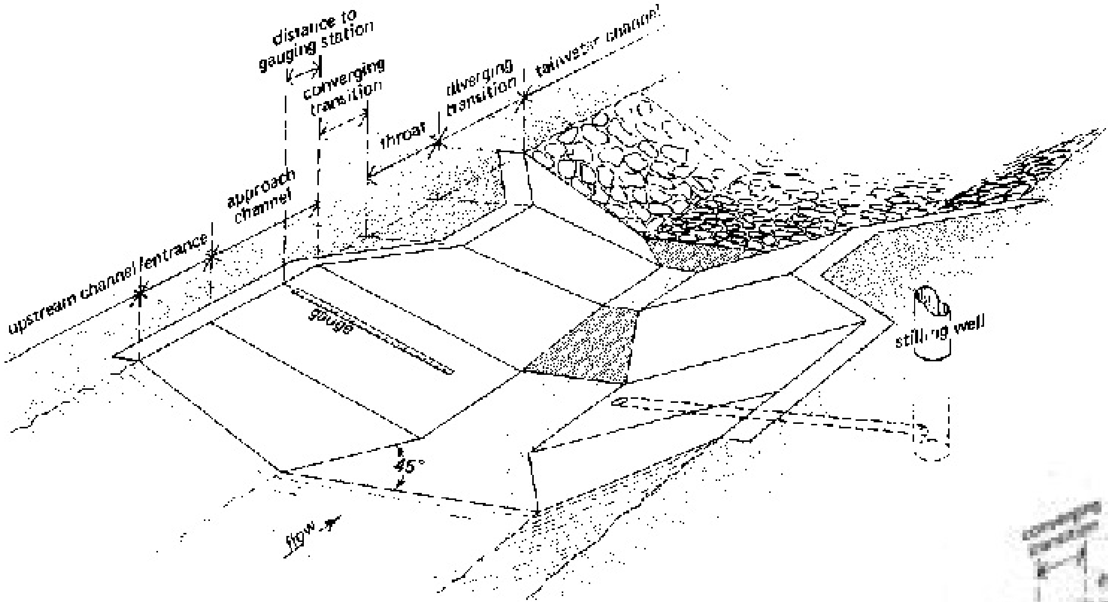

Horizontal contraction, trapezoidal cross section

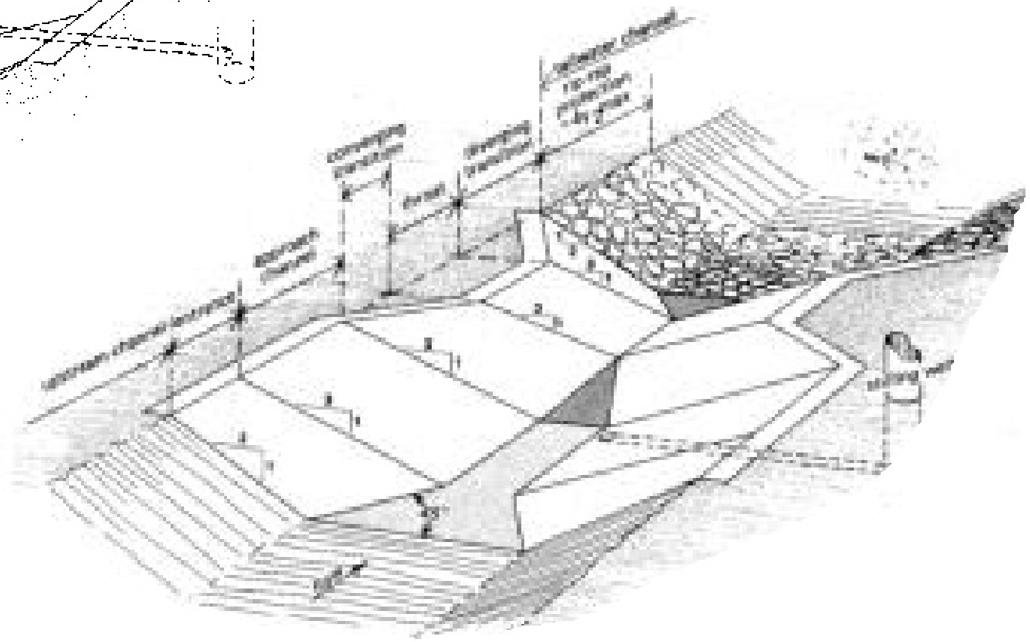

Horizontal and vertical contraction, rectangular cross section


Horizontal and vertical contraction, trapezoidal cross section

7. Discharge Measurement Structures

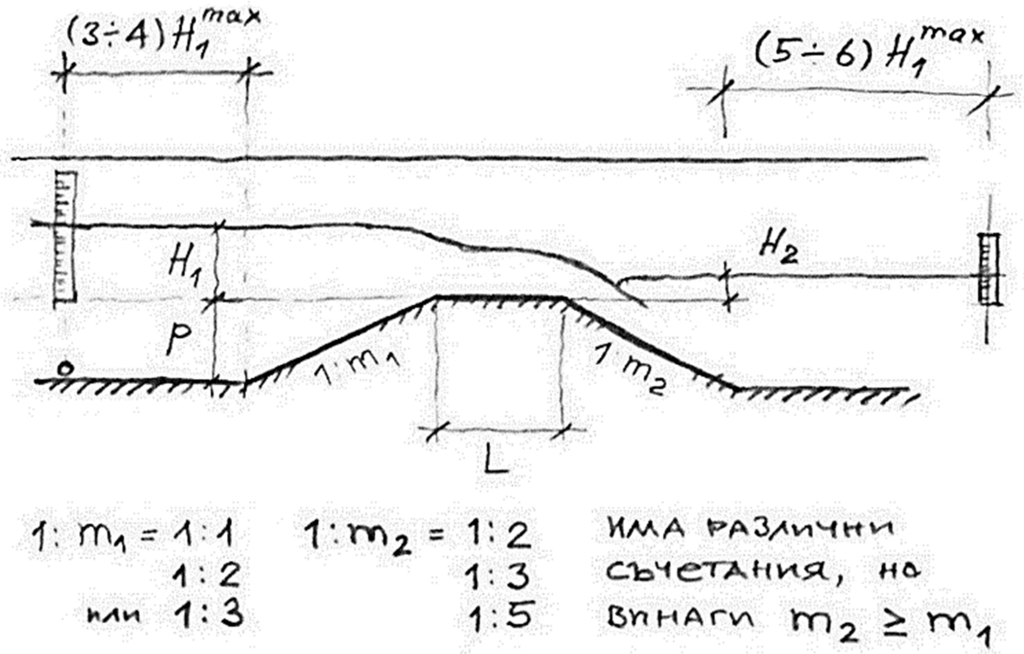
- **Flumes**
  - ➢ **Venturi Flumes (Long Throated Flumes)**

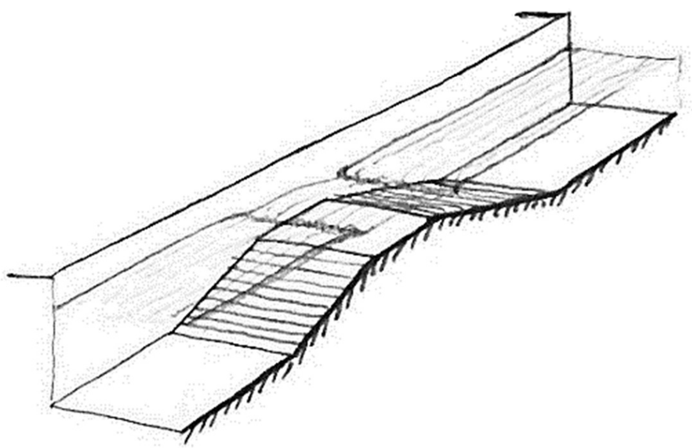




7. Discharge Measurement Structures

- **Weirs**
  - Trapezoidal weirs (ISO 4362)



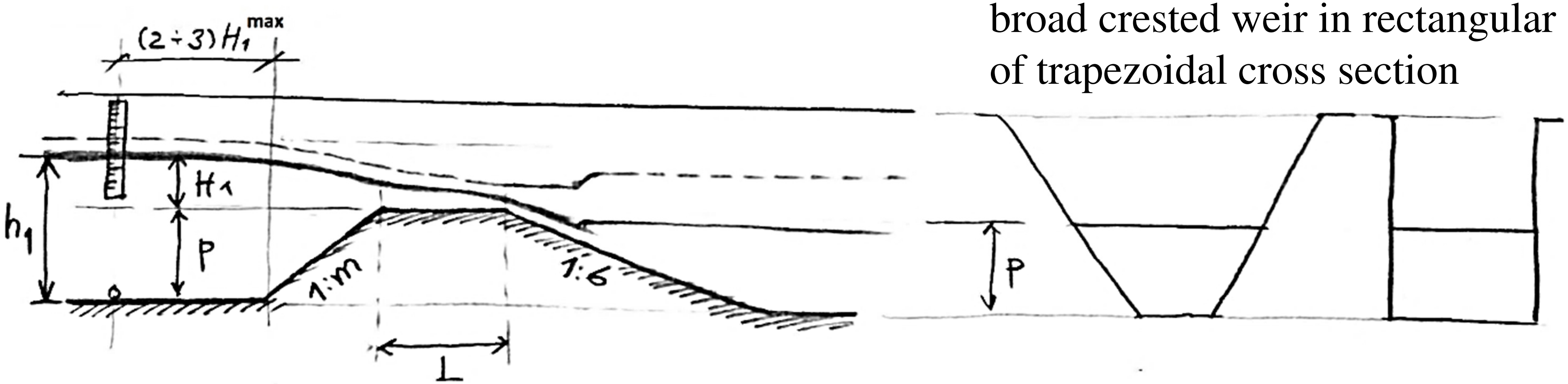


Intermediate case between venturi flumes and broad crested weirs

- For **rectangular cross sections**
- The structure can be designed to fit into any canal
- Discharges Q_{max} = 0,1 ÷ 10,0 m^3/s
- Wide range of measured flows
- Operates at free and submerged flow
- According to the combination of H_1 and L can be either broad crested, or nappe-shaped weir
- **Accuracy:**
  - **± 4% at free flow conditions**
  - **± 6% at submerged flow**

7. Discharge Measurement Structures

- **Weirs**
  - **Replogle Flume** - Trapezoidal weir / flume



broad crested weir in rectangular of trapezoidal cross section

✓ In case of rectangular cross section – it may have horizontal contraction in addition to vertical

✓ The structure can be designed to fit into any canal

✓ Discharges $Q_{max} = 0{,}5 \div 15{,}0\ m^3/s$

✓ Wide range of measured flows

✓ **Suitable for existing canals**

✓ Operates at free and submerged flow

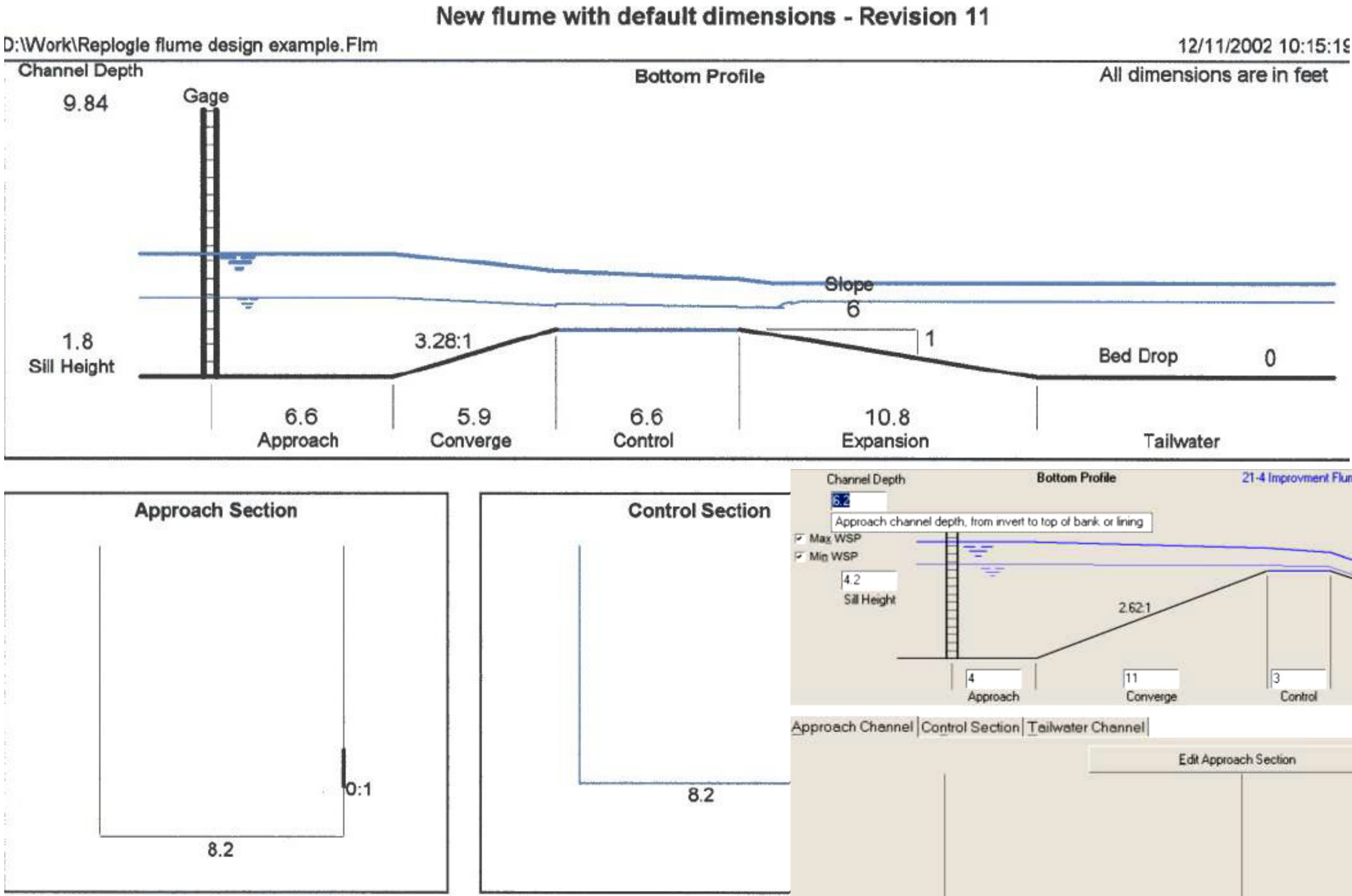
Accuracy:

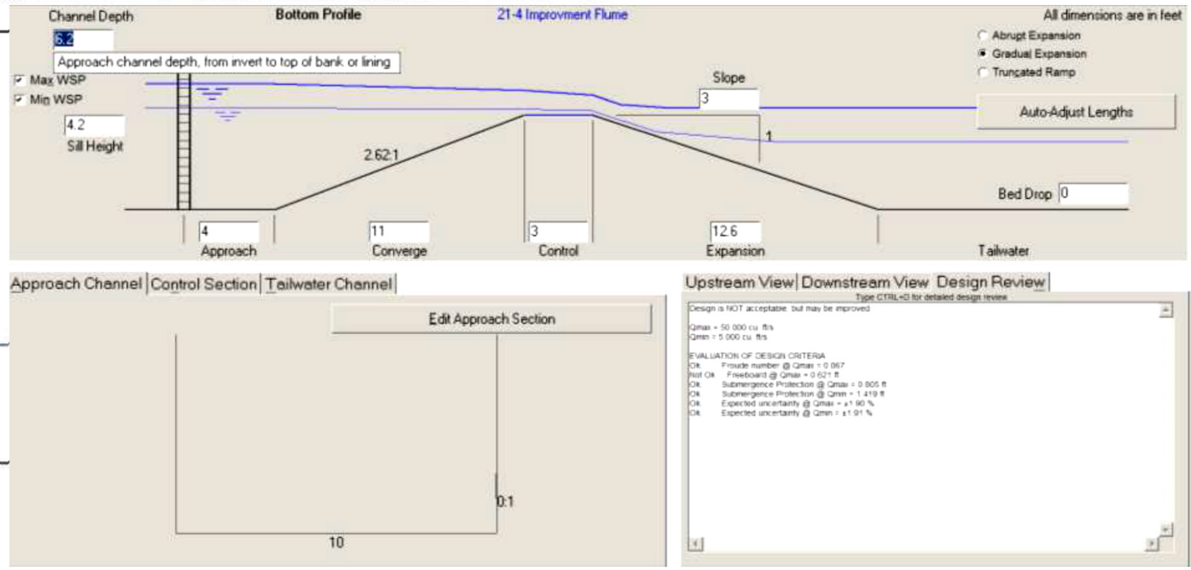
✓ **4% at free flow**

✓ **6% at submerged flow**

7. Discharge Measurement Structures

- **Weirs**
  - ➢ **Replogle Flume**





Source: ITRC (Irrigation Training and Research Center)

- Special software for design – **Win Flume** (freeware) – made by *ITRC* at CalPoly (USA)

7. Discharge Measurement Structures

- **Weirs**
  - ➢ **Replogle Flume**

Source: ITRC (Irrigation Training and Research Center)