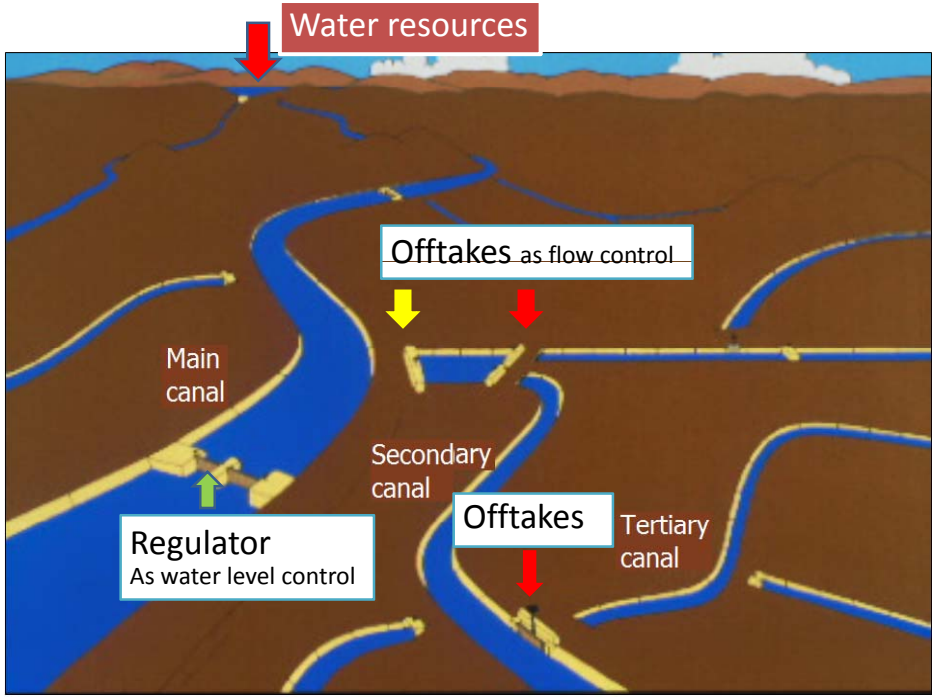
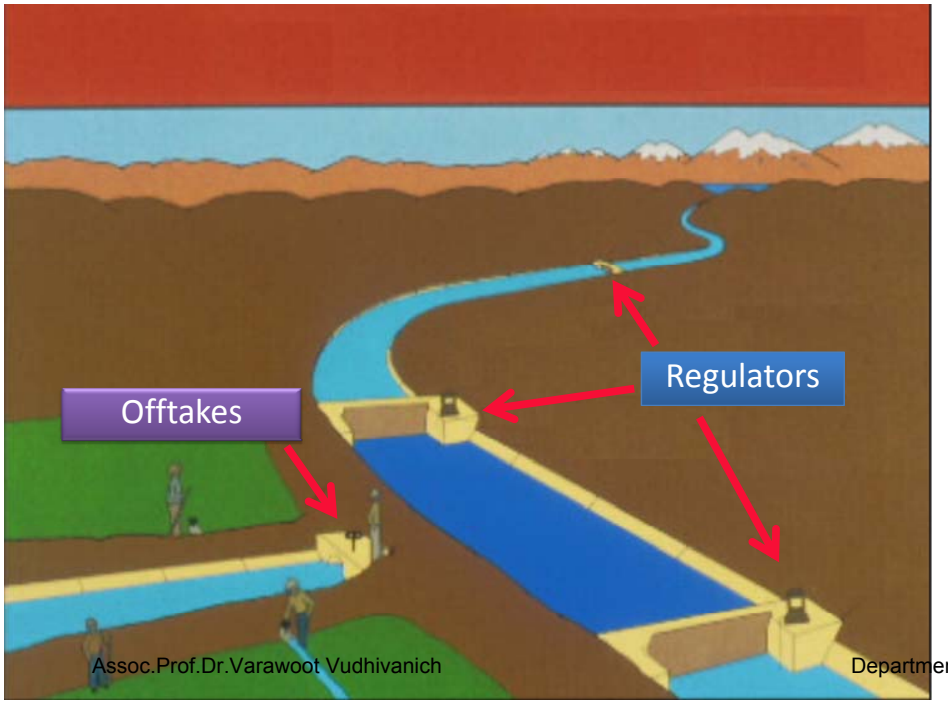
Concept of canal control

by Assoc.Prof.Dr.Varawoot Vudhivanich

Sources: Improving operation of canal irrigation system, FAO+EDI(World Bank)



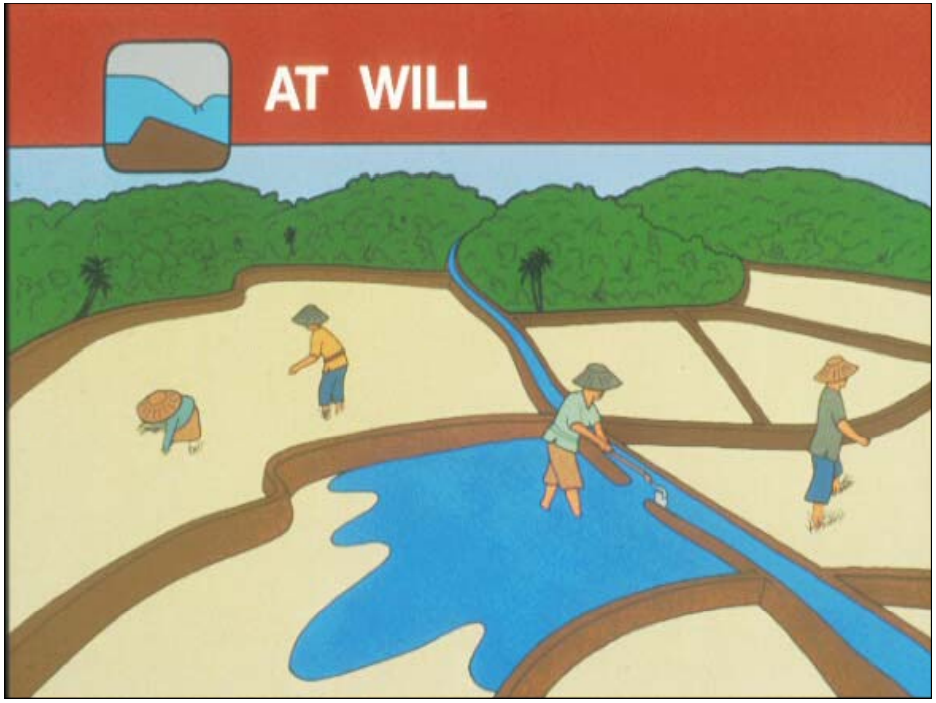


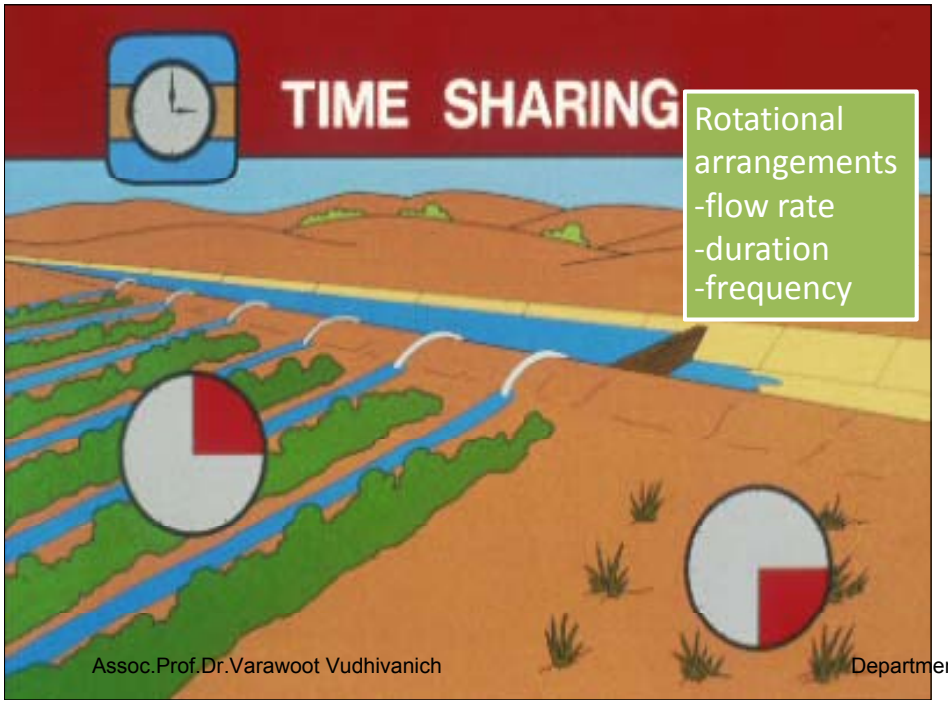
Main objectives of irrigation

- Quality of services
  - Efficiency
  - Equity
  - Adequacy
  - Reliability
  - Flexibility
- Low cost operation
- Simplicity

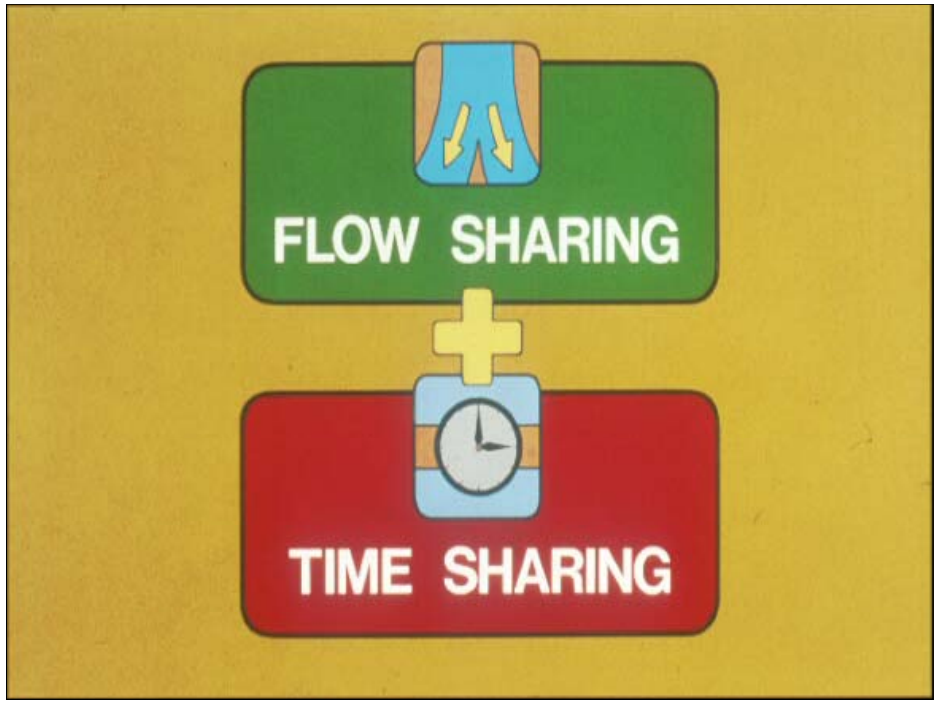
Basic water delivery techniques

AT WILL	ON DEMAND
TIME SHARING	ROTATION
FLOW SHARING	PARTITION





Flow sharing or partitioning



Basic fundamental for canal control

- Flow control
- Water level control

Reasons for flow control

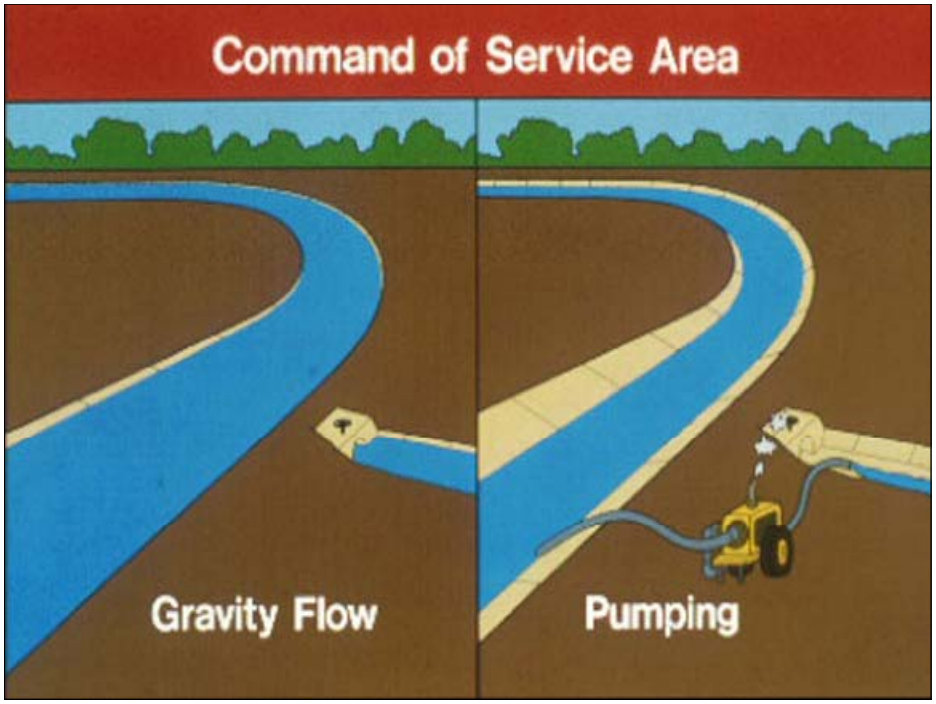
- Meeting crop water requirements
- Water savings
- Safety of operation

Offtakes as flow control

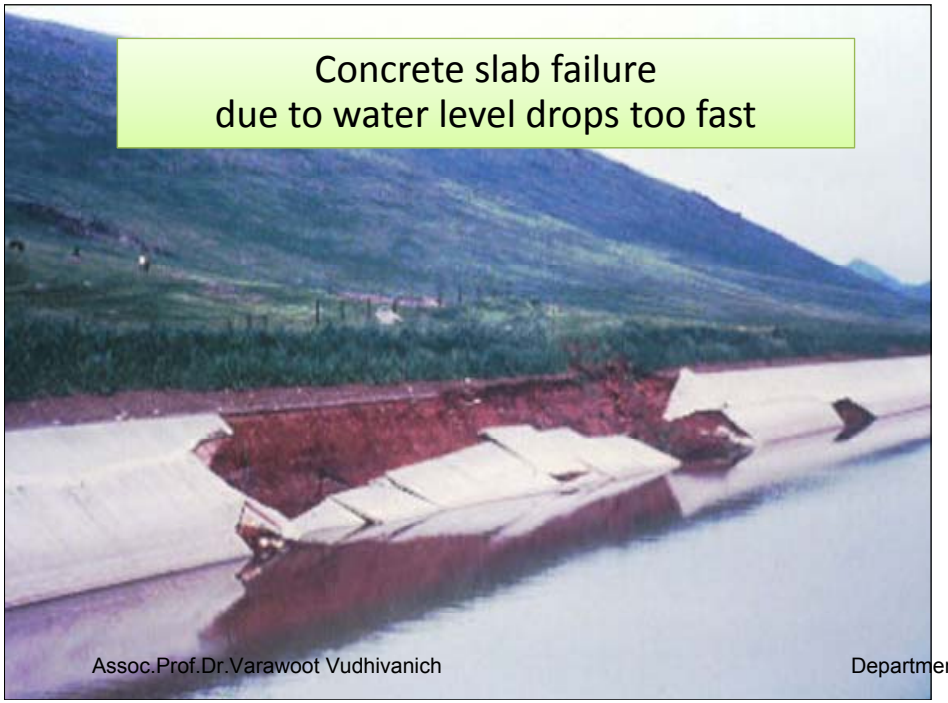
Reasons for water level control

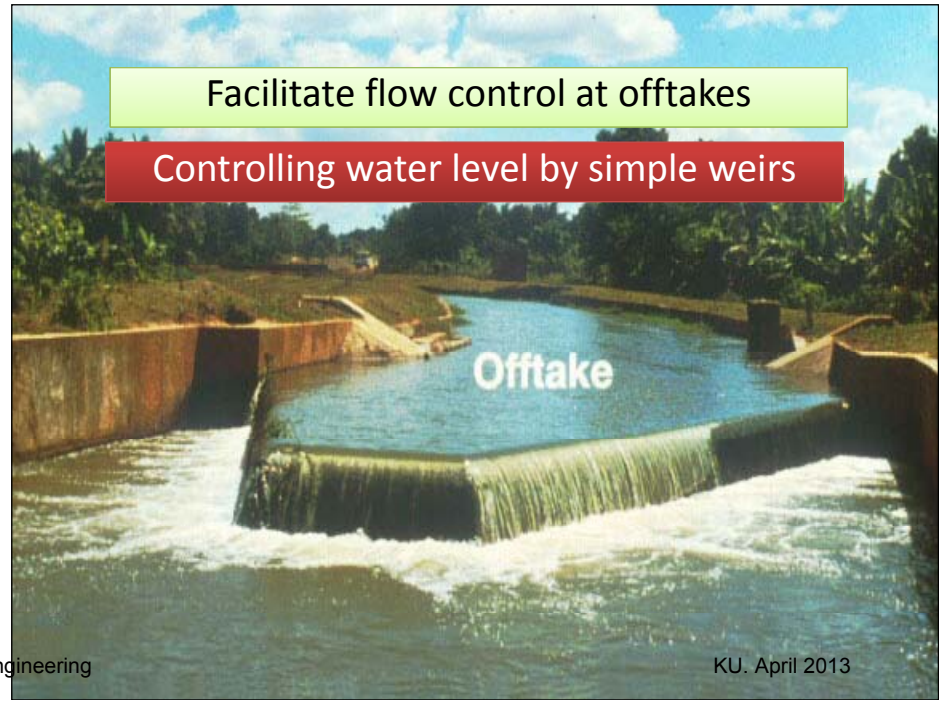
- Command of service area
- Canal protection
- Canal safety
- Flow control at offtakes

Regulators as water level control


Command of Service Area
Gravity Flow
Pumping

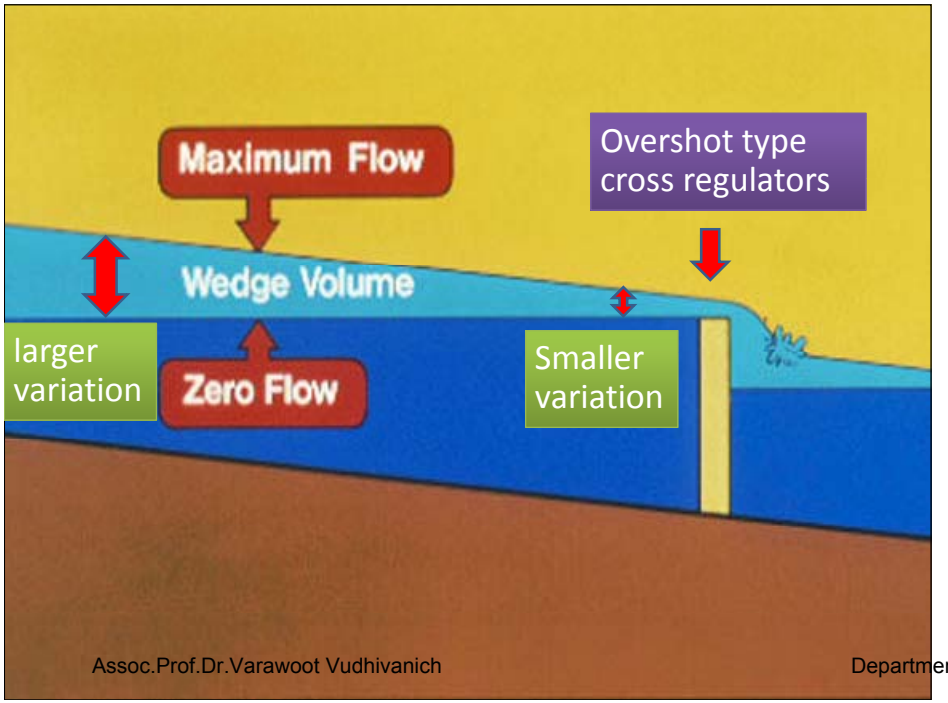

Too low water level.
Farmers have to pump water
to their farms.

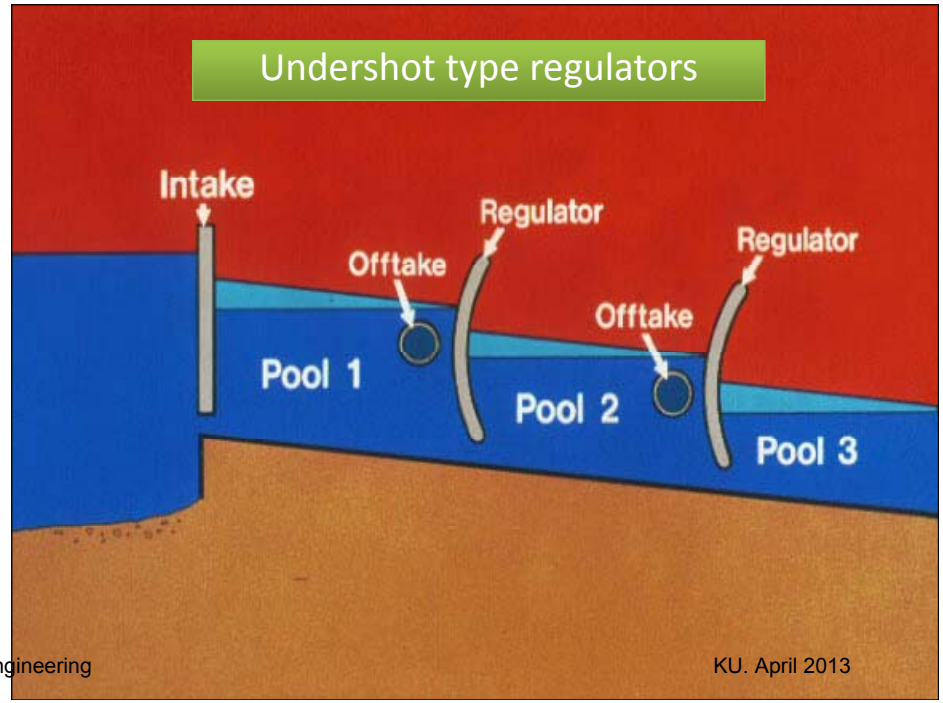

Concrete slab failure
due to water level drops too fast

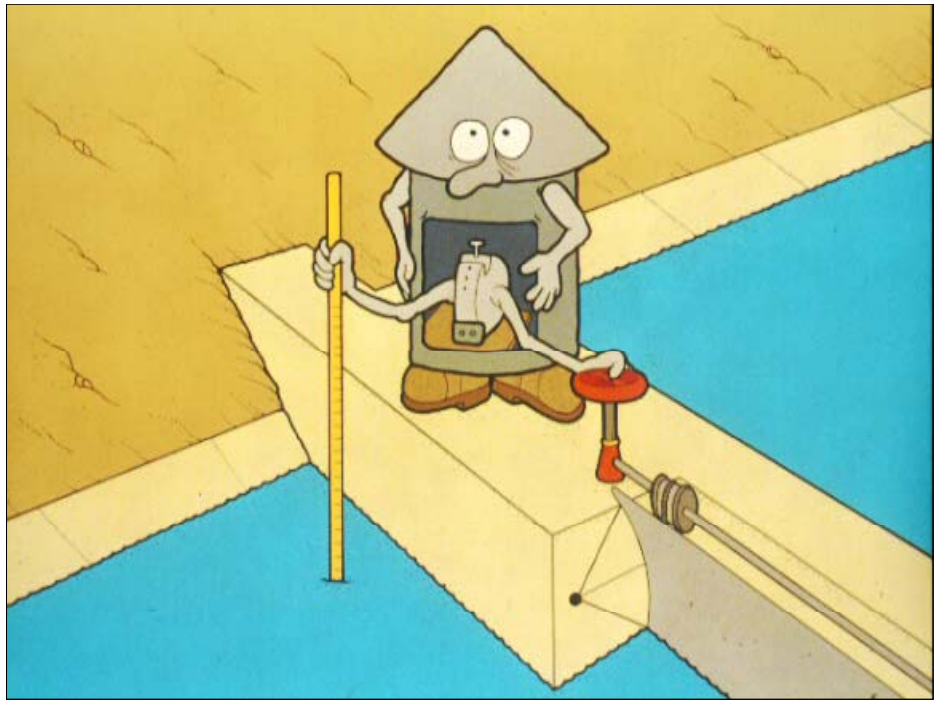

Facilitate flow control at offtakes
Controlling water level by simple weirs
Offtake

Controlling water level by gated cross regulators

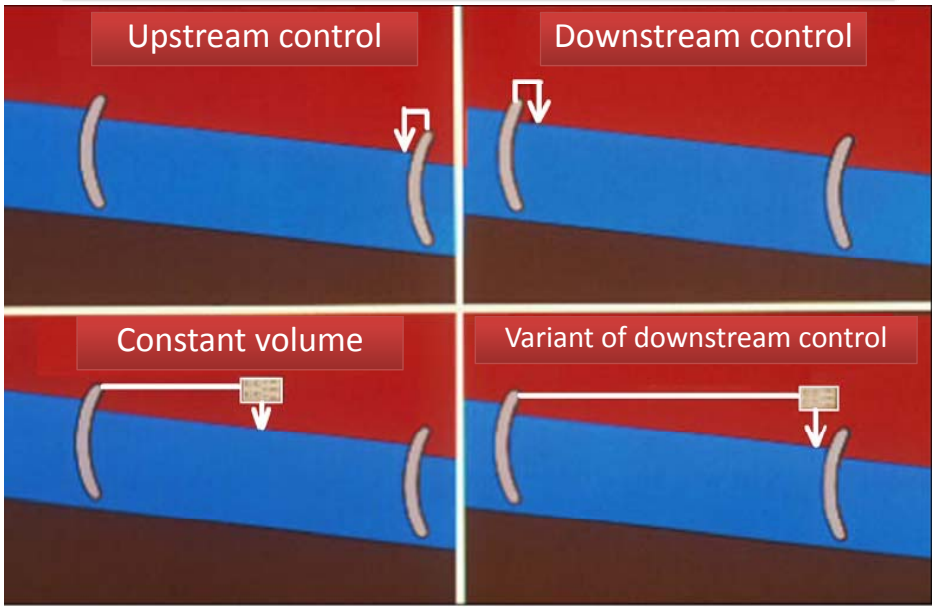
Controlling water level by mixed cross regulators

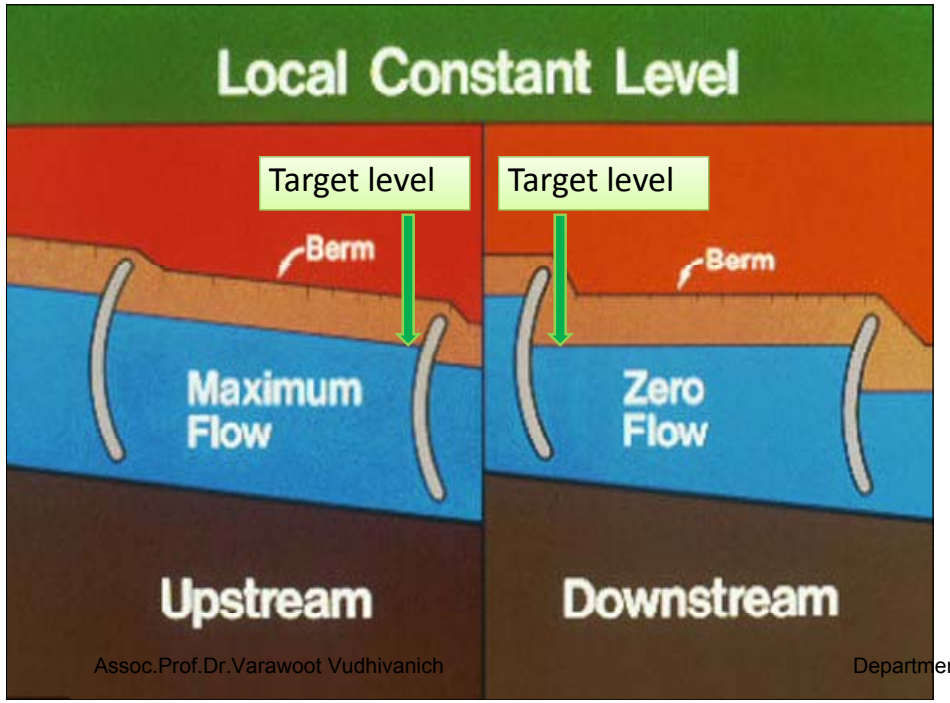


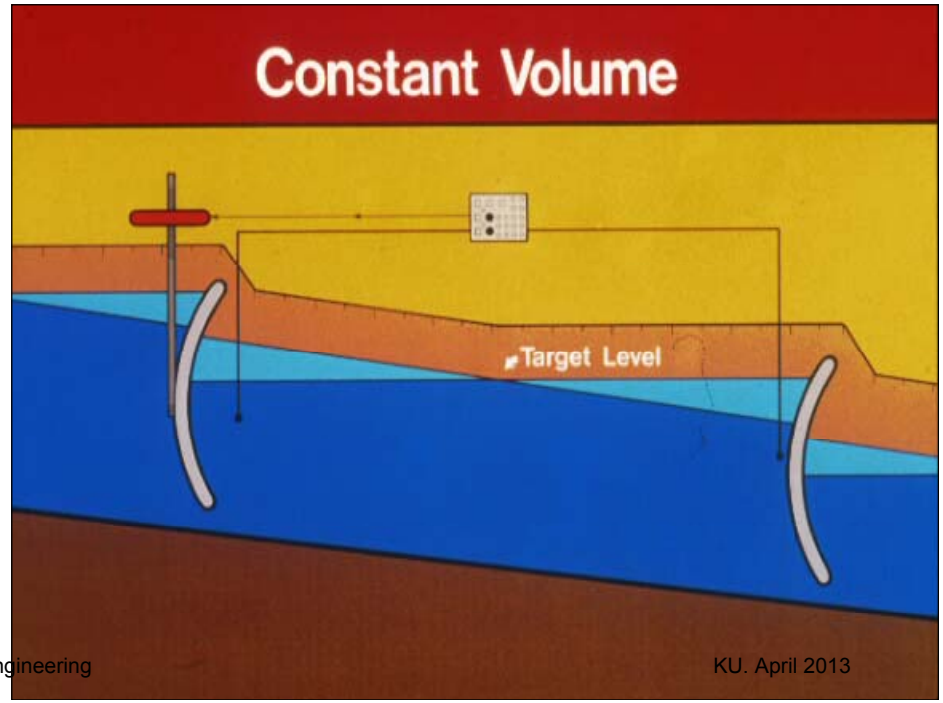


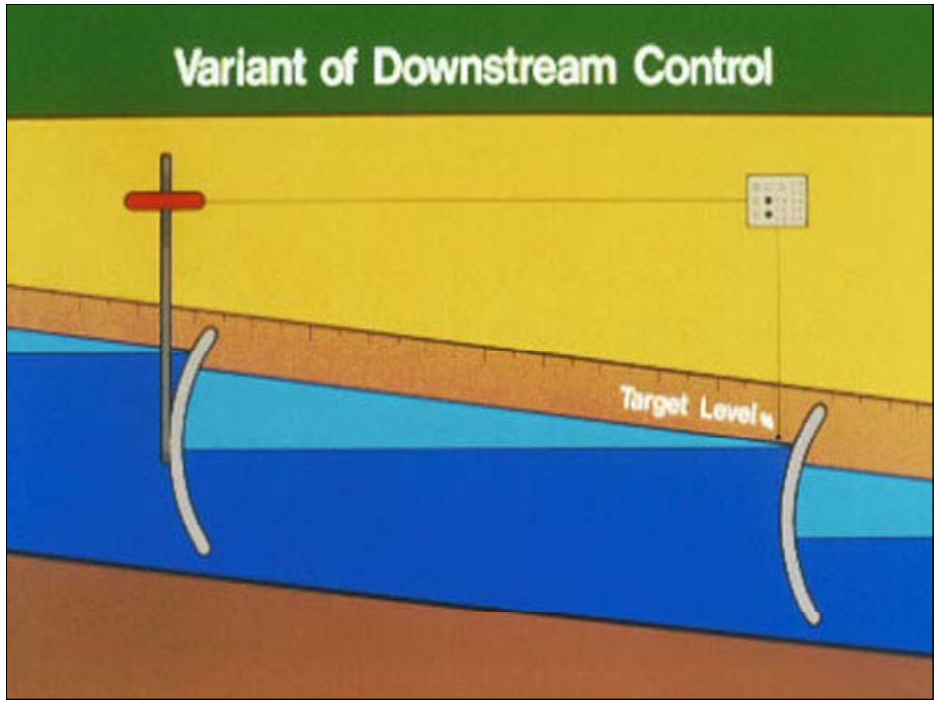


Basic methods of water level control



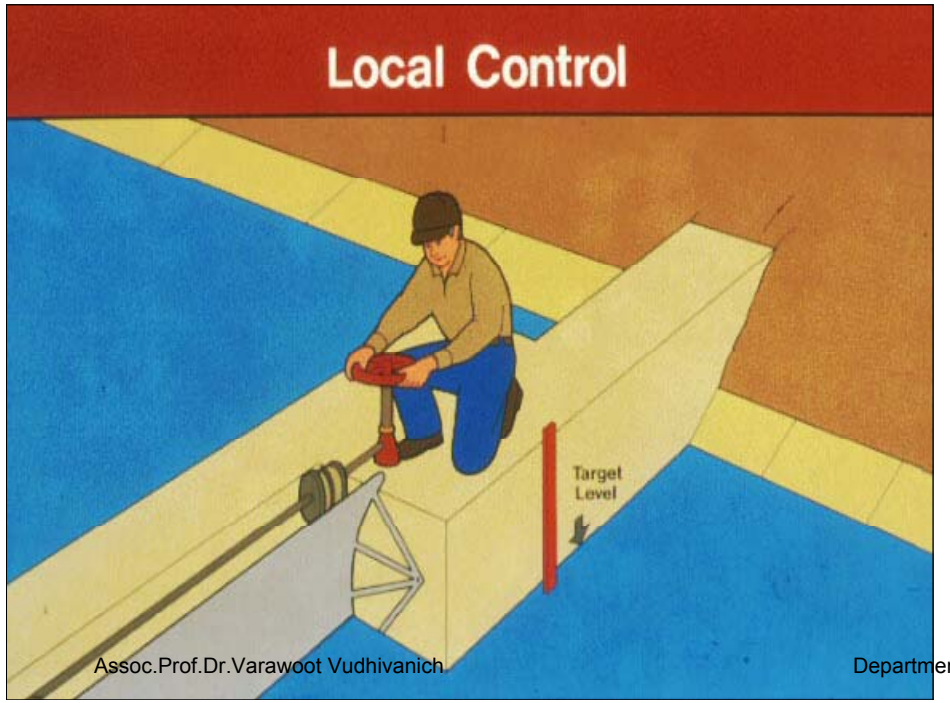


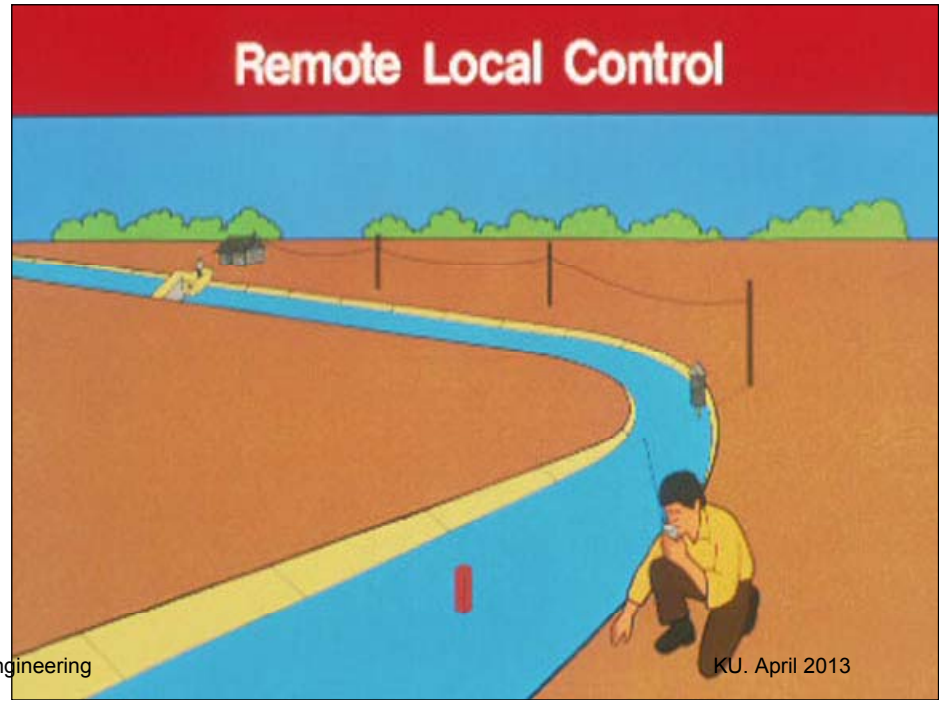


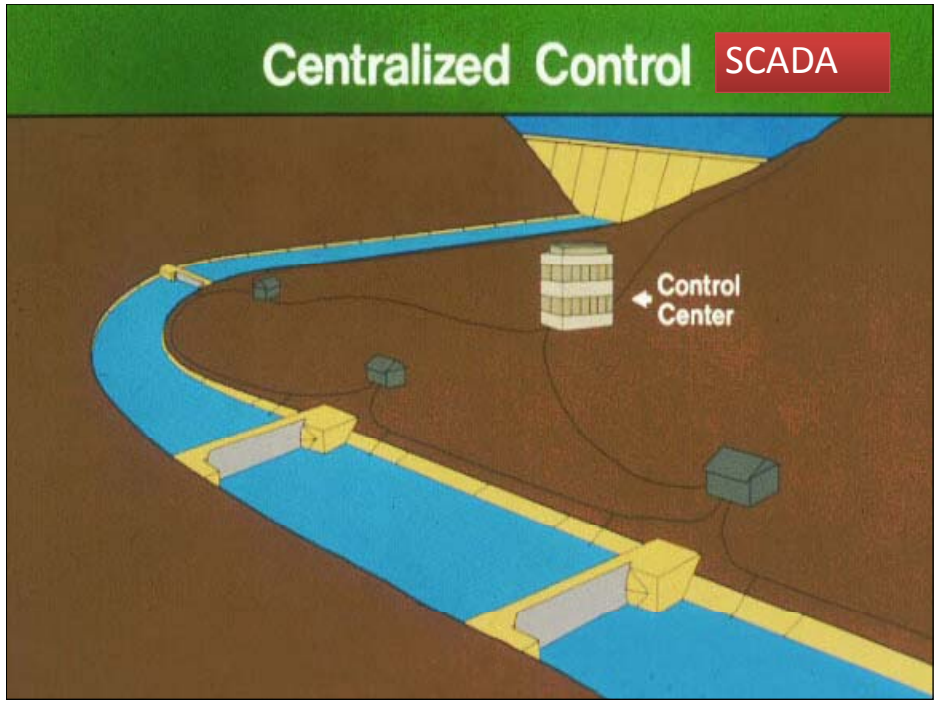


Methods of water level control

- Local control
- Remote localized control
- Remote centralized control

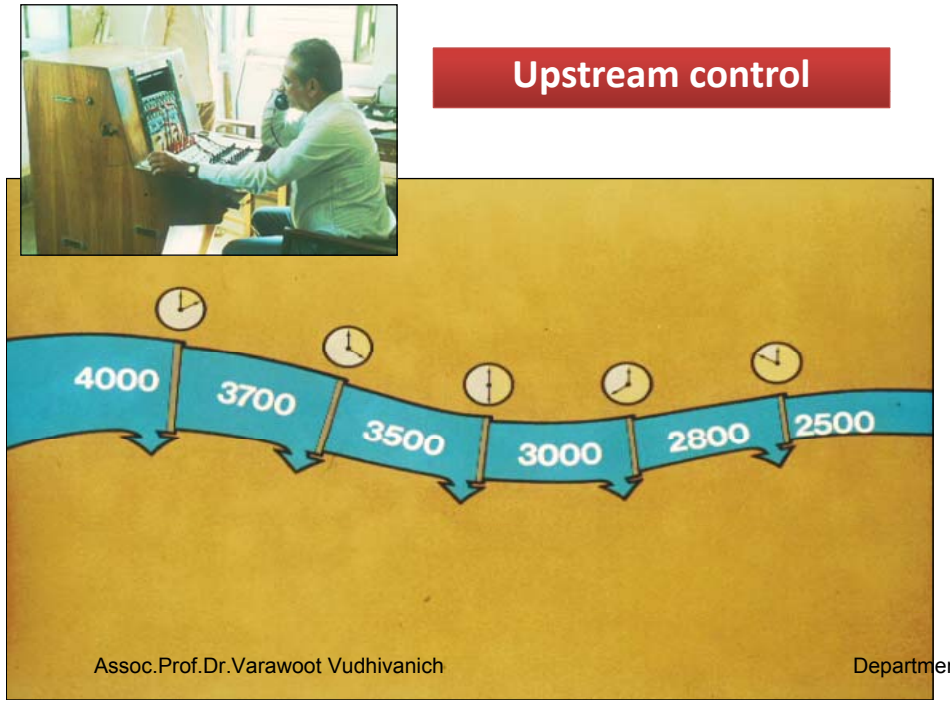


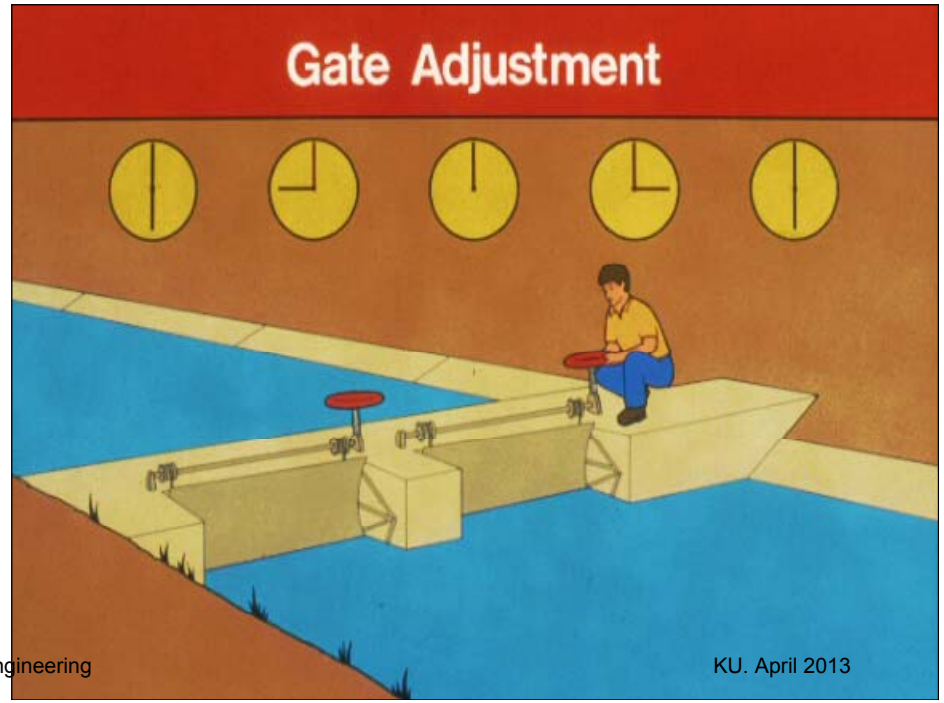


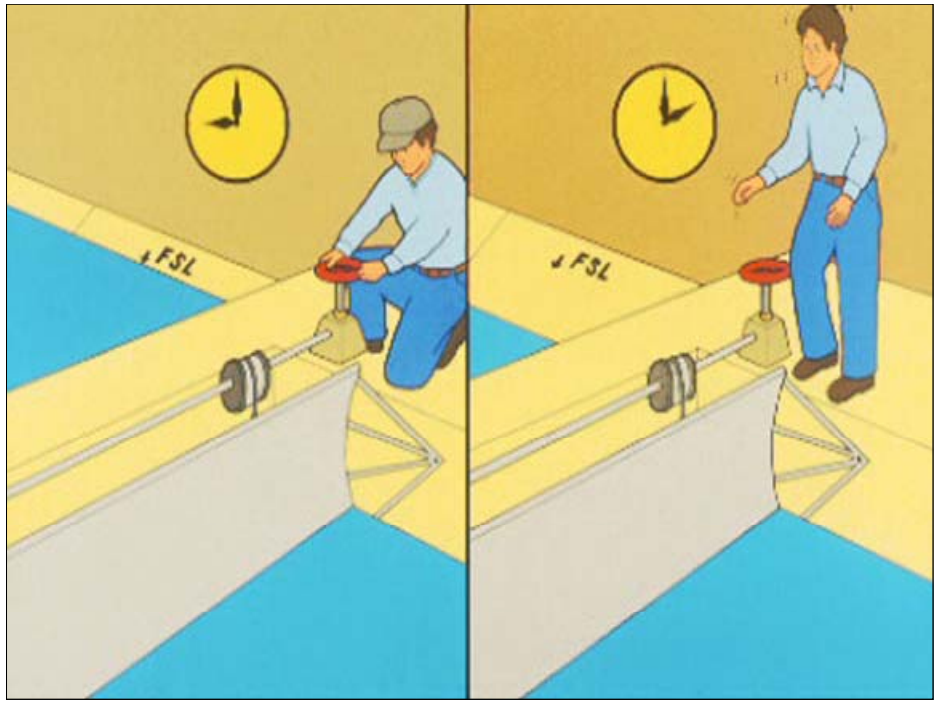


Information transfer in canal operation

Upstream control	Downstream control
❑ Aggregation of individual demand	❑ Hydraulic transmission

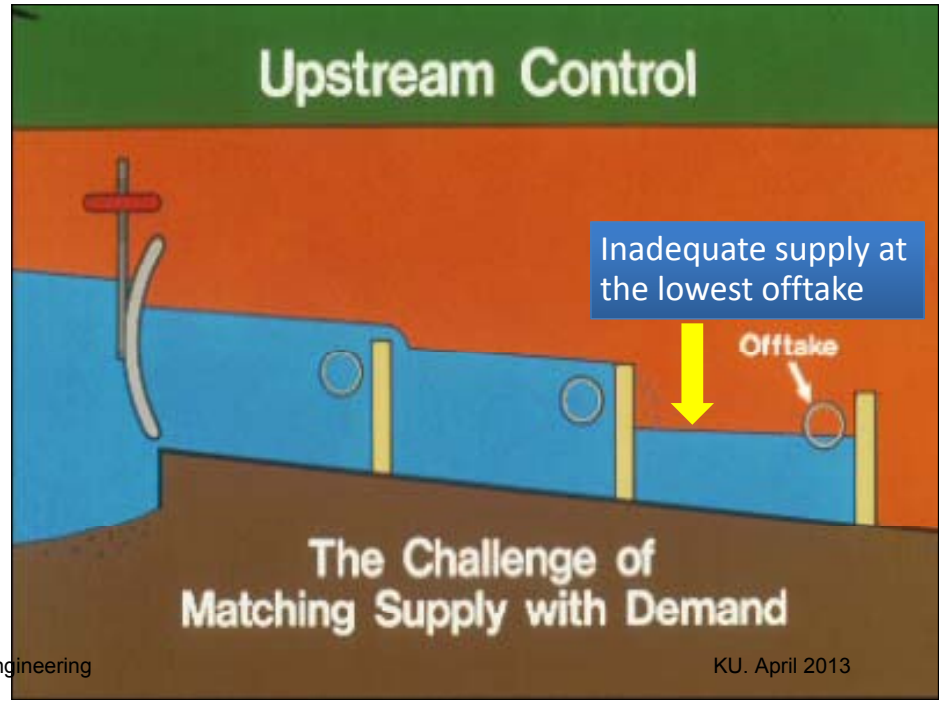


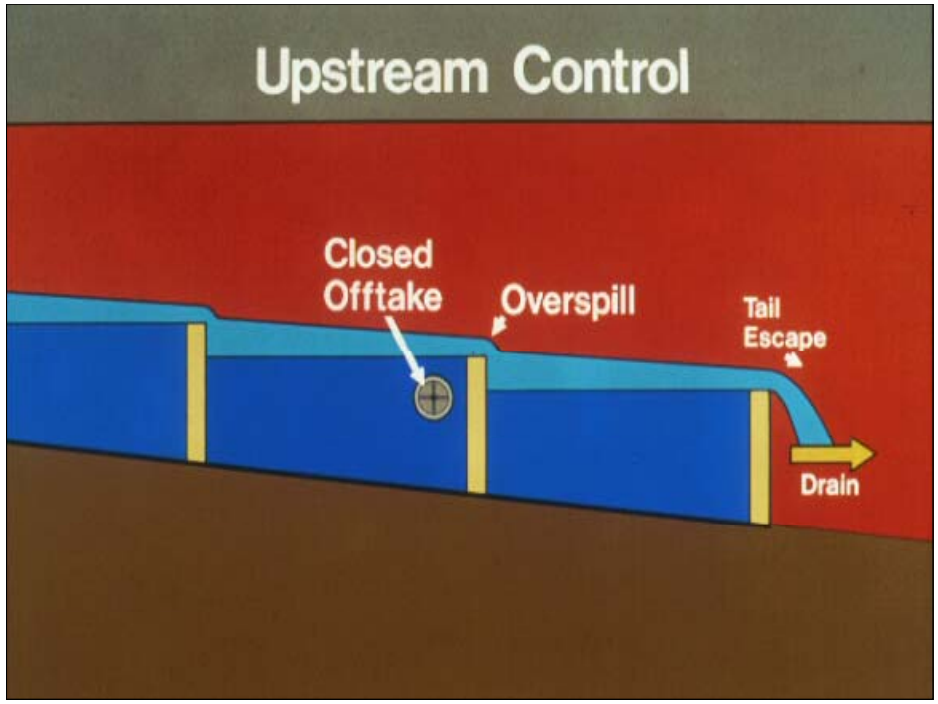




Disadvantages of upstream control

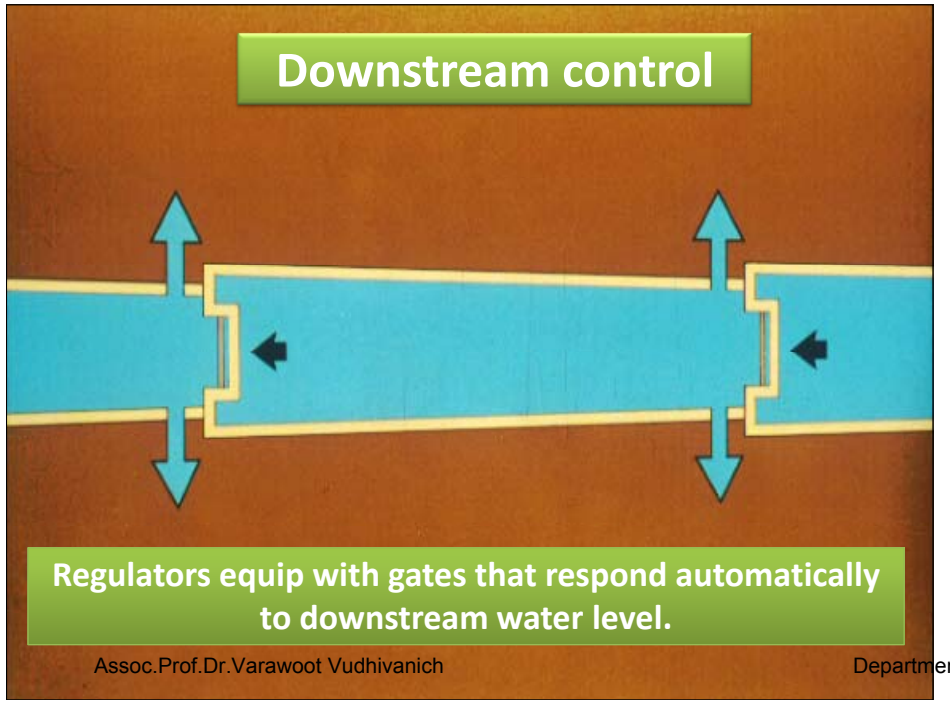
- Slow response to change in demand
- Water operational losses

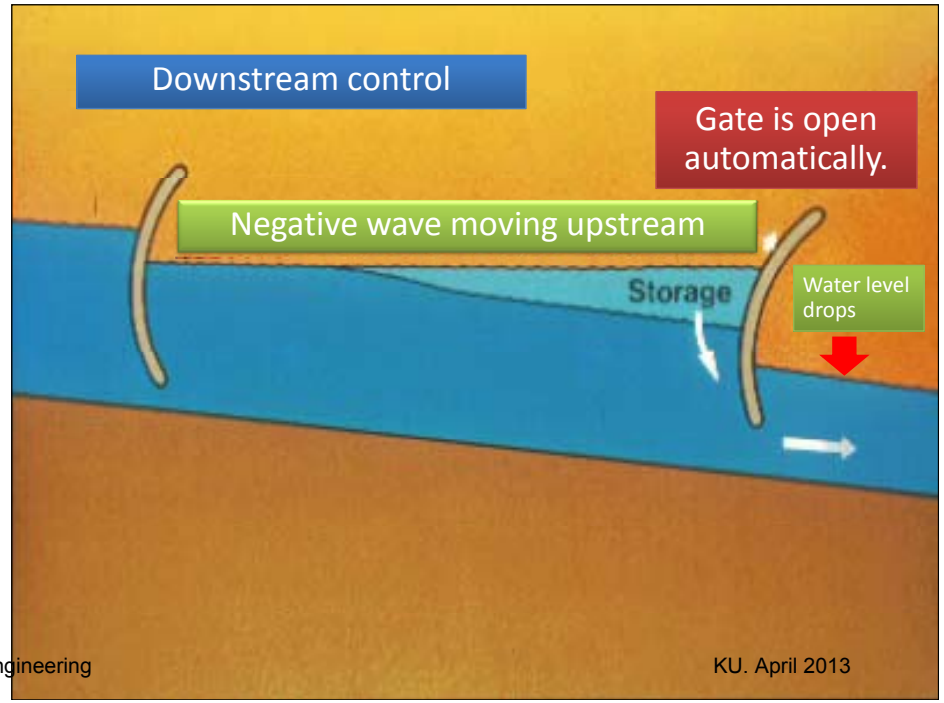


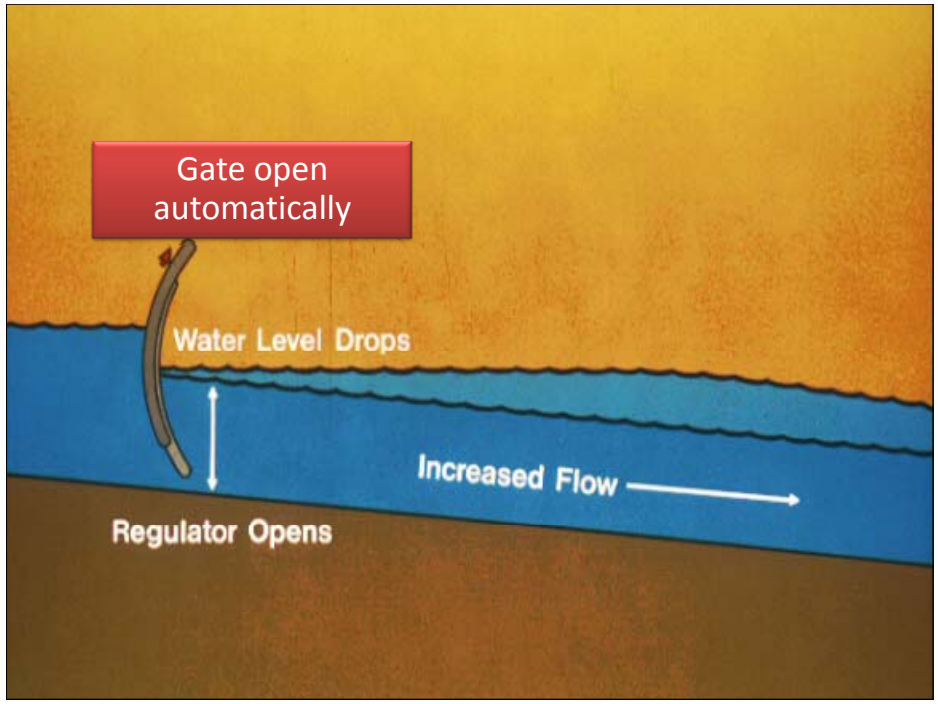


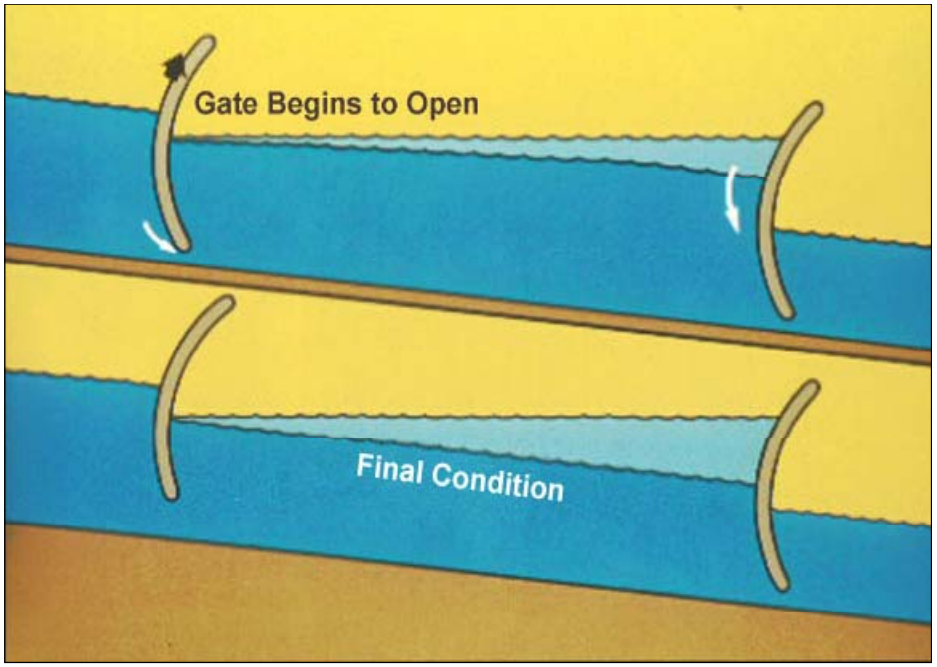
Information transfer in canal operation

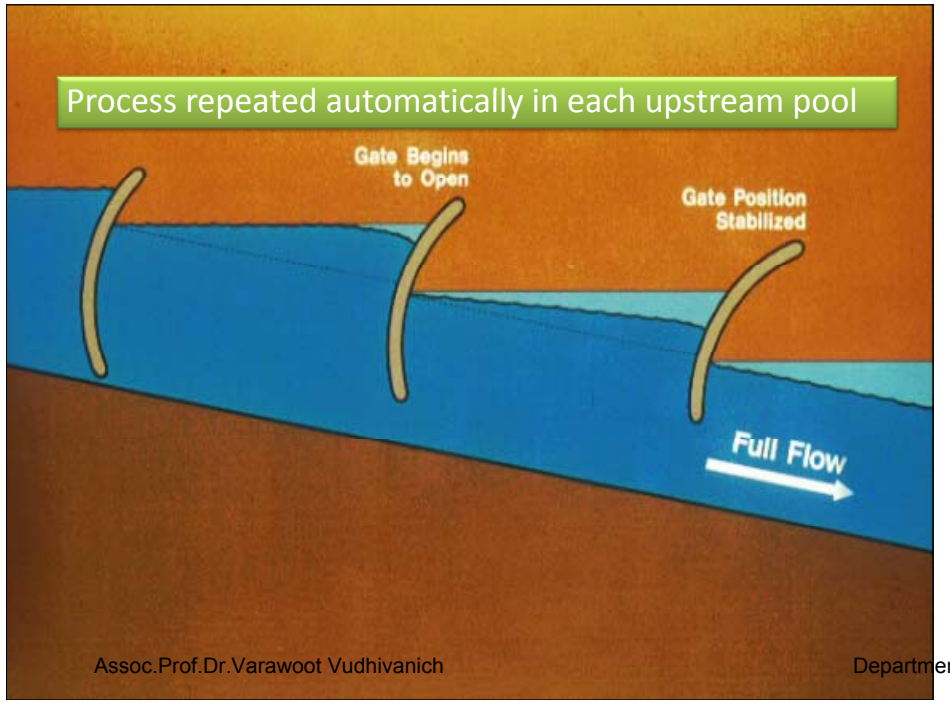
Upstream control	Downstream control
❑ Aggregation of individual demand	❑ Hydraulic transmission











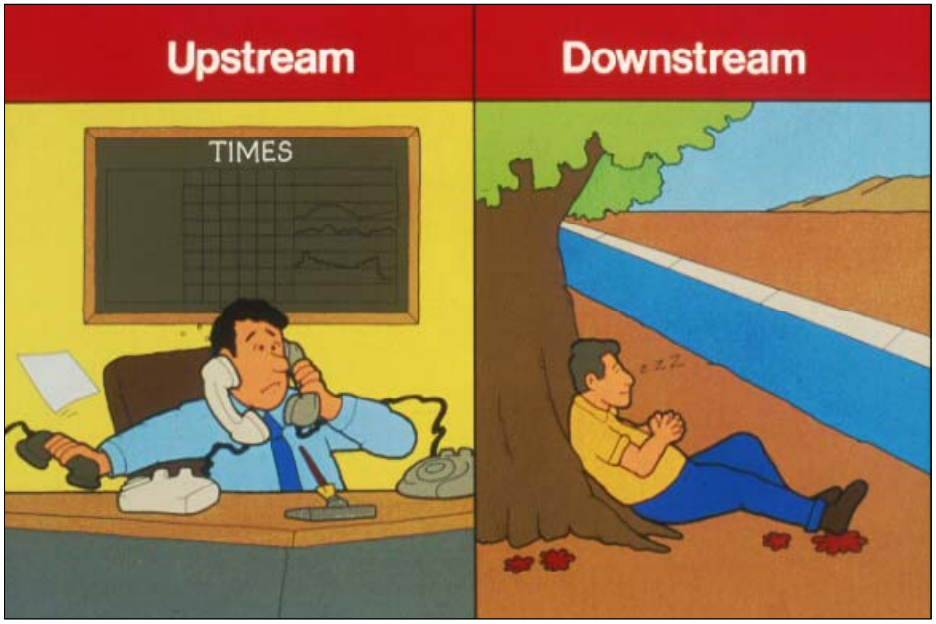
Downstream control

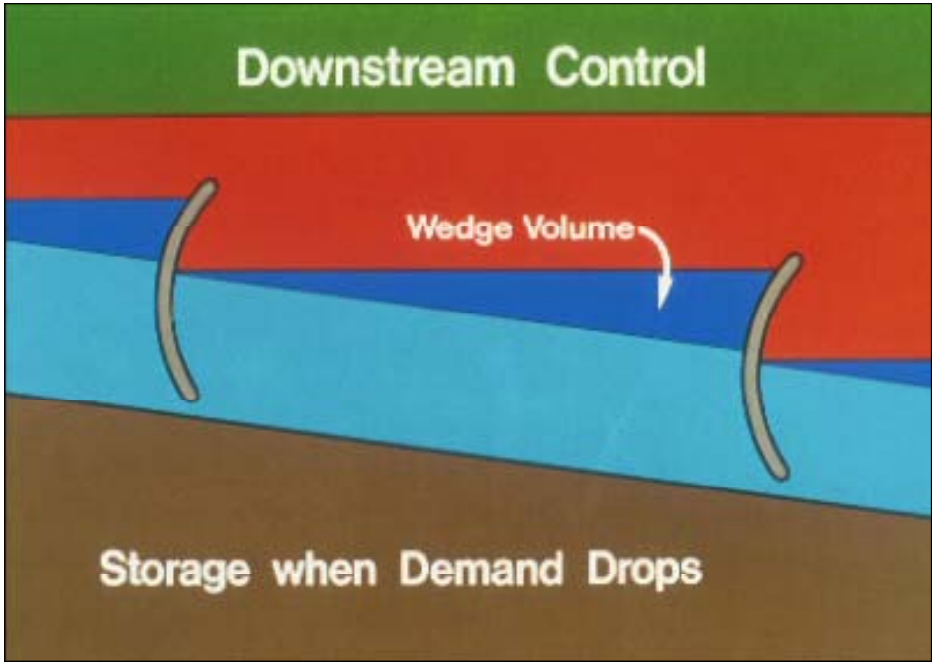
Advantages

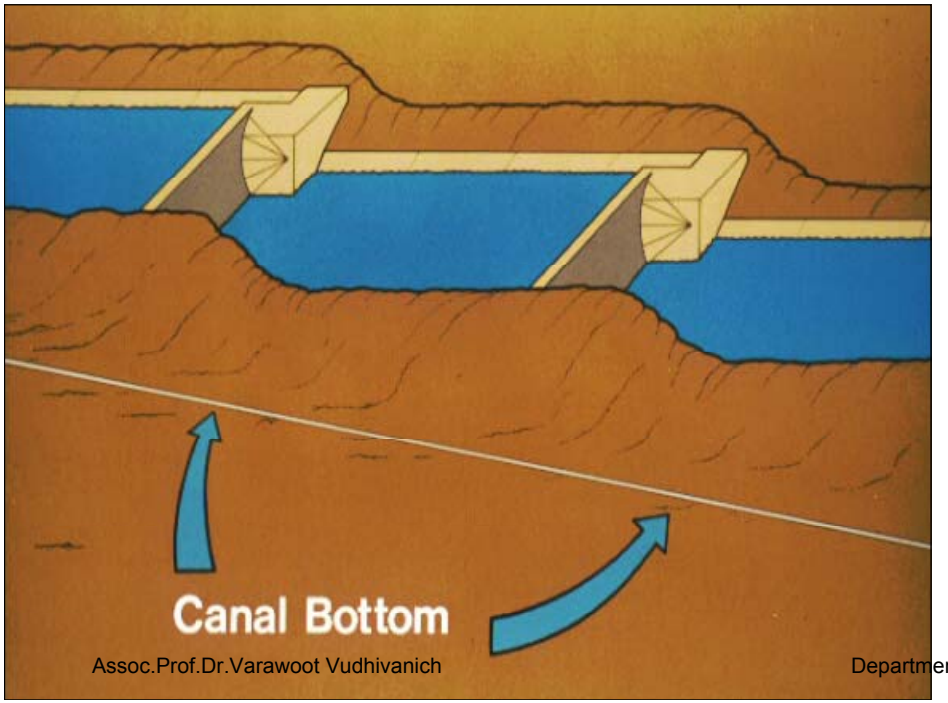
- Automatic distribution
- No operational losses
- Accurate and immediate response

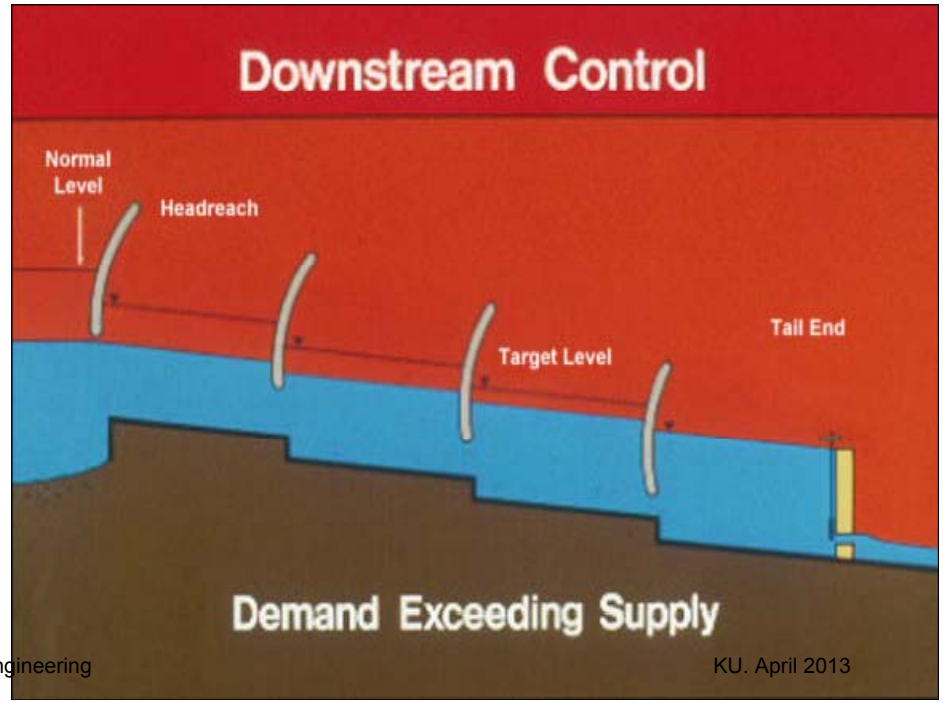
Disadvantages

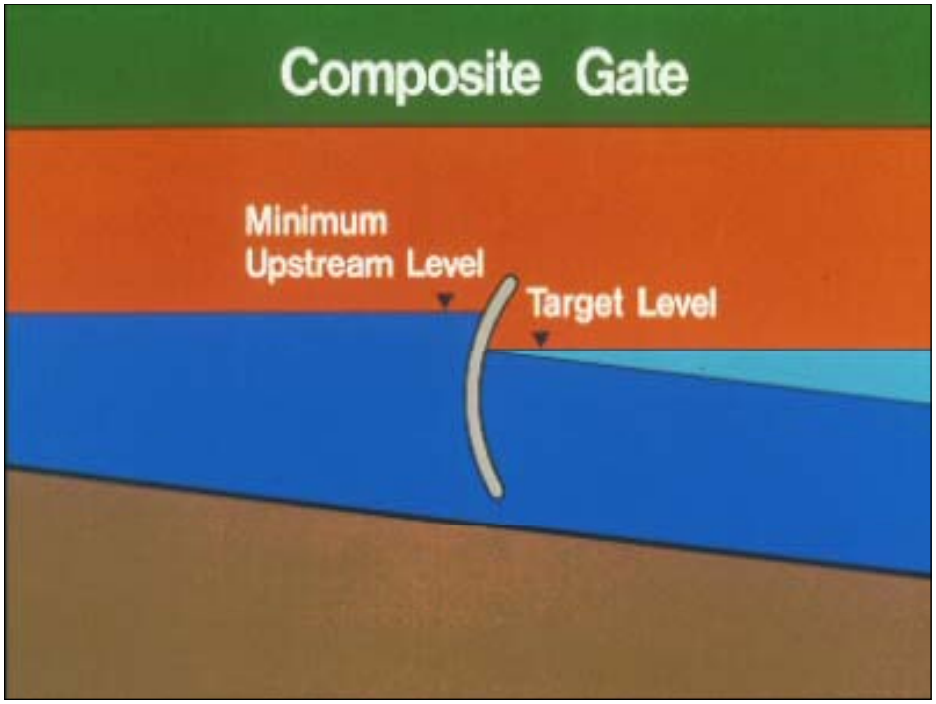
- Require additional canal embankment
- If Q at offtakes exceeding Q supply, headreach farmers will suffer.


Upstream
Downstream
TIMES

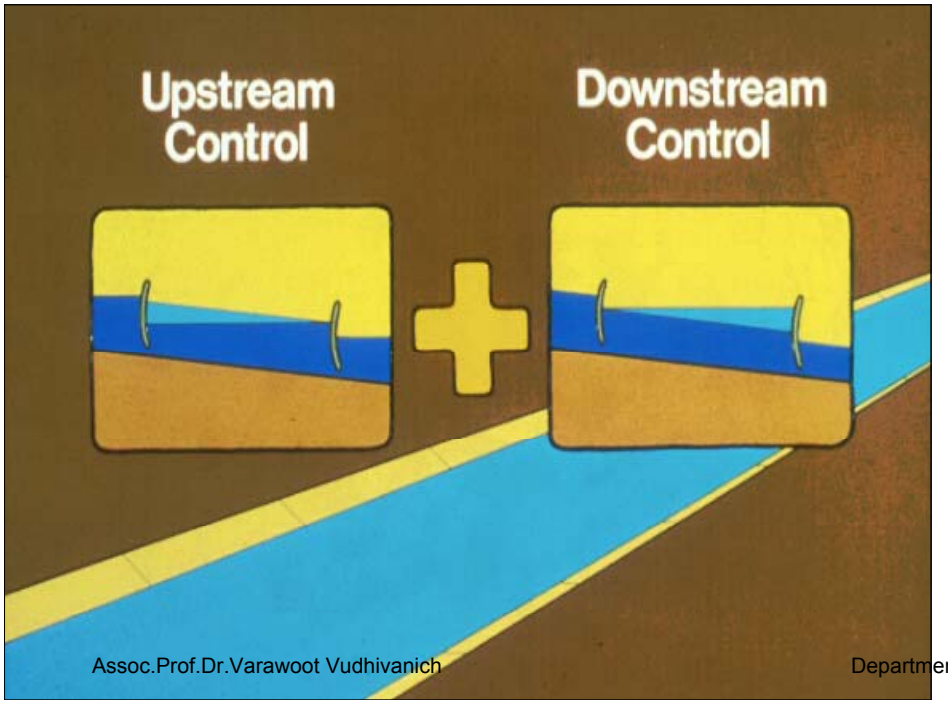

Downstream Control
Wedge Volume
Storage when Demand Drops

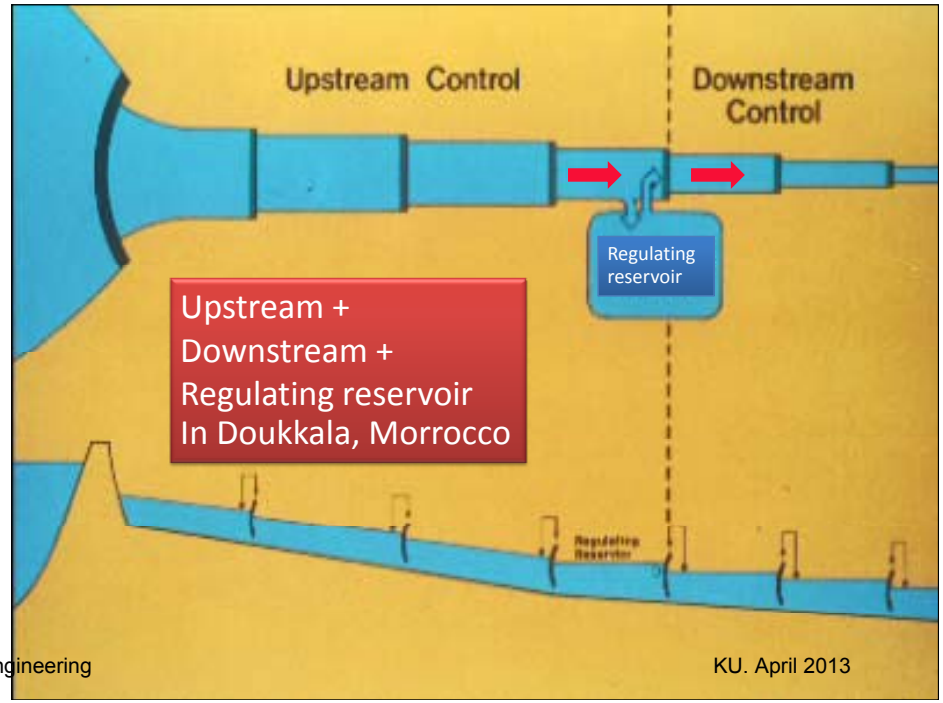

Canal Bottom

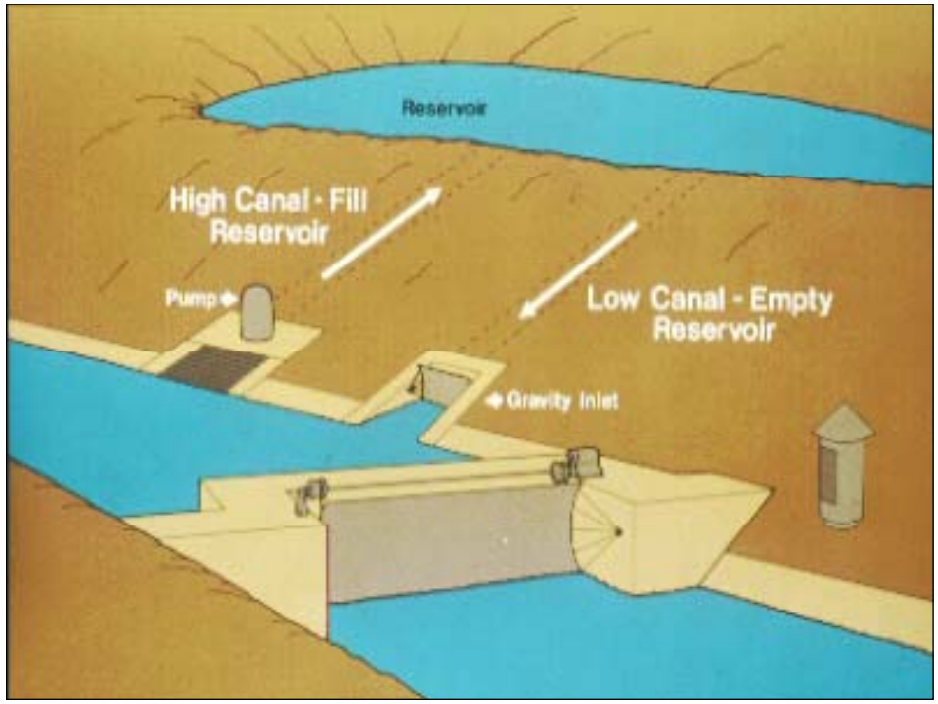

Downstream Control
Normal Level
Headreach
Target Level
Tail End
Demand Exceeding Supply

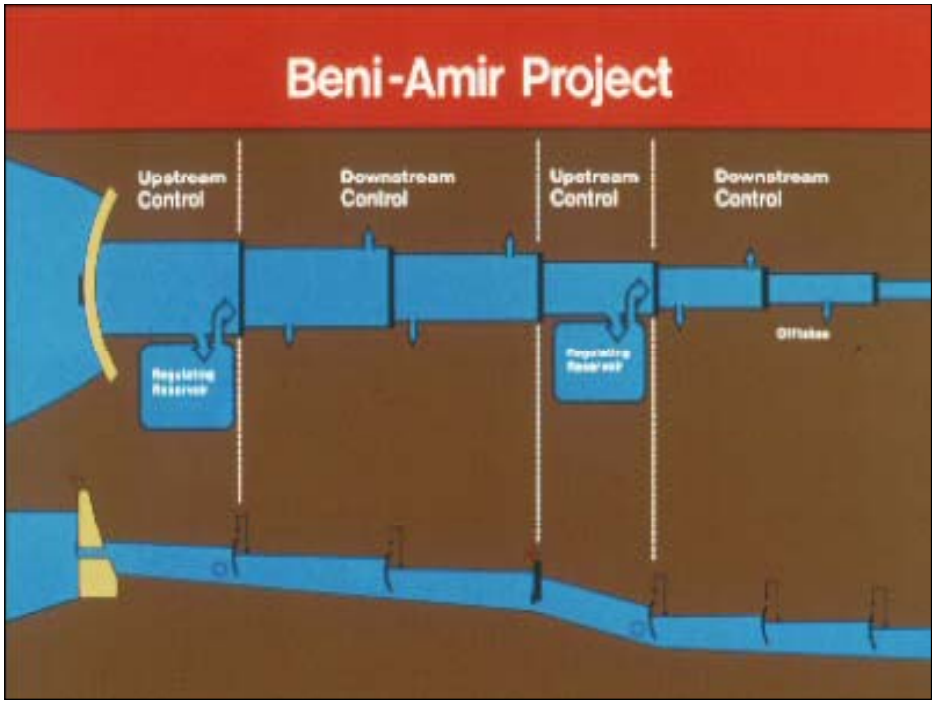

Composite Gate
Minimum
Upstream Level
Target Level


TYPICAL SYSTEM
OPERATION
Main Canal
Distribution
System
Downstream
Control
Upstream
Control

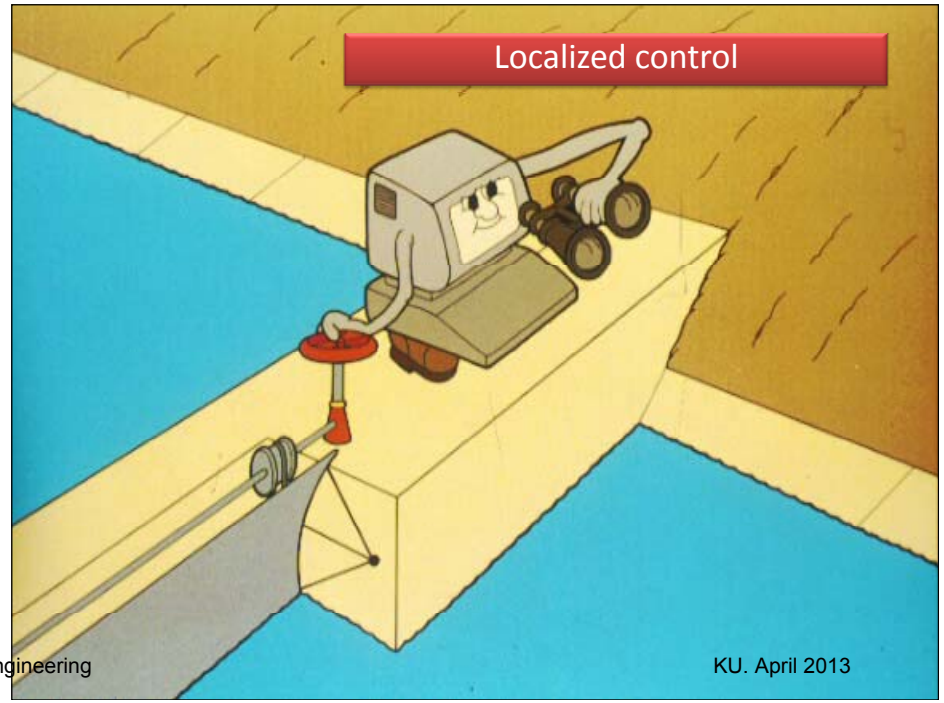

Upstream
Control
Downstream
Control

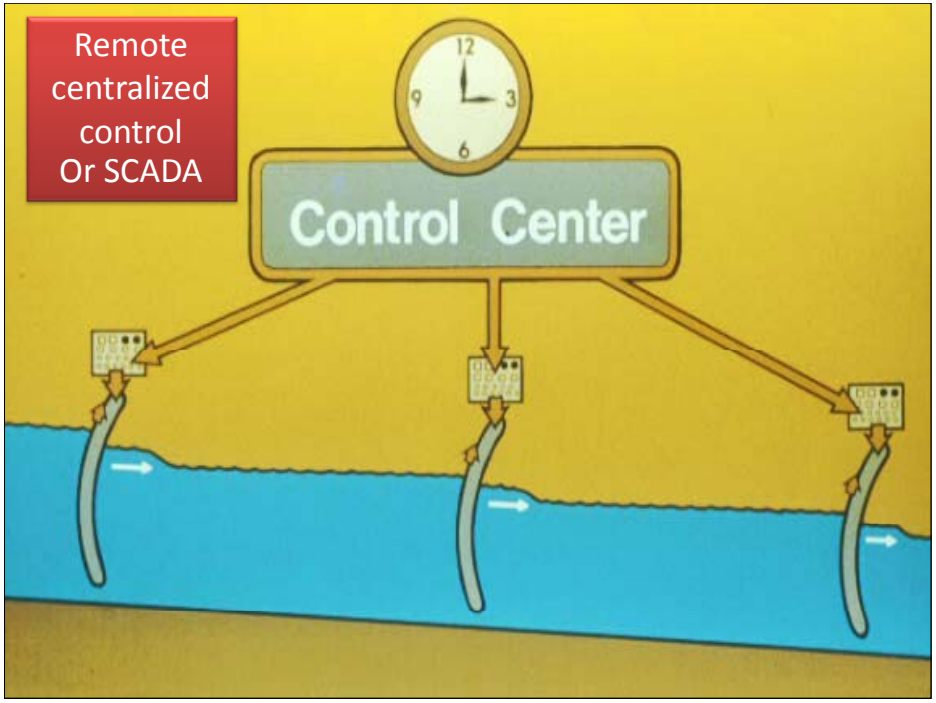

Upstream Control
Downstream
Control
Regulating
reservoir
Upstream +
Downstream +
Regulating reservoir
In Doukkala, Morrocco

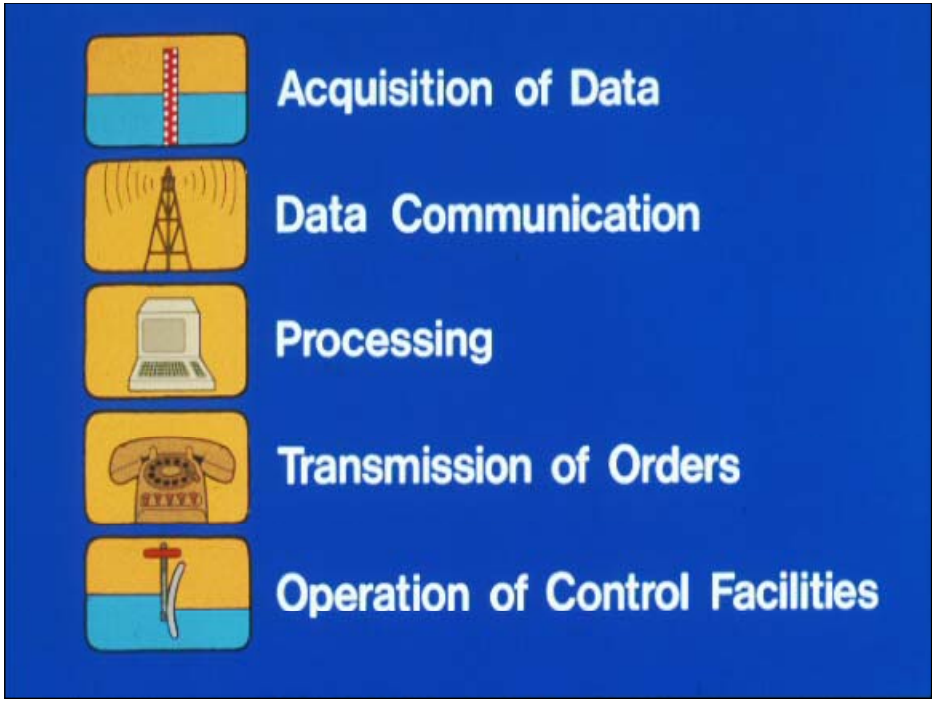


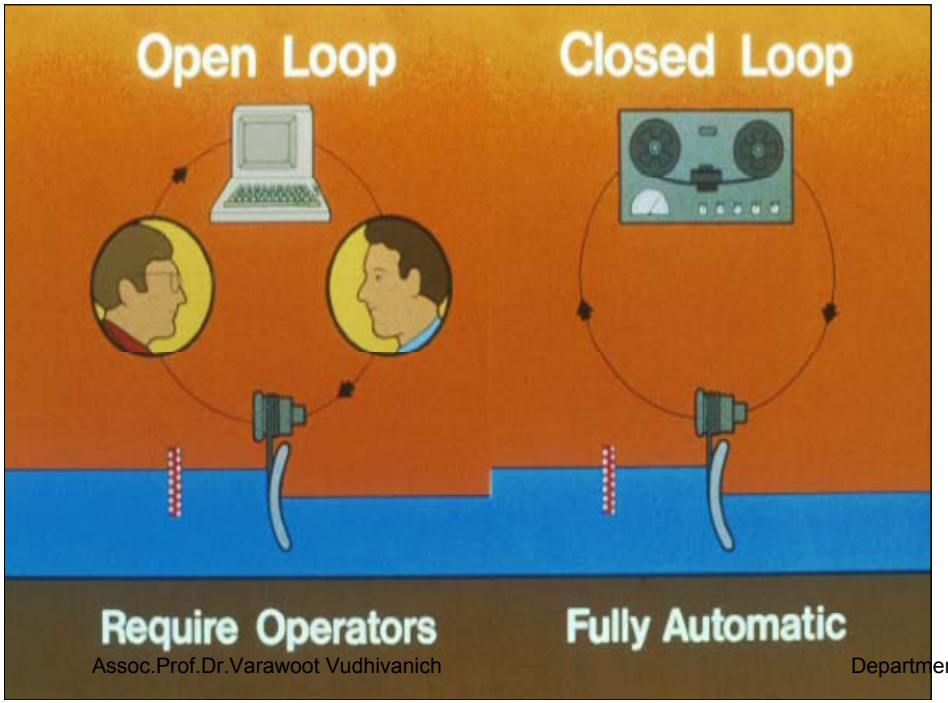


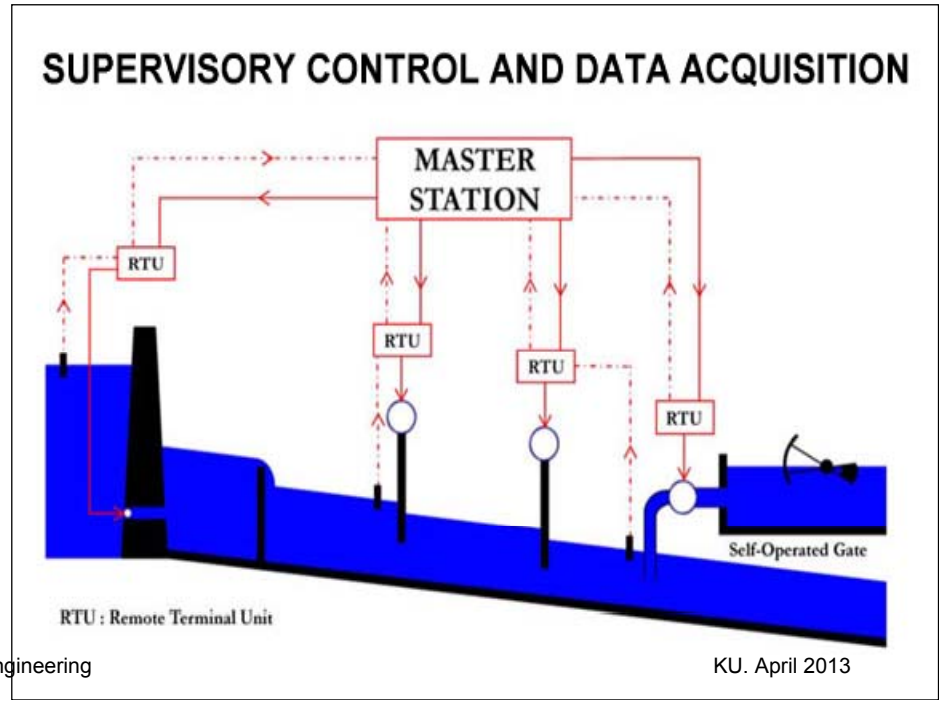
Localized vs. Centralized control




Remote centralized control Or SCADA
Control Center


Acquisition of Data
Data Communication
Processing
Transmission of Orders
Operation of Control Facilities


Open Loop
Closed Loop
Require Operators
Fully Automatic


SUPERVISORY CONTROL AND DATA ACQUISITION
MASTER STATION
RTU
RTU
RTU
RTU
Self-Operated Gate
RTU : Remote Terminal Unit

SCADA

- Reduces communications and computer capacity
- Less susceptible to the consequences of communications system failure
- Improves operation
- Enhances safety
- Increases flexibility and responsiveness

COMPONENTS

- Master station
- Communications
- Programmable logic controllers (PLC) or Remote terminal Units (RTU)
- Sensors
- Actuators

SCADA levels of control

- Remote monitoring
- Remote manual control
- Automatic control
- Report to management

SCADA IS AN ATTRACTIVE SOLUTION FOR IMPROVING PERFORMANCE OF EXISTING SYSTEMS

CONTROL EQUIPMENT

Local Control

- Flow Division
- Water Level Control
- Flow and Water Level Control
- Flow Control at Offtakes

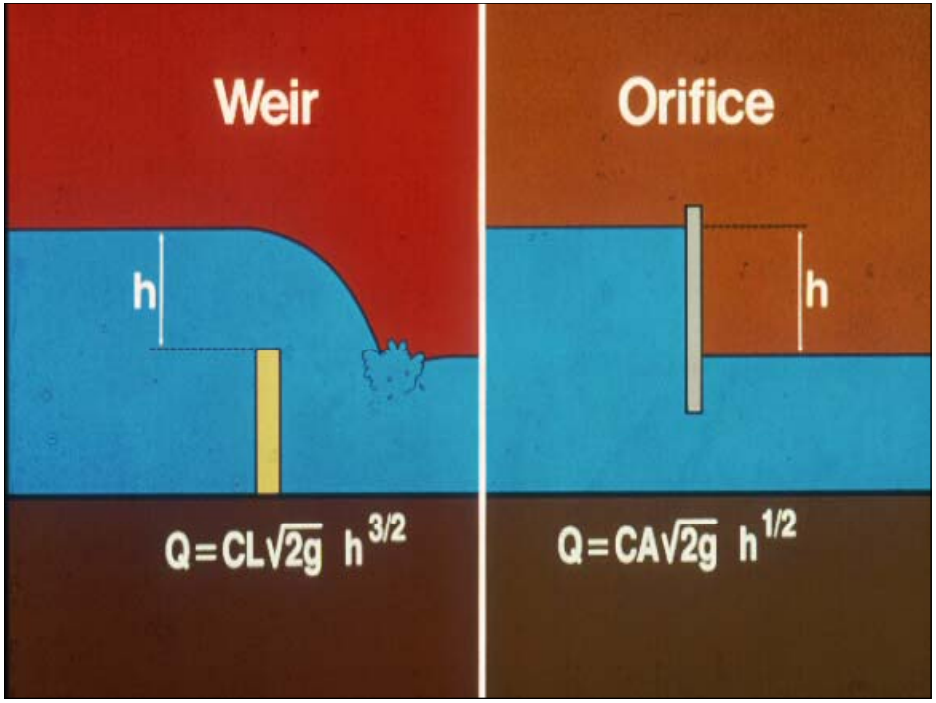
Remote and Centralized Control

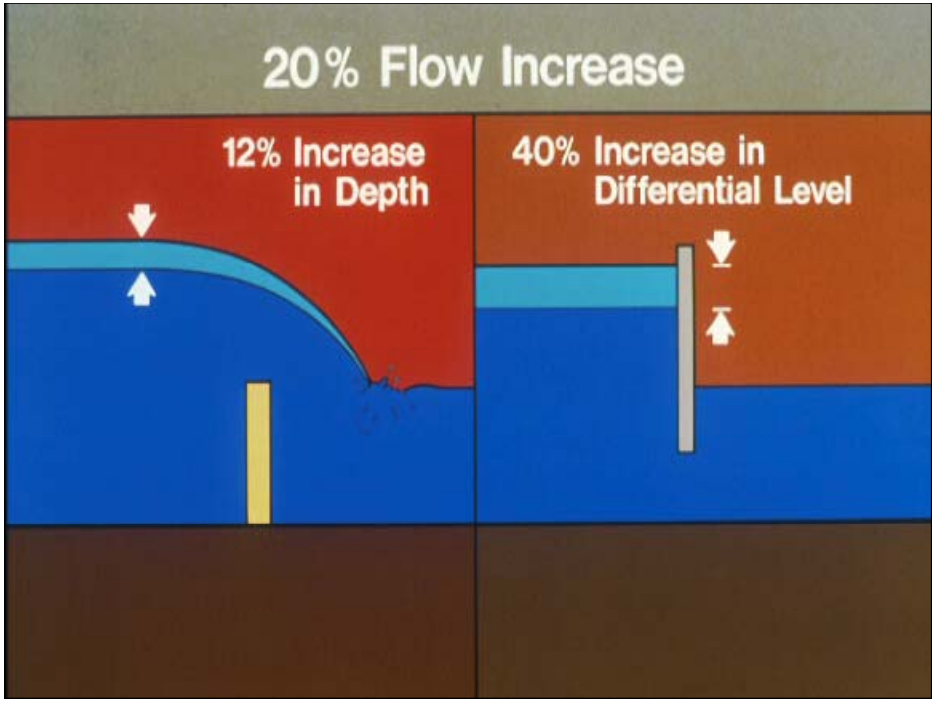
CONTROL EQUIPMENT

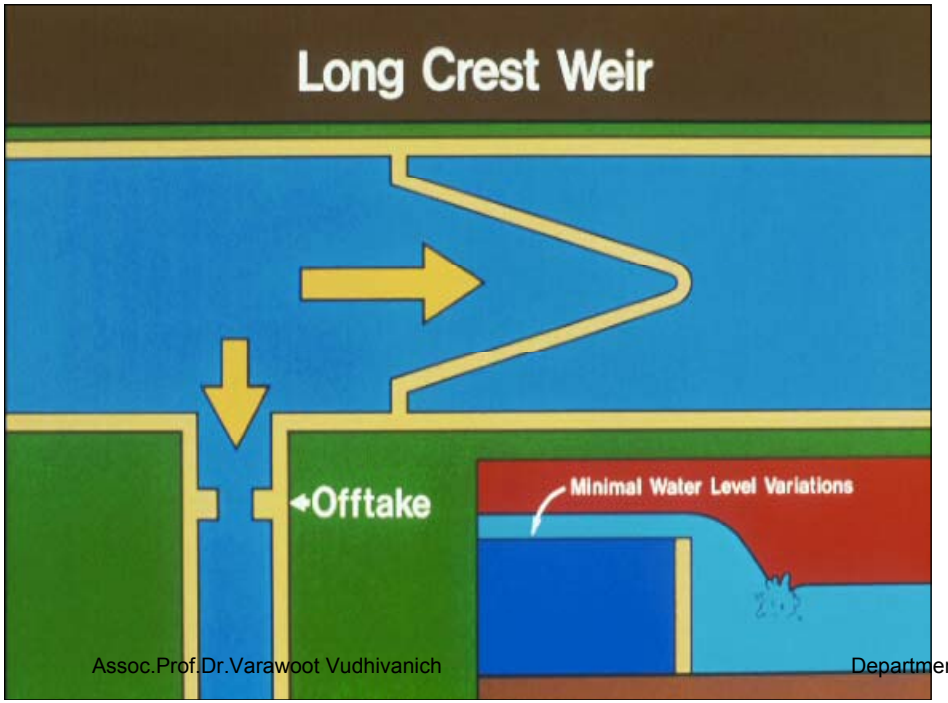
Local Control

- Flow Division
- Water Level Control
- Flow and Water Level Control
- Flow Control at Offtakes

Remote and Centralized Control


Weir
Orifice
h
h
$Q = CL\sqrt{2g}\ h^{3/2}$
$Q = CA\sqrt{2g}\ h^{1/2}$


20% Flow Increase
12% Increase in Depth
40% Increase in Differential Level


Long Crest Weir
Offtake
Minimal Water Level Variations

CONTROL EQUIPMENT

Local Control

- Flow Division
- Water Level Control
- Flow and Water Level Control
- Flow Control at Offtakes

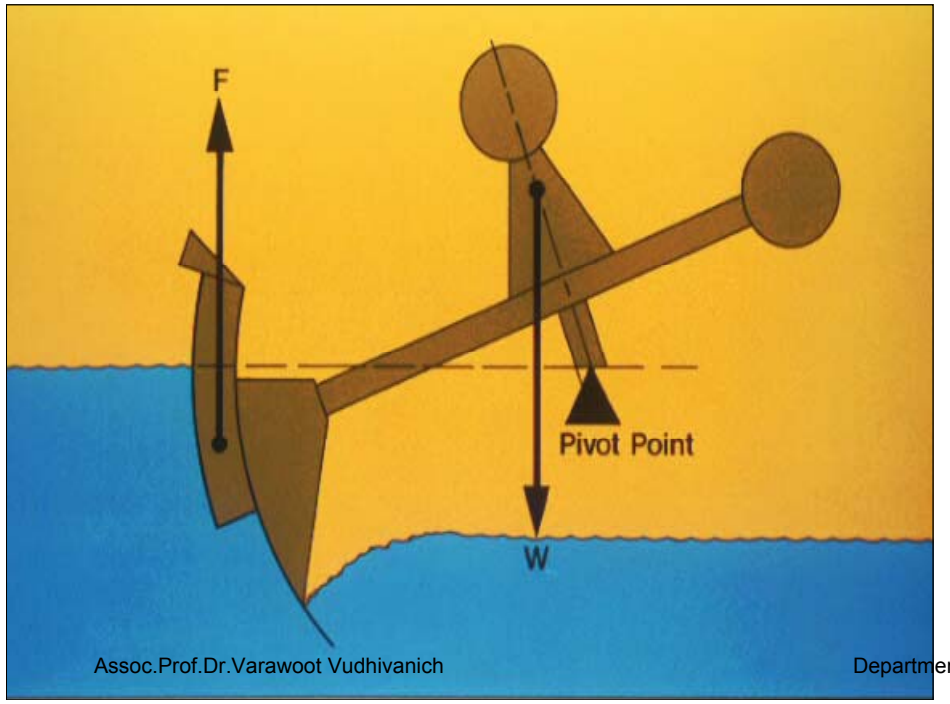
Remote and Centralized Control

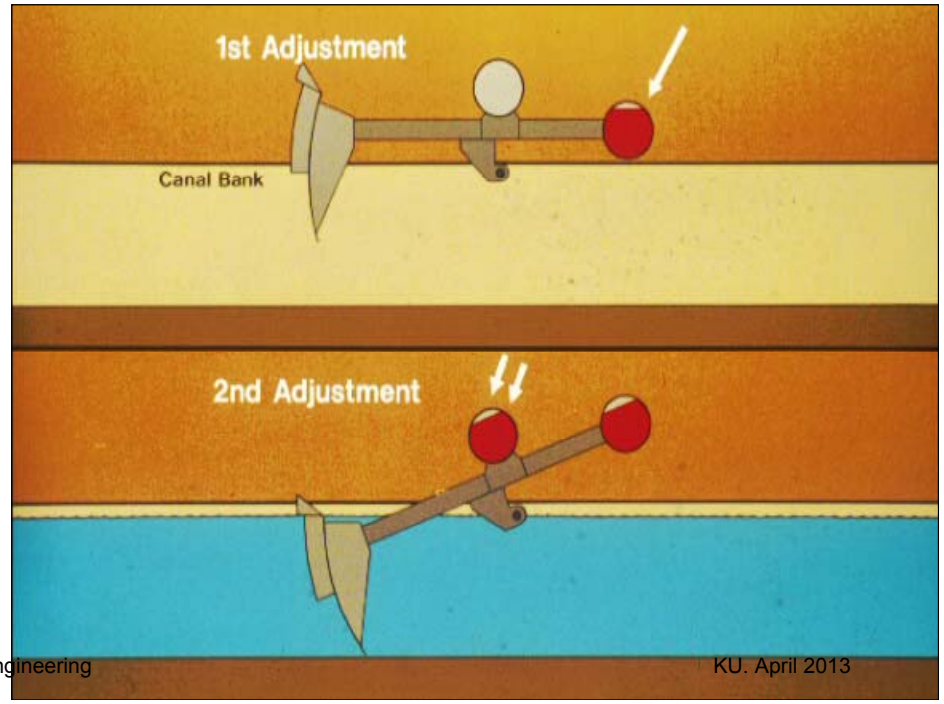
CONTROL EQUIPMENT

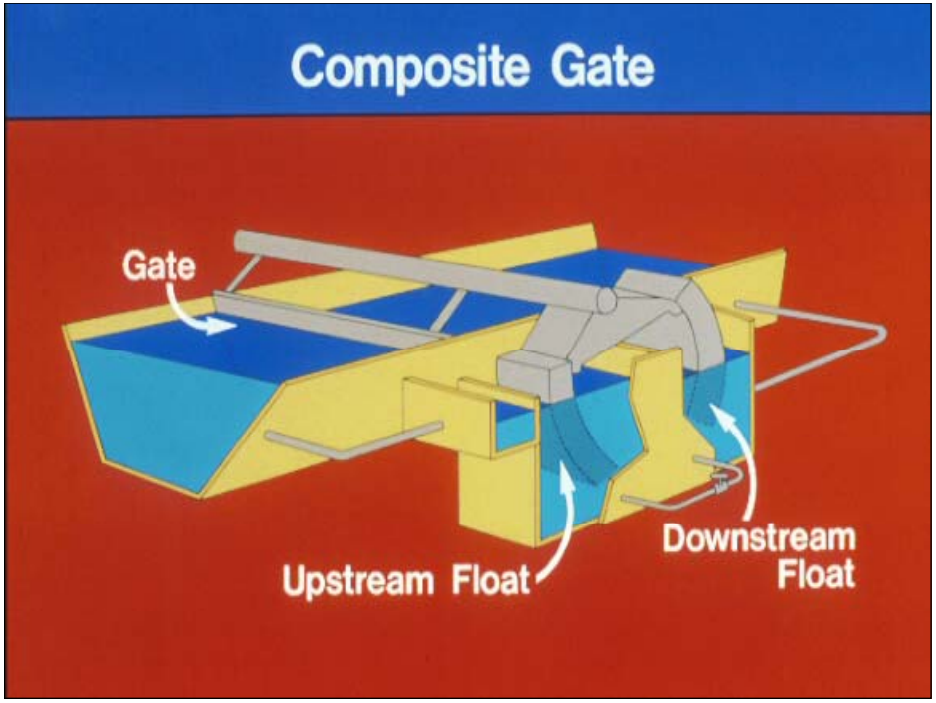
Local Control

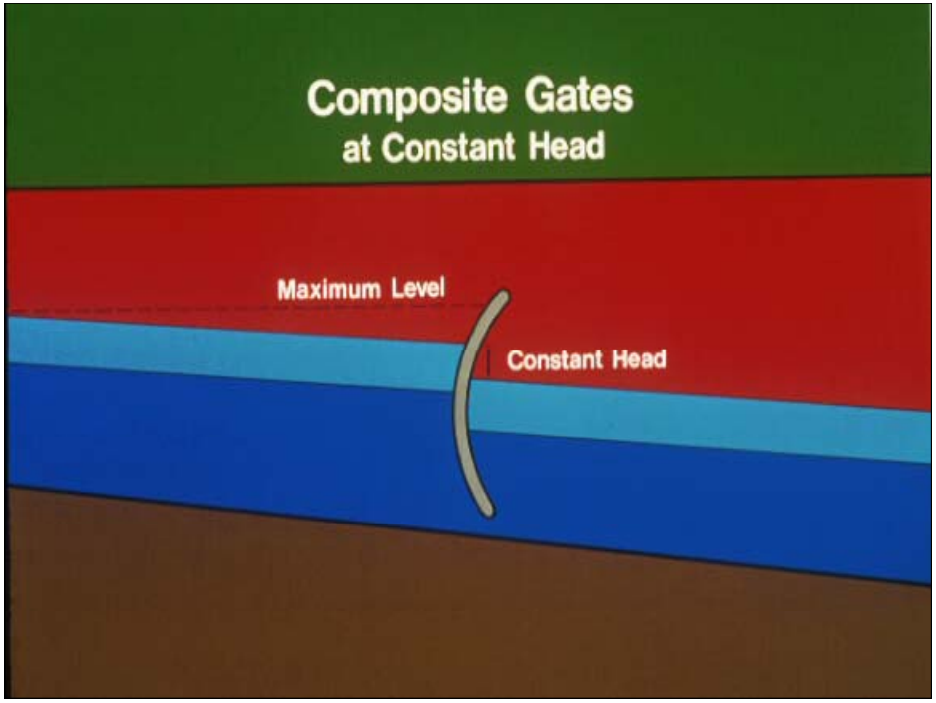
- Flow Division
- Water Level Control
- Flow and Water Level Control
  - Electrical Controllers
  - Automatic Hydraulic Devices
- Flow Control at Offtakes

Remote and Centralized Control







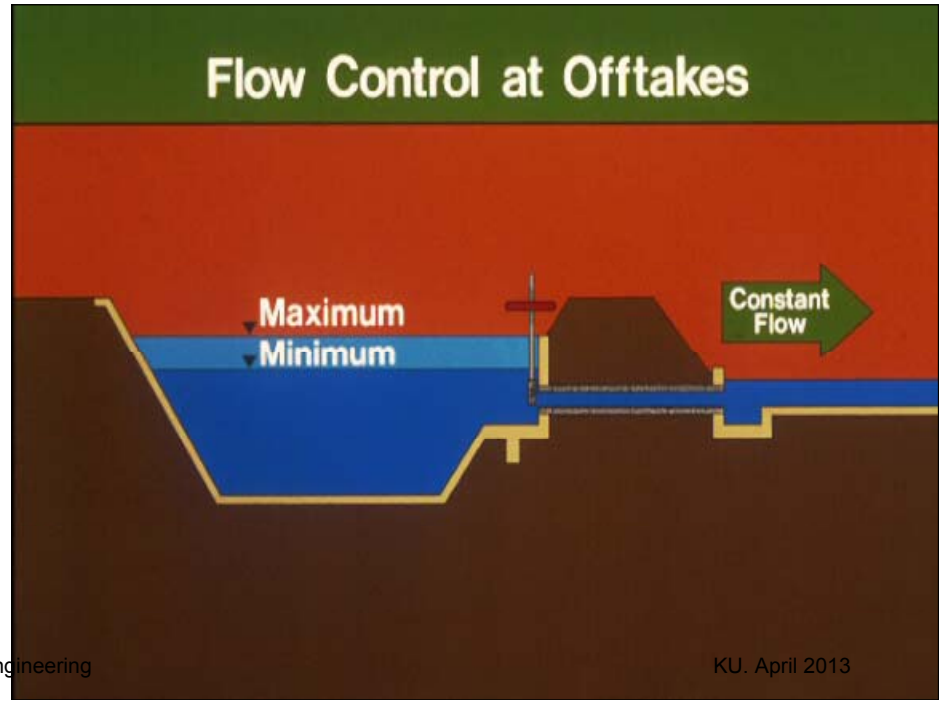


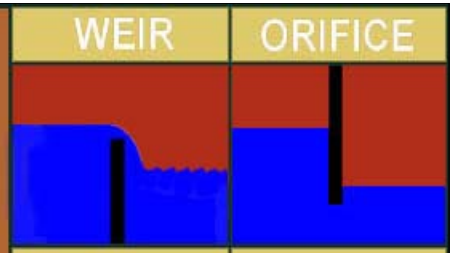
CONTROL EQUIPMENT

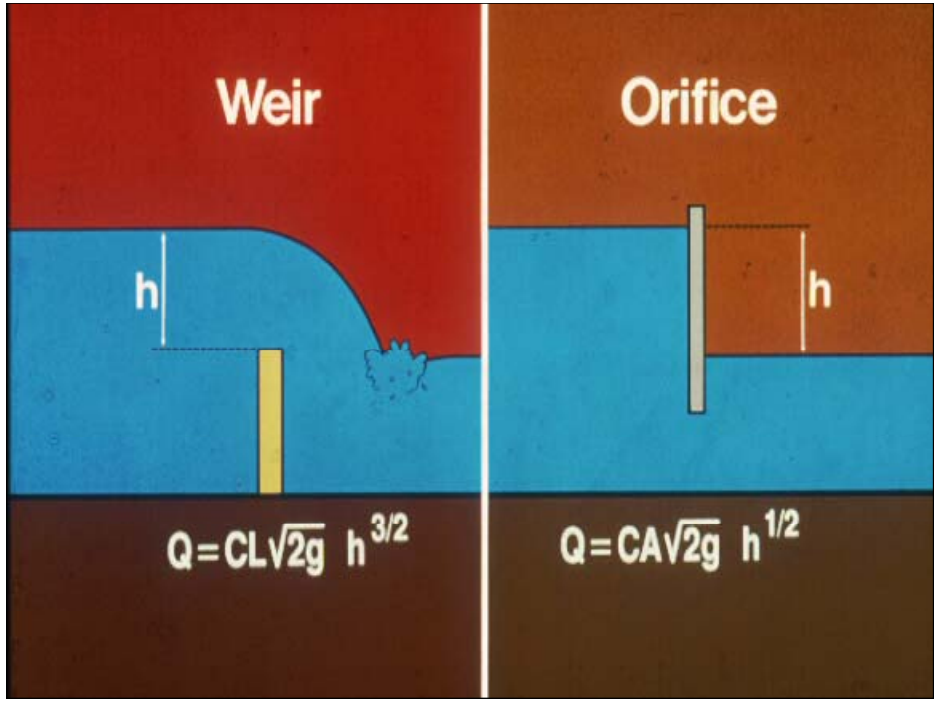
Local Control

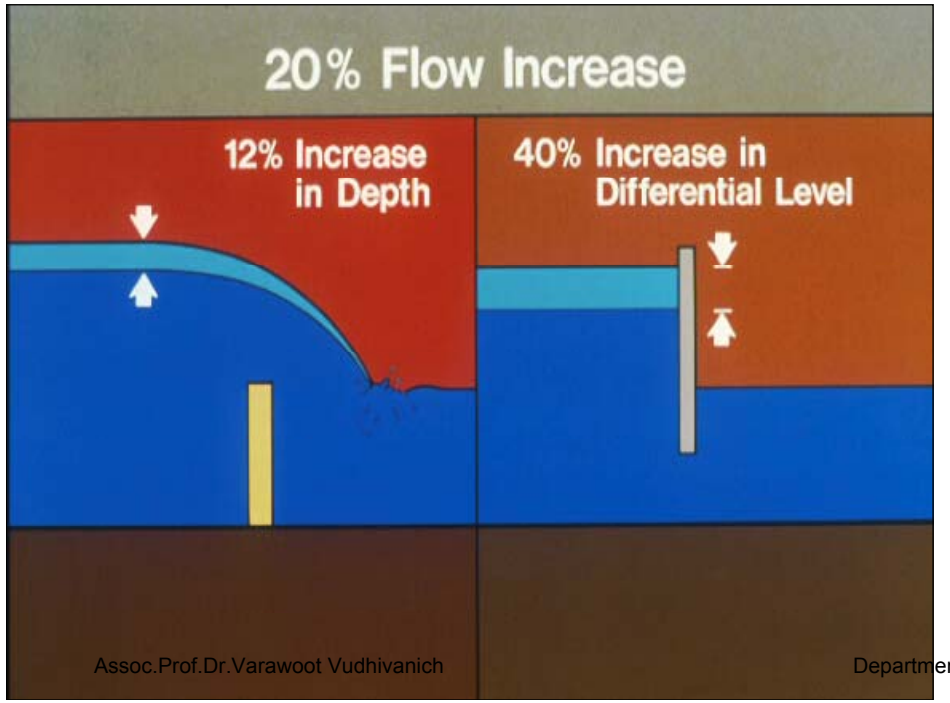
- Flow Division
- Water Level Control
- Flow and Water Level Control
- Flow Control at Offtakes

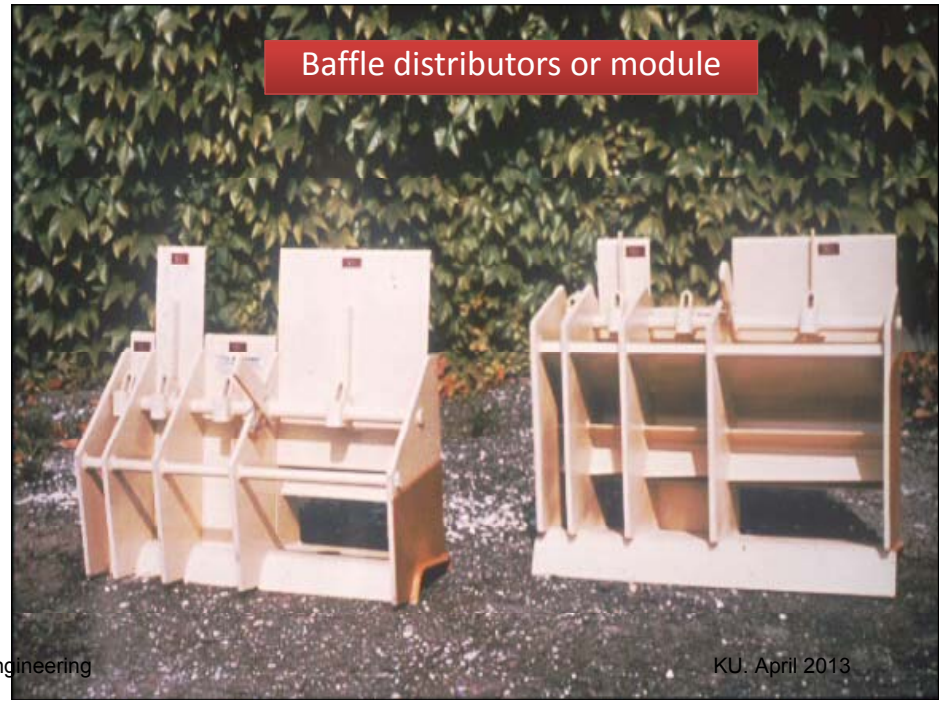
Remote and Centralized Control

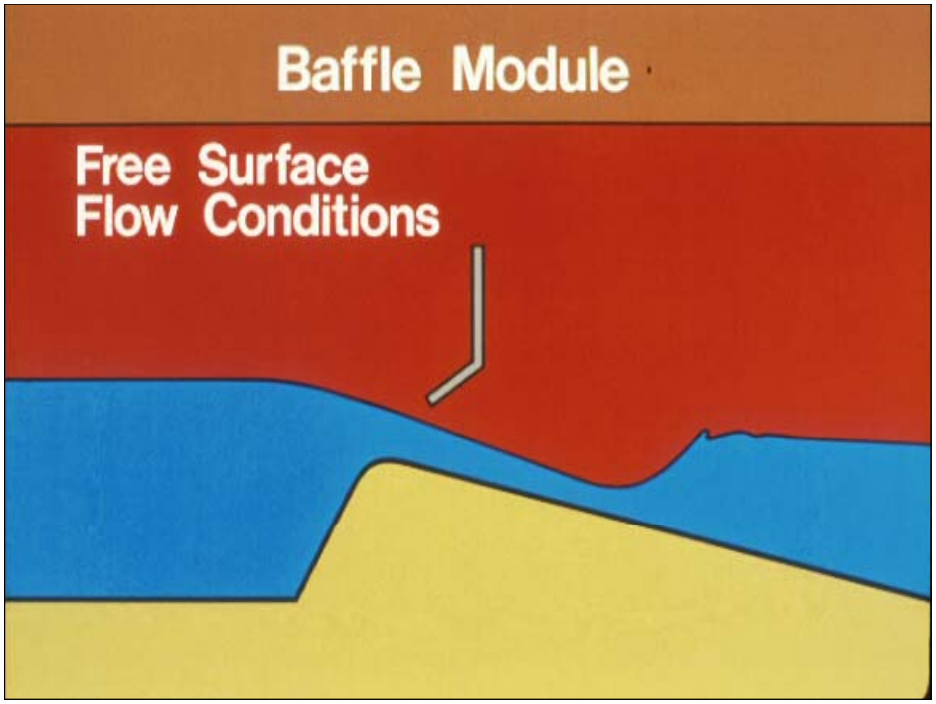


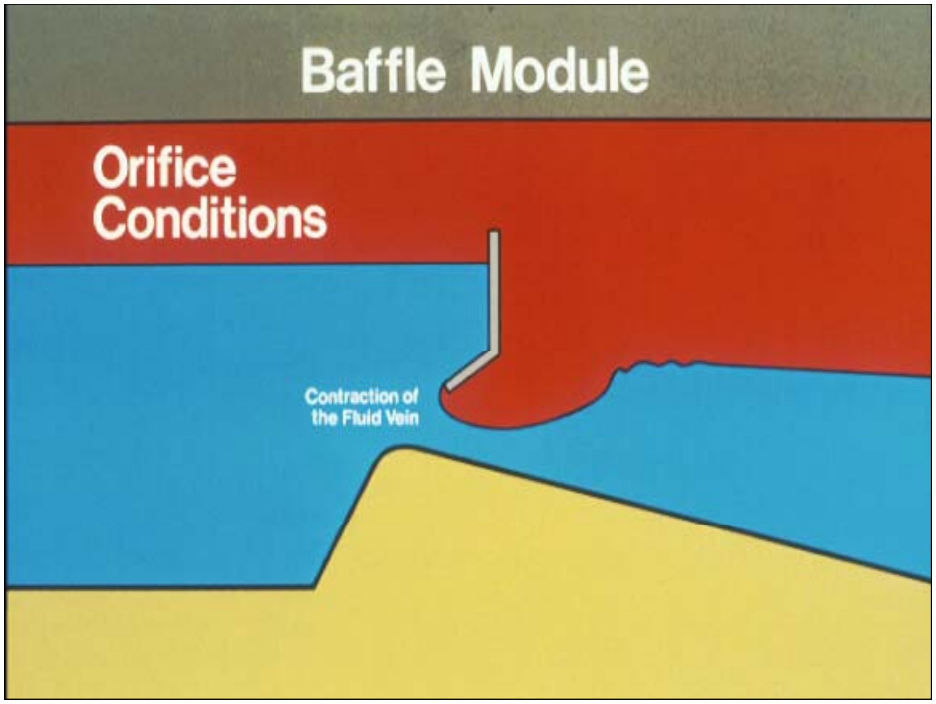
OFFTAKES	WEIR	ORIFICE
		
Sensitivity to upstream level variations	High	Low
Accuracy	High	Low
Recommended Use		
- without automated control function	No	✓
- with automated control function	✓✓	✓

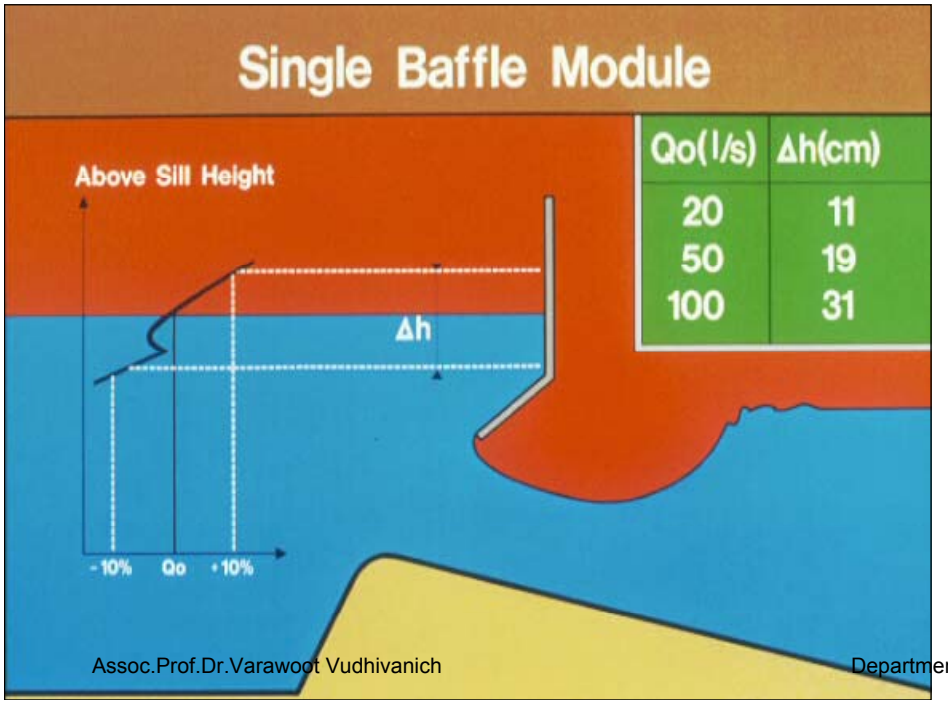


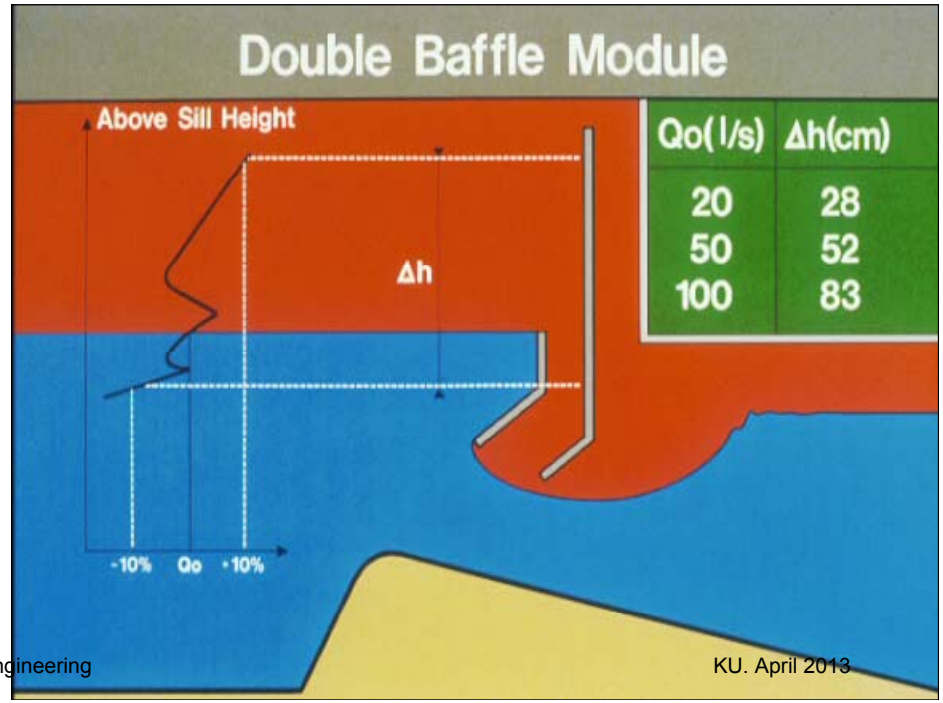





Baffle Module
Free Surface
Flow Conditions


Baffle Module
Orifice
Conditions
Contraction of
the Fluid Vein


Single Baffle Module
Above Sill Height
Δh
-10%
Qo
+10%
Qo(l/s) Δh(cm)
20 11
50 19
100 31


Double Baffle Module
Above Sill Height
Δh
-10%
Qo
+10%
Qo(l/s) Δh(cm)
20 28
50 52
100 83

CONTROL EQUIPMENT

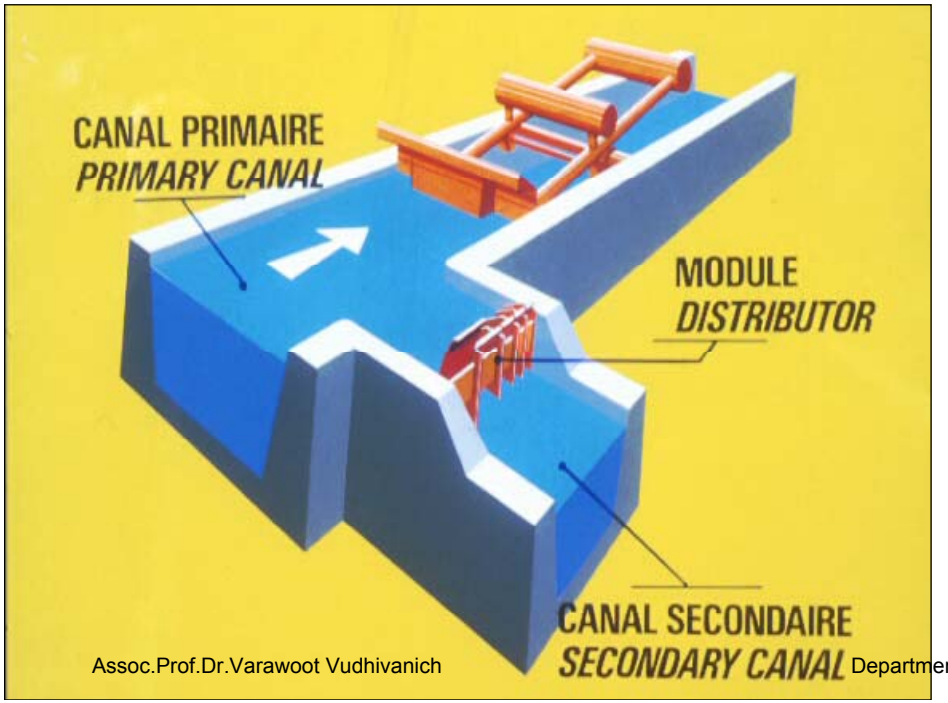
Local Control

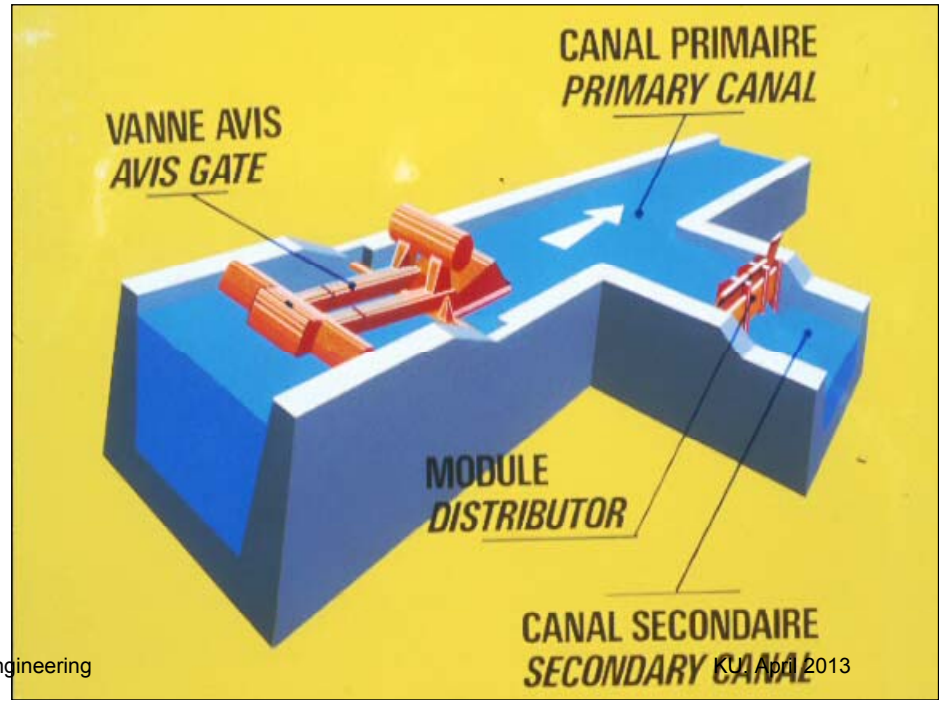
- Flow Division
- Water Level Control
- Flow and Water Control

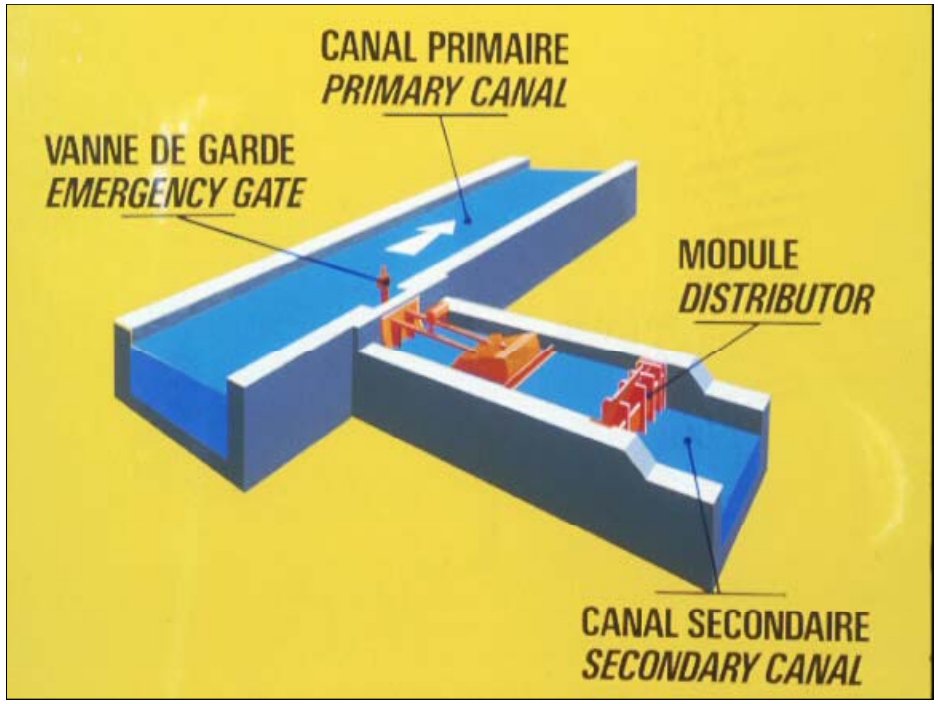
+

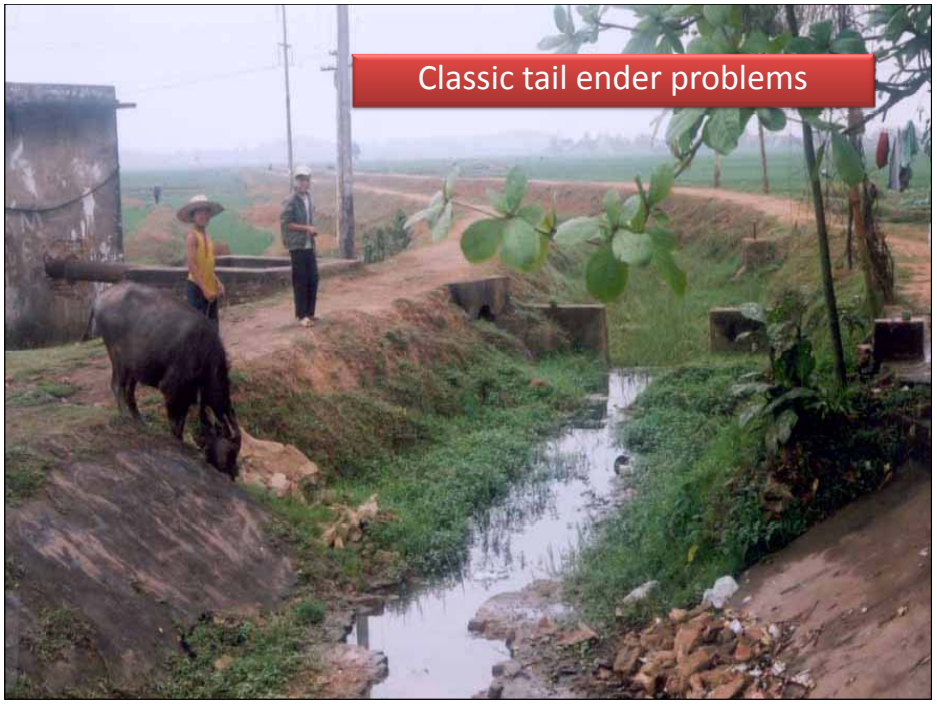
- Flow Control at Offtakes

Remote and Centralized Control









Part 2
Experiences on modern canal control in Thailand

SPN CAS
under KU-RID Project
2005 – 2011

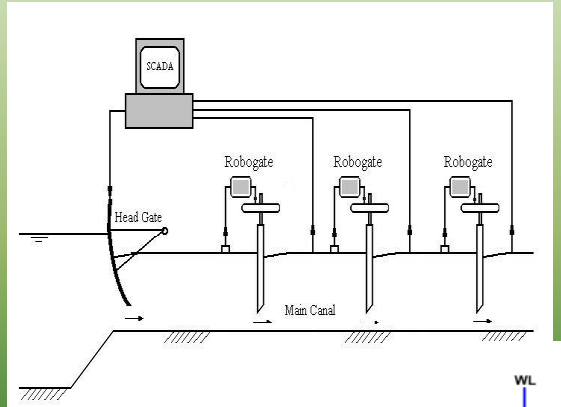
-real time monitoring

-remote control

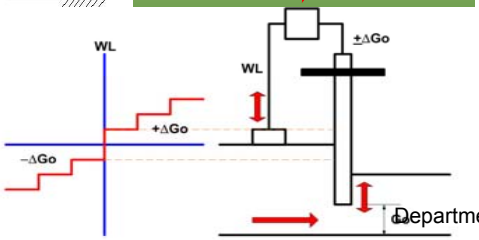
-local automatic upstream control

-low cost + locally available

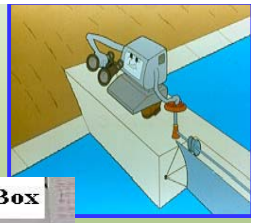
Robogate+SCADA=Canal Automation

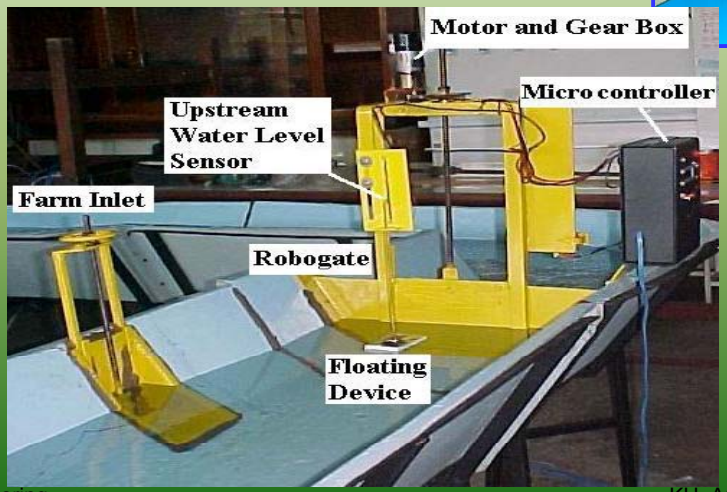


Micro-controller Check and Adjust @ 6 seconds



Robogate 1- 4 in laboratory (2005-2006)

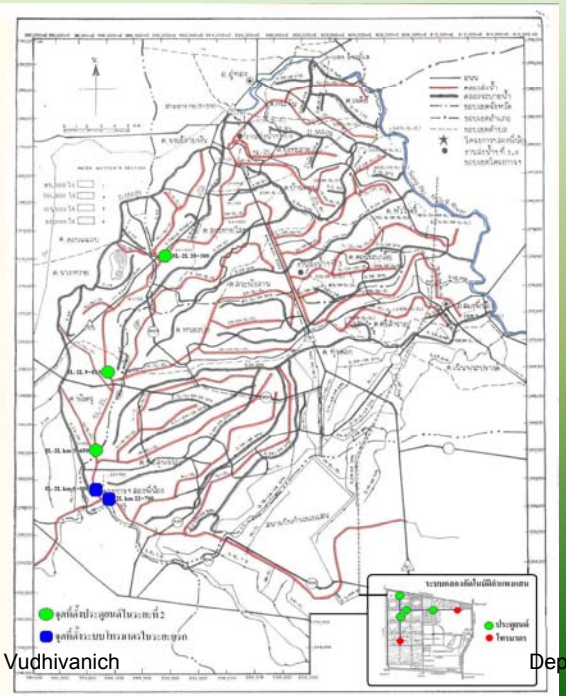




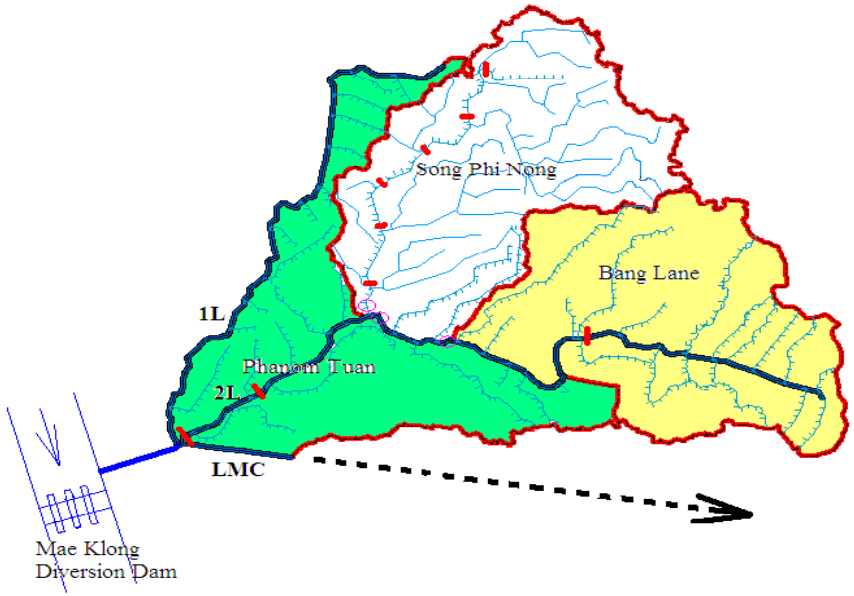
CAS laboratory model

First stage in 2006

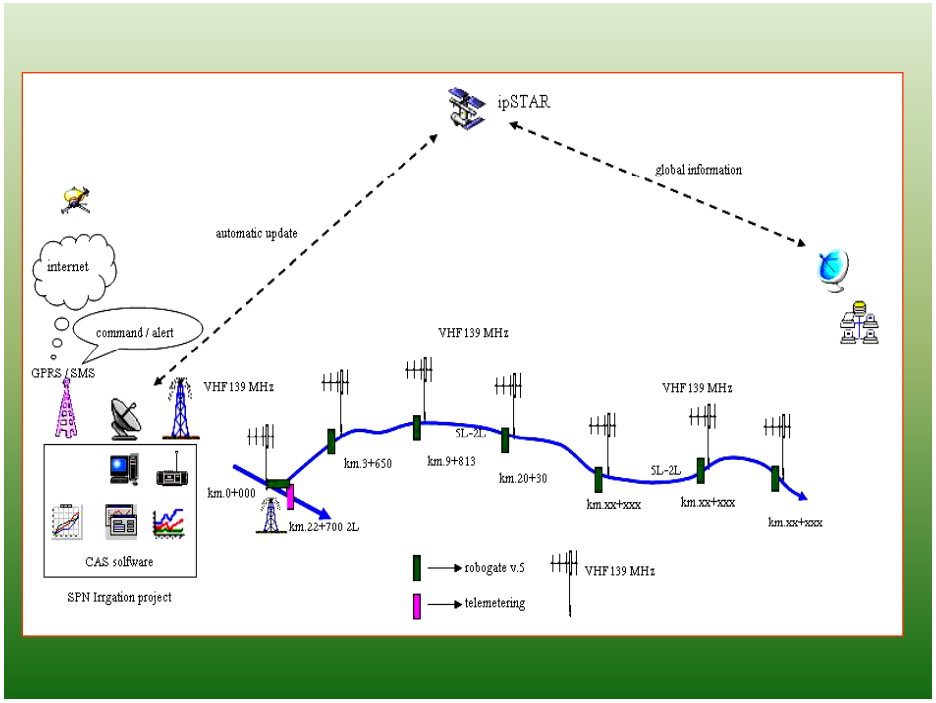
Install Robogate 5 in 2L and 5L-2L



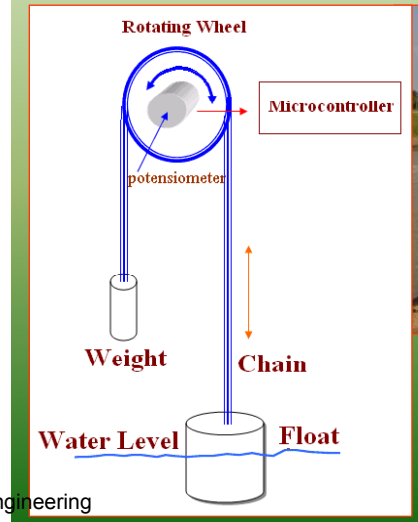
SPN-CAS Robogate Installation		
Stage	O&M projects	Location
I	SPN	Cross regulator 5L-2L km 3+650
	SPN	Cross regulator 5L-2L km 9+813
	SPN	Cross regulator 5L-2L km 20+300
II	PNT	Head regulator 2L km 0+000
	PNT	Cross regulator 2L km 10+300
	BGL	Cross regulator 2L km 49+750
	SPN	Cross regulator 5L-2L km 14+750
	SPN	Cross regulator 5L-2L km 26+401
	SPN	Cross regulator 5L-2L km 33+664



2L km.0+000, 10+300, 49+750
5L-2L km.3+650,9+813, 14+750, 20+300, 26+401, 33+664

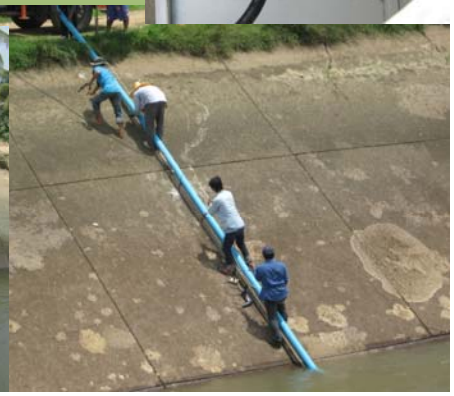


Floating Type Water Level Sensor

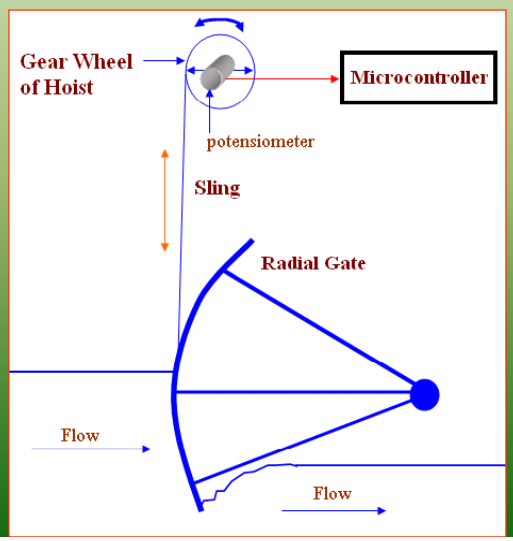


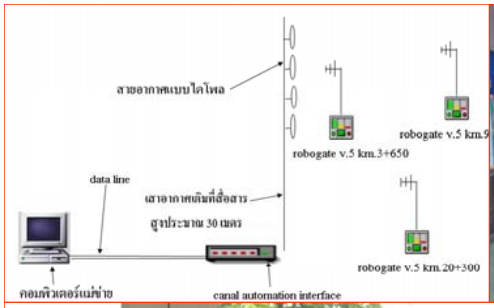
Pressure sensor

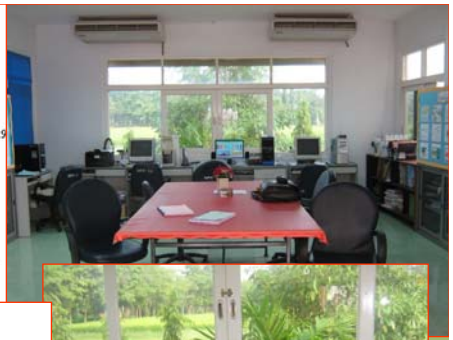


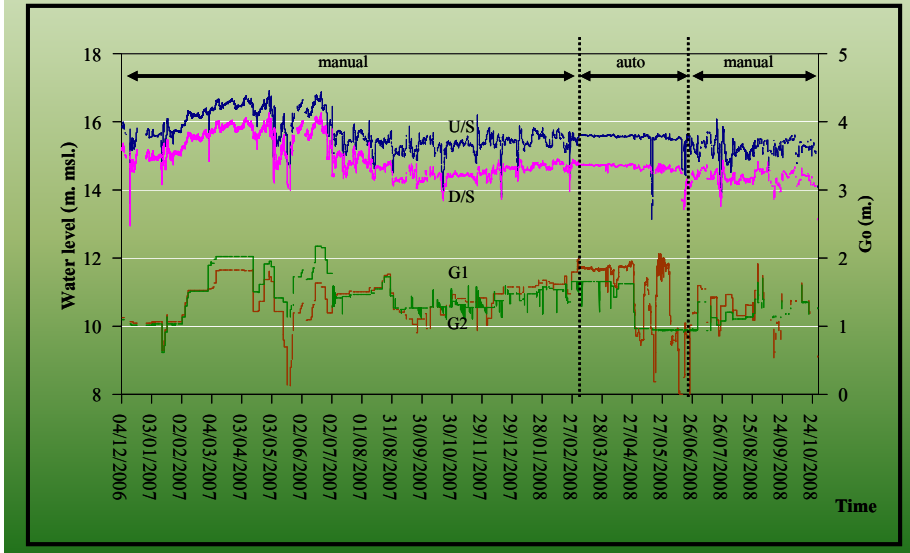
Gate Positioning Sensor



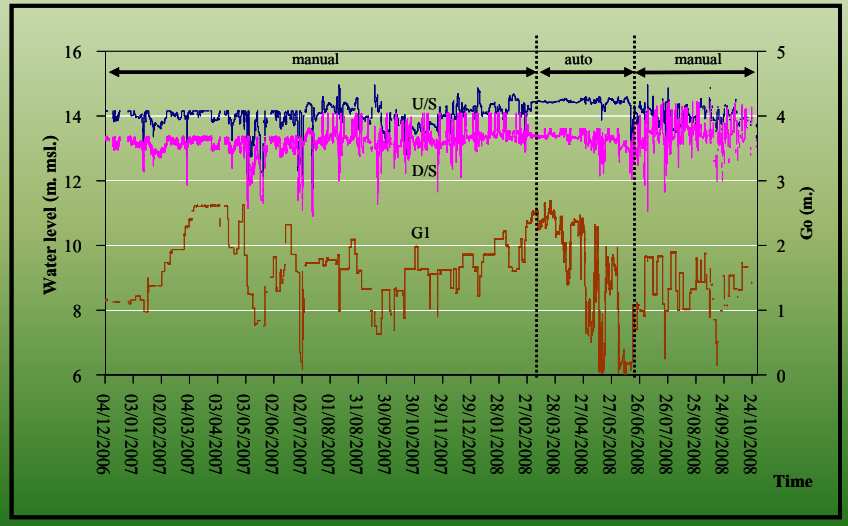




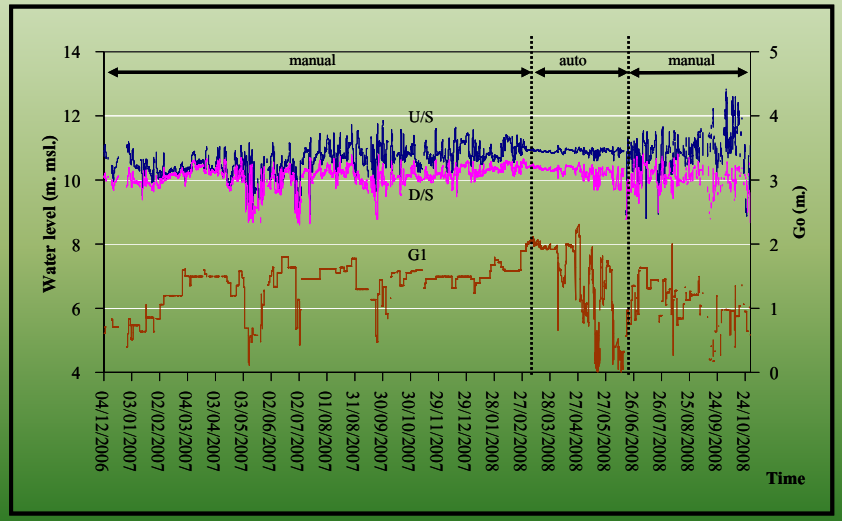
5L-2L Km 3+650



5L-2L Km 9+813



5L-2L km 20+300



Reliability of measurement by Robogate (during 4 Dec.2006-29 Sep. 2008)

No. of Data to be Recorded	No. of Data Recorded	% Reliability of measurement
111744	86251	77

RM = Reliability of Measurement (%)

RM= 100*No. of Data Recorded/Total No. of Data to be Recorded

Reliability of Water Level Control (%)
(during 4 Dec.2006-29 Sep. 2008)

No.of Water Level Measurement	No. of Time Water Level Drop Below the Target Water Level by 10%	% RWLC
79413	20645	74

RWLC = Reliability of Water Level Control (%)

=100*(1-No. of Time Water Level Drop Below the Target Water Level by the Given Tolerance(10%)/No.of Water Level Measurement)

Water delivery performance of 5L-2L SPN

Season	Reach 1		Reach 2		Reach 3		5L-2L canal		
	PA	PE	PA	PE	PA	PE	PA	PE	PEQ
Dry S. 2 (2007) 6 Mar-18 Jun 2007 Manual	0.95 Good	0.73 Fair	0.80 Fair	0.67 Poor	1.00 Good	0.22 Poor	0.92 Good	0.54 Poor	0.03 Good
Wet S. (2007) 3 Jul-29 Oct 2007 Manual	1.00 Good	0.56 Poor	1.00 Good	0.44 Poor	0.59 Poor	1.00 Good	0.86 Fair	0.67 Poor	0.28 Poor
Dry S. 1 (07/08) 1 Nov 07- 27 Feb 08 Manual	1.00 Good	0.18 Poor	1.00 Good	0.17 Poor	1.00 Good	0.43 Poor	1.00 Good	0.26 Poor	0.00 Good
Dry S. 2 (2008) 6 Mar-18 Jun 2008 Automatic	1.00 Good	0.41 Poor	0.96 Good	0.68 Poor	1.00 Good	0.58 Poor	0.99 Good	0.56 Poor	0.02 Good
Wet S. (2008) 3 Jul-22 Oct 2008 Manual	1.00 Good	0.16 Poor	1.00 Good	0.32 Poor	0.42 Poor	1.00 Good	0.81 Fair	0.49 Poor	1.69 Poor

Part 3
Total Channel control (TCC)


ICID Newsletter

ICID•CIID

Managing water for sustainable agriculture

Also at http://www.icid.org 2007/1

Message from the President

Which technology has the capability to revolutionise food production so that we can meet the challenge of producing 67% more food with only a modest increase in water use over the next 25-30 years?

It might be argued that the last great boost in food production was due largely to the increased groundwater irrigation, most notably in Asia, and especially coupled to the introduction of higher-yielding varieties the "green revolution"). What is going to be seen in future as the biggest technological driver of the next revolution?

For the last 20 years or so, the irrigation community has appeared more concerned with process improvements and "soft" technology, whereas our sister organisation ICOLD has witnessed a revolution in dam building based on the introduction of roller compacted concrete (RCC). The dams' community is now asking a question akin to the one posed above: what next?

Of course it is easy to make the excuse that irrigation is more process driven and very dependent on local conditions that make it less likely that a single technology will dominate. Yet it is important that we remain aware of those technologies that may be creeping up on us so that we realise the policy changes and process improvements that may be needed.

There is not much to be gained by talking about this in the abstract, so sticking my neck out, here are ten technologies that I think could be contenders:

1. Farmer controlled water supply, or total canals; call it what you will, but essentially an extension of the control that came with

groundwater, applied to surface sources and large systems.

2. Emitter delivery systems for precision irrigation and for undulating terrain, not just through drip systems but also through centre pivots, especially those that can be moved from centre to centre, and with sweeps

3. Wettin

4. Drain

5. Wettin

6. No-till

7. Fresh-saline irrigation, where saline and brackish water is used for part of the growing period without much loss of yield or detriment to the soil structure.

8. Salt and drought tolerant food crops, perhaps used in conjunction with 7, or independently, especially where irrigation is ephemeral or only supplementary.

A centre pivot irrigating young coffee plants in Brazil (Almost half of Brazil's 3.44 mha of irrigated land is under pressurized irrigation, of which 40% or that is under centre pivot

Let's have your views.

Peter Lee
President, ICID

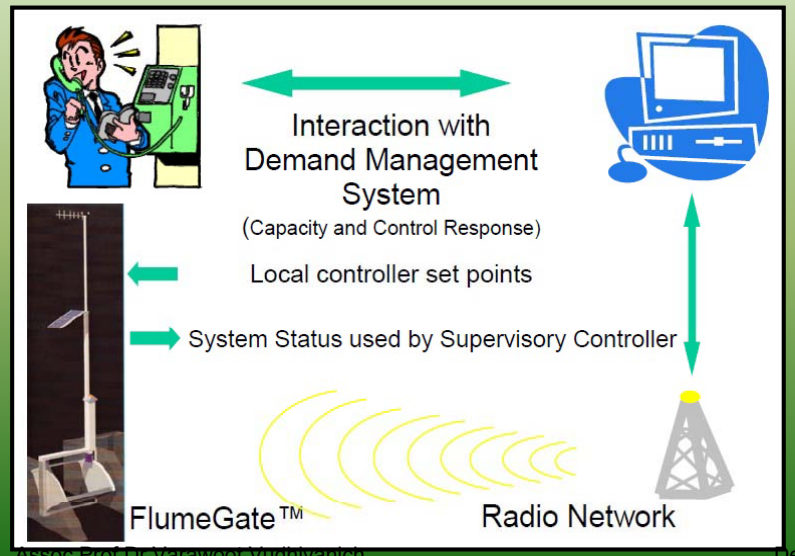
Top 10 I&D technologies (by Peter Lee, Ex-president, ICID)

1.Farmer controlled water supply, or total channel control or downstream control of canals……

Dethridge water meter

FlumeGate (Rubicon)

Total Channel Control (TCC™)



Rubicon controlling water delivery to farms

Thank you