Analysis of your system: what could you do…

December 14, 2011

Water Resources / Civil Engineering and Geosciences

TU Delft
Technische Universiteit Delft

Pampa de Chaparrí, Peru

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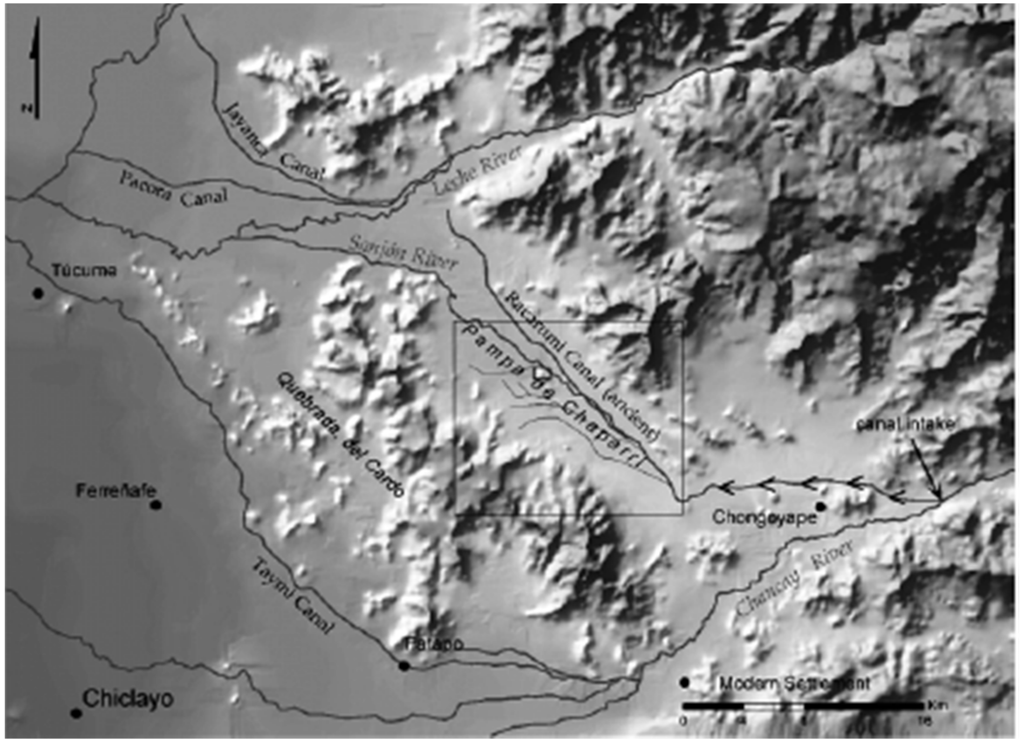
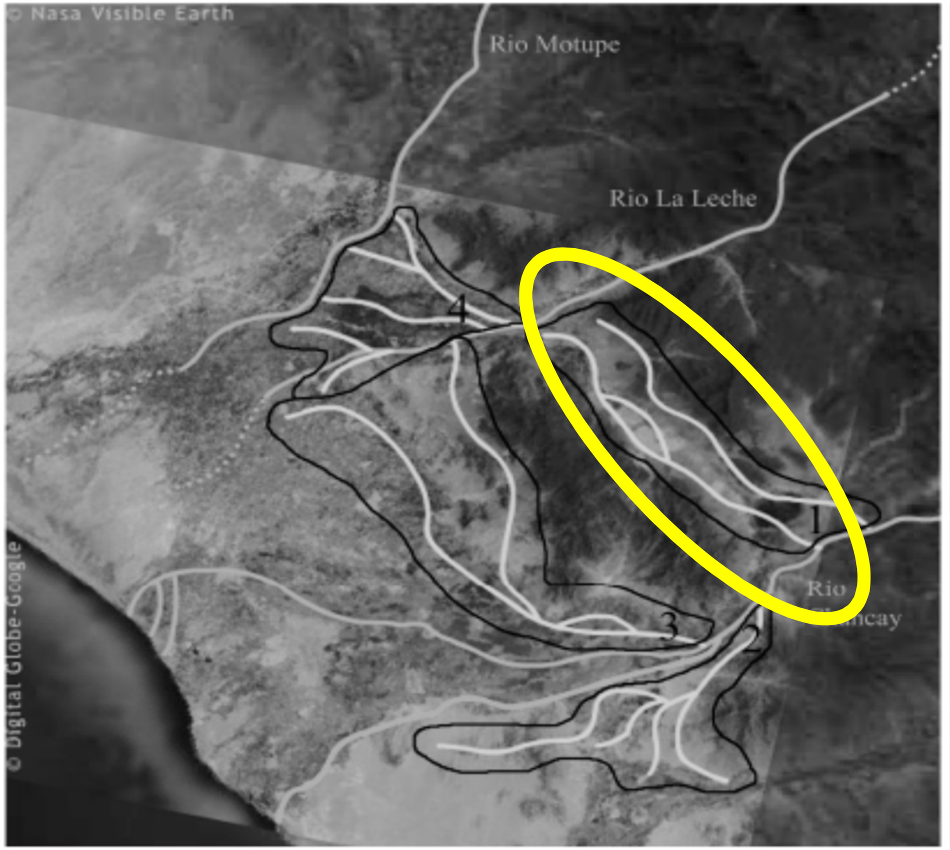


- Arid Peruvian north coast
- Pre-Colombian civilizations
- Sicán, Chimú and Inca
- Between 900 AD and 1532 AD
- Abandoned in the 16th century

Irrigated areas



- Three areas irrigated from Río Chancay
- One area from Río La Leche
- Río Chancay diverts to Río La Leche
- Chaparrí derived about 1/3 of the discharge

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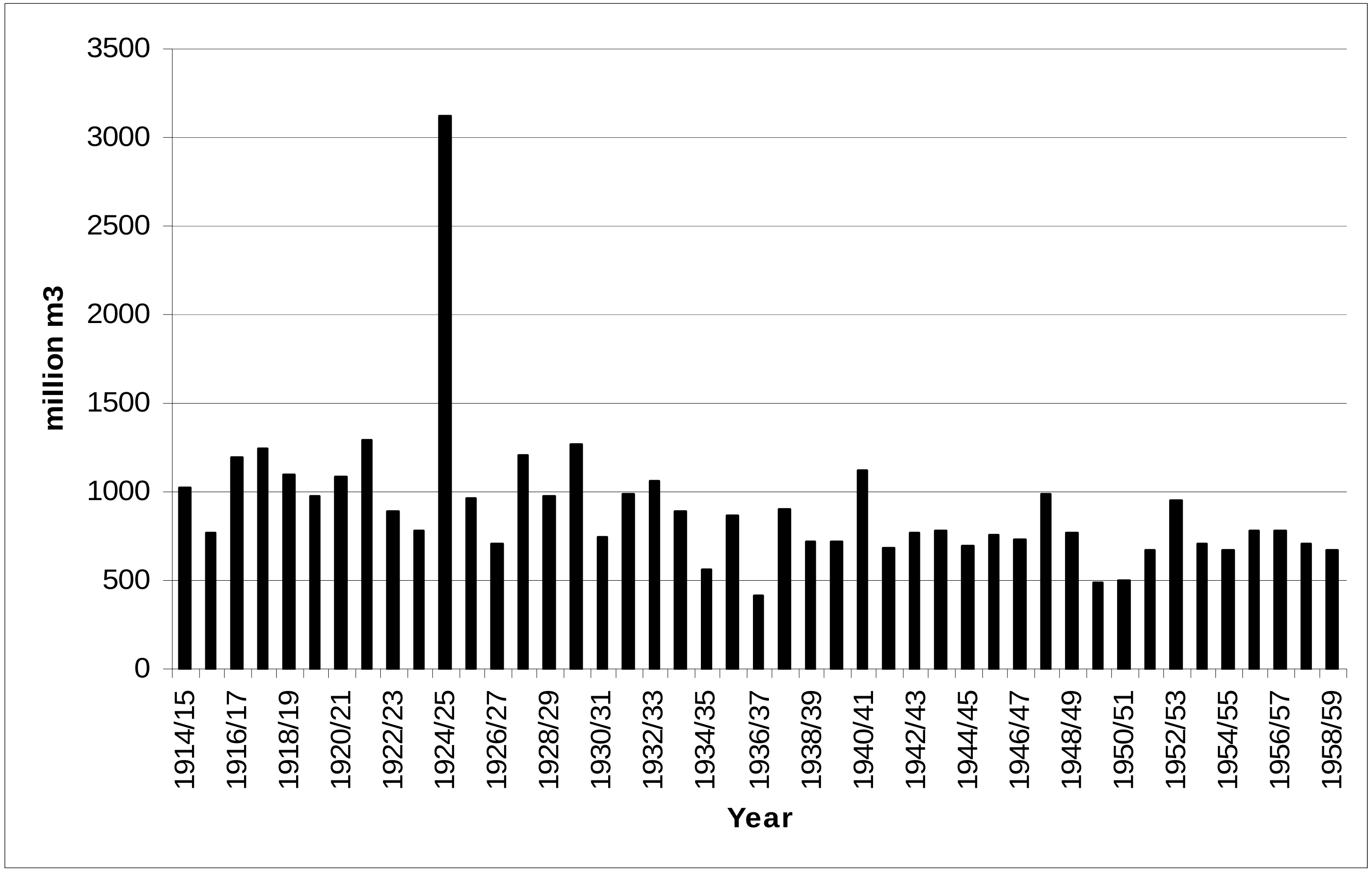
Discharges of Río Chancay



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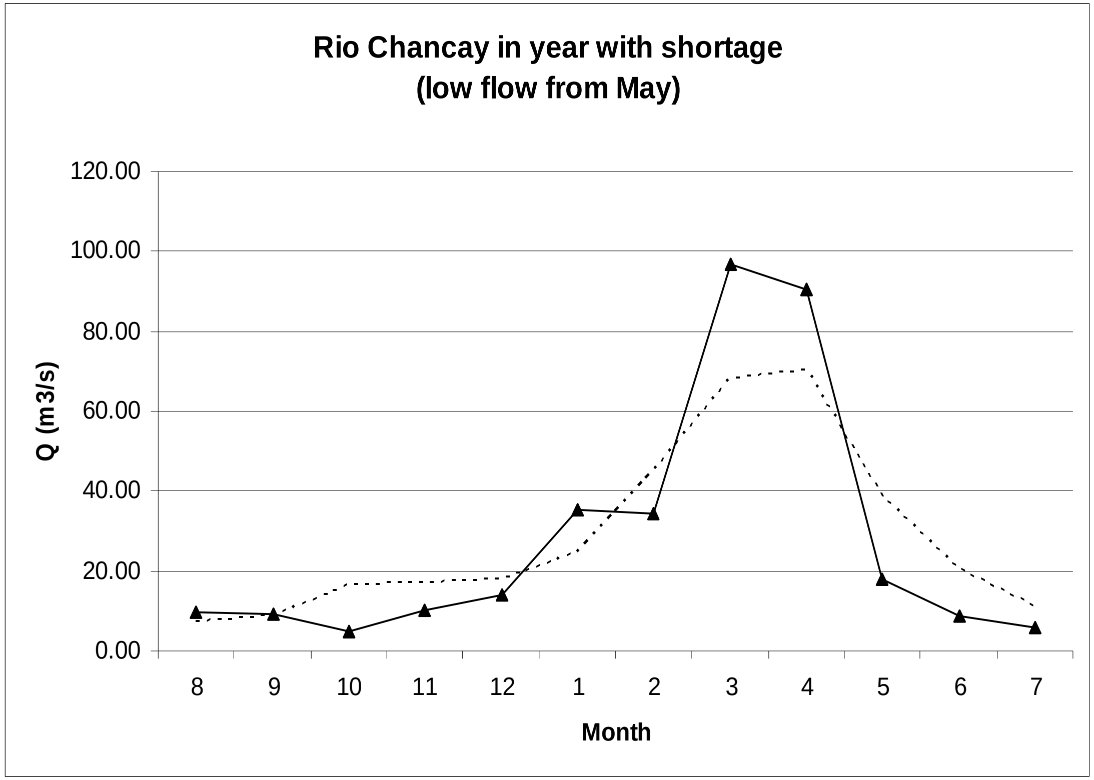
Irrigation: when did it go wrong?



- Lower discharges
- Start of higher discharges too late

- But also
- End of higher discharges too early (in graph)

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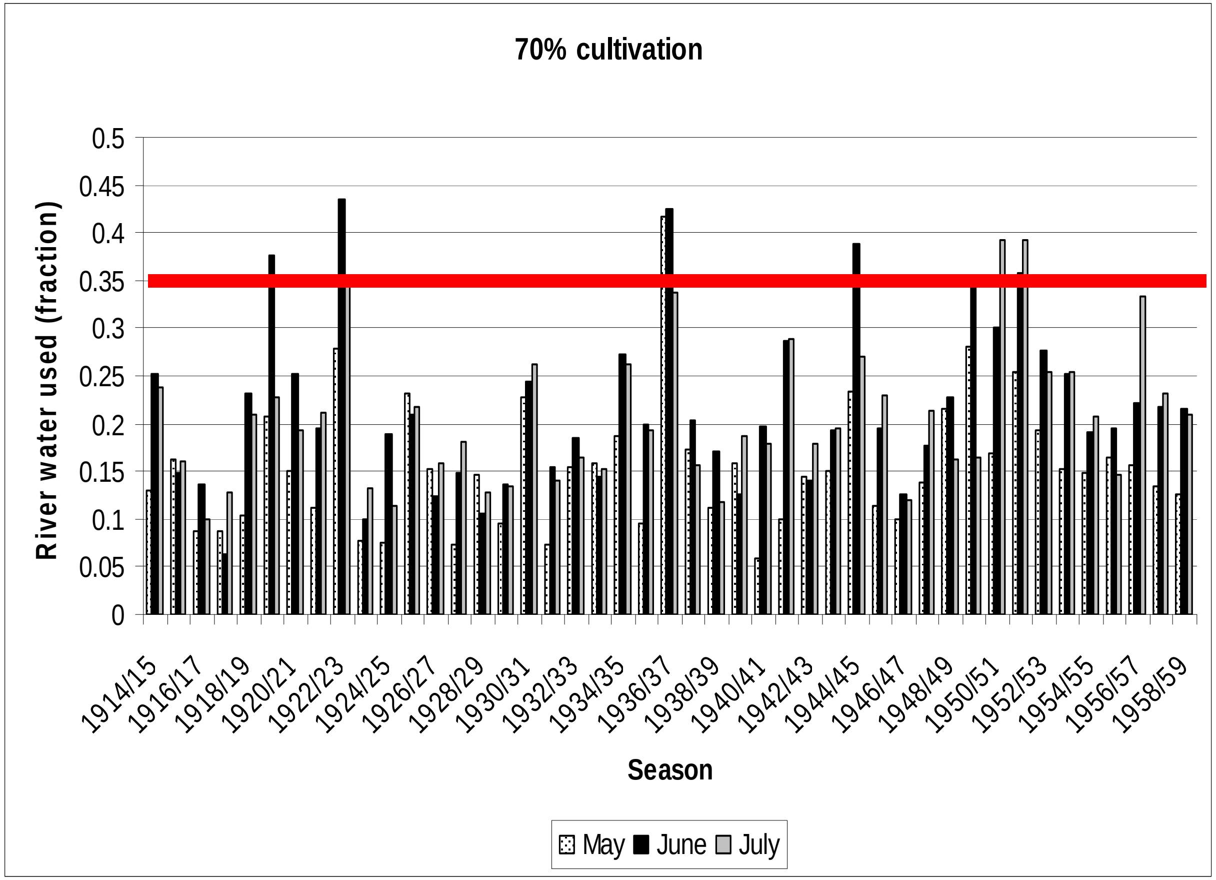
Irrigation: how often did it go wrong?



Water shortages:

- **70% cultivated:**
- 6 out of 45 years (less severe)
- **80% cultivated:**
- 8 out of 45 years (1 to 3 months)
- **100% cultivated:**
- 11 out of 45 years (severe)

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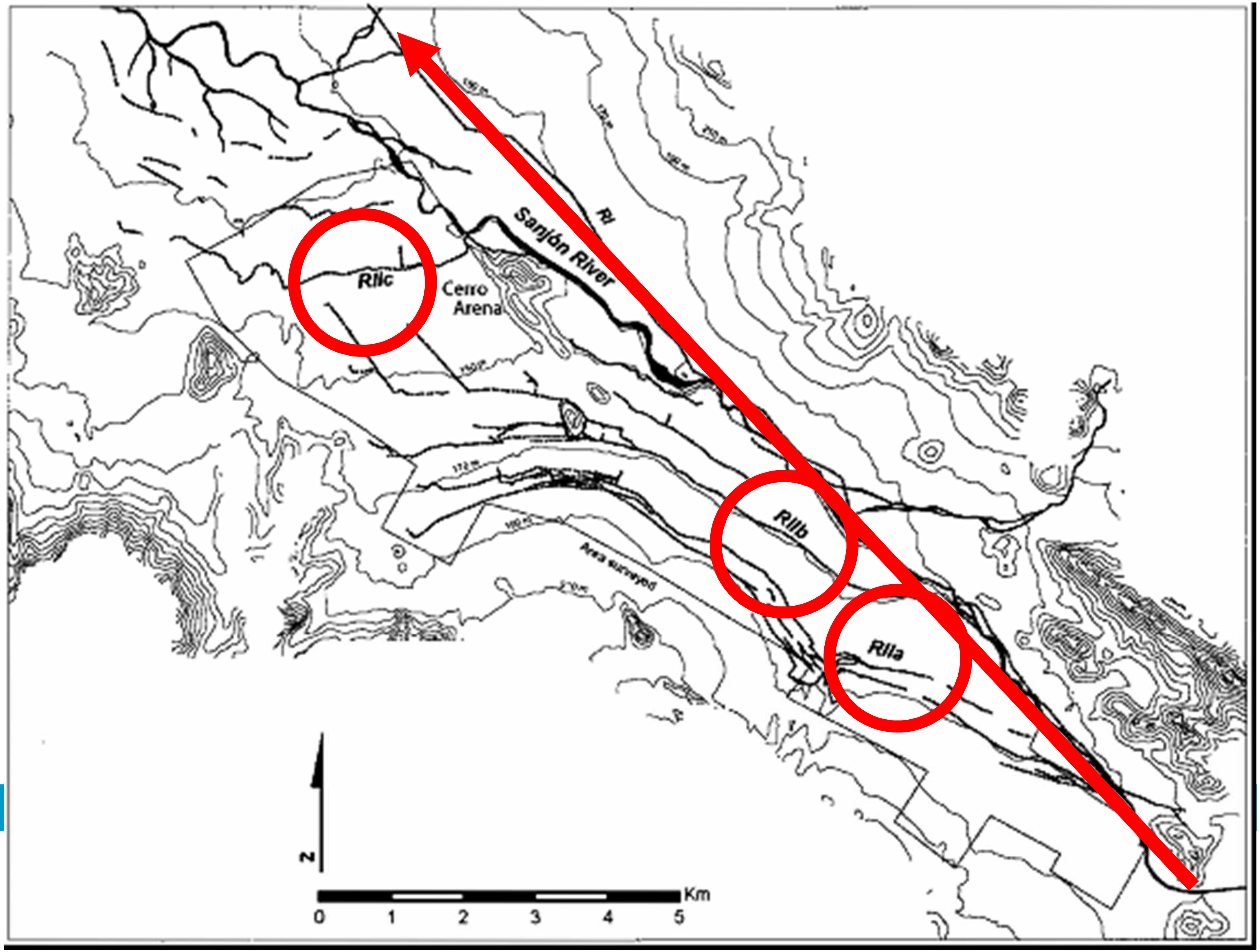
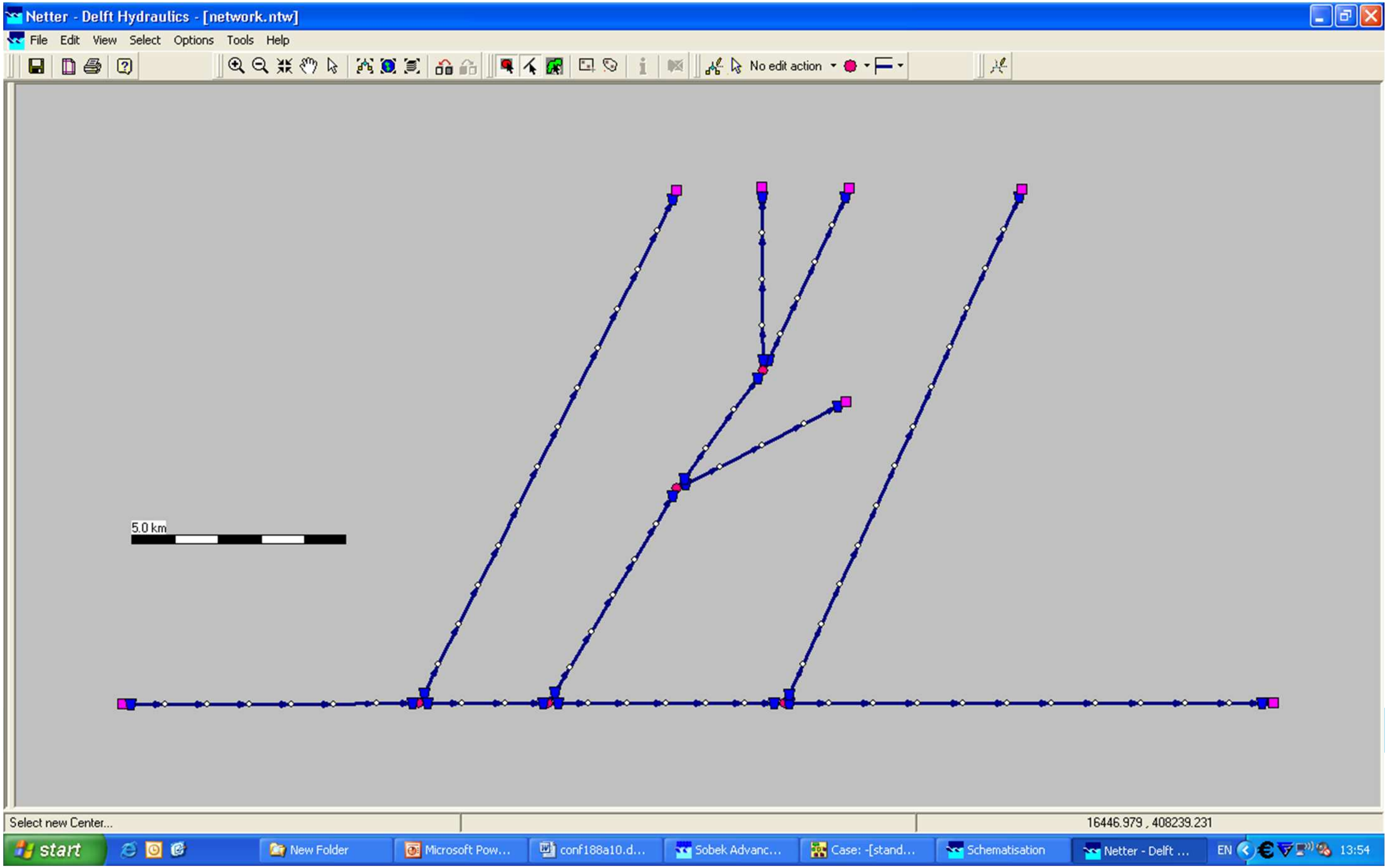
(Hayashida 2006)

What about the canal system?



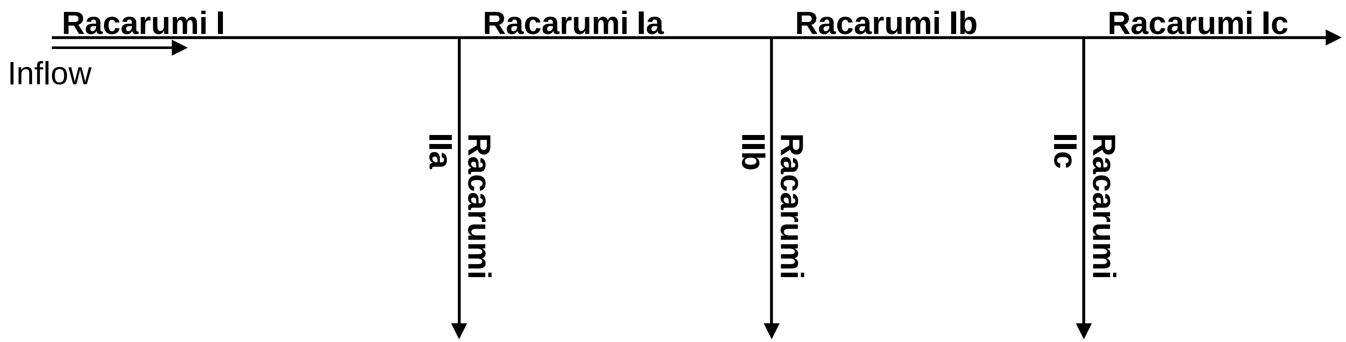
Simplified to this:

http://delftsoftware.wldelft.nl/index.php?option=com_content&task=view&id=110



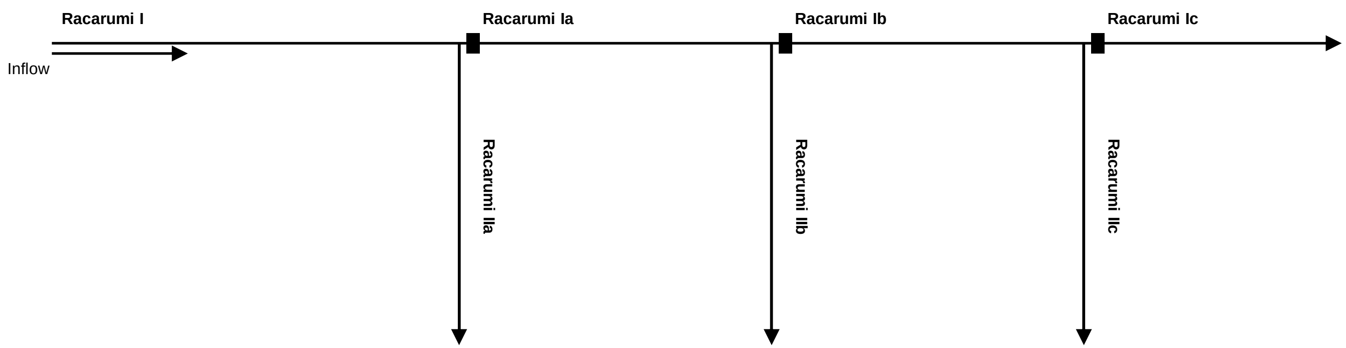
Three scenarios

A - Reference:
- Inflow gradual
- Inflow variable



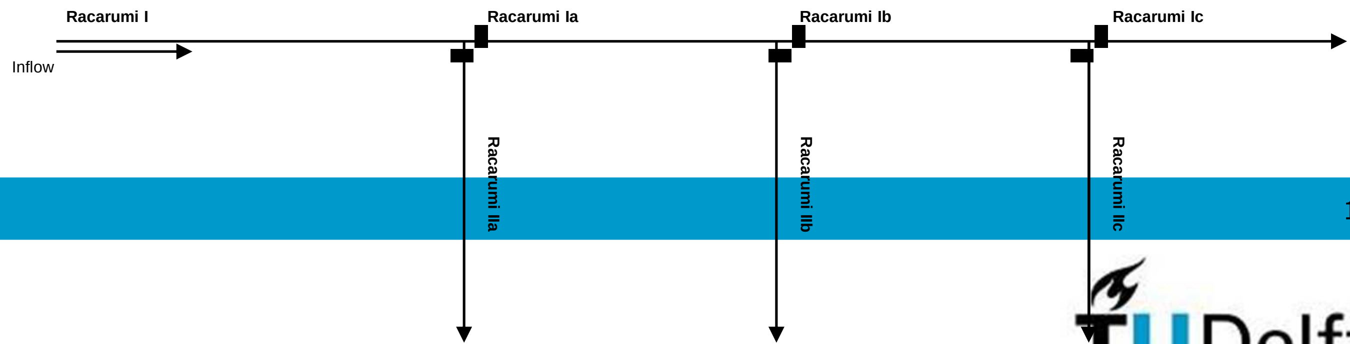
B - Main system:
- Both inflows

▬ ***weir***

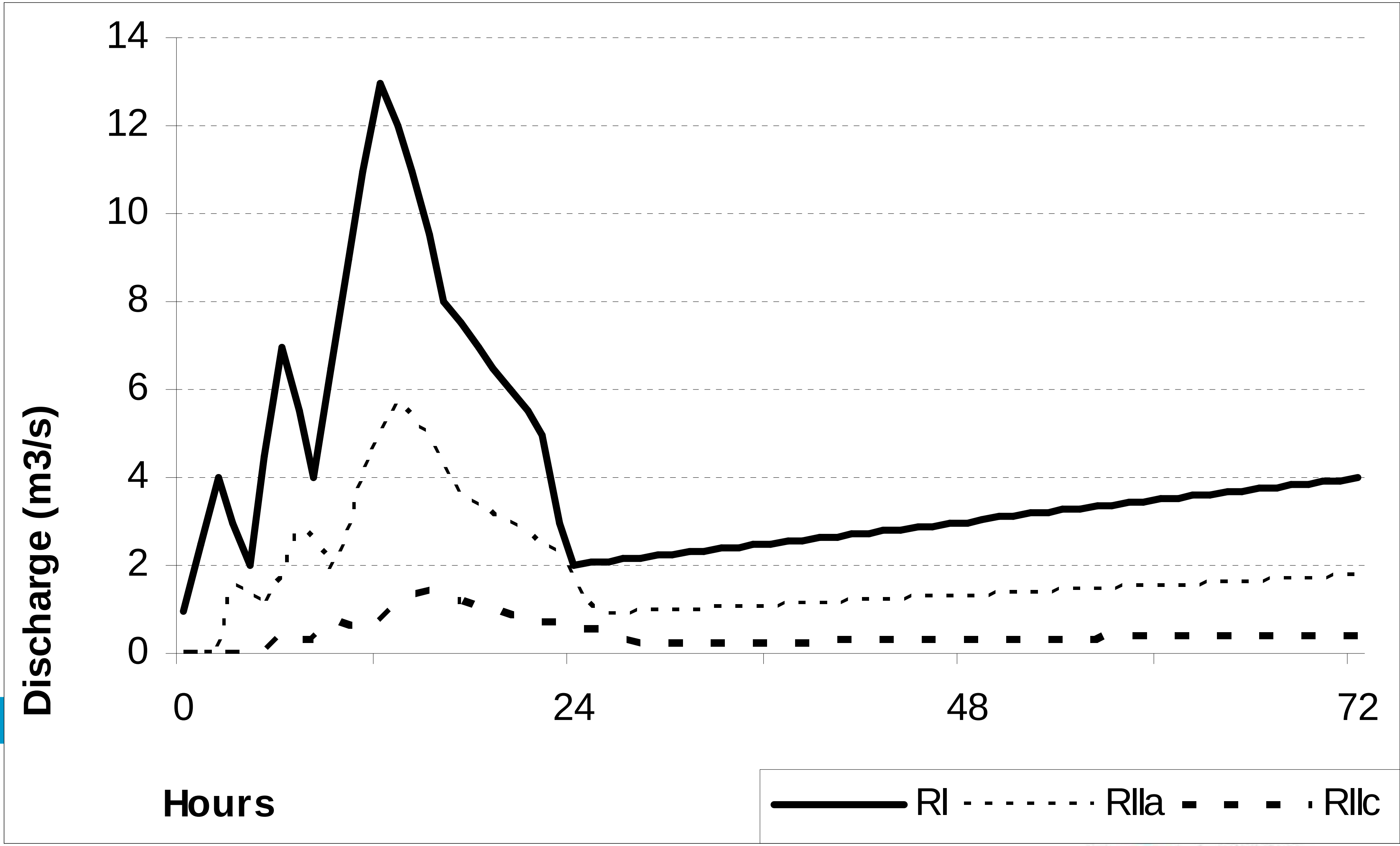


C - Proportional:
- Both inflows

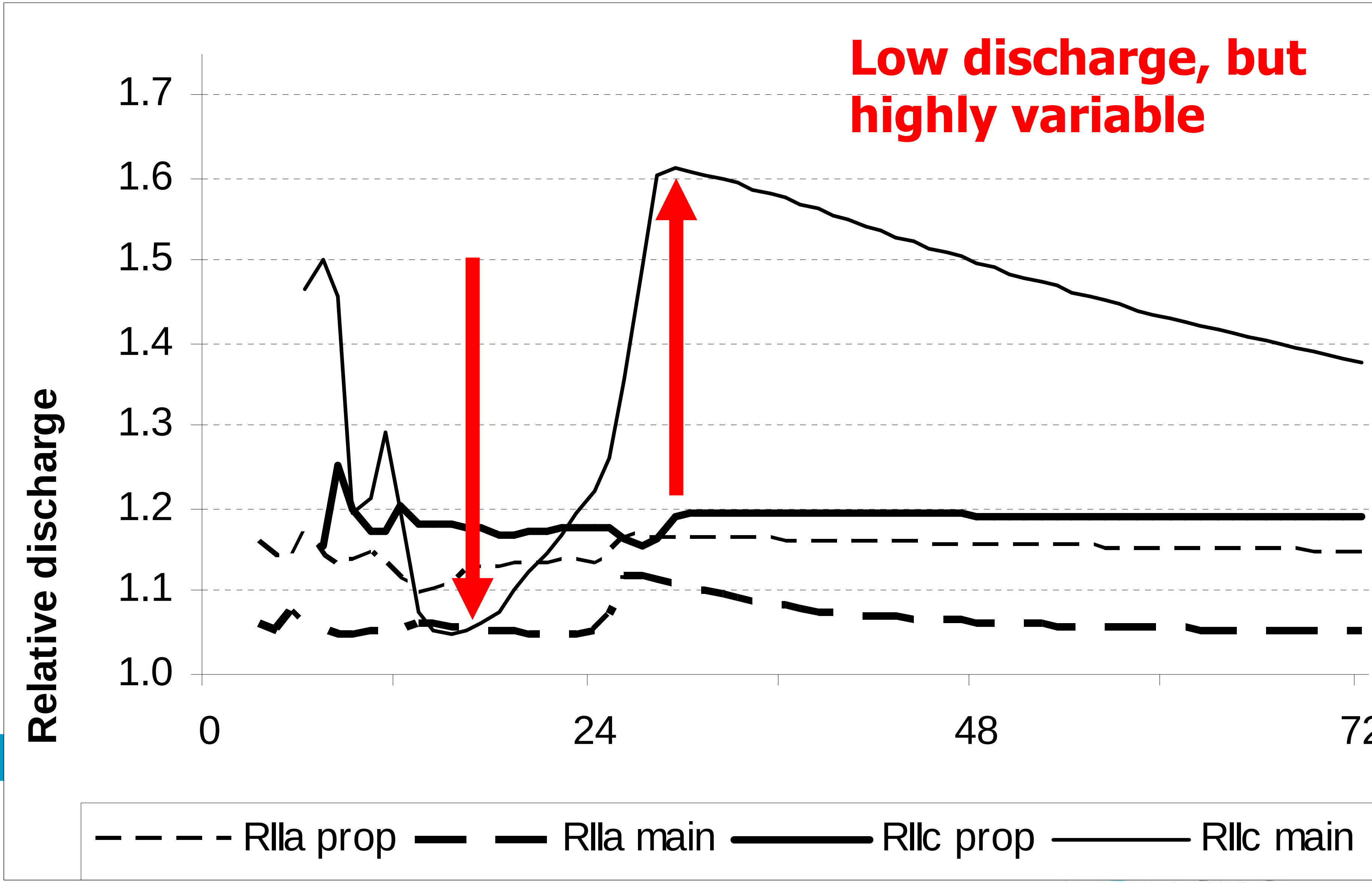
weirs



Reference layout and fluctuations



Fluctuations with weirs

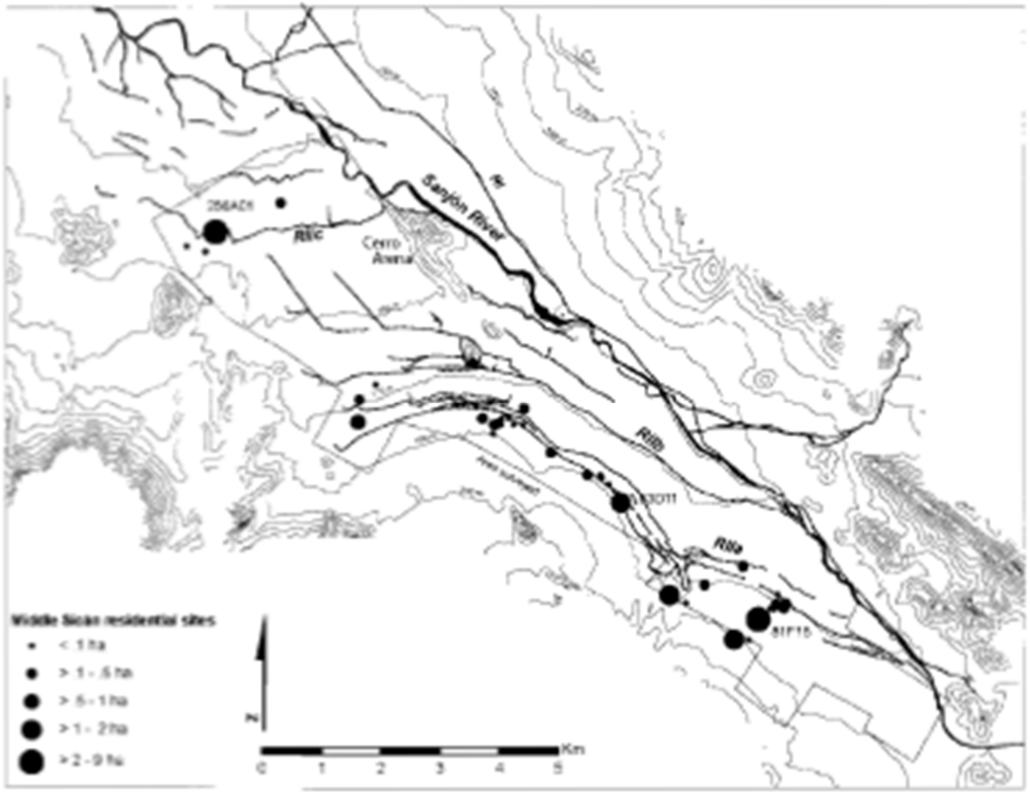


Fit with reality?

A 900 hectares area in the upstream area shows a highly regular canal system.

In the middle area canals and fields are more variable in shape, although still fairly regular.

The area downstream appears as a patchwork of varied plots and canals.



(Hayashida 2006)

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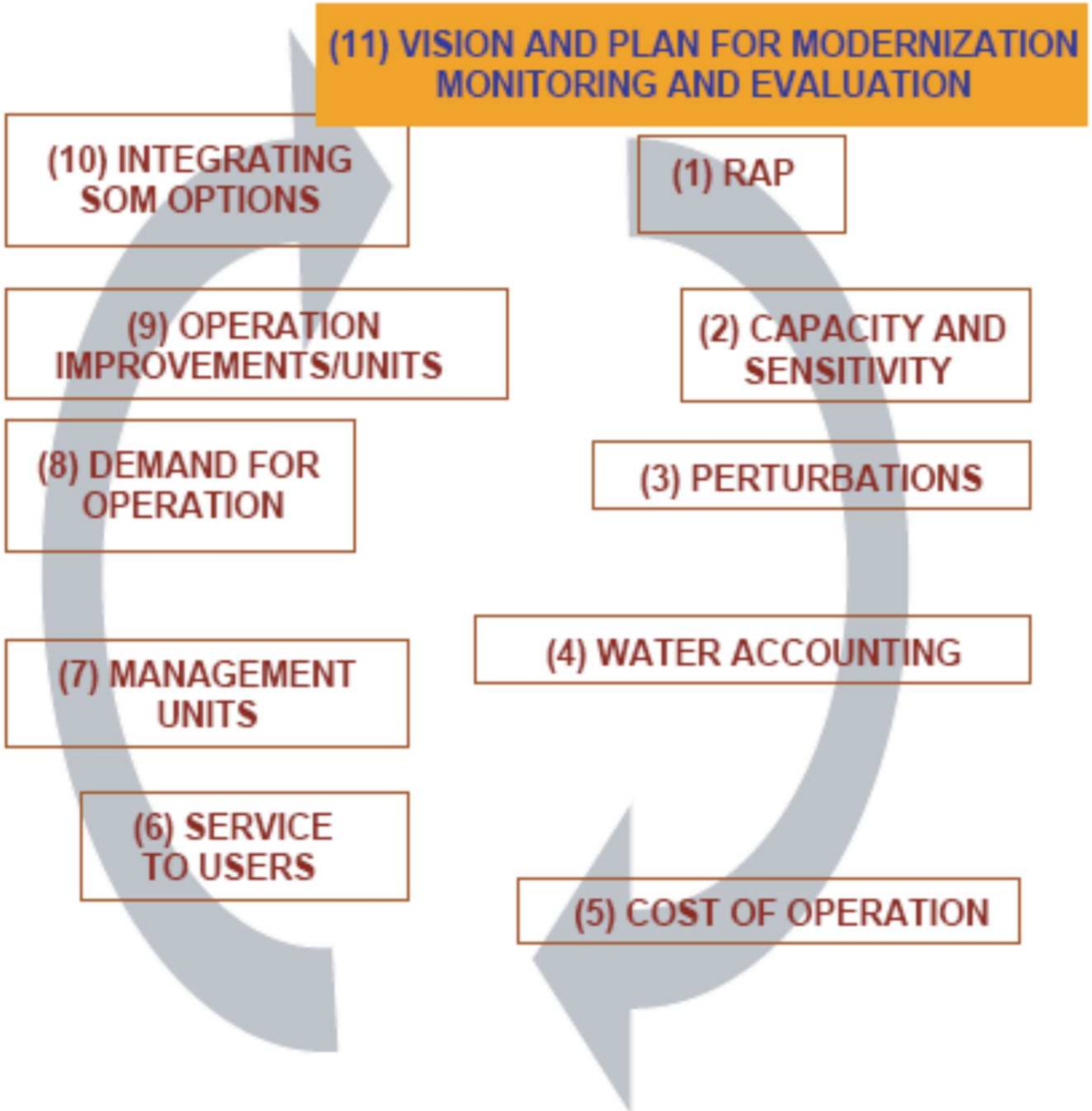
Renault et al



FAO - MASSCOTE

Procedure to describe and analyse

Subunits – criteria and options

	Options
Criteria for division into subunits	Managerial/institutional: the subunits should correspond to the institutional partition of the service area among the users (farmer groups, users associations, etc.).
	Homogeneity of the conditions for the desired level of service.
	Sensible limits *vis-à-vis* available water resources – both the surface water and groundwater networks.
	Drainage conditions that physically partition the service area between recycled and non-recycled.
	Cost efficiency (too many units may prove unfeasible).
	Scale and the sense of ownership.
Singular points of interest for partitioning	Highly sensitive regulators that detect upstream changes in the water balance (even low changes) are good points at which to check the downstream of the subunit.
	Well-measured points.
	Well-controlled points.
	Major physical partition points.
	Storage allows smoothing discharge fluctuations and re-starting flows for downstream subunits.

Types of operation, related activities goal, and objectives

Type of operation	Targets	Goal	Possible objectives
Scheduled operations	Targeted service at delivery points	Service to users	Produce the required service. Ensure high performance and efficiency.
Routine operations (unscheduled)	Unscheduled changes in inflows/outflows	Service to users	Manage perturbations and maintain a good service to users.
		Water management	Take advantage of surplus water, and compensate for water deficit.
Emergency operations	Sudden changes in the system creating high risk	Safety	Ensure safety of the canal under all circumstances.
Monitoring and evaluation (information)	Status of key variables (flow, water level, structure setting)	Service to users	Monitor, evaluate and improve performance and efficiency levels.
		Water management – decision for operation	Decision-making for better water management.

Example of an operation structure sheet

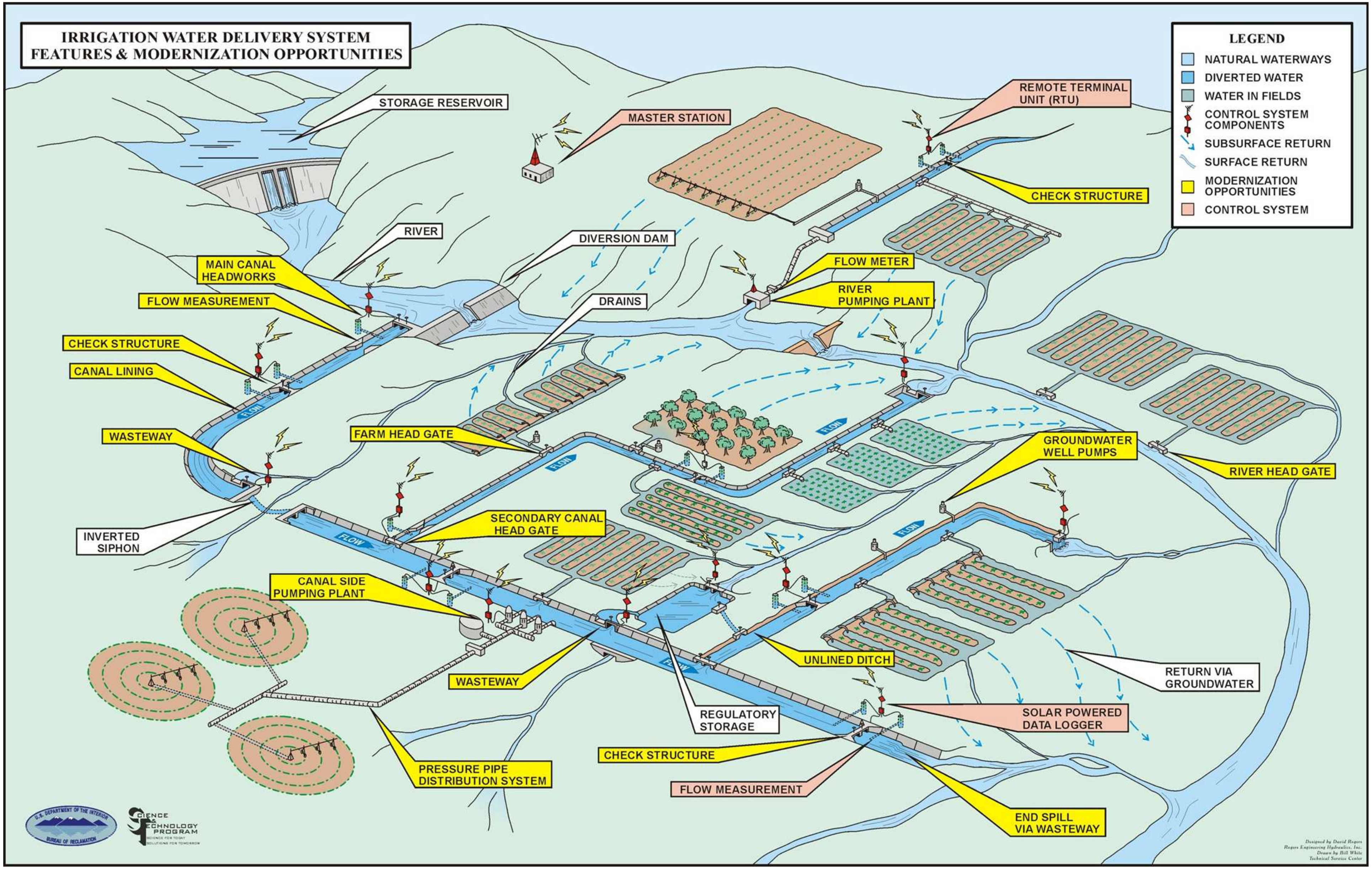
Structure X	Instructions
Function:	Diversion
Target:	From 0 to *Q* max. 100 litre/s
Tolerance:	+/-10%
Frequency of checking:	Twice a day
Modalities of checking:	Measure water level at the gauge of the downstream weir
Modalities of decision:	Centralized and/or localized
Modalities of interventions:	Opening and closing according to the operation plan by adjusting the gate opening after checking

Definitions of delivery scheduling methods

Schedule categories / water delivery service targets	Operation parameters			Flow control methods
	Rate	Duration	Frequency	
Free access / on-demand				
Unrestricted	U	U	U	DS-auto, US-auto-cent
Limited rate demand	L	U	U	DS-auto, US-auto-cent
Limited or arranged frequency	L	U	A	DS-auto, US-auto-cent
Limited duration	U	L	U	DS-auto, US-auto-cent
On-request / arranged schedules				
Arranged	A	A	A	DS-auto, US-auto
Limited rate arranged	L	A	A	US-auto, US-man
Restricted arranged	C	C	A	US auto, US-man
Fixed duration arranged	C	F	A	US-auto, US-man
Fixed rate / restricted arranged	F	C	A	US-auto, US-man
Rigid or imposed				
Central system	V	V	V	US-auto-cent; US-man
Fixed amount	F	F	V	US-auto; US-man
Fixed rotation	F	F	F	US-auto; US-man
Varied amount rotation	F(V)	F(V)	F	US-auto; US-man, Prop.
Varied frequency rotation	F	F(V)	F(V)	US-auto; US-man, Prop.
Continuous flow	F(V)	-	-	US-man, Prop.

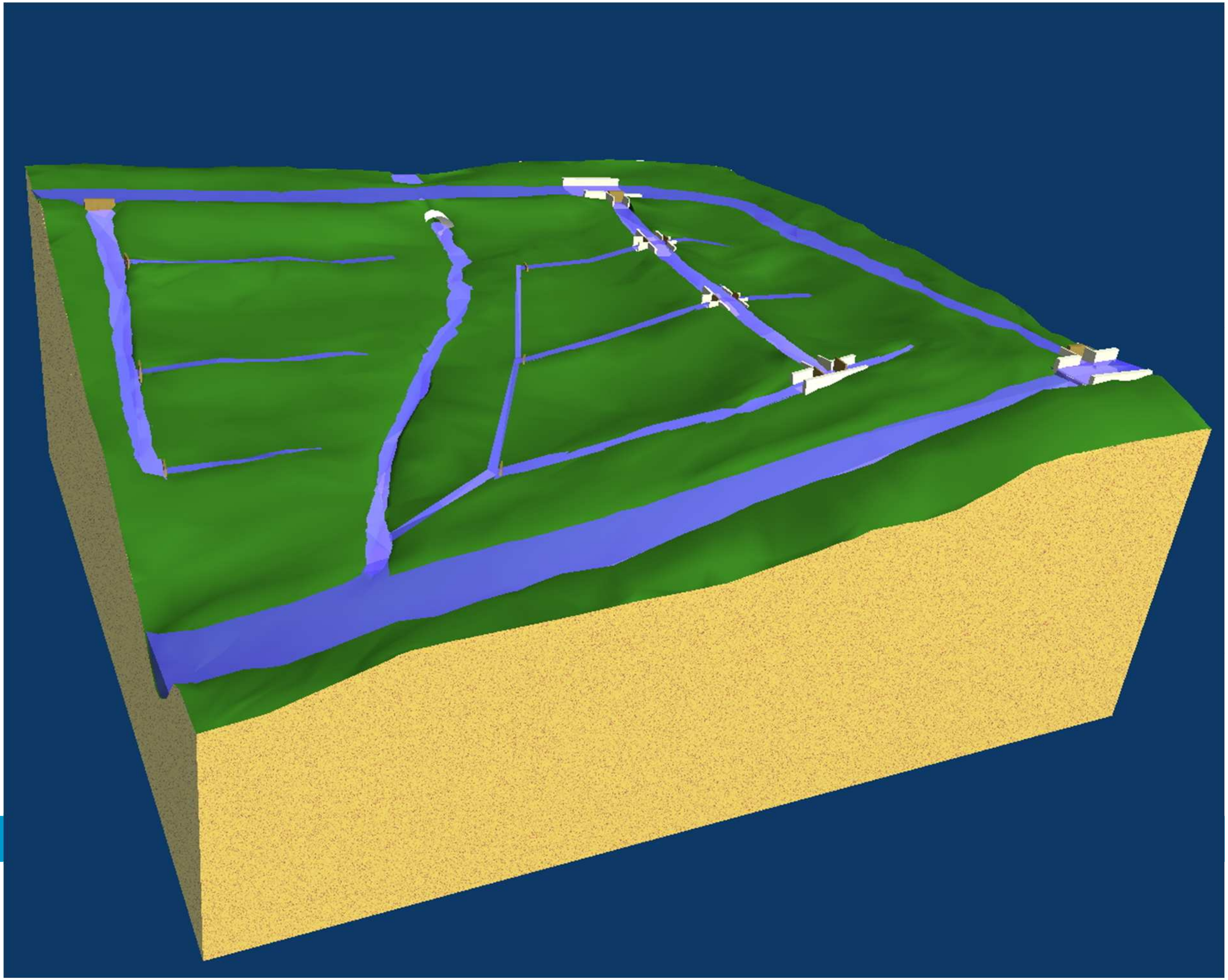
Note: U: unlimited, no restriction, under user control; L: limited to maximum flow rate, but still arranged; A: arranged between user and water authority; C: constant during irrigation as arranged; F: fixed by central policy; V: varied by central authority, at authority's discretion; (V): varied by central authority, seasonally by policy; DS-auto: downstream automatic; US-auto-cent: upstream automatic central; US-auto: upstream automatic (both central and local); US-man: upstream manual; Prop.: proportional.

Source: After Clemmens and Replogle (1987).

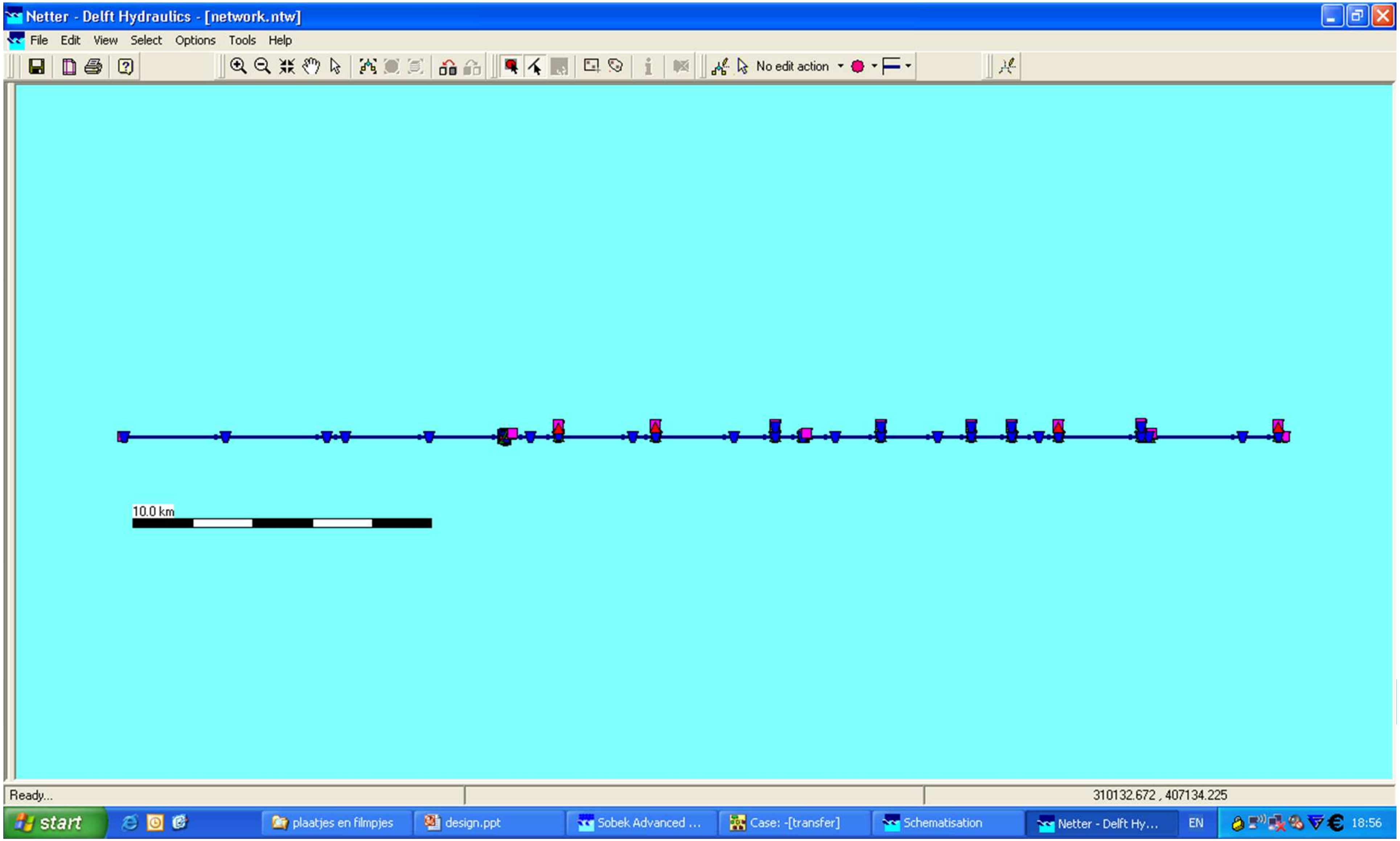


IRRIGATION WATER DELIVERY SYSTEM
FEATURES & MODERNIZATION OPPORTUNITIES
LEGEND
NATURAL WATERWAYS
DIVERTED WATER
WATER IN FIELDS
CONTROL SYSTEM COMPONENTS
SUBSURFACE RETURN
SURFACE RETURN
MODERNIZATION OPPORTUNITIES
CONTROL SYSTEM
STORAGE RESERVOIR
MASTER STATION
REMOTE TERMINAL UNIT (RTU)
CHECK STRUCTURE
RIVER
DIVERSION DAM
MAIN CANAL HEADWORKS
FLOW MEASUREMENT
FLOW METER
RIVER PUMPING PLANT
DRAINS
CHECK STRUCTURE
CANAL LINING
WASTEWAY
FARM HEAD GATE
GROUNDWATER WELL PUMPS
RIVER HEAD GATE
INVERTED SIPHON
SECONDARY CANAL HEAD GATE
CANAL SIDE PUMPING PLANT
UNLINED DITCH
WASTEWAY
RETURN VIA GROUNDWATER
REGULATORY STORAGE
SOLAR POWERED DATA LOGGER
CHECK STRUCTURE
PRESSURE PIPE DISTRIBUTION SYSTEM
FLOW MEASUREMENT
END SPILL VIA WASTEWAY
FLOW

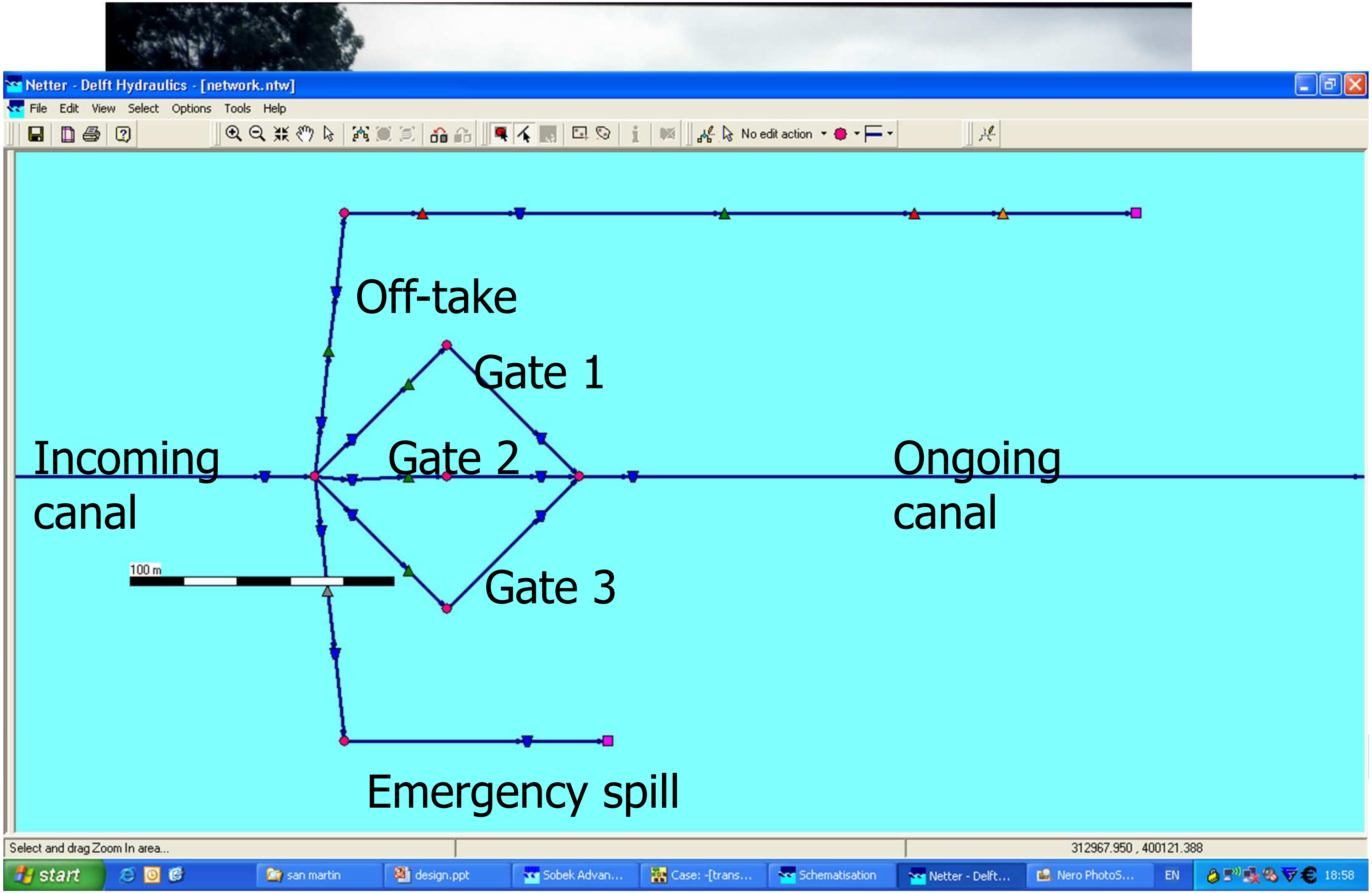
Bring back to this for the modeling



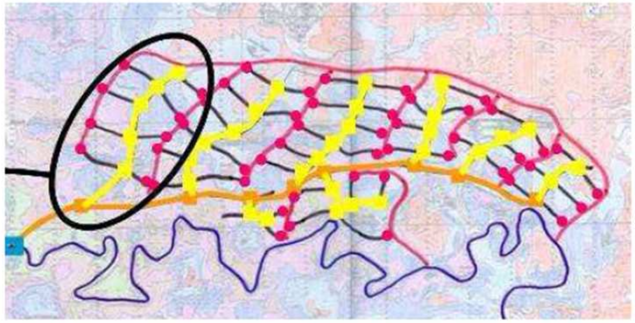
The SOBEK scheme

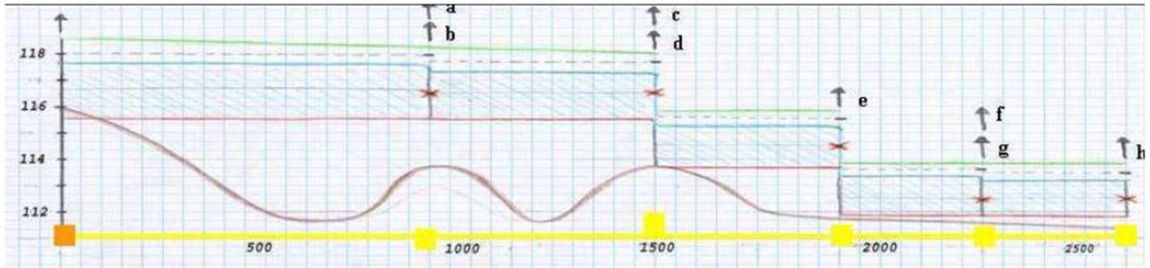


Detail in the schematization

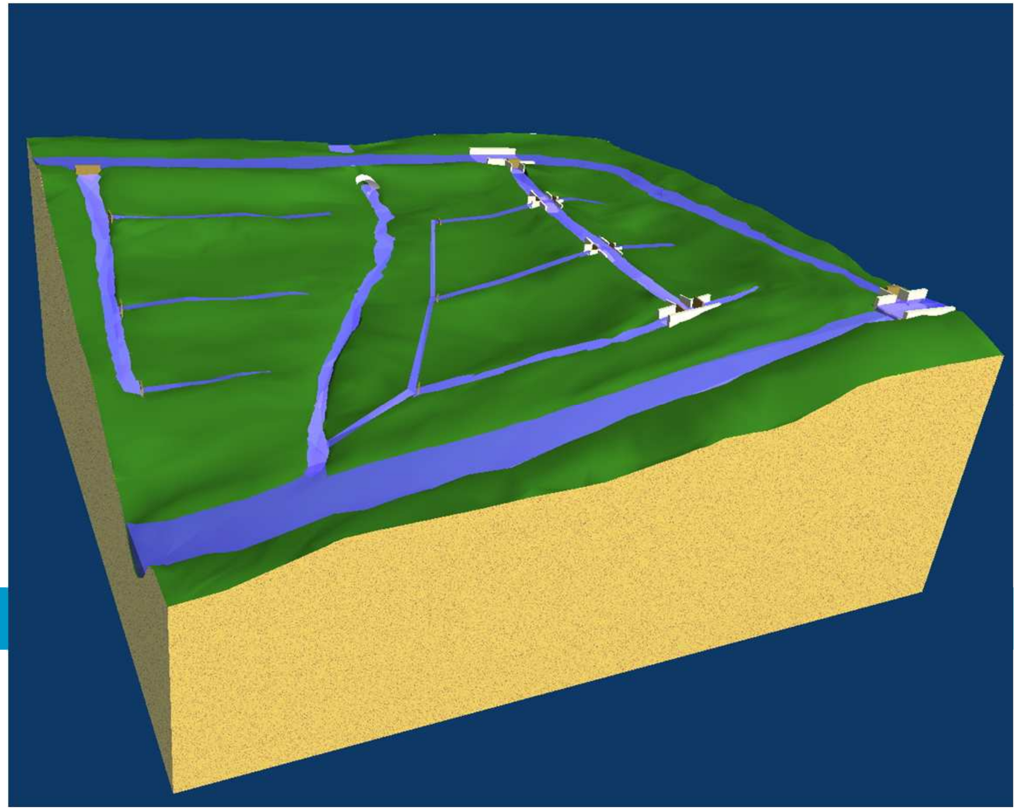


Step 1 for your own design





Try to bring your system back to something similar to the image to the right: select the main features of your system, take a representative stretch/part

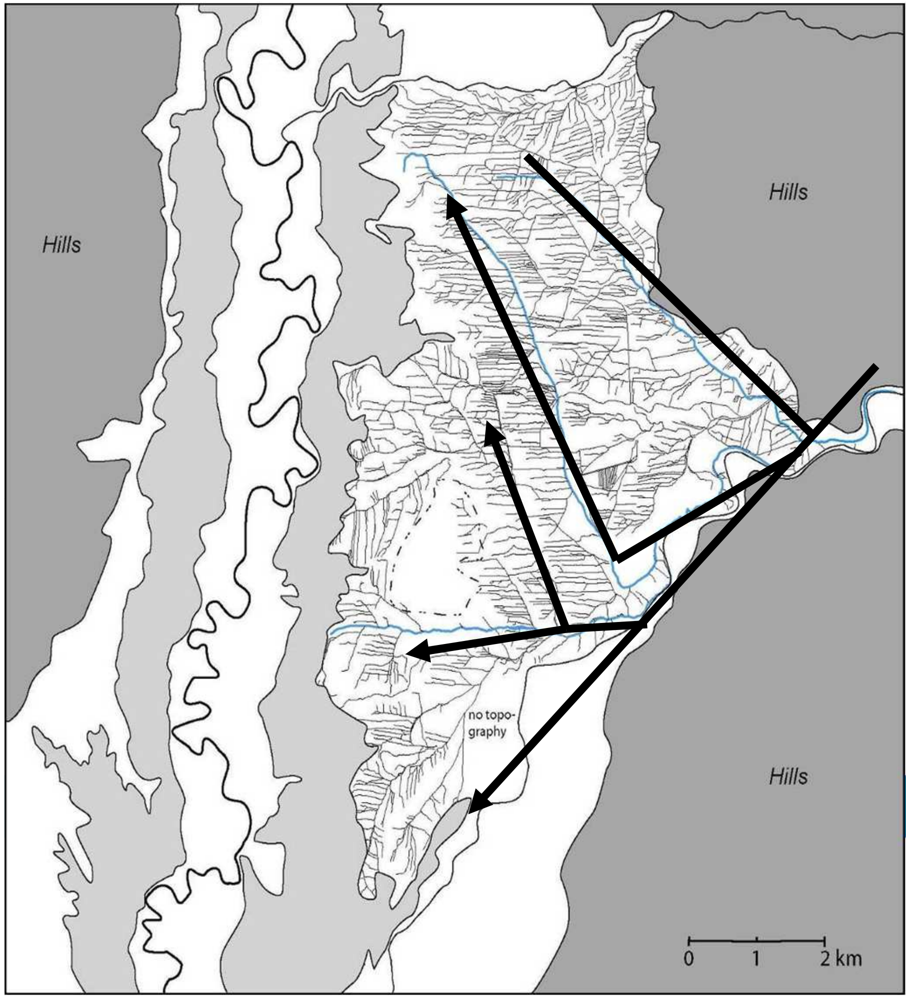


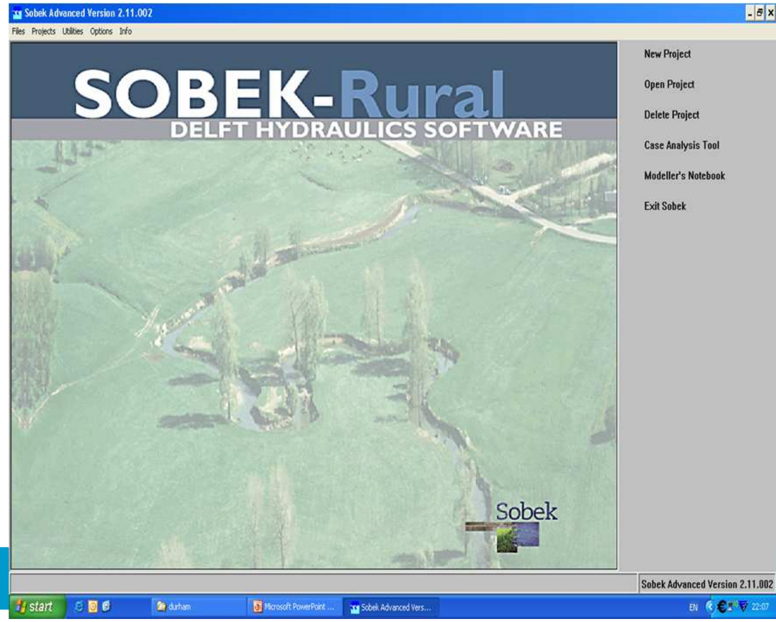
Step 2

Develop a model in Sobek.

Please note that all values to be put in Sobek need to be known beforehand.

See the hints and tips on Blackboard.





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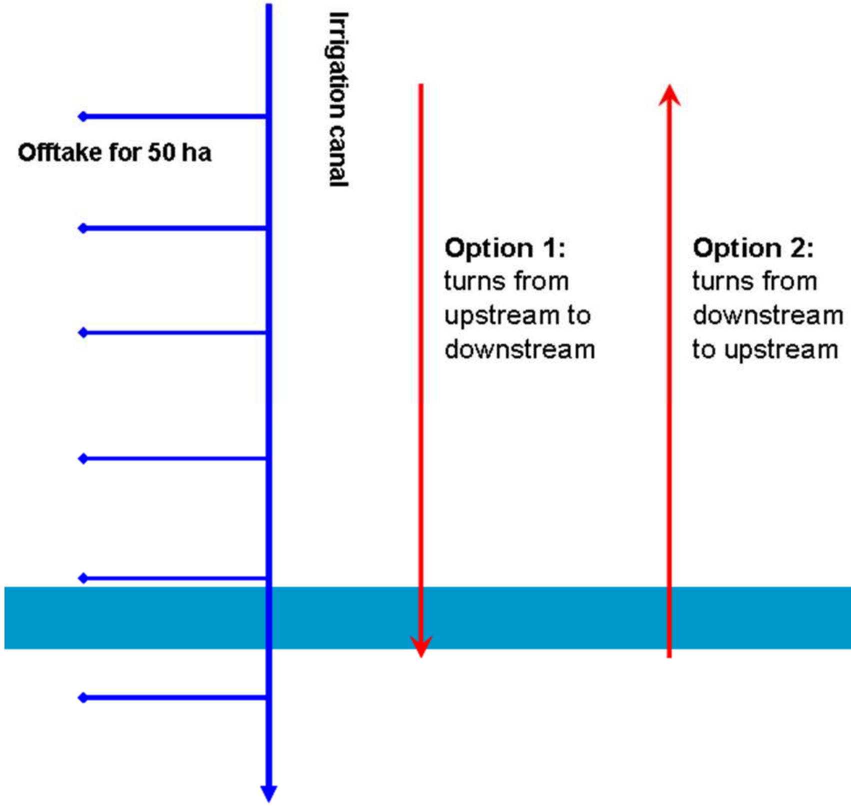
Step 3

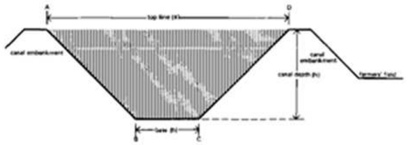
Run the scenario of a ‘typical day’ in the system.

Does the system function as planned on such a ‘typical day’?

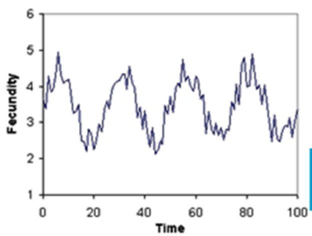
Try to predict how your system would respond to several “what happens if…” scenarios.



Complicating factor 1: seepage



Complicating factor 2: fluctuating inflows



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Improving and testing your system

- **1) Technicalities**
- Can all the fields/tertiary units be irrigated?
- Is there a canal?
- Is the energy head available sufficient?
- Can all the fields/tertiary units be drained?
- Are the calculations applicable and correct?
- …
- **2) Functionality of the system**
- Is it clear how the system has to function?
- Are the solutions selected suitable for the functions to be realized?
- How does a 'typical day' in the system look like?
- Does the system function on such a 'typical day'?
- …

What happens if?

- **3) What happens if…**
- All or some tertiary units do not irrigate?
- All or some tertiary units want to irrigate at the same time?
- Other crops are grown?
- Structures are damaged or reset?
- The maximum rainfall event and no irrigation coincide?
- There is no rainfall?
- …
- **4) Emergency scenarios: how vulnerable is the system?**
- Upstream users decide to take all the water?
- Farmers outside the area want to irrigate?
- A very dry year: minimum flows in the river are just half of mean minimum flow?
- …

Storage in the system??

- Could increase operational flexibility
- Could decrease dependence on the canal system

- On what level?
- Within the farm?
- Within tertiary unit?
- Within the secondary unit?

- In reservoirs?
- Or in canals?

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Boils down to hydraulic design of the (main) system

- **Hydraulic flexibility**
- How does the system behave and respond?

- **Operational flexibility**
- How easy is it to change operation and flows?

- **Reaction time of the system**
- How quickly does the system transport the flows according to the new setting?
- **Unsteady flow conditions may govern your system!!!!**

For now: let's move to room 1.97

- Do the Sobek tutorial, if you have not done already
- Check the two example Sobek schemes on Blackboard
  - Play with them, change them, understand them
- I have an example scheme available for you to build into Sobek

- Goal: learn Sobek en learn what information your own design should contain in order to model it properly