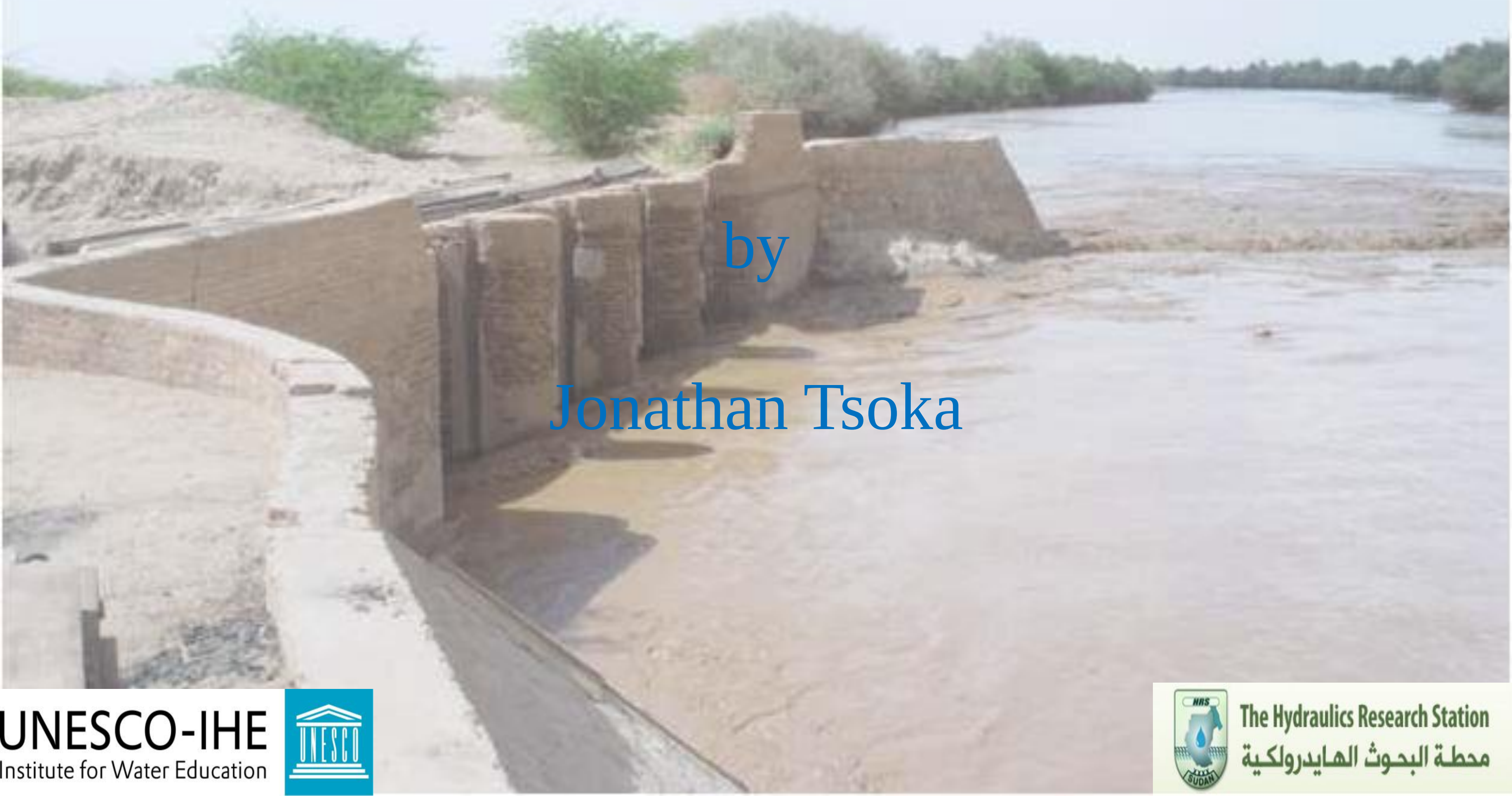
Optimization of the design of irrigation diversion structures in the GAS spate irrigation system:



by

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محطة البحوث الهايدرولكية

Outline of presentation

1. Background
2. Description of study area
3. Problem statement
4. Research objectives
5. Methodology
6. Review of existing canal design criteria
7. Analysis of design options
8. Conclusion
9. Recommendations

Background

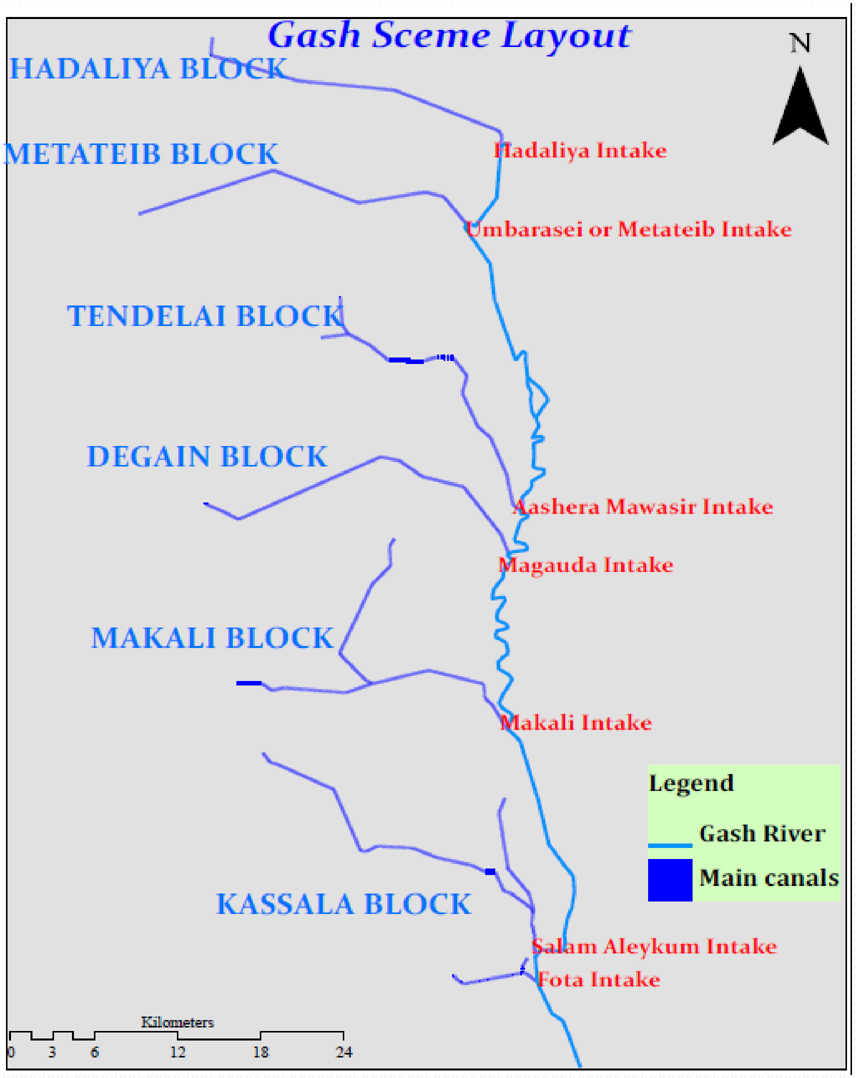
- Research is an outcome of the stakeholder workshop organized by the Hydraulic Research Station (HRS) in Sudan from 5 -6 June 2011.

- Main objective of the workshop was to identify research gaps in the Gash Agricultural Scheme (GAS)

- Key research programme: Towards increased agricultural production and productivity:
  - Optimizing design of intakes and canals

- The study was carried out in Eastern Sudan near Kassala town, in the GAS

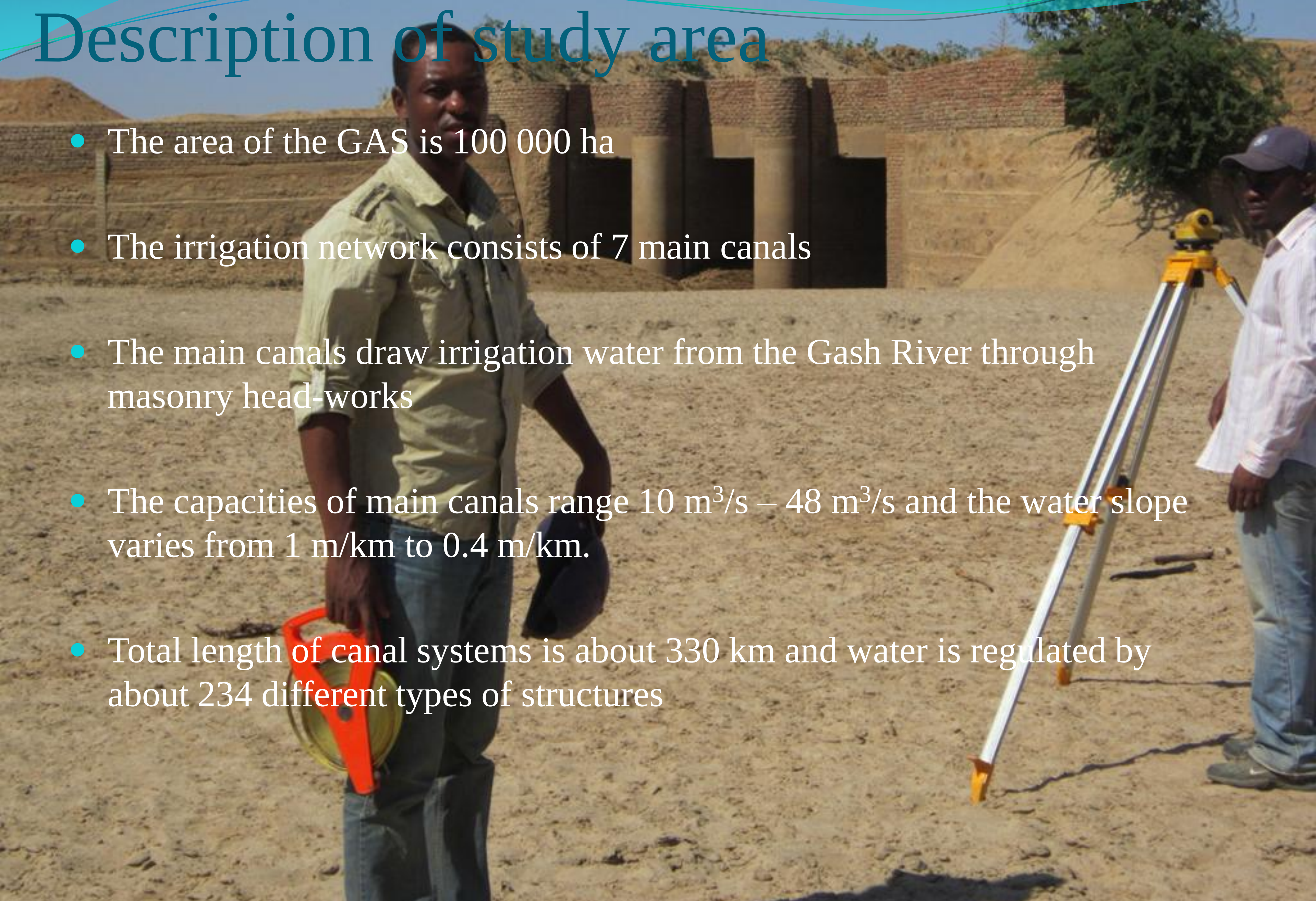
Description of study area



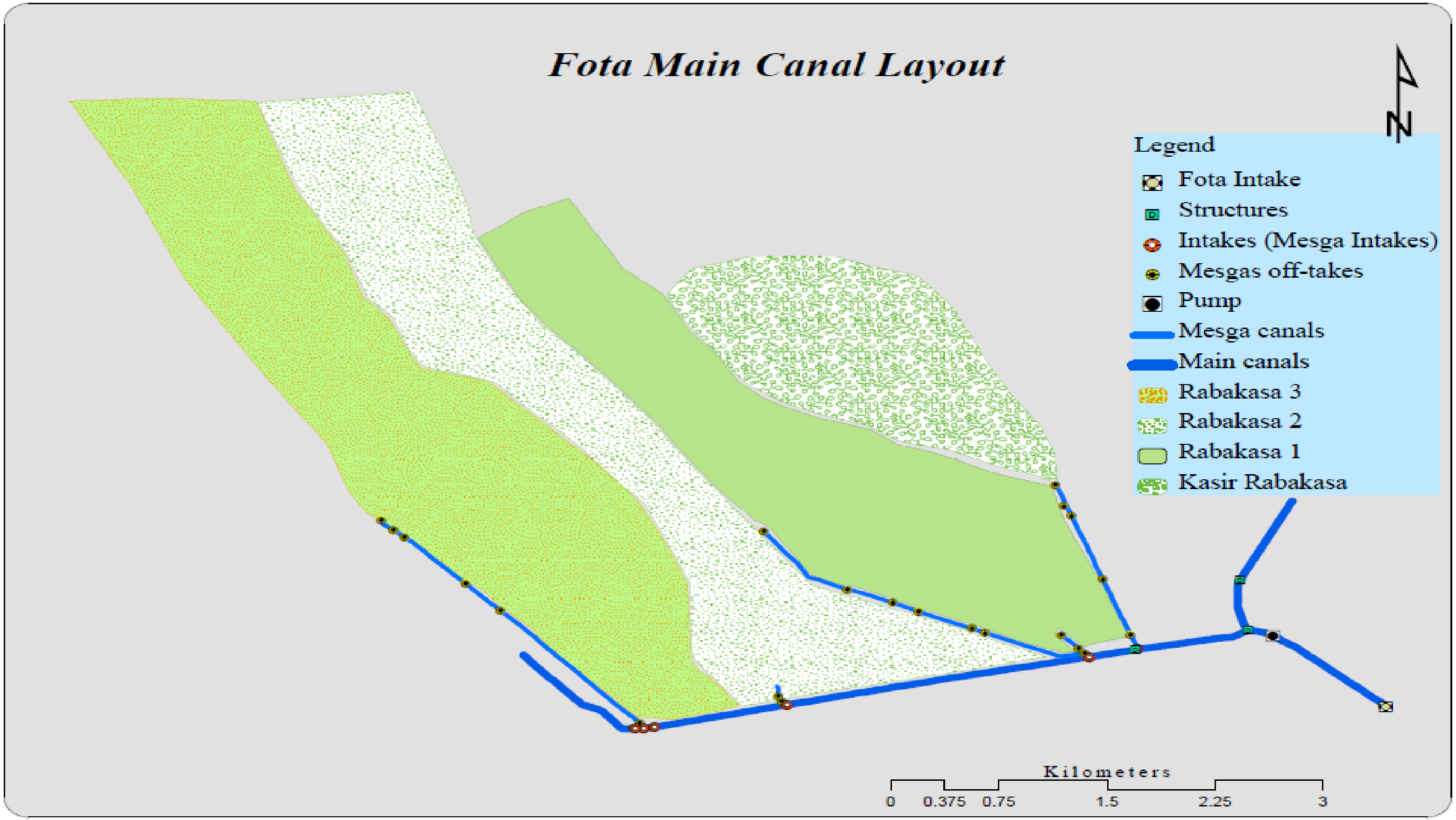
Temperature range : Max = 42 °C and Min = 16 °C
Average Annual Rainfall : 100 mm – 260 mm

Description of study area

- The area of the GAS is 100 000 ha
- The irrigation network consists of 7 main canals
- The main canals draw irrigation water from the Gash River through masonry head-works
- The capacities of main canals range 10 m^3/s – 48 m^3/s and the water slope varies from 1 m/km to 0.4 m/km.
- Total length of canal systems is about 330 km and water is regulated by about 234 different types of structures



Study area cont…



- Area of Fota: 13 500 Fd (5 670 ha)
- Consists 5 secondary canals
- Main canal intake has a capacity of 18 m^3/s
- Length of main canal is 1.17 km

Problem Statement

- Poor performance by Fota intake – abstraction is less than the required discharge of 9.4 m^3/s
- Poor water distribution in the Fota canal
- Only about 60% of Fota command area is irrigated
- These problems have existed for over 30 years and the local authorities are looking for a practical-oriented solution

Research Objectives

Objectives

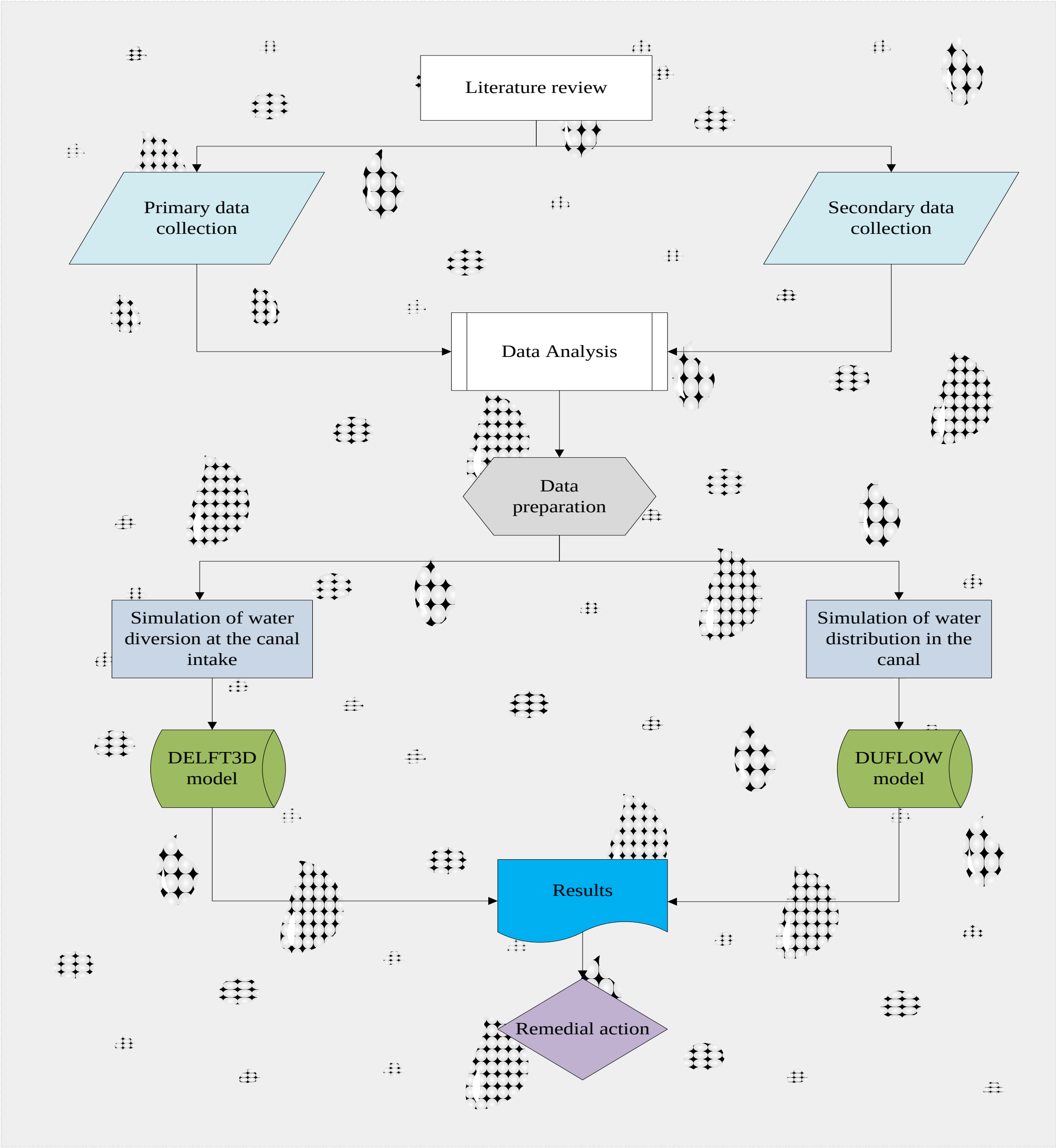
- Optimise irrigation diversion structures in the GAS for improving productivity and rural livelihoods.

Specific Objectives

- Review the existing design criteria and identify its limitations if any
- Simulate and analyse design options in the context of different flood scenarios.
- Evaluate the impacts of the options
- Suggest the most optimal practically viable remedial measures

Research Methodology

Logical Framework



Review of existing design criteria of Fota canal

Design based on 1 $m^3/s/210$ hectares (approximately 5 l/s/ha)

Application depth	Misga	Area (ha)	Q Volume (1000 m^3)	Time of application (days)	Q (1000 m^3/day)	Q (m^3/s)
1230 mm	Kasir Rabakasa	294	3629	30	121	1.4
	Rabakasa 1	546	6739	30	225	2.6
	Rabakasa 2	630	7776	30	259	3
	Rabakasa 3	756	9331	30	311	3.6
	Rabakasa 4	924	11405	30	380	4.4
	Fota 1	546	6739	30	225	2.6
	Fota 2	714	8813	30	294	3.4
	Fota extension 1	756	9331	30	311	3.6
	Fota extension 2	504	6221	30	207	2.4

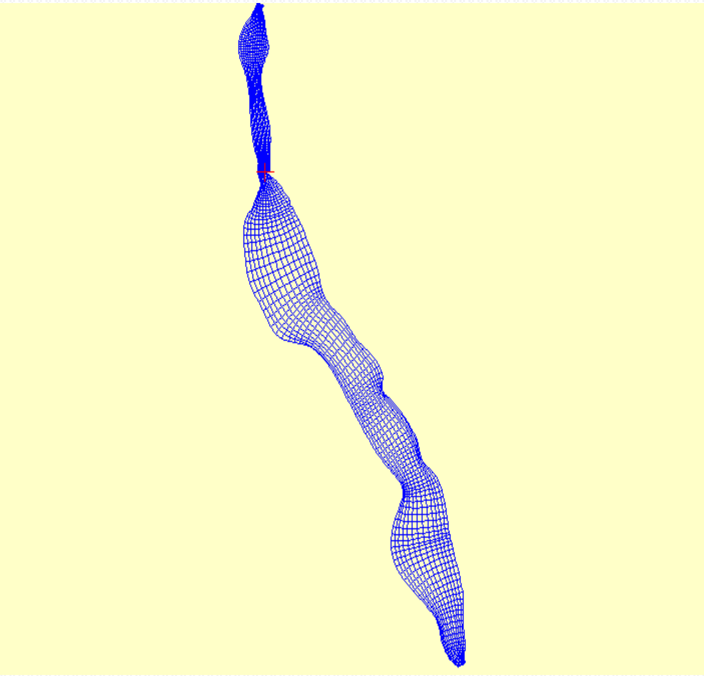
Review cont…

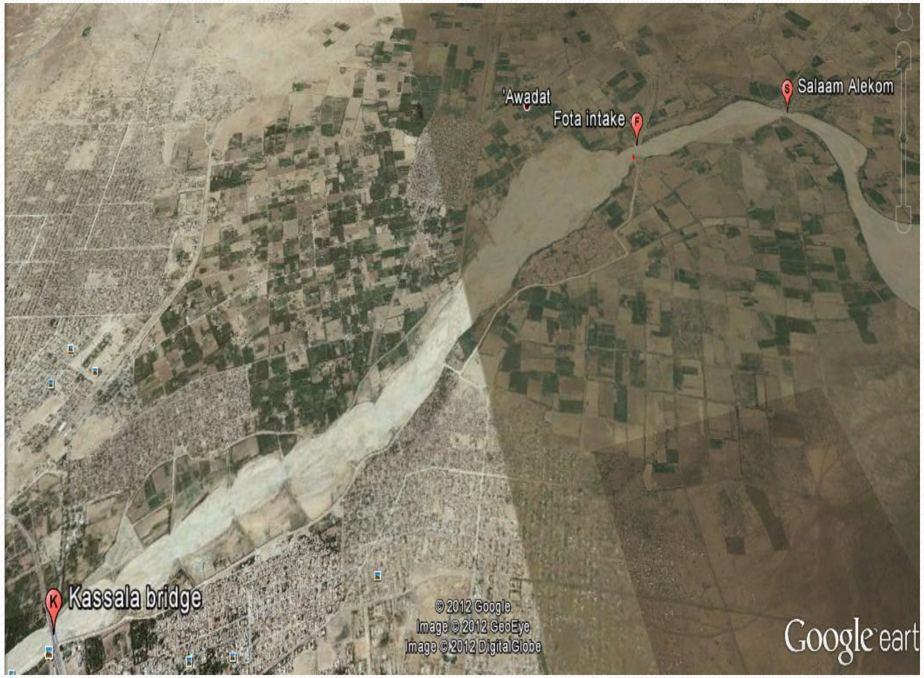
Discharge required from Fota intake

First irrigation	**Discharge (m^3/s)**
Kasir Rabakasa	1.4
Rabakasa 2	3.0
Fota 1	2.6
Fota extension2	2.4
Total	**9.4**

Model set up and calibration

DELFT3D





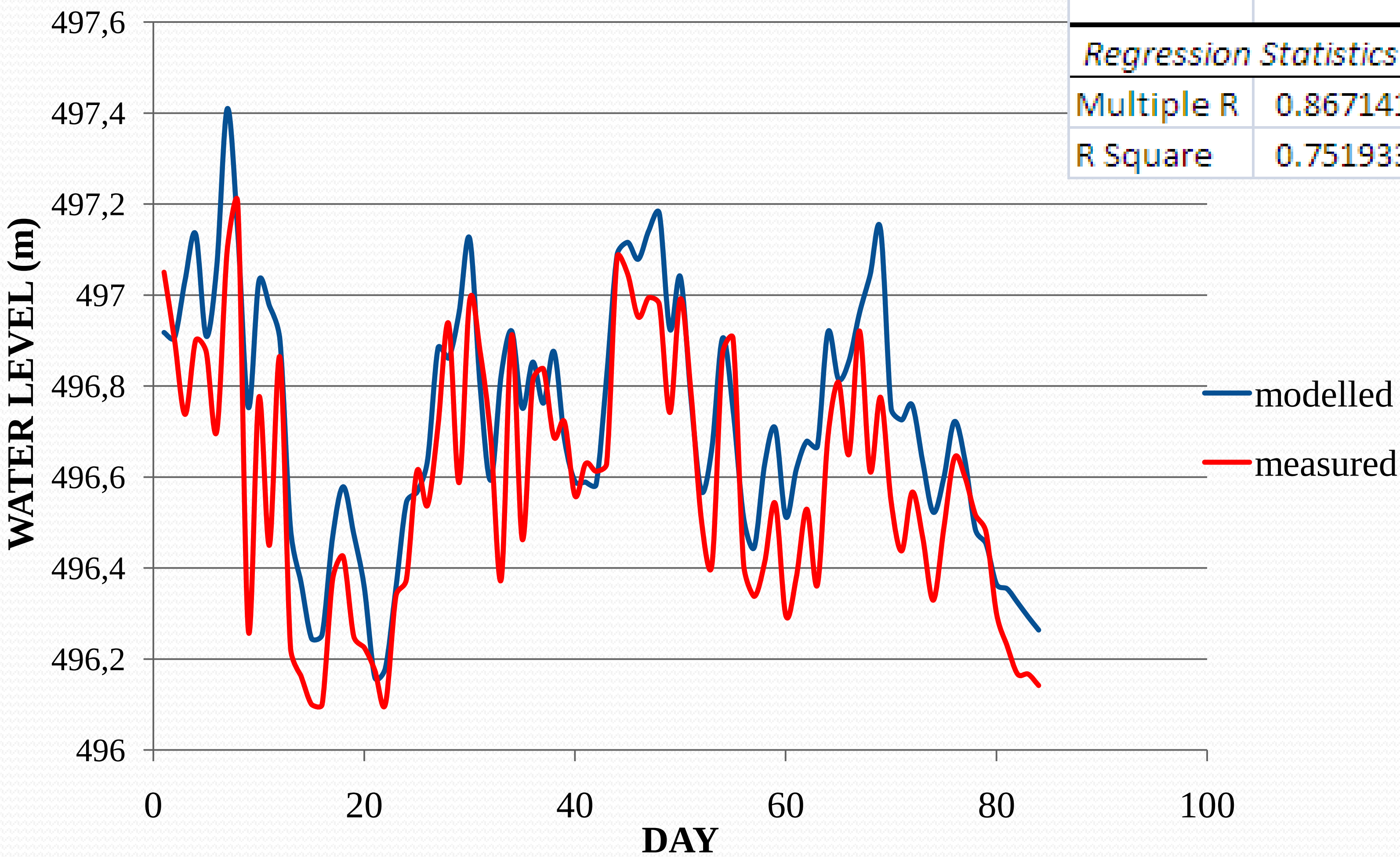
Boundary conditions:

Upstream boundary Kassala Bridge – Type of open boundary is discharge

Down stream boundary: Salaam Alekom - Type of open boundary is water level

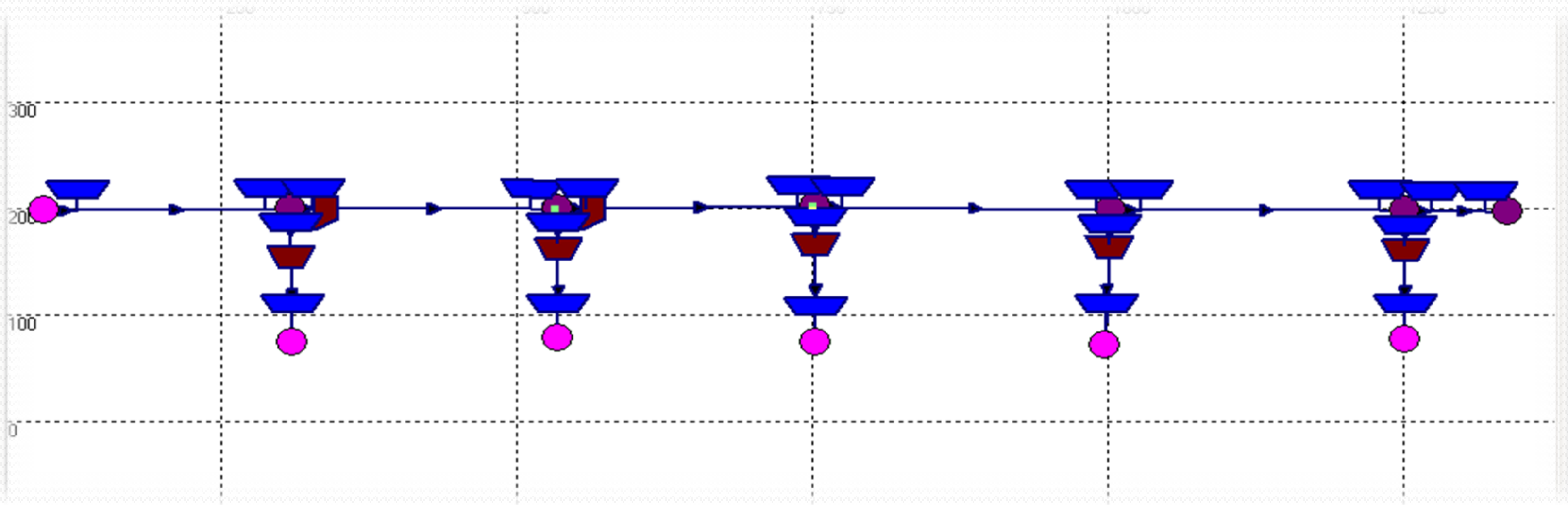
DELFT3D Model Calibration

Model Calibration



SUMMARY OUTPUT	
Regression Statistics	
Multiple R	0.867141
R Square	0.751933

DUFLOW



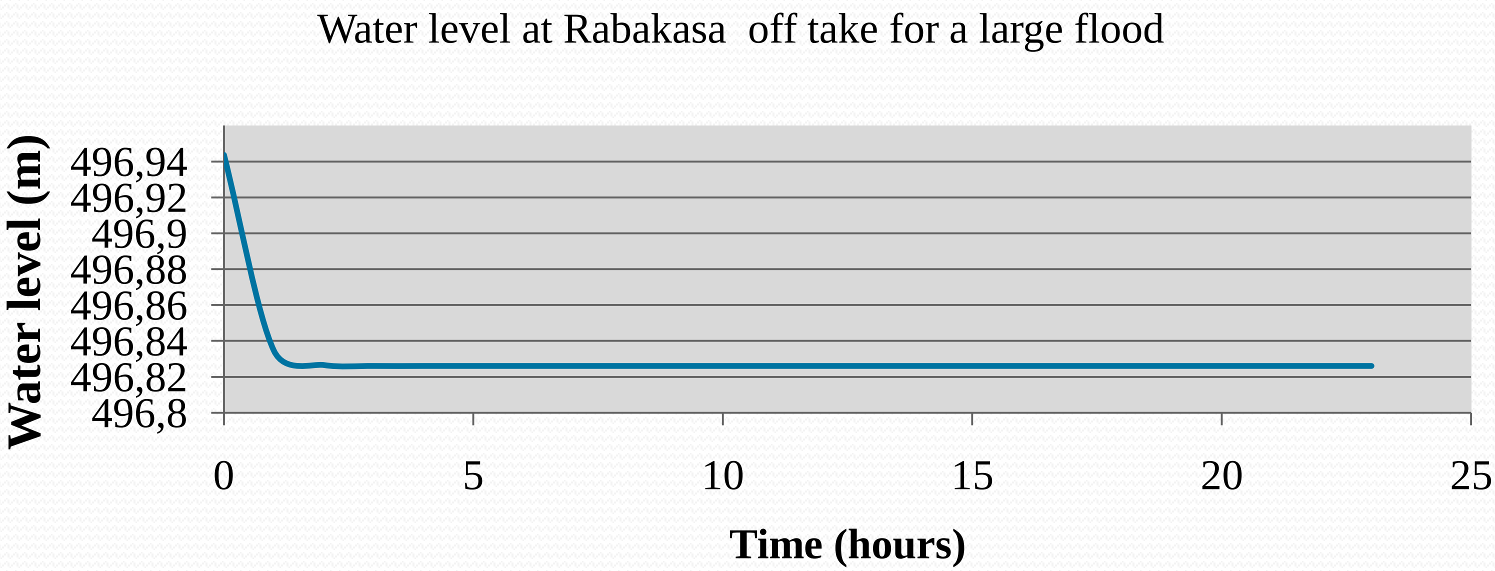
Initial conditions

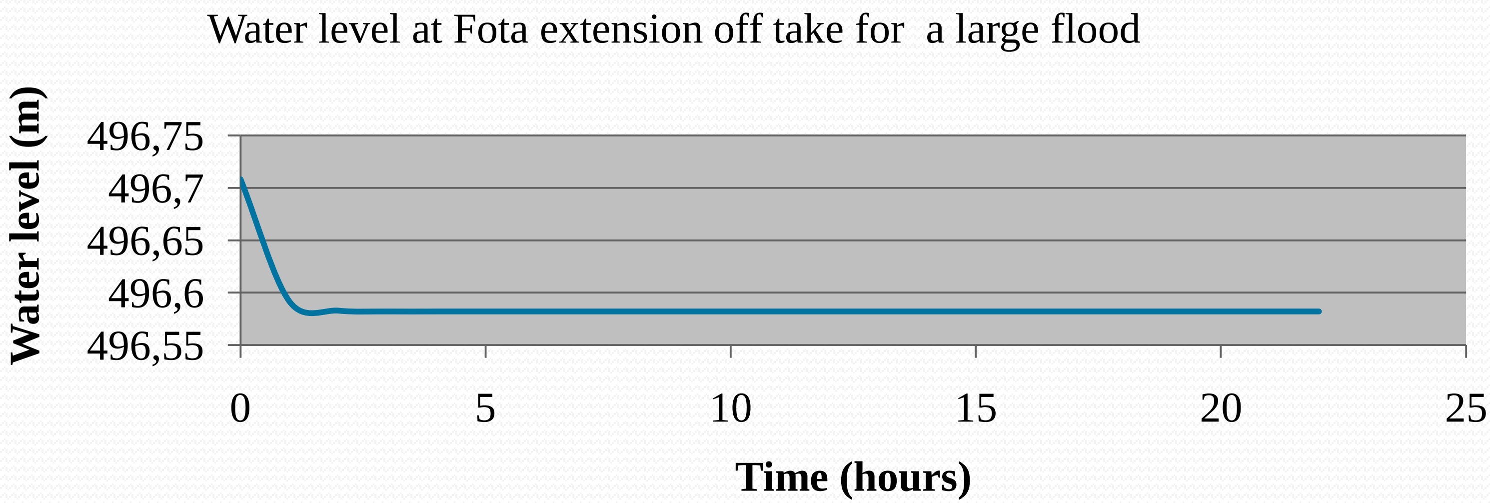
Water level - 497 m and discharge - 0 m^3/s.

Boundary conditions

The boundary conditions : discharge on the upstream and the Q-H curves on the downstream nodes.

DUFLOW model calibration

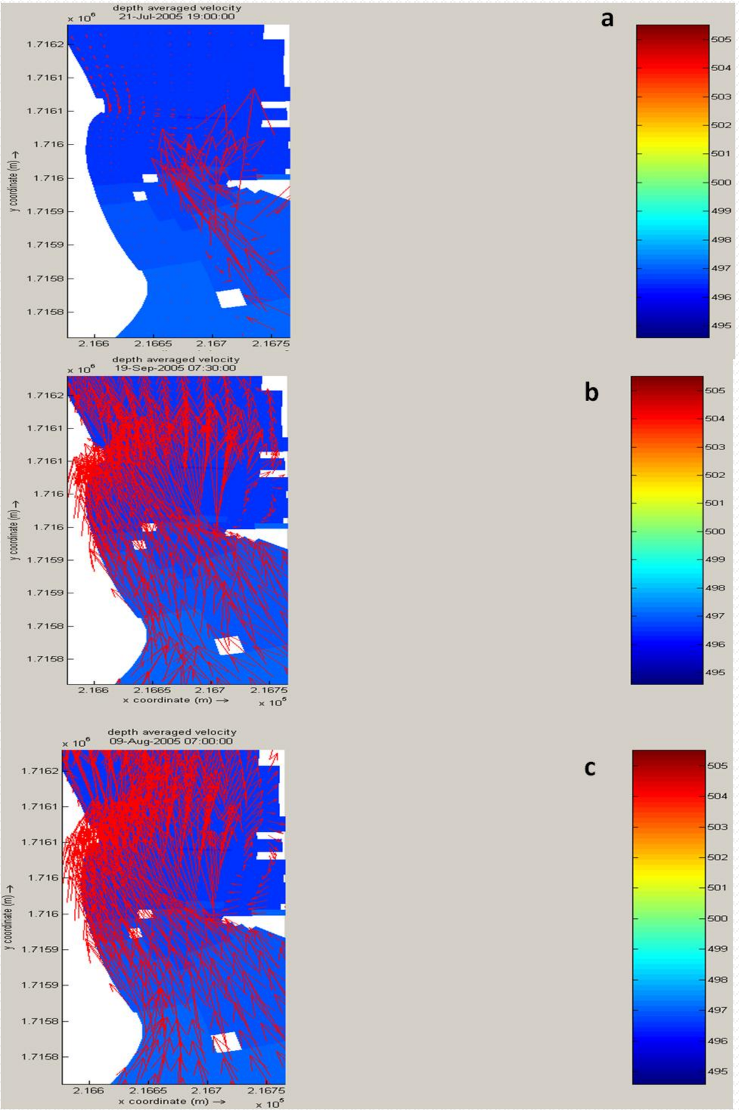


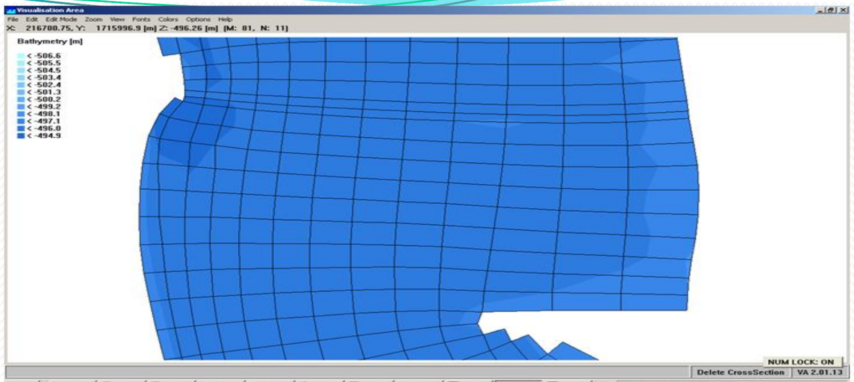


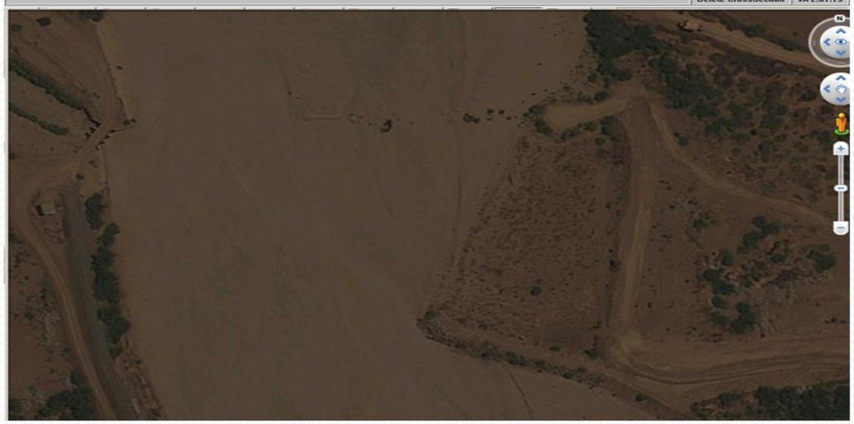
Results

DELFT3D Results

Existing situation

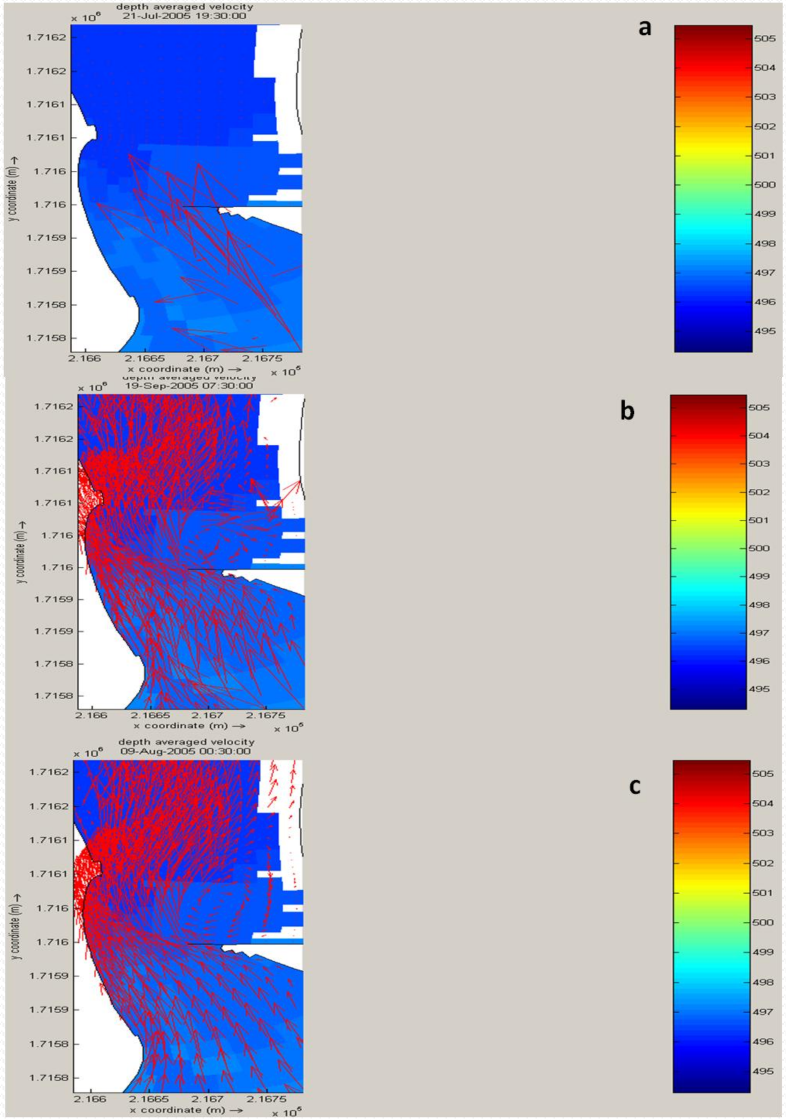


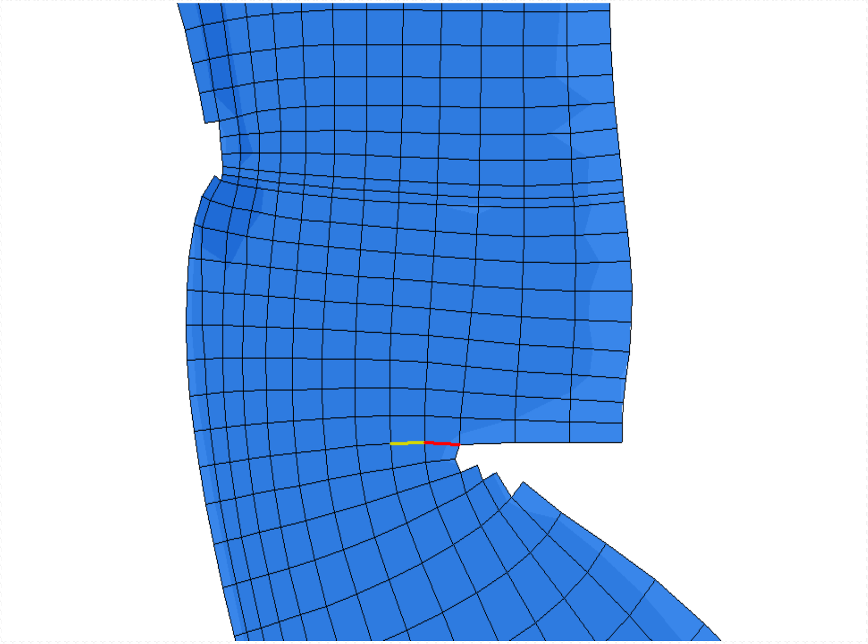




Output		
Flood type	**Water level (m)**	**Discharge uptake by Fota intake (m^3/s)**
Low flood (discharges)	496.4	3.3
Medium flood	496.75	8.1
High flood	497.44	16

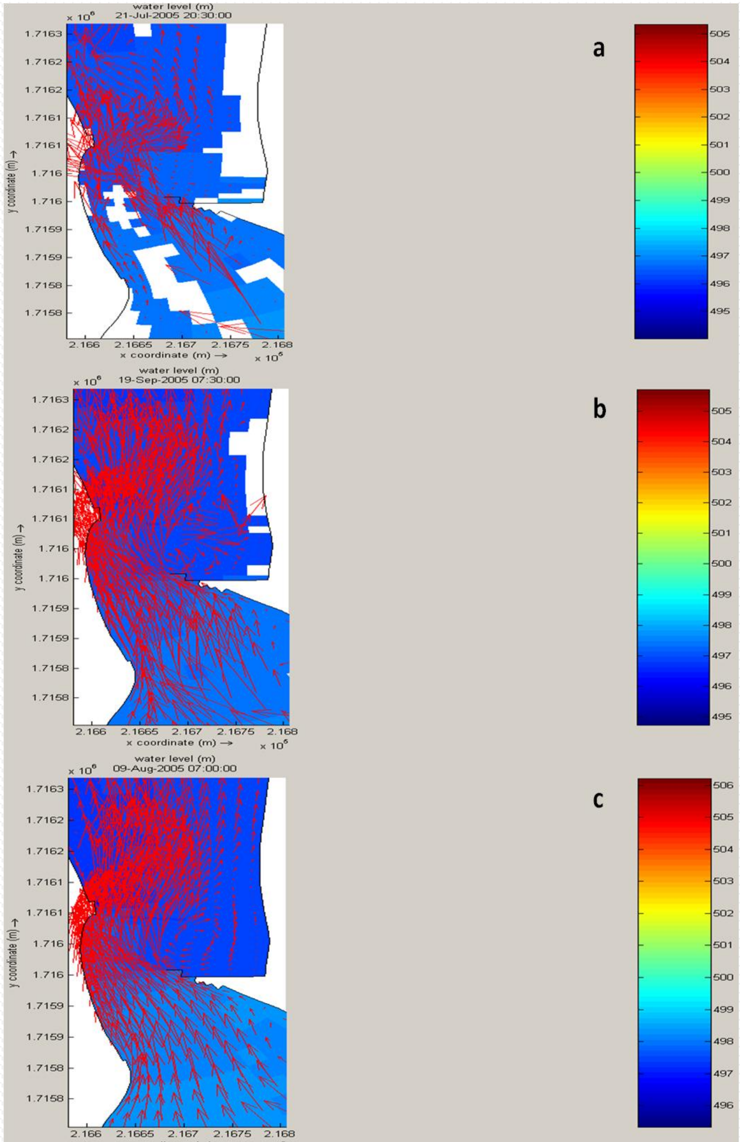
1. Effect spur extension by 27 m at 90 degrees to flow direction

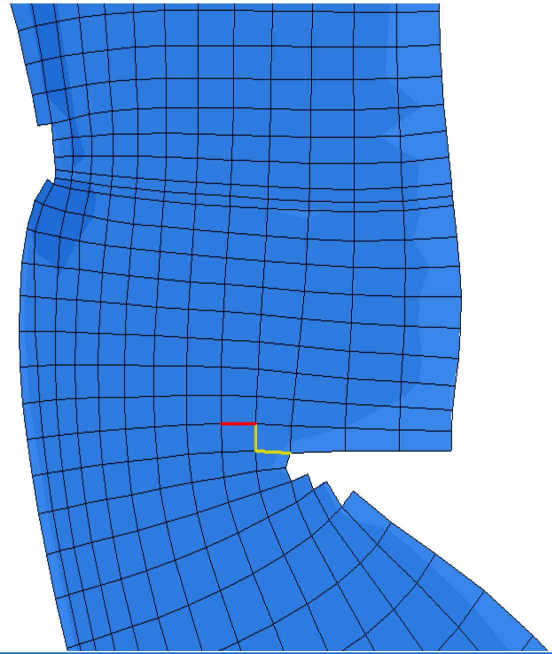




Output		
Flood type	**Change in Water level (m)**	**Change in Discharge (m^3/s)**
Low flood	0.16	1.3
Medium flood	0.25	2.0
High flood	0.38	3.1

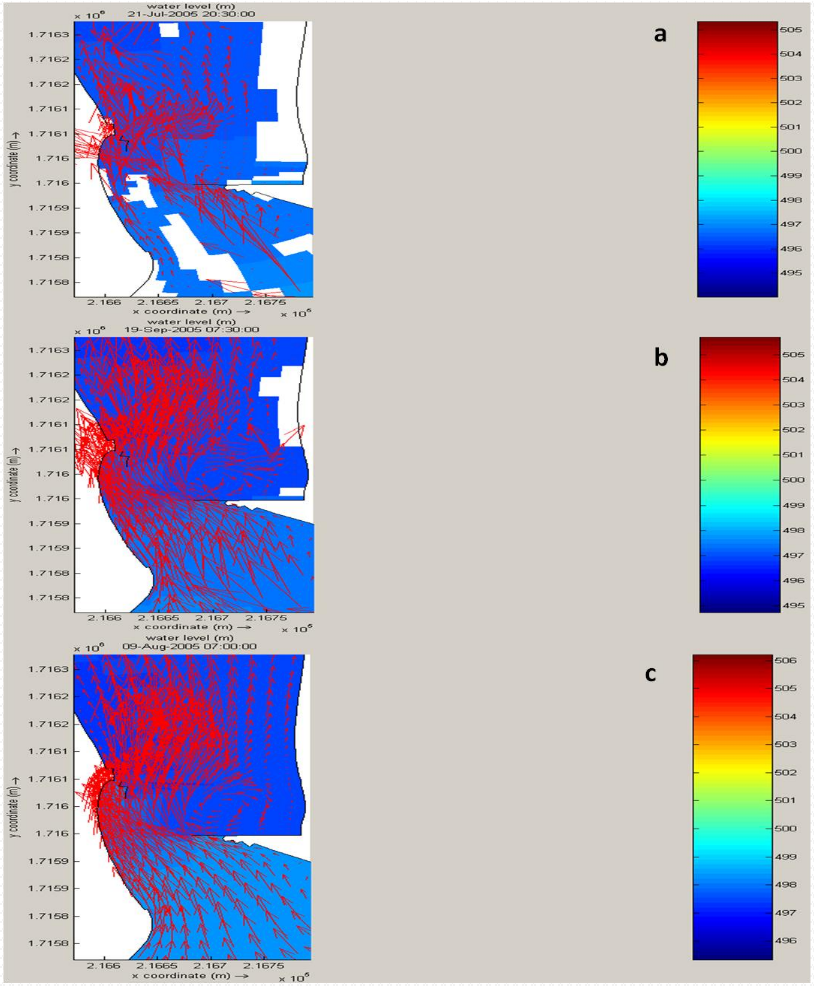
2. Effect of spur extension by 27m in downstream direction at 45 degrees

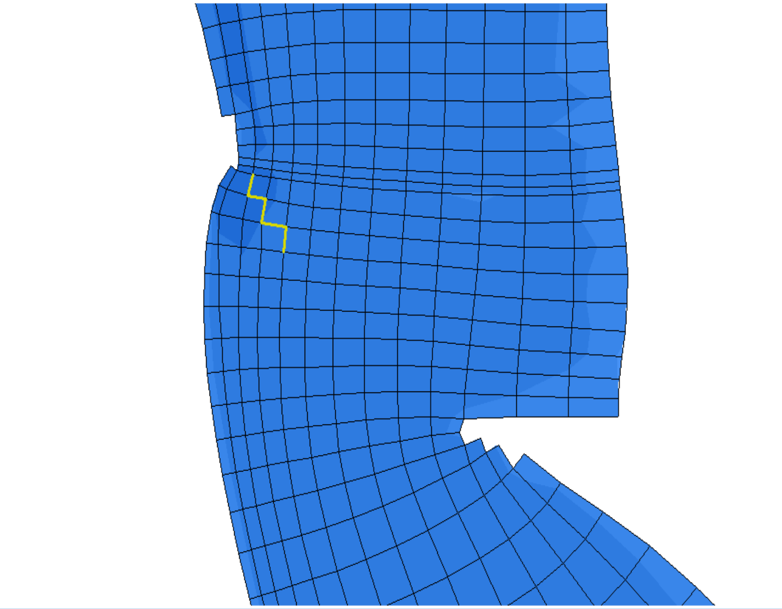




Output		
Flood type	**Change in Water level (m)**	**Change in Discharge (m^3/s)**
Low flood	0.16	1.3
Medium flood	0.25	2
High flood	0.35	2.8

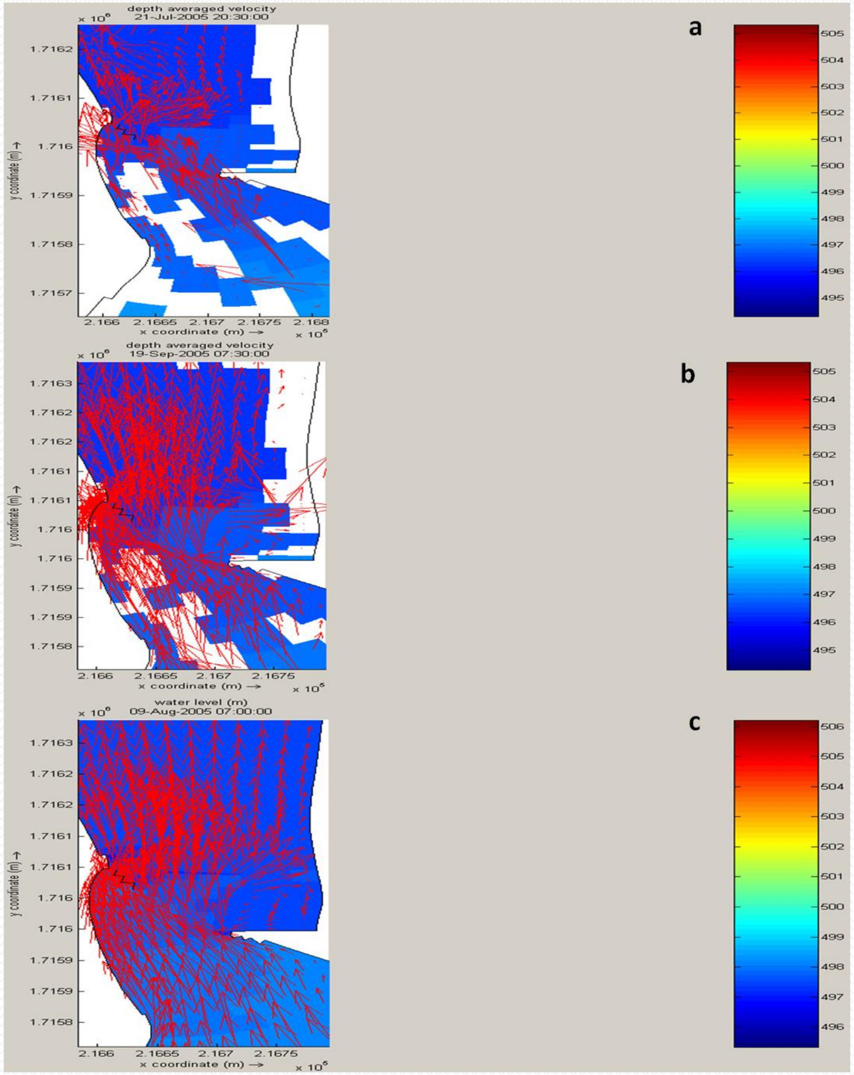
3. Effects of 20 Guiding wall

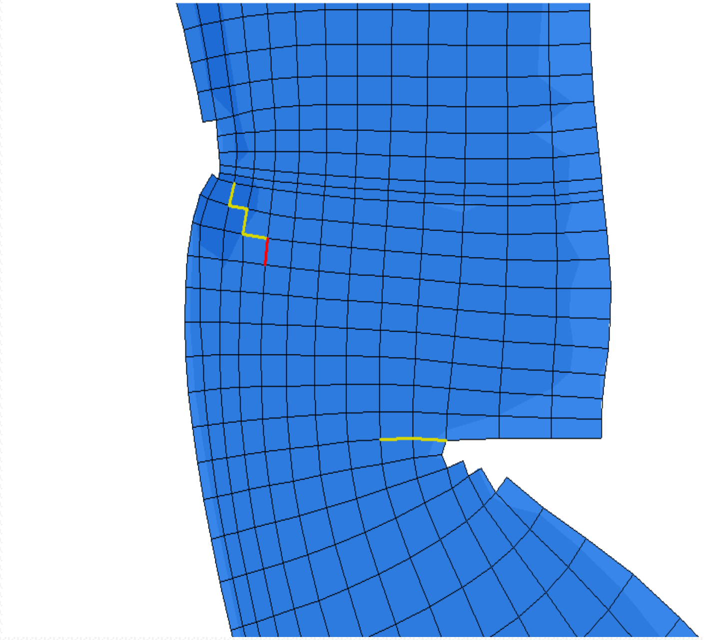




Output		
Flood type	**Change in Water level (m)**	**Change in Discharge (m^3/s)**
Low flood	0.17	1.4
Medium flood	0.26	2.1
High flood	0.25	2.0

4. Guiding wall + extended spur





Output		
Flood type	**Change in Water level (m)**	**Change in Discharge (m^3/s)**
Low flood	0.28	2.2
Medium flood	0.45	3.6
High flood	0.5	4.2

Results summary

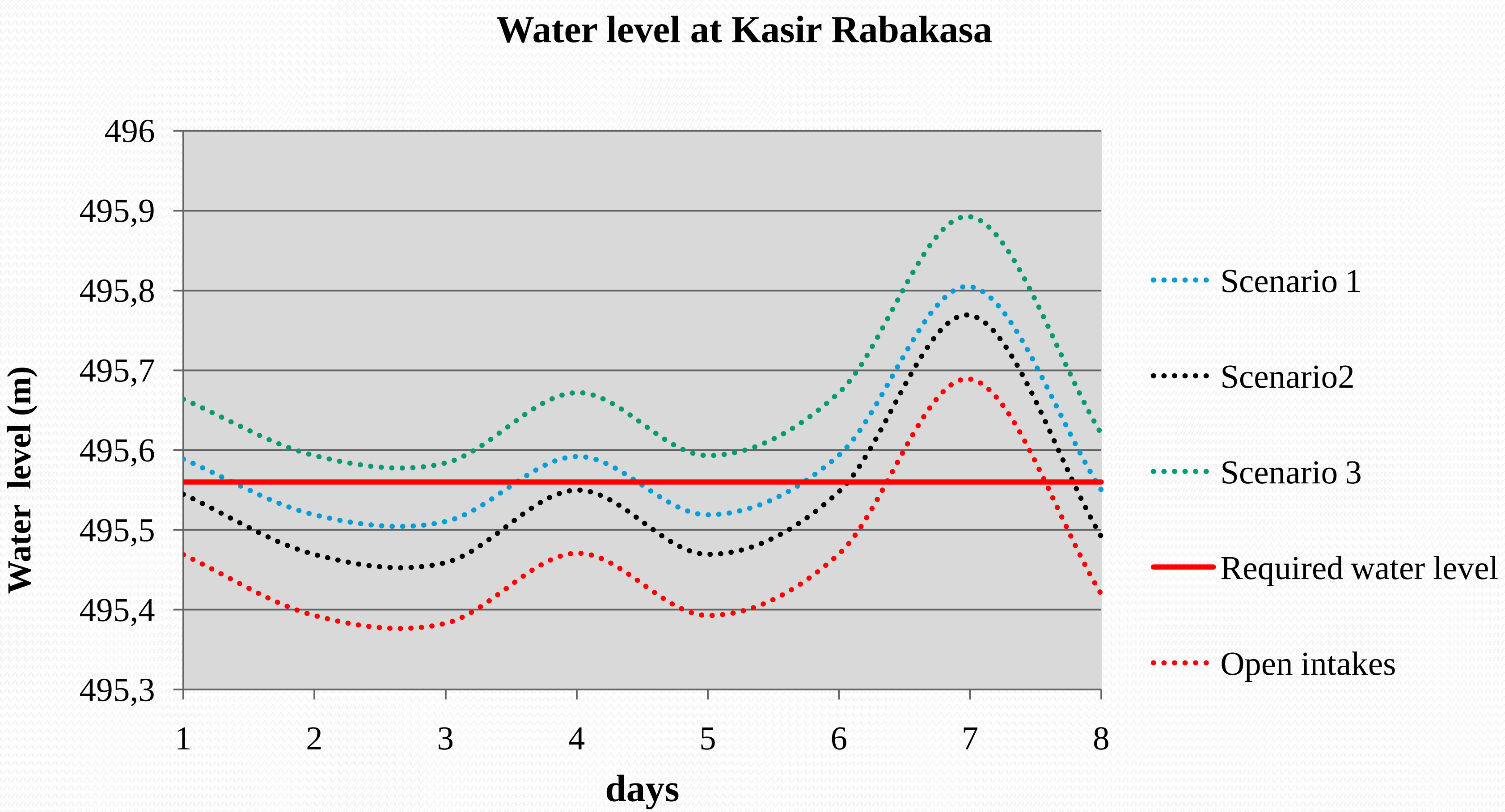
Summary table of the discharge of the scenarios

	Discharge (m^3/s)		
Scenario	Low	Medium	High
Existing situation	3.3	8.1	16
1	4.6	10.1	19.1
2	4.6	10.1	18.8
3	4.7	10.2	18
4	5.5	11.7	22.2

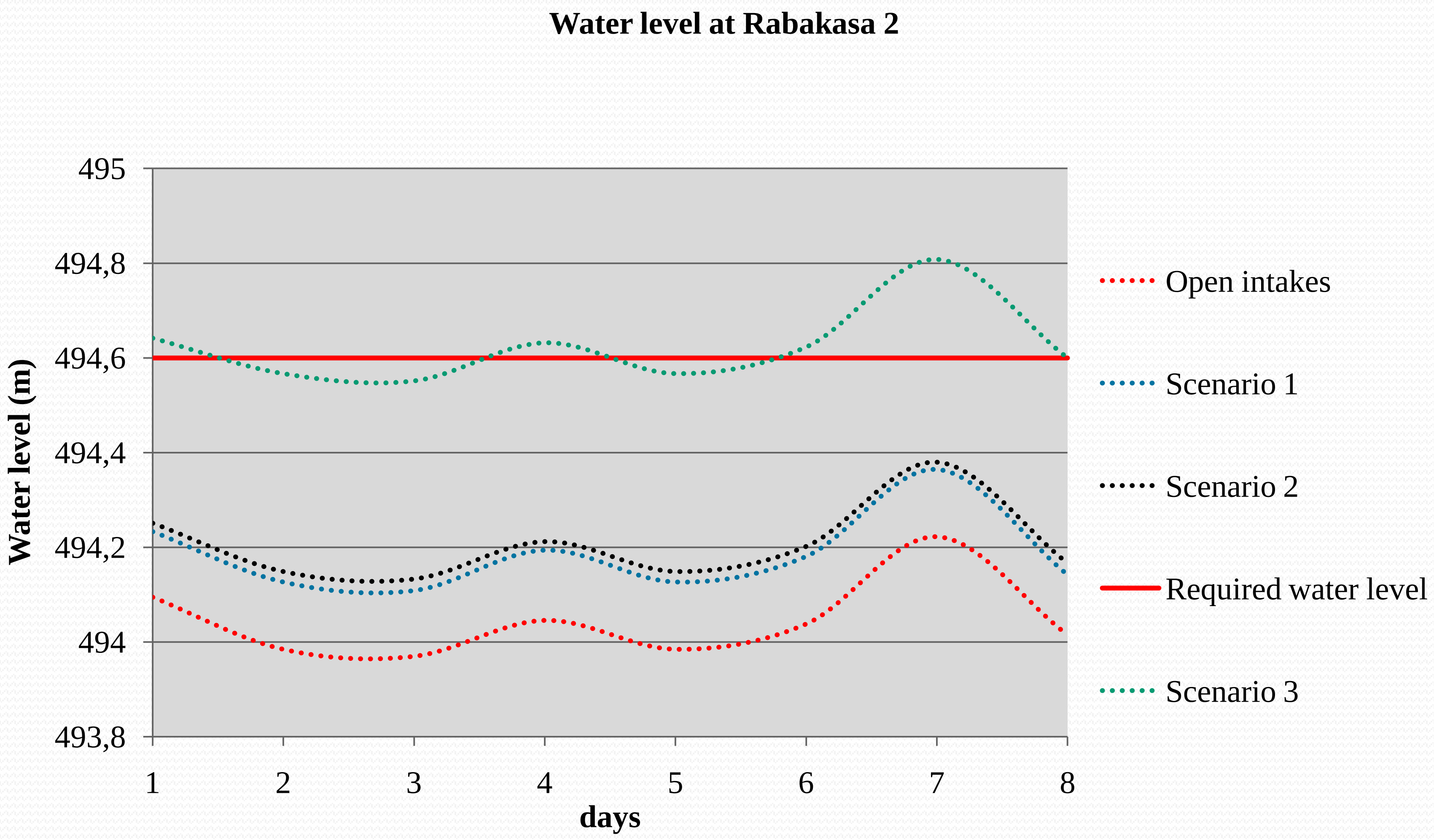
DUFLOW Results

Scenarios

1. Operating the system with all intakes open
2. Scenario 1: Closing cross regulator at the 800 m point in the Rabakasa canal (K 0.8) by 0.4 m
3. Scenario 2: Closing cross regulator at K 0.8 by 0.2 m
4. Scenario 3: Increasing canal width by 1 m in the Kasir Rabakasa reach and introducing a new cross regulator at the 3.3 km point in Rabakasa canal (K 3.3), closing it by 0.9 m



Water level at Kasir Rabakasa
496
495,9
495,8
495,7
495,6
495,5
495,4
495,3
Water level (m)
1
2
3
4
5
6
7
8
days
Scenario 1
Scenario2
Scenario 3
Required water level
Open intakes


Water level at Rabakasa 2
495
494,8
494,6
494,4
494,2
494
493,8
Water level (m)
1
2
3
4
5
6
7
8
days
Open intakes
Scenario 1
Scenario 2
Required water level
Scenario 3

Conclusion

- The 1 $m^3/s/210$ ha design criteria results in a canal capacity of 9.4 m^3/s and with 30 days application provides a depth of 1230 mm which is sufficient for most crops grown in the area. The existing design criteria has no problem.

- Scenario 4 (the combination of a guiding wall and spur extension) gives the highest water level at the canal intake for all flood types.

- The combination of spur extension and a guiding wall gives flow increments of 3.6 m^3/s and 4.16 m^3/s for medium and high floods respectively, and this could increase the irrigated area by 800 ha.

- Increasing the canal width in the Kasir Rabakasa reach by 1m ensures that 1.4 m^3/s is received in the Kasir Rabakasa canal.

- Introducing a cross regulator at the 3.3 km point in the Rabakasa canal and shutting it by 0.9 m will ensure 3.0 m^3/s will be drawn by Rabakasa 2 canal.

Recommendations

- Scenario 4 (the combination of a guiding wall and spur extension) should be considered for implementation
- The spur and guiding wall should be reinforced to avoid damage by large floods and the guiding wall should have a side spillway to allow excess flood water to be released.
- The canal width in the Kasir Rabakasa reach by should be increased by1 m.
- A new cross regulator should be introduced in the system at the 3.3 km point to increase the abstraction of water by Rabakasa 2 off take.
- Maintenance of canal widths should be ensured by the authorities so that their capacities do not change as this could lead to under supply and or over supply of water to some sections in the system
- Modification of the area around the diversion structure should be done to ensure increased abstraction of water.

Thank you