Government of India

Ministry of Water Resources, River Development and Ganga Rejuvenation

National Water Mission

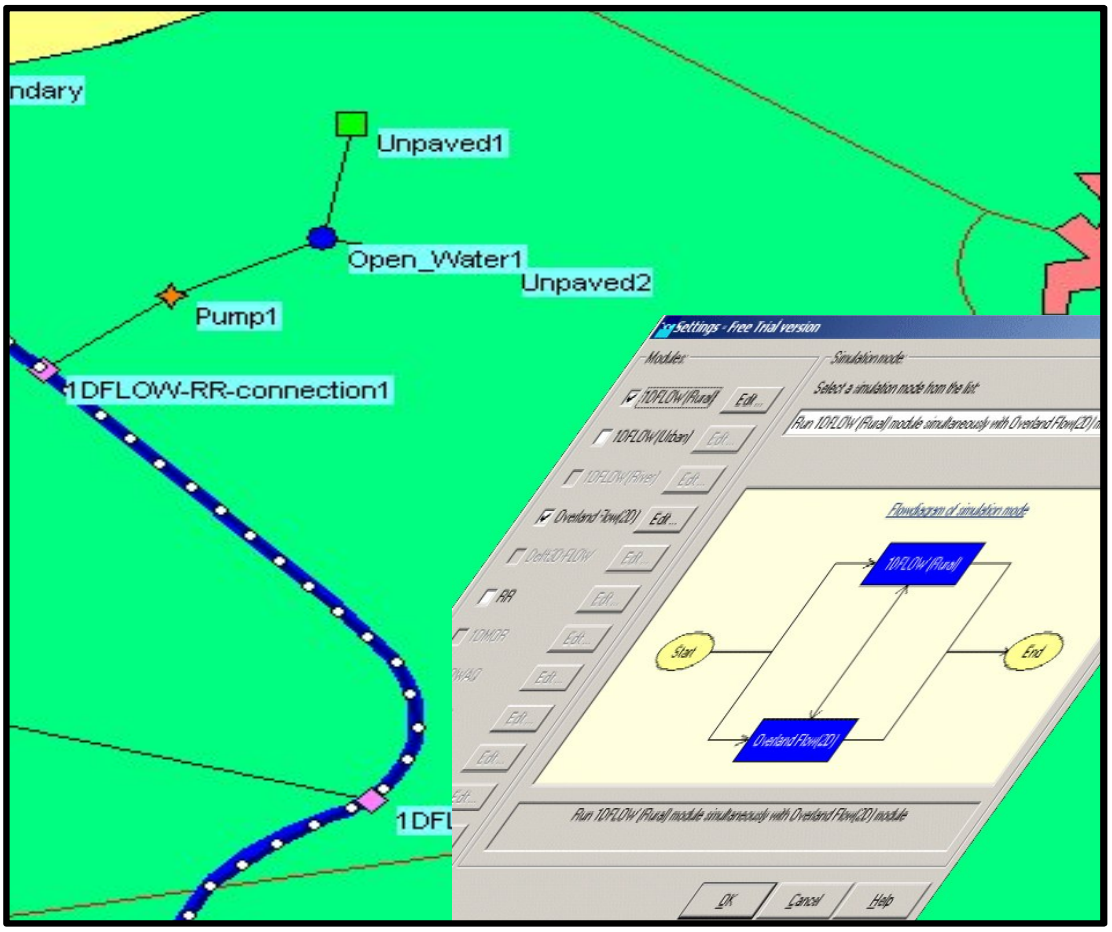
Central Water Commission

DFID

Asian Development Bank

Policy and Advisory Technical Assistance 8089 IND Phase II

# Operational Research to Support Mainstreaming of Integrated Flood Management under Climate Change




## Volume 8

## SOBEK Training Course

Final

December 2015

Deltares in association with RMSI and JPS

## Disclaimer

# CONTENTS



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# Chapter 1 Introduction

## 1.1 Background

A major component of the study on Mainstreaming of Integrated Flood Management under Climate Change is the Modelling to develop the Flood Hazard and Flood Risk Maps for both the Burhi-Gandak and Brahmani-Baitarani basins under climate change scenario. The Client, namely, the Central Water Commission was to advice the Consultants to use Modelling software out of very common commercial software available I the context.

Earlier, during the presentation of the Inception report to the Project Over-view cum Steering Panel on the 30th of June-2014, the august gathering gave the verdict that the Consultants would make a presentation to senior officers of the Central Water Commission and that of the state governments of Bihar and Odisha about the merits and demerits of the popular software like the Mike-11 and SOBEK. Subsequently, the Panel advised the Central Water Commission to give their final option for the Software to be used in the study in consultation with the senior state government officers..

Accordingly, the Modelling Adviser of the Consultants made a detailed presentation about the merits/demerits of the above mentioned software to the senior officers of Central Water Commission. The presentation was made at Central Water Commission Premises on the 11th of July-2014.

## 1.2 Presentation of merits and demerits of the models identified to be used in the study

The Modelling Adviser of the Consultants' Team made a presentation to the Senior Officers of CWC and the Senior Project Officer (Natural Resources and Agriculture) of ADB. He described the Model Structures, Capabilities and suitability for the objective of the study and the cost aspects of each of the software. He mainly focussed the presentation with respect to Mike 11 plus Mike Flood and the SOBEK Models. The full presentation is attached as a powerpoint file (Appendix A)

The various aspects presented covered broadly:

- Whether it is advantageous to use either one software out of SOBEK and MIKE or to use a judicious combination of both
- Description of the SOBEK and MIKE software
- A comparison of the two software on Hydrological, Hydro-dynamic facilities, Structure Control, Overland flow, Calibration and application in urban areas .
- Elaboration on different MIKE packages
- Comparison of the cost of the two software packages

For clarity to some other senior officers of Central Water Commission, as per the request of CWC, a repeat presentation was made by the Consultants in September-2014. Subsequently, after due

considerations/discussions, CWC opted for the SOBEK software; and communicated their decision to the Consultants in October 2014.

## 1.3 Preparations for SOBEK Training Programme:

As per the ToR, the Consultants are to conduct a training programme to senior officers of CWC (as identified by CWC).The scheduling/duration of the training on the SOBEK software for the CWC officers were finalised by consultations with CWC in February-2015. The dates were fixed for 4 days from 23-03-2015. Fourteen CWC trainees and one trainee from NWM participated. The venue was fixed as the training unit (Surface Water Centre) in the fourth floor of the old building in the Central Soil and Materials Research station, in Ole Pale Marg, New Delhi. The budget for the expenses for the conduct of the training including training material was prepared in consultation with CWC. This budget was put up to ADB and received their approval; the internal/external coordination was carried out jointly with CWC so that all gaps were filled up for the ensuing training.

Course Coordinators: Mr. Ruben Dahm (Deltares),
Mr. R.J. Verma (Dir. P&D, Central Water Commission)
Mr. S. Sethurathinam (RMSI)

# Chapter 2 The Training Conduct

## 2.1 Objective of the training

The objective of the SOBEK training course is to transfer knowledge on SOBEK model development and use to CWC.

SOBEK is a powerful modelling suite for flood forecasting, optimisation of drainage systems, control of irrigation systems, sewer overflow design, river morphology, salt intrusion and surface water quality. The programmes within the SOBEK modelling suite simulate the complex flows and the water related processes in almost any system. The programmes represent phenomena and physical processes in an accurate way in one-dimensional (1D) network systems and on two-dimensional (2D) horizontal grids.

## 2.2 Results

In the 4 days sessions 15 participants (see participant list in Chapter 3) worked along with the Consultant's HFA and enthusiastically picked up all that was taught and gained the confidence to run the software by them. The inauguration of the training was made by the Deputy Team Leader of the Consultants and by the Director (River Data Directorate) of CWC.

With the help of the User Manual prepared by the Modelling Adviser of the Consultants and his guidance, the participants performed each step enthusiastically in their respective systems.

The important topics covered in the 4 days are discussed below:

*Extending the Model schematization*
The various steps covered are:

- The objectives
- Viewing the existing Schematization
- Creating a measurements file
- Comparing the Model with the measurement data
- Extending the Model.
- The User Manual prepared for the utility of the participants covered all the step by step instructions for the full practice of the software running.

*D-Flow 1-D Open Water*
This core aspect was conducted in such a way that the participants grasped the philosophy of this part. Elaborate details along with hands-out exercises were the highlights. The contents were addressing the following core steps in running the part of the software.

- Importing of Networks
- Settings
- Meteorological data

- Schematization
- Saving the Network and the Model-stage 1
- Simulation
- Results in Maps
- Results in Tables
- Results in charts
- Interpolation over a connecting node
- Final saving of the Networks and Model

*D-Rainfall-Runoff modelling*

The rainfall-runoff aspect was conducted in such a way that the participants became aware of the library of rainfall-runoff concepts available in the SOBEK modelling suite. The NAM-concept was discussed in detail and a hands-out exercise was carried out. The content of this part addressed the following steps.

- Theory on rainfall-runoff modelling with different RR-concepts
- Extensive description of the NAM-concept
- Schematization of a RR-model
- Connecting a RR-model to a D-FLOW 1-D open water schematization
- RR-routing according to Muskingum
- Pre-processing the necessary meteorological input files
- Importing GIS-files to set up a RR-model
- Validation and simulation

*D-Real Time Control*

The theory on schematizing the operational / real-time control of structures in the SOBEK modelling suite was explained. The controllers available within the D-Flow 1-D open water module were discussed.

- Time controller
- Hydraulic controller
- Interval controller
- PID controller
- Feed forward – Feedback control
- Local control versus Central control

*D-Flow 2-D modelling*

This core aspect on 1D-2D flood modelling was conducted in such a way that the participants grasped the philosophy of why and when to use this type of schematization. This part of the training course discussed the application areas of 1D-2D flood modelling and essential schematization methods. A hands-out modelling exercise was carried out.

- Flood mapping using 1D approaches and 1D-2D modelling
- Hydraulics models for flood mapping: 1D, 2D, 1D-2D
- Horizontal and vertical connections between 1D and 2D
- 1D-2D modelling
- Nested grids
- Settings
- Setting up a 1D-2D model
- Validation and simulation

## 2.3 Detailed curriculum and programme

Table 1 Training programmme

| Date | Time | Speakers/ guidance | Topic(s) |
|---|---|---|---|
| Monday | 09:30 - 09:40 | CWC representative | Introduction |
| | 09:30-10:00 | Ruben Dahm | SOBEK introduction |
| | 10:00-12:00 | Ruben Dahm | Introduction to 1D hydrodynamics and Hands-on: Tutorial Hydrodynamics in open water |
| | 13:30-14:00 | Ruben Dahm | Wrap up: 1D hydrodynamics |
| | 14:00-17:00 | Ruben Dahm | Introduction to rainfall-runoff modelling and Hands-on: Tutorial rainfall-runoff modelling |
| | 17:00-17:30 | Participant | Wrap up day 1 |
| Tuesday | 09:30-12:00 | Ruben Dahm | Introduction to Sobek-1D2D and Hands-on: Tutorial 2D Hydrodynamics |
| | 13:30-17:00 | Ruben Dahm / Group work | Exercises and presentations on several topics:<br>- Running a model – error solving<br>- Tips & Tricks |
| | 17:00-17:30 | Participant | Wrap up day 2 |
| Wednesday | 09:30-12:00 | Ruben Dahm | SOBEK RTC |
| | 13:30-14.00 | Ruben Dahm | Introduction to exercise: Rengali Dam |
| | 14:00-17:00 | Group work | Exercise: Brahmani-Baitarani basin |
| | 17:00-17:30 | Participant | Wrap up day 3 |
| Thursday | 09:30-11:00 | Group work | Exercise : Brahmani-Baitarani basin (cont.) |
| | 11:00-12 :00 | Ruben Dahm | Topic to be decided by participants |
| | 12:00-13:00 | CWC representative | Certificate handover and closure |

# Chapter 3 Participants list

Table 2 Participants list

| No. | Name | Function | Designation |
|---|---|---|---|
| 1 | Rajesh Kumar | Director | Flood Management-II Dte |
| 2 | Sushant Kumar Samal | | M&A Dte |
| 3 | Manoj Kumar | Deputy Director | Planning & Development Dte |
| 4 | Ramjeet Verma | Director | Planning & Development Dte |
| 5 | Ravi Ranjan | Deputy Director | Hydrology Dte |
| 6 | S.C Misra | Assistant Director | Hydrology Dte |
| 7 | S.K.Singh | Deputy Director | Climate Change Dte |
| 8 | V. Vasanthakumar | Assistant Director | Planning & Development Dte |
| 9 | Ritesh Kattar | | FCA Dte |
| 10 | S. Lakshminarayanan | | FFM Dte |
| 11 | Sunder Singh | | Coastal Erosion Dte |
| 12 | Indrajeet Kumar | Assistant Director | Monitoring Dte, Patna |
| 13 | Ajaj Kumar Sinha | Director | Morphology Dte |
| 14 | Asheesh Kumar Singhal | Assistant Director | River Management Coordination Dte |
| 15 | Arijit Ganguly | Young Professional | National Water Mission |
| | | | |
| | Ruben Dahm | Course coordinator / HFA | Deltares |
| | S. Sethuratinam | Deputy Team Leader | RMSI |

# Appendix A Presentation of flood simulation models

Policy and Advisory Technical Assistance (PATA) 8089 IND.
Operational Research to Support Mainstreaming of Integrated Flood Management under Climate Change – Phase II

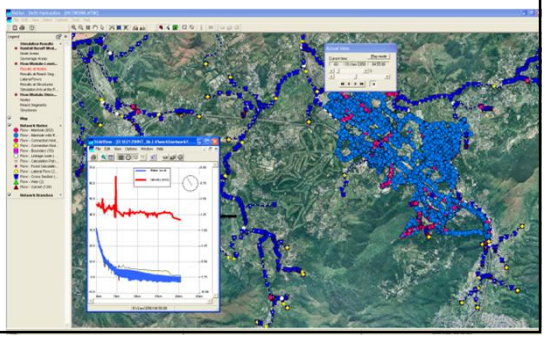
# Modelling Software choice: Whether CWC proceeds with SOBEK or MIKE for the project.

July 11, 2014

## Background information on SOBEK

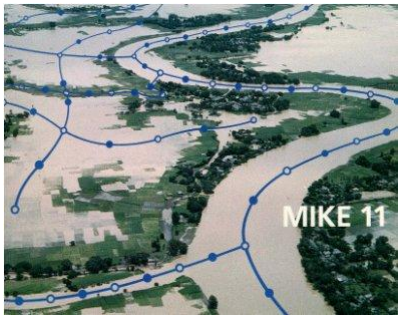
SOBEK is a powerful modelling suite for flood forecasting, optimisation of drainage systems, control of irrigation systems, sewer overflow design, river morphology, salt intrusion and surface water quality. SOBEK simulates the complex flows and the water related processes in almost any system.

It represents phenomena and physical processes in an accurate way in one-dimensional (1D) network systems and on two-dimensional (2D) horizontal grids



## Background information of MIKE11

MIKE 11 provides an array of computational methods for steady and unsteady flow in branched and looped channel networks, and flood plains. MIKE 11 is applicable to flow conditions ranging from steep river flows to tidally influenced narrow estuaries, and describes subcritical and supercritical flow locally. MIKE 11 includes advanced formulations for simulating flow through a variety of standard structures as well as complex structures such as operational structure or dambreak structures.




March 2014

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## Comparison

| Topic | SOBEK 1D2D | MIKE 11 |
|---|---|---|
| Hydrodynamics | Fully dynamic solution to the complete nonlinear St. Venant equations for open-channel flow. Includes also Muskingum for simplified channel routing. | |
| Hydrology (lumped, conceptual, continuous) | A variety of Rainfall-Runoff concepts are included. Both software systems include the NAM-concept. | |
| Hydrology (distributed | By using OpenStreams. This runs outside SOBEK (www.openstreams.nl ) | This runs within MIKE . |
| Structure Control (for user-defined operating strategies) | RTC-module. This runs within SOBEK | SO (Structure Operation) add-on. This runs within MIKE. |

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## Comparison

| Topic | SOBEK 1D2D | MIKE 11 |
|---|---|---|
| Overland Flow | 2D-module. Solves complete SV-equation. Includes fully integrated coupling with 1D and dam/dike breaks. | Uses a simplified, semi-distributed method, or a 2D diffusive wave method. This allows simplified 1D/2D flood modelling. Combines with the DB (dam break) add-on. |
| Calibration | By using OpenDA. This runs outside SOBEK (www.openda.org) | By using AutoCal. This runs within MIKE. |
| Urban (pipes, manholes) | Urban-module. This runs within SOBEK. | Different package needed. Either MIKE Urban or MIKE Flood |

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## Different MIKE packages

MIKE 11: river and channel modelling with simplified overland flow.

MIKE Urban CS: Modelling of storm water and wastewater collection systems

MIKE Flood: River flood modelling. Uses Mike 11, Mike Urban and Mike 21 engines for river modelling and overland flow.

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## SOBEK or MIKE modelling software package?

**Arguments Pro SOBEK:**

- CWC has the opportunity to experience working with a new modelling package
- The HFA has extensive experience with SOBEK and Deltares' back office is available: More specific/detailed support can be given to CWC officers
- The hydrological NAM concept (developed by DHI) is available in SOBEK.
- SOBEK has an integrated 1D-2D coupling/module within the same license.
- SOBEK can be used FREE OF COST during and after the project. After the project has finished a SOBEK service package may be purchased: 8,200 USD (4,93,000 Rs).
- It will be easier to carry out the project extension via UNESCO-IHE (2D flood modelling). UNESCO-IHE contracting Deltares to use SOBEK seems logic, in contrast to 'contracting Deltares to use MIKE FLOOD.'
- Probabilistic framework is set up to support SOBEK input/output.

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## SOBEK or MIKE modelling software package?

**Arguments Con SOBEK:**

- CWC officers have no experience yet with SOBEK.
  - *Tackled by providing a 2-3day SOBEK training course. In total 10-15 CWC staff could participate during such a training course.*
- The SOBEK user interface is currently being updated. During this project the former interface will still be used and this interface has, according to present standards, limited user 'comfort.'
- The process of learning a new software package can be distressing also in view of the project planning deadlines.

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## SOBEK or MIKE modelling software package?

**Arguments Pro MIKE:**

- CWC officers have modelling experience with MIKE 11 (version 2005 and 2007).
- CWC is in the process of finalising the purchase of MIKE FLOOD (in the pipeline).
- User interface of MIKE might be more user friendly than the current SOBEK interface.

**Arguments Con MIKE:**

- A MIKE 11 license has to be purchased. Estimated costs Rp. 1.3 million plus 12.36% tax (network for single user) (Rs2.2 million ++ for 2 users ≅ $42,000)
- The HFA has limited experience yet with MIKE 11/FLOOD.
- A modelling course with MIKE will not be provided by the HFA/project to CWC
- Additional time/funding will be needed as not all (Matlab) probabilistic analysis tools available for SOBEK are immediately suitable for MIKE.

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## Conclusion (1)

*On 12 July 2014 a two hour meeting was convened at CWC, headed by M. P. Singh, to discuss the choice of modeling software for the project.*

The outcomes of the discussions were as follows:

**1. Technical specifications:**

- Technically speaking the software packages are both capable of carrying out the requirements of the project, i.e. preparing flood risk maps
- Both can be used as component in a flood forecasting system
- For 1D and quasi 2D modeling MIKE 11 is sufficient
- For dynamic 2D flood modeling it is required to have MIKE FLOOD
- SOBEK has both 1D and 2D flood modeling standard in the package.



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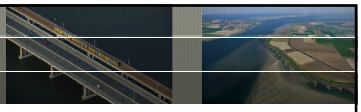
## Conclusion (2)



**2. Financial implications**

- For MIKE a license has to be obtained: two users license costs 41,200 USD inclusive of taxes. If this has to be shouldered by the project, this would imply a significant reduction of funds available for surveys and data acquisition.
- SOBEK can be used during and after the project free of cost. A maintenance contract can be purchased for 8,200 USD per year, but is not mandatory.



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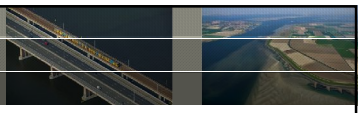
## Conclusion (3)



**3. Practical implementation**

- It was found undesirable to work with two different packages simultaneously. This would lead to unnecessary confusion and inefficiency.
- Although the counterpart CWC modellers are not used with SOBEK yet, they have an open mind to use it. It was decided to provide a temporary license of SOBEK for them to get acquainted with the software using the tutorial.

**At the end of the meeting there was a consensus towards the selection of SOBEK for the PATA 8089 project. A final decision will be made after the Bihar and Odisha State representatives have been consulted as well.**



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