

# TUTORIAL

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HYDROEUROPE

With

ISIS  
Software  
Suite



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## Tutorial for Better Modelling Using ISIS Software Suite

The ISIS Software Suite is a flexible and complete range of tools for designing cost-effective engineering schemes and developing catchment strategies.

ISIS is a full hydrodynamic simulator for modeling flows and levels in open channels and estuaries.

ISIS is able to model complex looped and branched networks, and is designed to provide a comprehensive range of methods for simulating floodplain flows. ISIS incorporates both unsteady and steady flow solvers, with options that include simple backwaters, flow routing and full unsteady simulation.

The simulation engine provides a direct steady-state solver and adaptive time-stepping methods to optimize run-time and enhance model stability.

ISIS provides full interactive views of the model data and results using plan views, long sections, form based editing tools and time series plots. Results can also be reported in text and tabular formats.

The software includes a wide range of diagnostic error checks and a comprehensive on-line help system.

### Task Description

An objective for this exercise is to become more familiar with ISIS Software Suite. Data for following exercise is taken from MIKE11 cross section file. Through modeling with ISIS Software Suite students are getting wider picture about different river modeling tools that can be used for same set of data. In this case the given data are lower river Var (approximately 24km long part of the river).

After “setting up” the model in ISIS student are going to do calibration of the model with respect to:

measured water level at weirs (There are nine weirs in model)

measured hydrograph at napoleon III bridge (located at downstream section, Branch12S5).

Next step will be comparison of the Halcrow results from ISIS model with results obtained from MIKE11.

## List Of Tasks To Perform For Each Team

- Hydraulic modeling of lower Var river and simulation for the flood of November 1994 with ISIS.
- Calibrate ISIS model for the Var low valley in respect to measured water levels at weirs.
- Choose and define strategy for flood wave approach.
- Check validity of results using measured water levels at weirs and comparison of hydrographs at Napoleon II bridge (weir at Branch 12).
- Make comparison of results vs recorded water levels (at weirs) and also comparison Halcrow model with results obtained from MIKE11 model.
- Checking the influence of the tidal effect along the river and estimate how far the influence reaches.

Following steps can provide you more information about river modeling with ISIS Software Suite.

## CHAPTER 1

In chapter 1 the consist introduction in ISIS Software Suite with explanations of making changes in \*.dat file, how to create \*.ief file and how to run simple simulation.

### Type Of Files In ISIS

Before start the quick introduction with type of files in ISIS.

File with extension \*.dat has all cross sections in model and also boundaries (upstream and downstream). File with extension \*.dat can be opened with notepad (my advice is to use TextPad, it is easier to follow the lines and decimal places).

File with extension \*.ief has necessary data for running the prepared model.

### Making Changes In ISIS \*.dat Files

As it was mentioned data (cross sections) for ISIS model is the same as for MIKE 11 model.

Changes in \*.dat file can be done directly using ISIS interface. Changing data directly in ISIS interface is useful when some small modifications are necessary.

Another way of making changes in ISIS is using TextPad editor. ISIS files can be opened using Notepad or TextPad (\*.txt). Following screen shots presents part of the \*.dat file opened with TextPad.

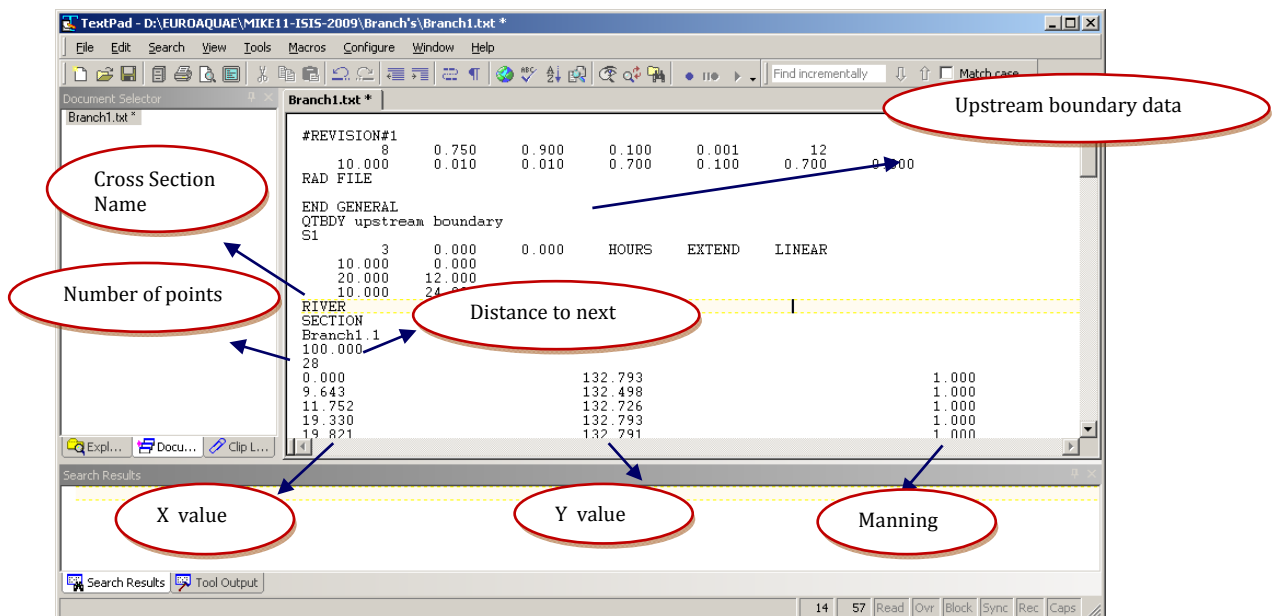


Figure 1: ISIS \*.dat file opened using TextPad

## ●●● Useful

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The \*.txt file has a precise number of places (10 space places) for each data (Cross section chainage, elevation of the cross section, Manning's coefficient, number of nodes in cross section, slope etc) so the user needs to pay attention while inserting or changing the data. For easier data manipulation we can deal with all the changes using EXCEL spreadsheet and later save as appropriate extension and copy into the existing \*.dat file.

The manipulation in EXCEL is following:

- Open the ISIS **\*.dat** file using TextPad
- Copy the data from **\*.dat** file to EXCEL
- Select the columns in EXCEL and change the widths of each column to 10
- Made the changes in data
- Save the EXCEL file with extension **\*.prn**. If you do not have an option in EXCEL to save with \*.prn extension you can make changes in Windows Commander.



Figure 2: File made with \*.prn extension

- Now open the **\*.prn** using Text Pad, copy data and paste the data into the opened **\*.dat** file
  - Save the changes in **\*.dat** file.
-

## Step 1

### Getting Started With ISIS Interface

#### 1. Start ISIS

Following description represent the comprehension of making river network.

When ISIS is started the interface shows following:

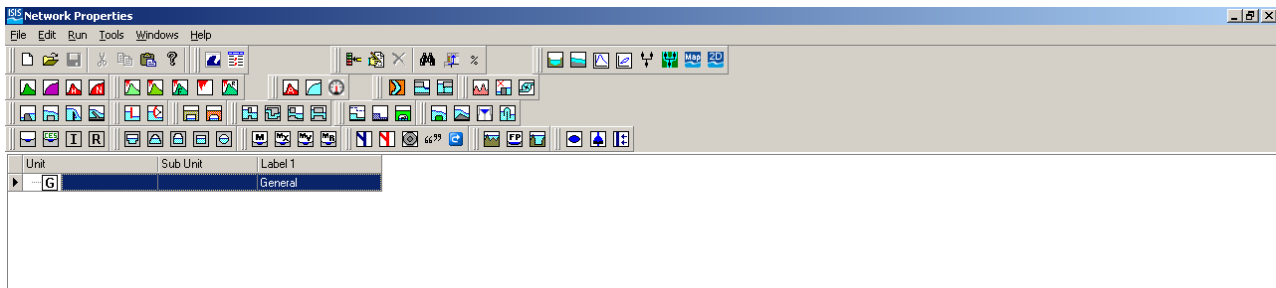


Figure 3: ISIS interface

How to create cross section?

Go to *Edit* than click *Insert* than *Channels* than choose *River* than *Cross Section*

The result is Insert new unit window, where user can choose between different hydraulics units (Channels, Structures, Boundaries, Junctions, etc).

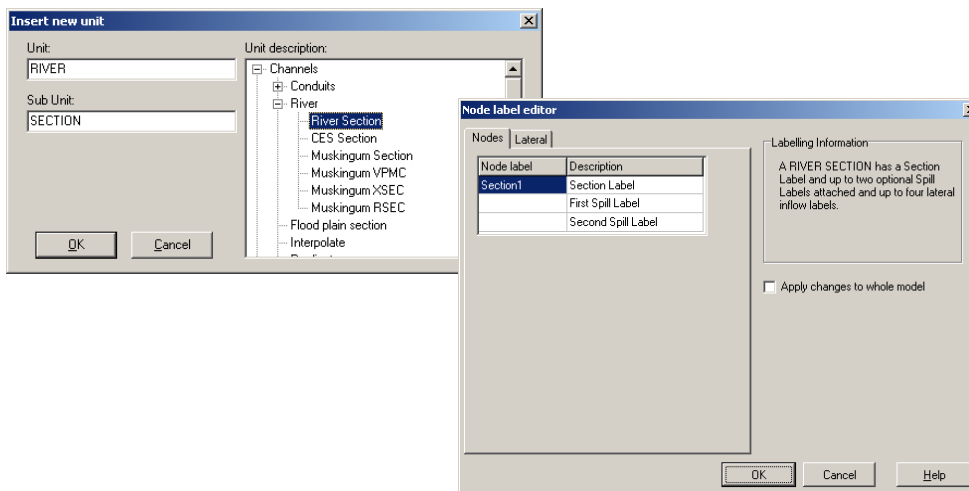


Figure 4: How to insert cross section

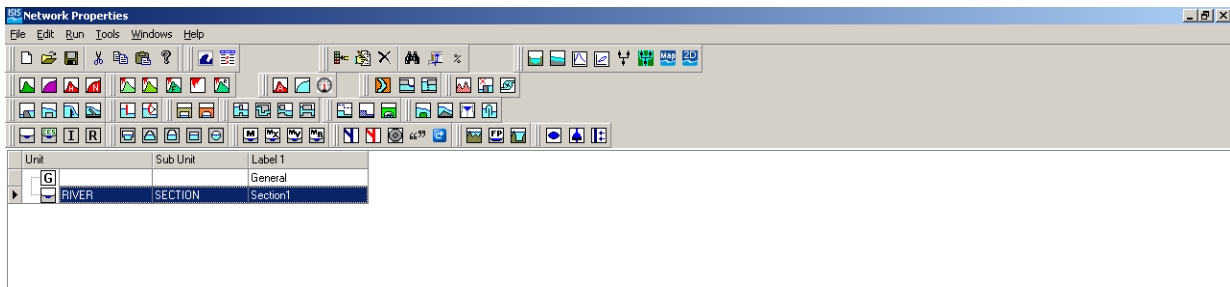


Figure 5: Insert a river section

Next step is inserting data for cross section. User can open the River Section properties with right mouse click and click Properties, or simple double mouse click on selected hydraulics unit.

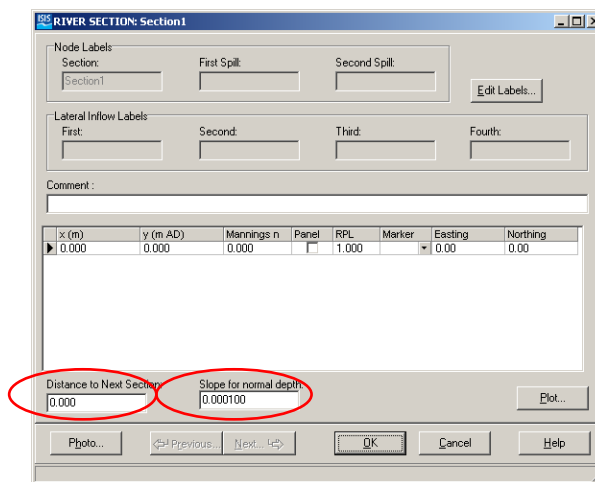


Figure 6: Cross section interface

In ISIS Software Suite user do not have to know chainage, just distance to the next cross section and to calculate slope.

In this file user also create upstream and downstream boundaries. Visualize view is also available for created cross sections. User can see visualized view of cross sections with click on icon (figure 7).

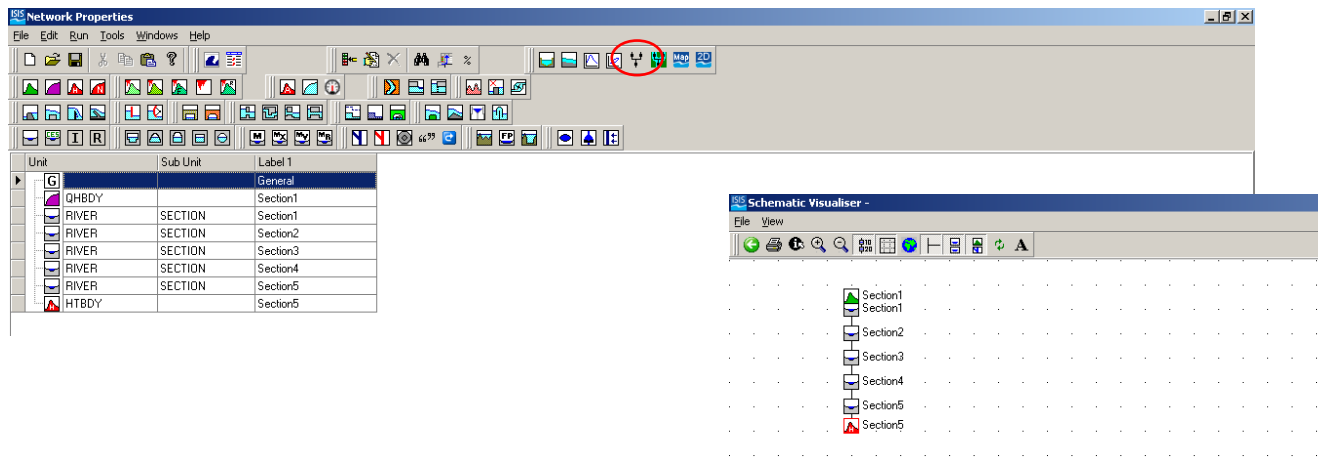


Figure 7: Simple river network with visual network view

Basic network is created, with both boundaries.

For more detail explanation concern building model in ISIS see ISIS Help Quick Start Guide (figure8).

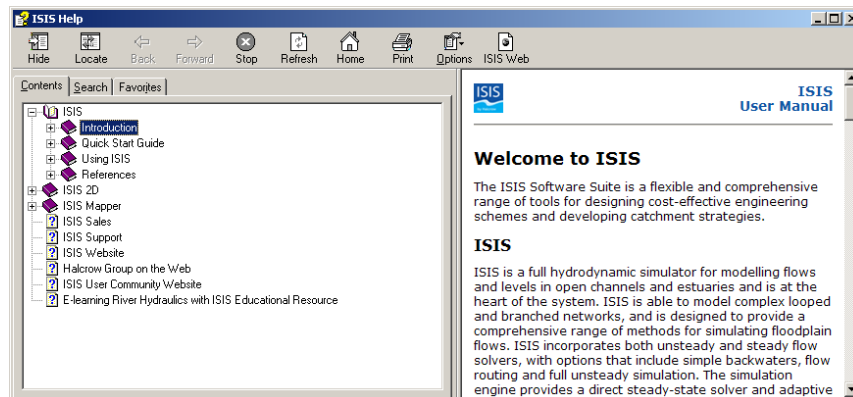


Figure 8: Quick Start Guide in ISIS Help

2. Open data file VarCrossSections going in the File than click Open VarCrossSections
3. Now user have cross section file with sections like in MIKE11 model.
4. Insert new data for upstream boundary. For upstream boundary use the hydrograph from MIKE SHE simulation (hydrograph from higher Var catchment)

Useful

User can edit the upstream boundary following the previous explained procedure about changing the data in ISIS \*.dat file using EXCEL and TextPad.

5. For downstream boundary there are few different solutions:

- Downstream water level equal to sea level,
- Water depth hydrograph (water level/time) at downstream and
- Normal or critical water depth as a condition at the downstream end of the river Var.

User can insert the boundaries following the instructions:

Edit than choose Insert than Boundaries and choose proper type of boundary (figure 9).

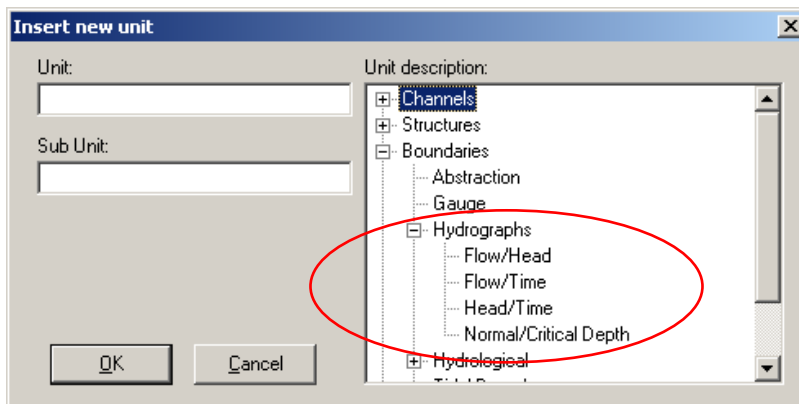


Figure 9: Inserting the boundaries

## Step 2

Next step is running the simulation.

From \*.dat file go on *Run* than to *Flow Simulation* than click on card *Files* than chose and set data file path than click on card *Times* than chose *Run Type* than set parameters and save the ISIS Event file (\*.ief) and click *Run* (figure 10).

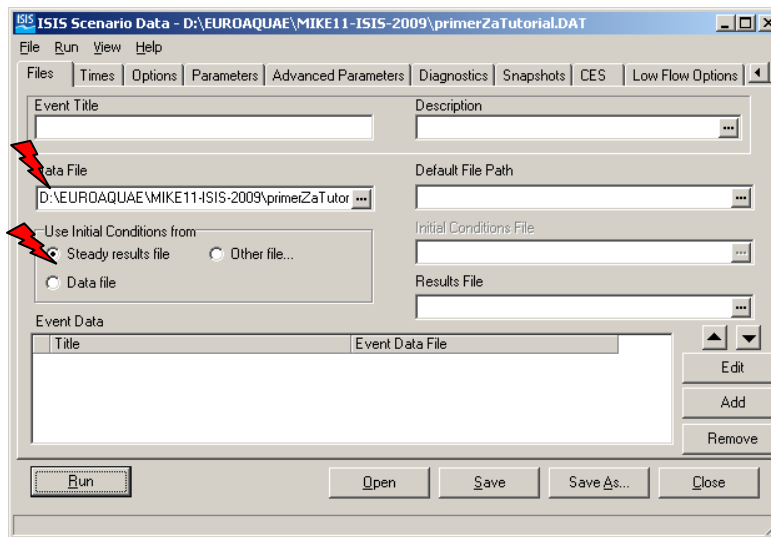


Figure 10: Interface of ISIS event file

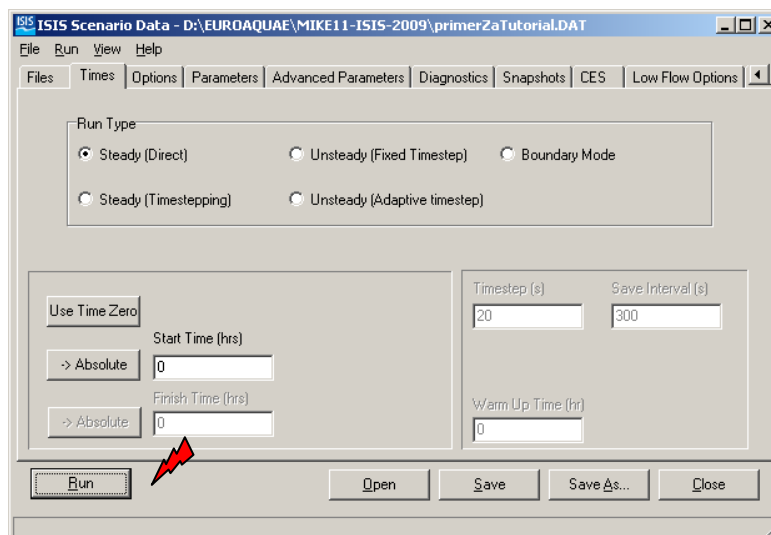


Figure 11: Interface of ISIS event file

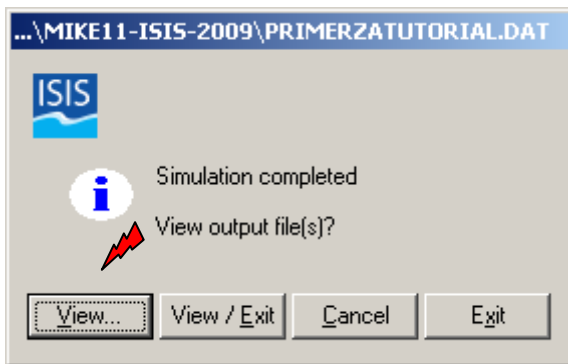


Figure 12: Message that the simulation is completed

After simulation is completed user can take a look to results. Simulation has longitudinal preview. User can select the cross sections clicking with right mouse click and pick option *Long Section*.

## CHAPTER 2

Chapter 2 will give some advices for upcoming calibration part in modeling, how to parse graphical interface for unsteady run type simulation.

### Run the Model

After making all necessary arrangement with cross sections and after inserting both boundaries (downstream and upstream) user is moving to another issue, running the model.

Following can be taken as a recommendation for faster and better dealing with running and calibration issues.

- Chose the right \*.dat file for running the model (figure 10).
- Specify run type (Steady(Direct), Steady(Timestepping), Unsteady(Fixed Timestep), etc)(figure 11)
- Run the simulation (figure 11)

#### Useful

It is better to run first Steady (direct) run type to see is everything with cross sections and with boundaries OK and then try to run Unsteady run type.

Usual problems that user need to solve are related to inserting the interpolated cross sections. After steady run type simulation is finished user can see the message about inserted cross sections by program and recommendation of places where user need to add cross section manually (figure 13).

```

Direct method extra sections information (W2017)
Reach between labels      Sections added by      Sections recommended to
upstream  downstream      the direct method      be added by the user
Branch1S9  B1S92                3                        0
B1S92     B1S91                1                        0
B1S91     B1S93                1                        0
B1S93     B1S94                1                        0
B1S94     B1S95                1                        0
B1S95     B1S96                3                        0
B1S96     B1S97                1                        0
B1S97     Branch1S8            7                        1
Branch1S8  Branch1S7            7                        1
B1S71     B1S72                1                        0

```

Figure 13: Information about places where interpolated cross sections need to be

After finishing the part with interpolated cross sections next step will be to run model with unsteady run type. First time try to use smaller time step. When model is running the unsteady run type user can see graphically time step, model convergence and total flows (figure 14).

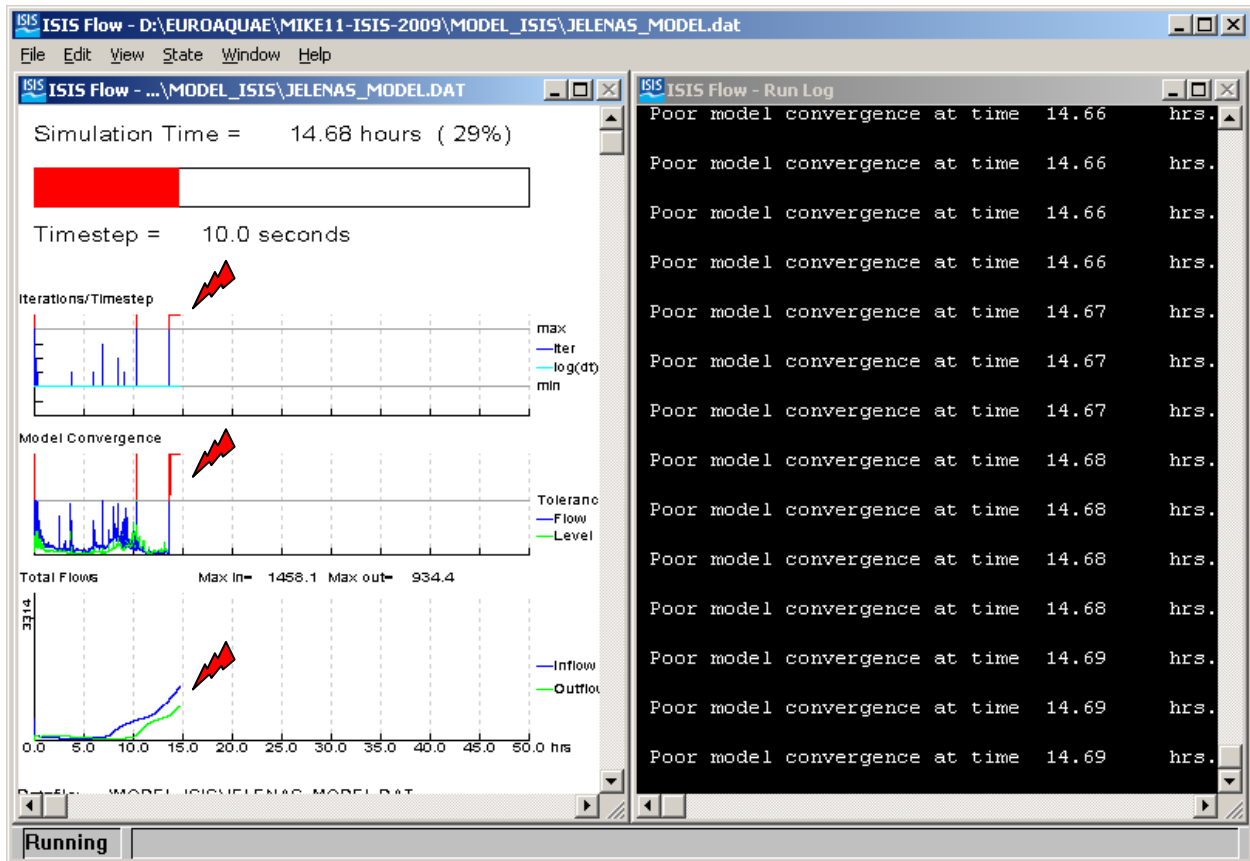


Figure 14: Graphical interface while unsteady run type is running

Graphical preview is very useful since user can see is the time step optimal for the model or not. The red line in graph shows user that the time step is to small or too big for the simulation, also it can implicate that the model is diverging.

Also the shape of Inflow and Outflow can be monitored during simulation.

**If the values of model convergence and iterations are between tolerant boundaries and also both discharge hydrographs have the same shape the model is stable.**

## Weirs

Lower valley of the river Var has nine hydraulics structures (weirs). The scheme of riverline with marked branches and weirs are presented on figure 15.

ISIS Software suite has a bit different way of defining the weirs than it is a case in MIKE11. To define a weir user need to insert and to connect the structure with two cross sections (upstream and downstream cross section). Different type of weirs demands a different data for description.

Weirs on the river Var are broad crested round-nosed weirs. Data that need to be provided are (figure15):

- Downstream and upstream depth of the weir
- Geometry of the weir:
  - Elevation of the crest
  - Breath of the crest
  - Length of the weir
- Coefficient of the velocity - the range of values recommended by Halcrow are between 0.7 and 1.7. The lower value of the coefficient is used for weirs with relatively rough weirs, and the higher value for the coefficient can be used for very smooth weirs (i.e. brand -new weirs). This coefficient essentially signifies the change of the velocity for the water going over the weir and is normally used for calibration of the model alongside with the Manning's coefficients.

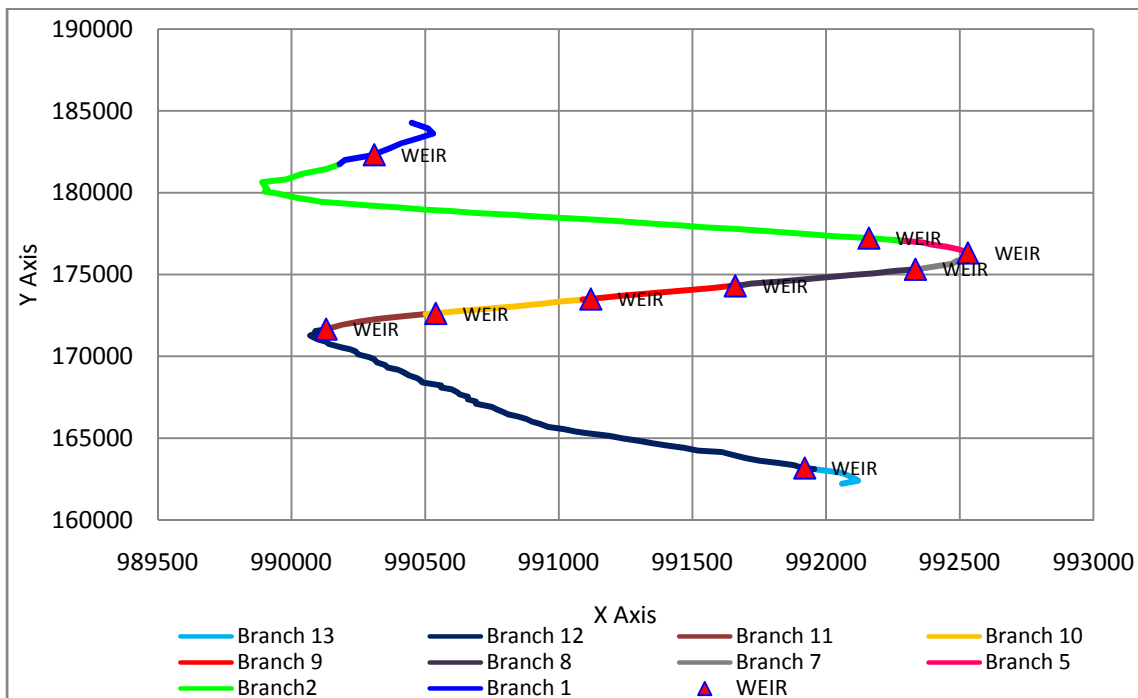


Figure 15: Riverline of river Var low valley with marked branches and weirs

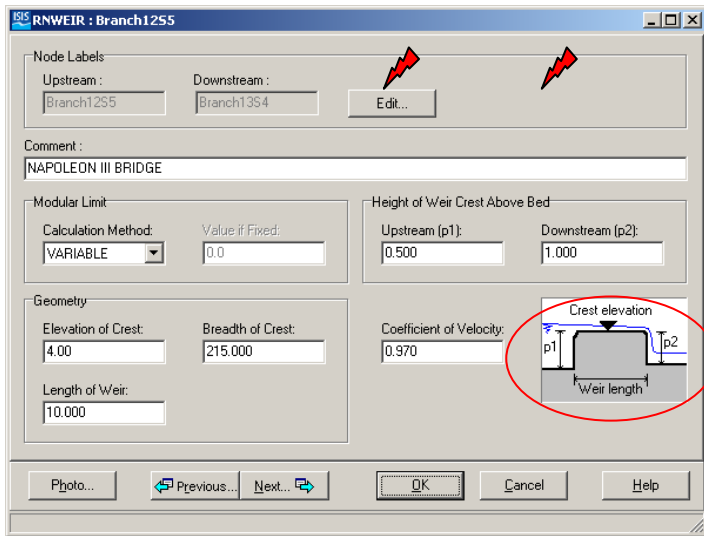


Figure 16: Screen shot of interface for broad crested round-nosed weir

Weir geometry in MIKE11 does not include the upstream and downstream depth. For that reason the upstream and downstream cross section of the weir (in MIKE11) has the regular shape like weir cross section with different bed elevation.

In ISIS there is no need for regular cross sections (like it is a case in MIKE11) because the upstream and downstream depths are already defined (figure 16). For further details concern weirs see ISIS Help were is detail explanation.

## CHAPTER 3

Chapter 3 correspond to model calibration and exporting results from ISIS.

### Calibration

Calibration is done by adjusting the value of Manning coefficient and value of coefficient of velocity (for weirs) For the calibration part of the task the main point is to achieve the measured water levels at weirs (table 1) and comparison with discharge hydrograph (figure 17) at Napoleon III bridge (weir at Branch12):

	Branch	Measured Level (flood, November 1994.)
1	Branch 1	121.65
2	Branch 2	79.96
3	Branch 5	74.35
4	Branch 7	68.39
5	Branch 8	62.40
6	Branch 9	57.59
7	Branch 10	51.80
8	Branch 11	47.09
9	Branch 12	8.49

Table 1: Measured water levels at weirs during the flood (November 1994.)

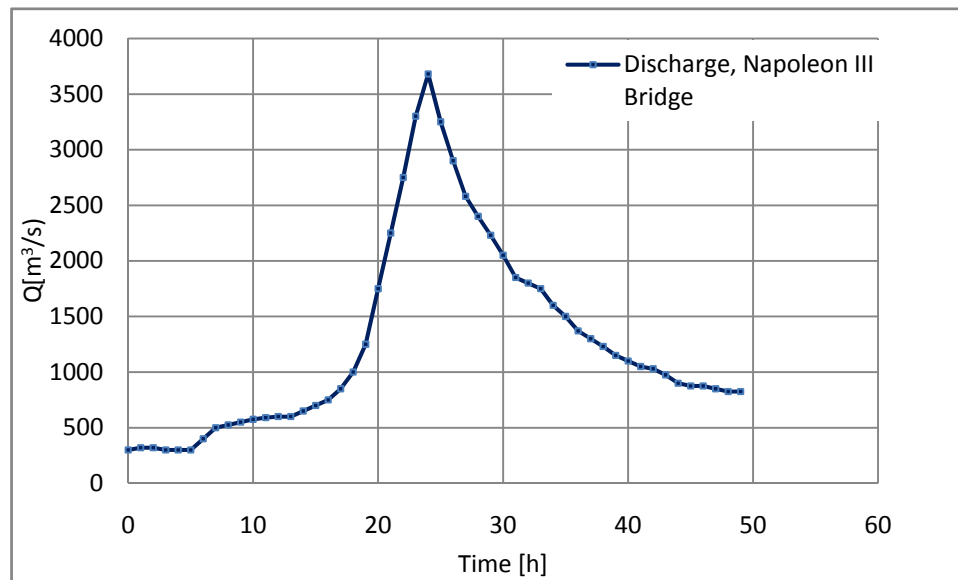


Figure 17: Discharge hydrograph at Napoleon III bridge (weir at Branch 12) during November 1994. Flood event

Presented data can be fined at:

<http://www.hydroeurope.org/jahia/Jahia/site/hydroeurope/op/edit/lang/en/pid/6304>

Useful

As it was mentioned the flood occurs at November 1994. while the cross section data are from 2004. year, so comparison of water level at all cross sections cannot be much accurate.

Bearing in mind that flood (November 1994.) had very strong influence on river morphology (the cross sections has changed), with erosion on flooded area and cross sections, the comparison with water levels measured at weirs should give the better results during calibration process than with measured water levels on all cross sections.

### Exporting results from ISIS

After simulation is finished user can export results from ISIS.

For the discharge comparison (figure 18):

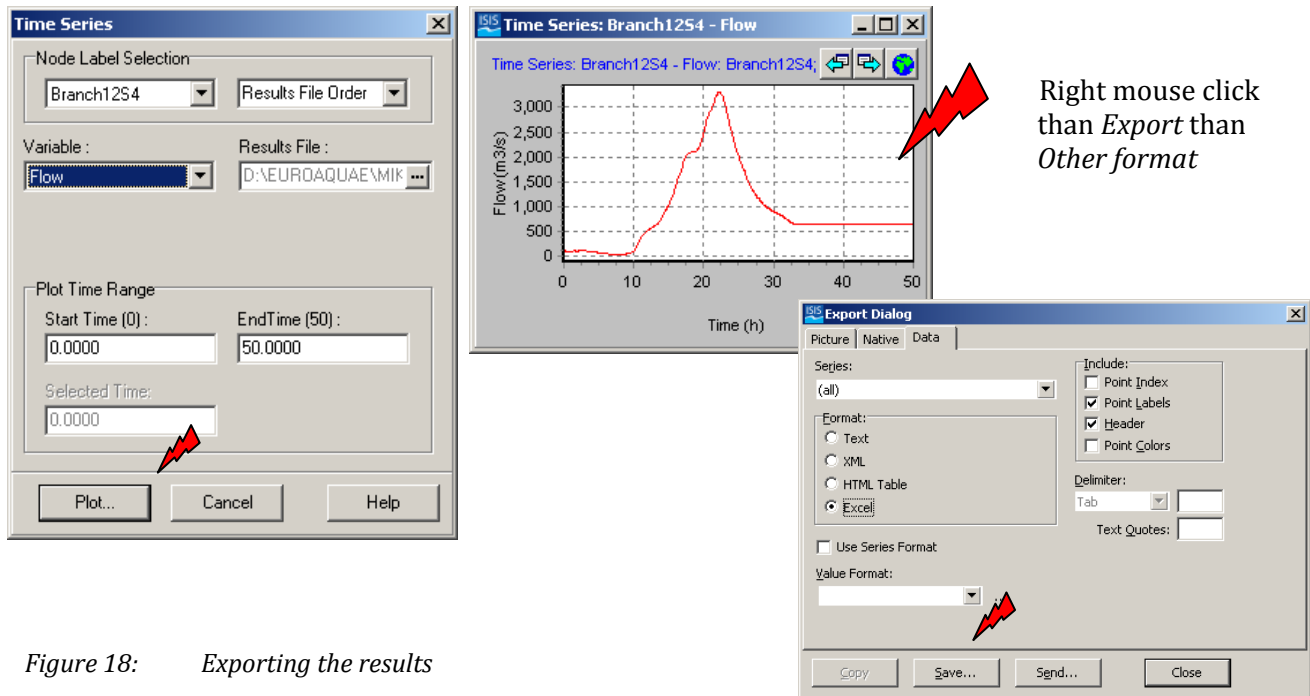


Figure 18: Exporting the results

After saving the exported data user can do the comparison with observed discharge hydrograph at Napoleon III bridge (weir at Branch12) ( for flood, November 1994.).

The same procedure is for water level comparison at weirs.

Now the comparison of Halcrow’s discharge hydrographs with observed water levels, and results of MIKE11 model can be done.

## CHAPTER 4

Chapter 4 is dealing with different downstream boundaries. The idea is to notice the influence of downstream boundary on water levels at upstream sections.

### Different Downstream Boundaries

Through this model there is few downstream boundaries that have been considered for exercise:

- Downstream boundary equal with sea level (0.0 m).
- Minimizing the influence of downstream boundary. In this case the last cross section is moved into the sea for about 1000 m.
- Critical depth – the water level at last cross section at Branch13S1 is equal to critical depth.
- Tidal effect – influence of tide on upstream water level. In this case the tide is due to raising of sea level as a consequences of climate change.

### Downstream Water Level Equal to Sea Level (0.00 m)

In this case the downstream boundary condition is equal to sea level. Figure 19 shows the type of boundary used in this model. Type of boundary is HTBDY (head – time boundary).

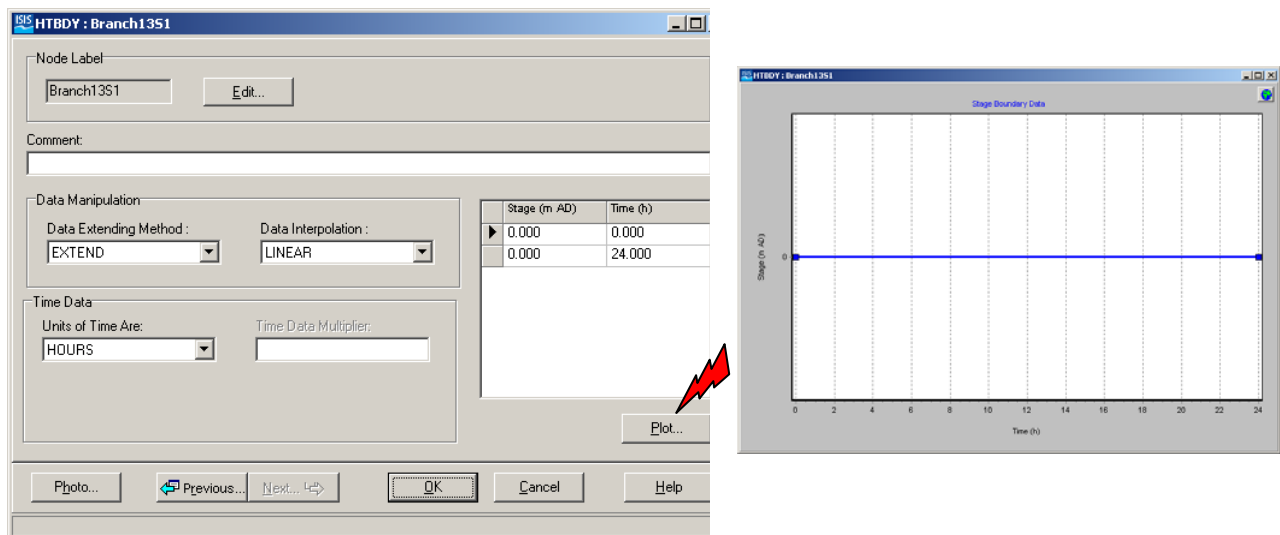


Figure 19: Downstream boundary equal to sea level


## Minimizing the Influence of Downstream Boundary

The idea is to move downstream cross section into the sea (for about 1000m ) and with this type of downstream boundary to minimize its effect. For exercise the cross section is moved into the sea and also few interpolated cross section are added. The new cross section (CH001) is section Branch13S1 just lowered for the slope ( $s=0.001977$ ). Slope is taken from first upstream cross section Branch13S2. Cross sections are presented on the figure 21.

Between the cross section CH001 and Branch13S1 it is recommended to insert the Interpolate cross sections so that there is no such a big difference between the neighboring cross sections. The interpolate cross sections do not have to be inserted at equal intervals, it is sufficient to create them at the distances of 100m, 200m, 300m and the last one - 400m (figure 20), so that there is a gradual change in the distances to next.

For this exercise the type of boundary is HTBDY (head - time boundary).

INTERPOLATE		B13S28
INTERPOLATE		B13S29
RIVER	SECTION	Branch13S1
INTERPOLATE		CH1
INTERPOLATE		CH2
INTERPOLATE		CH3
RIVER	SECTION	CH001
HTBDY		CH001



label	y	flow	stage	froude no	velocity	umx
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Figure 20: Screen shot of inserted cross sections

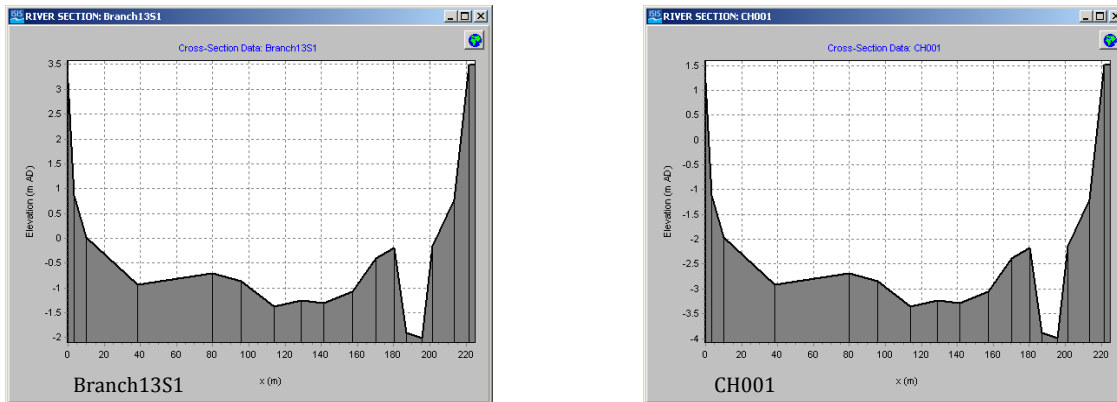


Figure 21: Cross section Branch13S1 and new cross section CH001

## Water Level Equal to Critical Depth

Downstream boundary for this case is critical depth. Figure 22 shows the type of boundary (NCBDY) used in this model. The Normal/Critical Depth Boundary (NCBDY) unit enables the user to specify a downstream boundary, which automatically generates a flow-head relationship based on section data. The options available to the user are to apply normal depth (from Manning's equation), or critical depth.

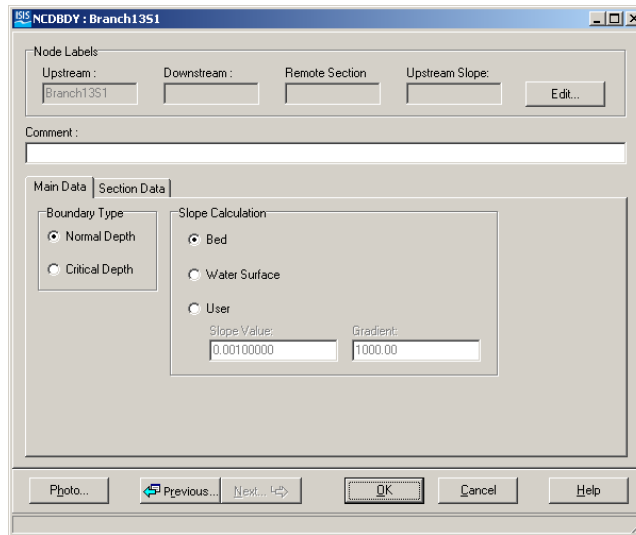


Figure 22: Type of boundary used in this exercise

## CHAPTER 5

### Climate Change

For the exercise purpose the climate change scenario will be consider.

Based on the 12 atmosphere-ocean general circulation models (AOGCMs) used in the study, the scientists said higher concentrations of gases will trigger higher temperatures throughout the sea. Temperature changes and more mass may also trigger changes in sea levels in the long run. The level of the whole Mediterranean will rise by between 3cm and 61cm (figure 23) on average as a result of the effects of warming <sup>41</sup>.

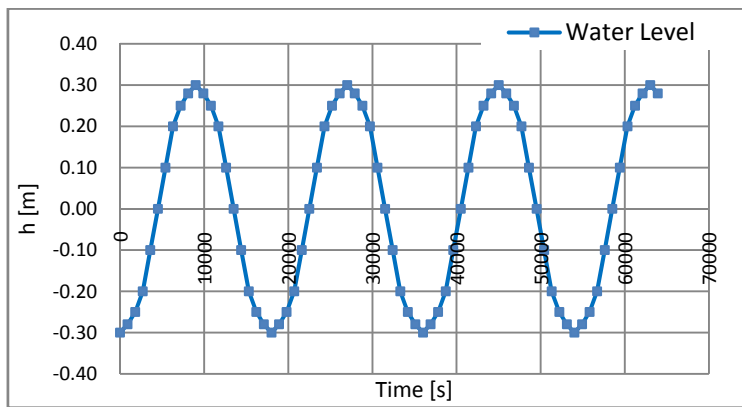


Figure 23: Water level hydrograph as a downstream boundary

### Tidal Effect Scenario

Tide that comes from sea can have a significant influence on upstream areas of river Var. For the exercise the downstream boundary is represented by HTBDY (head - time boundary) (figure 24).

After the simulation with tidal effect as downstream boundary the result is a flooding in upstream areas. The flooding area due to tidal effect is up to Napoleon III bridge (Branch 12 section 5).

#### Useful

For model simulation tidal effect other water level hydrographs can be used (bigger tide). However the cross section geometry proposes some limitation. If the tide level is bigger than cross section banks the simulation will have errors. Another thing is, even if the tide level is smaller than cross section banks the simulation will run but with message “poor model convergence....”. In that case user need to add interpolated cross sections on places mentioned in message after steady run type simulation.

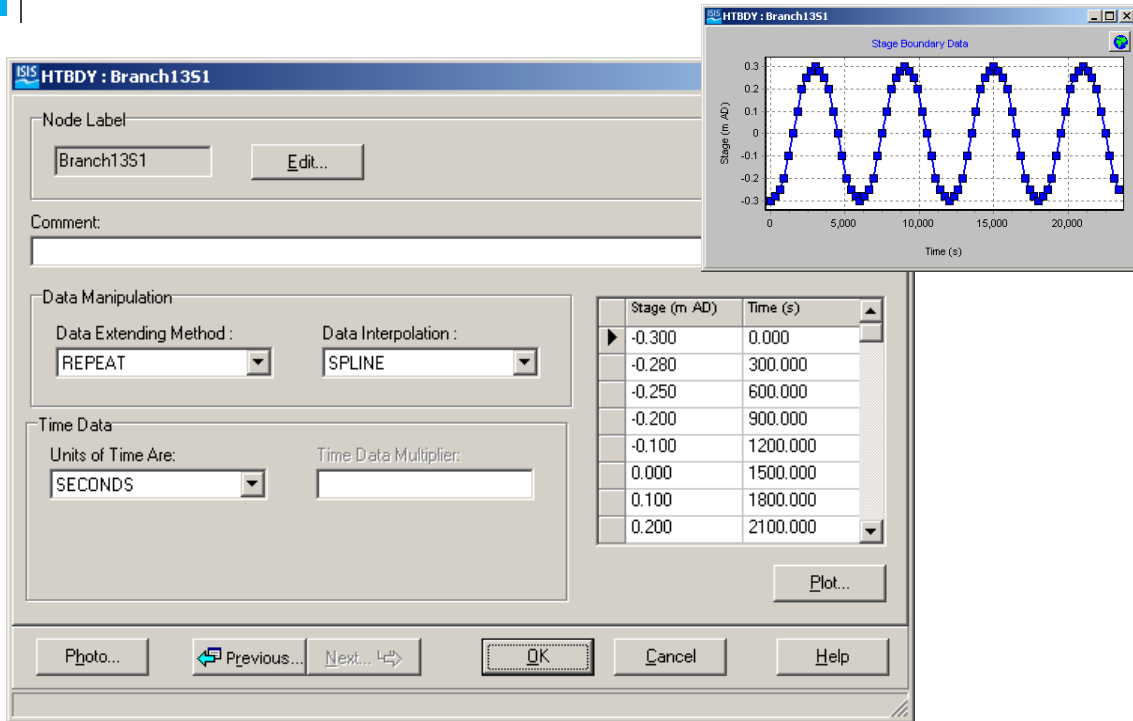


Figure 24: HTBDY (head – time boundary) boundary as a consequence of climate change



## Resources

1. <http://www.halcrow.com/isis/>
2. [http://www.isisuser.com/docs/manuals/elearning\\_riverhydraulics/Teaching\\_Hydraulics\\_Using\\_ISIS.htm](http://www.isisuser.com/docs/manuals/elearning_riverhydraulics/Teaching_Hydraulics_Using_ISIS.htm)
3. <http://www.euroaquae.org>
4. <http://www.hydroeurope.org>
5. [http://ec.europa.eu/research/headlines/news/article\\_09\\_03\\_19\\_en.html](http://ec.europa.eu/research/headlines/news/article_09_03_19_en.html)

*Nice, September 2009.*

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<sup>i</sup> [http://ec.europa.eu/research/headlines/news/article\\_09\\_03\\_19\\_en.html](http://ec.europa.eu/research/headlines/news/article_09_03_19_en.html)